■ SESSION: D [DG1]
10월 18일(목), 12:30 - 14:15
장 소: 탐라홀B

D-01 **Evidence of Nearly Flat Layers and AB Stacking Order of Graphite Oxides** 정 혜경, 이 윤표[1], LAHAYE Rob[1], 박 민호[2], 안 계혁[3], 김 익준[4], 양 철웅[5], RUOFF Rodney[6], 박 종윤[1], 이 영희[1](*성균관 대학교, 물리학과 (BK21). [1]성균관 대학교, 물리학과. [2]성균관 대학교, 신소재공학과. [3]전주 기계 연구원. [4]한국전기연구원. [5]성균관대학교, 신소재공학과. [6]Northwestern University, 기계공학과.*) Graphite oxide (GO) sample were prepared by a simplifiled Brodie method of our invention. Hydroxyl, epoxide, carboxyl, and some alkyl functional groups are present in the graphite oxide, as identified by solid-state C-NMR, FT-IR, and XPS. Starting with pyrolytic graphite, the average interlayer distance after 1 hour of reaction increased to 5.62 Å and then increased with further oxidation to 7.37 Å after 24 hours. Other aspects of the chemical bonding were assessed from the NMR and XPS data and are discussed. AB stacking of the layers in the GO was inferred from an electron diffraction study. The elemental composition of GO prepared using this simplified Brodi method was obtained and is discussed.

D-02 **Study of Optical properties of thin Au &Al films using surface plasmon resonance technique** 이 송매, 박 충현, 조 용훈(*충북대, 물리학과.*) The optical properties of very thin gold films have bee evaluated by Fresnel analysis, employing optical boundary conditions pertaining to the surface plasmon resonance (SPR) at the gold–air/water interface. Thus various simulations has been performed for gold reflectance data as a function of variation in the gold film thickness. The magnitude of the resonance, i.e., the SPR signal is sensitive to the film thickness. A sharply defined thickness of 50 nm is required, to achieve optimum SPR excitation conditions, and instrumental sensitivity. We also calculated similar simulation on Aluminum films and obtained an optimum Al thickness of 15nm. By Comparing the simulated data with the experimental results, we could optimize the SPR setup for improving its sensitivity.

D-03 **Measurement of fluorescence quantum yield of CdSe Nanocrystals.** 김 상민, 양 호순, 경수 홍[1](*부산대학교 물리학과. [1]한국기초과학지원연구원 부산센터.*) During the past decade. chemically synthesized semiconductor nanocrystals have been studied in wide areas. CdSe nanocrystals exhibit an efficient photoluminescence, whose energy can be controlled by adjusting their size. In addition, CdSe nanocrystals show much larger photostability than the organic dyes used routinely and they facilitate multicolor experiments. For this application, both the efficiency and the line width of the photoluminescence are important. Line width of the photoluminescence depends strongly on the size dispersion of nanocrystals. The surface condition of nanocrystals affects the efficiency of photoluminescence significantly. Therefore, core/shell structured nanocrystals are styudied for the improvement of photoluminescence efficiency. CdSe nanocrystals are synthesized using CdO in this study. The line width of the photoluminescence is between 30 and 35nm. The efficiency of photoluminescnec is obtained with the quantum yield, where Rhodamin 6G is used. The quantum yields of CdSe core nanocrstals and core shell structured CdSe/ZnS are compared.

D-05 **Fabrication of CdSe nanocrystal-based local fluorescent probes by active polymerization** 이 규승, WANG Hao, 이 선균, 조 용훈(*충북대, 물리학과.*) A well-studied process that can be exploited to get better resolution is fluorescence resonant energy transfer (FRET) between fluorophores. A donor molecule or other fluorescent center located in the tip apex is used to excite the fluorescence of an acceptor center of the sample (or vice versa). We have investigated the photosensitive polymerization fabrication process of the local fluorescent aperture probes for FRET research using CdSe nanocrystals as donors. Photosensitive epoxy attached a tip to a cleaved fiber end by photopolymerization. A beam of blue laser light introduced at the other end of the fiber and thus initiates polymerization. Therefore, since the polymer component remains firmly attached to the optical fiber thanks to hydrogen bonds, it can be inferred that the component grown following this procedure will be an extension of the fiber core. In our experiment, the CdSe nanocrystals were embodied in the epoxy resins. Therefore, the local fluorescent aperture probes were realized by the polymerized tip formation with CdSe nanocrystals at the fiber end.

D-06 **Intercalation of dyes into graphite oxide** LEE Young Hee, AN Kay Hyeok[1], JEONG Hae Kyung[2], JIN Mai Hua[2], LEE Yun Pyo[2](*BK 21 Physics division, Department of Physics, Center for Nanotubes and Nanostructured Composites, Sungkyunkwan Advanced Institute of Nanotechnology, Sungkyunkwan University. [1]Chonju Mechanics Reasearch Center,Chonju. [2]BK21 Physics division, Department of Physics, Sungkyunkwan University.*) Graphite oxide (GO) has been known since the 19th century. Recent interests have grown due to the proposed application for electrode materials in battery and supercapacitors. The GO was synthesized by a simplified Brodie method, and then intercalated by several organic dyes. We found that the interlayer of GO increased to about 7 Å with fuming acid treatment from pure graphite, and was further enhanced to about 10 Å with dye intercalation, which was confirmed by X-ray diffraction. In order to investigate stability of the structure of composites, we annealed the intercalated GO and their characterization will be discussed.

D-07 **Study of Surface Waves at the Air-Water Interface Covered by a Monolayer** YUN Sungyoung, KIM Mahn Won(*KAIST, 물리학과.*) We have measured complex surface wave frequency using thermally excited surface wave spectroscopy and complex surface wave vector using externally excited surface wave spectroscopy at an air-water interface. The interface is covered by positively charged lipids(dioleoyl trimethylammonium propane chloride-DOTAP) adsorbed by poly-anions(Poly Styrene Sulfonic Acid,Sodium Salt) with different chain length and monomer. From

the data, we can obtain informations about comprssibility and dilational and shear surface viscosities. At low frequency(200Hz~400Hz), the change of chain length of PSS in the subphase affects damping constant in surface wave. However at high frequency(2kHz~7kHz), this tendency is dissapeared. Kramer's dispersion relation can not explain our data. But Harden's general dispersion relation for viscoelastic polymer film can do. This means that the surface waves are highly affected by adsorbed polymer.

D-08 **Structure changes of cylindrical micelle for additional charged surfactant** KIM Sanghyun, KWON Suyong[1], MOON Junhyuk, KIM Manwon(*KAIST, 물리학과. [1]KRISS.*) The structure changes of cylindrical micelle for adding a small amount of charged surfactants were measured by using small angle neutron scattering. In dilute solution with small amount of charged surfactant(less than 10mol%), the cylindrical local structure of micelle was identical for all samples. The scattering curves of over 6mol% doping level sample were well fitted to the uniform cylinder model with screened Coulomb potential MSA. The micellar length was decreased as increasing charged surfactants and for the first time we observed the micellar length shortening as concentration increase in cylindrical micelle. It means that the composition changes in aggregates as total concentration have to be considered in thermodynamics of mixed surfactant solution.

■ SESSION: D [DA1]
10월 18일(목), 12:30 - 14:15
장 소: 탐라홀C

D-09(초) **Vastly Extended Thermodynamic Stability of Epitaxial Oxide Thin Film Growth by Pulsed Laser Deposition** SONG Jong Hyun(*Dept. of Physics, Chungnam National University.*) Oxide thin films have been attracting much attention due to their exotic physical properties ranging from insulator to superconductor and possibility of device applications. Here we examine the growth phase diagram of $La_{0.7}Sr_{0.3}MnO_3$ thin films grown by pulsed laser deposition, which are heavily studied for their magnetoresistive properties even at room temperature. Unlike previous reports, we obtained stoichiometric films as grown, despite extremely reducing growth conditions, with bulk-like Curie temperatures exceeding 360°C. Masking this stability is a particularly strong dependence of film stoichiometry on the laser profile at the target and also on kinetics of ablated species on the substrate surface. These results indicate that bulk thermodynamic limitations can be overcome in perovskite films using epitaxial stabilization.

D-10 **Effects Of Spin-orbit Couplings On Electronic Structures And Magnetic Ground States Of Zinc-blende II-V Compounds** LI Yun, YU Jaejun(*서울대학교 물리학부.*) We performed a series of fully relativistic non-collinear density functional theory (DFT) calculations including spin-orbit couplings in order to investigate the electronic and magnetic properties of zinc-blend II-V compounds. Previous non-relativistic DFT studies predicted that the binary compounds of zinc-blende structure composed of group II elements (Ca, Sr, and Ba) and group V elements (N, P, As, Sb, and Bi) are half metallic ferromagnets (HMFs) and have a magnetic moment of one Bohr magneton per formula cell. However, our fully relativistic DFT calculations led us to different conclusions. For those compounds composed of lighter group V elements such as N or P, the spin-orbit coupling is negligible so that the HMFs still remain as the same as in the results of non-relativistic DFT calculations. On the other hand, for those compound composed of heavier group V elements such as Sb and Bi, the influence of spin-orbit couplings on the electronic structures is very remarkable. ASb (A = Ca, Sr, and Ba) are not half metal but still are ferromagnets with a magnetic moment of Bohr magneton per formula cell. And ABi (A = Ca, Sr, and Ba) are neither half metal nor ferromagnet. The arsenides are found to be right at the critical point between half-metal and non-half-metal, which have a spin polarization rate of about 95% at Fermi energy. From the analysis of spin-orbit and exchange coupling strengths, we could understand the variation of both electronic and magnetic properties of zinc-blende II-V compounds.

D-11 **^{55}Mn and ^{27}Al NMR investigation of YMn_4Al_8 single crystal** KANG Kihyeok, MEAN B. J., HAN K. S., KWON S. K., NAM S. K., CHOI S. H., CHOI H. H., KIM S. H., KWON D. J., SUNG S. J., LEE Moohee[1], CHO B. K.[2](*Konkuk university, Dept of Physics. [1]Konkuk university, Dept. of Physics. [2]GIST, Department of Materials Science and Engineering.*) ^{55}Mn and ^{27}Al NMR measurements have been performed on a single crystal of YMn_4Al_8 at 8 T down to 4 K. NMR spectrum, Knight shift, linewidth, spin-lattice relaxation rate $1/T_1$, and spin-spin relaxation rate $1/T_2$ are measured as a function of temperature for the c-axis parallel and perpendicular to magnetic field. ^{27}Al NMR spectrum showed two different sites with five satellites for each site. ^{55}Mn NMR spectrum exhibited broad five satellites for the spin of I=5/2. Temperature dependence of Knight shifts and Korringa product T_1T as well as the magnetic susceptibility show a large decrease at low temperature indicating the opening of a pseudo gap in YMn_4Al_8.

D-12 **Effects of Finite Heat Capacity of Conducting Electrons on Nuclear Spin-Lattice Relaxation in Metallic Si:P** JEONG Minki, SONG Myeonghun, UENO Tomohiro[1], MIZUSAKI Takao[2], SASAKI Yutaka[3], MATSUBARA Akira[3], FUKUDA Kohji[1], CHIBA Meiro[4], LEE Soonchil(*KAIST, Dept. of Physics. [1]Kyoto Univ., School of Health Sciences. [2]Toyota Physical and Chemical Research Inst.. [3]Kyoto Univ., LTM Center. [4]Fukui Univ., Dept. of Applied Physics.*) The study of nuclear spin-lattice relaxation usually assumes that the heat capacity of a lattice is infinite. In metals, for example, the heat capacity of conducting electrons dominates the total heat capacity at low temperatures and the Korringa's relation that the relaxation rate depends linearly on temperature is built on the assumption of infinite heat capacity of conducting electrons. Strong magnetic fields and very low temperatures, however, introduce the heat capacity due to nuclear Zeeman order

known as Schottky anomaly, which may become comparable to and even takes over that of conducting electrons. Heavily doped semiconductors such as Si:P have small value of Sommerfeld constant so the effects of Schottky anomaly are expected to be observed relatively easily. We performed the ^{31}P nuclear magnetic resonance experiment on Si:P under high magnetic fields around 7 T and as low temperatures down to 45 mK. A clear two-exponential relaxation in nuclear magnetization was observed below 1 K. The time constants obtained from the fast-relaxing components seem to follow the Korringa's relation while those from the slowly-relaxing ones are an order of magnitude longer than expected from the Korringa's. The latter is attributed to thermal bottleneck occured between conducting electrons and 3He bath.

D-13 **자석의 근거리 자기장과 자력** 리 의재, 이 흥렬 (*한국 생산기술 연구원.*) 永久 자석의 자기장 세기(H)는 자성 회전능(magnetic moment), 극성의 세기(pole strength) 등 개체로서의 자석의 일반적 자력을 규정하는 중요한 개념 중 하나이다. 한편으로 두개 이상의 자석들이 존재할 때 이들 사이의 인력과 척력을 계산하여 알아냄에 있어서도 이들과 자속밀도 등의 매개치(parameter)를 정확히 아는 것은 필수요건이다. 그럼에도 불구하고, 전자기학에서 상론되는 수식들은 자석길이의 15 배 이내의 근거리에서는 적용할 수 없는 理論的 한계를 갖고 있었다. 이 문제를 극복하기 위하여, 근거리 자기장과 자력이 자축방향으로 표면에서 떨어진 거리(x)의 함수로 표현되어 永久 자석을 사용하는 각종 기기 및 장비 제작과 사용 시 쉽게 적용할 수 있도록, 일반형 지수함수 [f(x)=a·exp(bx)]를 활용하여 관계식들을 유도·확정하였다. 여기서 a 는 표면 자속밀도(H_0)로서, 관련식은 $H=H_0 \cdot e^{bx}$ 형태로 표현된다. 희토류(Nd-Fe-B) 자석(N35 형)의 자기장 세기(H)를 나타내는 수식을 위한 a_H 값은 exp(8.324) 즉 4130 [G] 또는 0.413 [T]이고, b_H 값은 -0.1556 [mm^{-1}]으로 결정하였다. 다른 종류 자석들의 경우에도 같은 방식을 적용한다면 다양한 응용이 가능하다. 이렇게 유도된 연산식과 측정치[1]가 잘 부합함을 검증하면서, 永久자석의 자력이 거리[간격]의 4제곱에 반비례한다[2]는 정설과 달리 제곱에 반비례한다는 주장들[3],[4]은 분명 옳지 않은 것임을 확인할 수 있었다. 또한 유한요소(finite element) 방식으로 자기장과 자력을 수치해석[5]하여 유도식과 비교해본 결과, 근거리 자력계산에 탁월하게 유용함도 알 수 있었다. 일면, 표준연구원[6]에서 별도로 측정한 자성 회전능 값과는 판이한 결과를 보임은 심각한 토론의 대상이 될 수 있다. ----- 각주 1) 이 광연, 순천향대 차 귀수 교수 연구실 박사과정. 2) F.C. Moon, "Superconducting Levitation", Wiley, New York (2004), 12쪽. 3) A. Romer, AJP 41(12), p.1332 (1973). 4) R. Lufburrow, AJP 31(1), p.60 (1963). 5) 곽 상엽, 서울대 정 현교 교수 연구실 박사과정. 6) 박 포규, 개인적 교류 내용.

■ SESSION: D [DH1]
10월 18일(목), 14:30 - 16:15
장 소: 한라홀A

D-14 **Direct Observation of Dynamic but Confined Fluctuations on Nanowire: Si(111)5×2-Au** 강 필규, 염 한웅(*연세대학교, 물리학과, 원자선 원자막 연구단.*) Au adsorption on vicinal Si(111) is fascinating due to one dimensional (1D) structures with well-defined electronic band structures. However, these systems have defects on the surface in common. For the 1D system, even a weak scattering by defects drastically change the electronic systems due to the localization. Although the defect effect is one of the central issues in 1D physics, it is not fully understood yet because partly of the difficulty of the systematic defect control. Among the 1D systems on the Si surfaces, the Si(111)5x2-Au has been known as a self-organized 1D chain system with two Au rows separated by a Si row [1]. Extra Si atoms substituted with Au become adatom impurities randomly distributed on the chains [2]. In particular, it has been known that such adatom impurities can be systematically controlled by additional Si evaporation and rapid thermal annealing [4]. the microscopic effect of the adatoms on 1D atomic chains is not clear. Here, we observed inhomogeneous fluctuations on the Si(111)5x2-Au with relatively low adatom impurity density by scanning tunneling microscopy (STM). STM reveals that the fluctuation, strong extra contrast in the image, occurs in the odd-length chain segments [na_0, n=9, 11, 13,..., a_0 is the lattice constant of the (111) plane] defined by two neighboring Si adatoms. Furthermore, the fluctuation exhibits dynamic behavior at room temperature (RT). Upon cooling, the fluctuation is frozen, which shows the existence of an 1D domain wall in the odd-length segments. Therefore, this dynamic fluctuation at RT can be interpreted in terms of a moving 1D domain boundary (dislocation), "soliton", confined by the adatom impurity.
[1] A. A. Baski, et al., Phys. Rev. B 41, 10247 (1990). [2] A. Kirakosian et al., Phys. Rev. B 67, 205412 (2003). [3] R. Bennewitz et al., Nanotechnology 13, 499 (2002). [4] W. H. Choi et al. (to be published).

D-15 **Intermixed dimensions in the electronic band structure of Pb nanowires on stepped Si(111)** KIM Keun Su, MORIKAWA Harumo, CHOI Won Hoon, YEOM Han Woong(*Institute of Physics and Applied physics and Center for Atomic Wires and Layers, Yonsei University.*) Low-dimensional systems have fueled the significant research activity due to their exotic quantum phenomena such as density waves, non-Fermi liquid behaviors, and, more recently, massless Dirac particles through enhanced many-body interactions. In particular, self-assembled metallic nanowires on semiconducting substrates have been shown to exhibit well-defined one-dimensional (1D) metallic band structures [1] and, indeed, served for the observation of interesting and intriguing 1D physics such as multiple Peierls instability [2], real-space fluctuations near Peierls transition [3]. While the central issue in the metallic wire systems are related to their intrinsic instability of metallic phase, recent studies for Pb nanowires on a stepped Si(111) surface, Si(557), showed a distinctive temperature-dependent conductivity, a stable 1D metallic conductivity down to 4 K through a drastic dimensional crossover from 2D at 78 K [4]. In the present work, we investigate using angle-resolved photoemission directly the electronic band dispersions and Fermi surfaces of well-ordered Pb nanowire arrays. In spite of the highly oriented form of nanowires shown in scanning tunneling microscopy, we observe essentially two-di-

mensional Fermi contours modulated one-dimensionally perpendicular to the wires. The interaction of electrons with the step-superlattice makes the 2D bands to be modulated into a few strongly wiggled (ill-nested) quasi-1D bands. The strong two(quasi-one)-dimensional nature of the band structure explains the stability and anisotropy of the metallic phase at a very low temperature reported recently [4]. A simple tight binding model successfully simulates this modulated band structure based on the Pb overlayer covering each nanoterrace densely and quantifies the electron coupling within these "nanostripes" and between them across step edges.

References [1] H. W. Yeom et al, Phys. Rev. Lett. 82, 4898, (1999). [2] J. R. Ahn et al, Phys. Rev. Lett. 95, 196402, (2005). [3] S. J. Park et al, Phys. Rev. Lett. 95, 126102 (2005). [4] C. Tegenkamp et al, Phys. Rev. Lett. 95, 176804 (2005).

D-16 **Adsorption of C_{60} on the KBr(100) Surface: DFT Calculations** JUNG Sung Chul, KANG Myung Ho(*포스텍 물리학과.*) We investigate the adsorption of a single C_{60} cluster on the KBr(100) insulator surface by using density-functional theory calculations. The most stable is the structure where C_{60} adsorbs atop the surface K atom with its bottom hexagon toward the surface. The electronic structure analyses show that a weak interaction between the p orbitals of C and Br atoms contributes to the stabilization of this structure. The present calculations for a single C_{60} cluster on KBr(100) will be used to discuss the adsorption properties of a close-packed C_{60} monolayer phase on KBr(100), recently reported by an atomic force microscopy study.

D-17 **Density-functional Study of the C_{60}/Si(111)-(7x7) Surface** LEE Ji Young, KANG Myung Ho(*포스텍 물리학과.*) The interaction of C_{60} with the Si(111)-(7x7) surface has received great attention in connection with semiconductor technology. One important problem is to determine the adsorption structure of a single C_{60} cluster. Based on the density-functional pseudopotential calculations, we propose an atomic model for the C_{60}/Si(111)-(7x7) surface. In this model, C_{60} adsorbs at a position deviated by about 1 Å from the middle of the half unit cell with a C-C double bond toward the surface. This model is energetically stable, and its calculated STM images and surface density of states are in good agreement with STM and PES data, respectively. Our charge character analysis clarifies the bonding nature as covalent by the evidence of C-Si σ bond formations.

D-19 **Ag(001)에 성장된 NiO 극초박막의 화학 결함 연구** YANG Seolun, SEONG Shijin, KIM J. -S., HWANG Hanna[1], HWANG ChanKuk[1], CHANG Young J.[2], PHARK Soo-hyon[2](*Sookyung W. Univ., Surface Physics. [1]Pohang Acceleration Laboratory. [2]Seoul National Univ., Physics.*) 3d 전이 금속 산화물 박막 중 NiO는 의사 2차원적 특성, 기판에 의한 strain 효과, 기판과의 상호작용 등에 의해 bulk NiO와는 다른 물성을 가질 수 있다. 또한 epitaxial하게 성장된 NiO 박막은 magnetic pinning layer나 laser 등 다양한 분야에 응용될 가능성이 있다 그러나 산화물 박막들은 일반적으로 높은 화학 결함 밀도를 갖는다. 따라서 결함 구조들을 identify하여 이들의 spectroscopic finger print를 얻는 것은 향후 NiO 극초박막 연구와 응용에 긴요하다. 본 연구진은 성장 온도와 산소 분압, 물 분압 등을 달리하여 NiO 극초박막 성장 과정에서 생성되는 결함 구조를 XPS를 이용하여 내적 일관성 있게 분석하였다. 그 결과 main peak으로부터 relative binding energy가 +1.3 eV인 shoulder peak은 O^{-1}가 아닌 1) 잔존한 물 분자에 의한 NiO-OH의 형성이 원인으로 보인다. 또한, relative binding energy가 +2.0 eV인 shoulder peak은 2) NiO-Ag 계면 합금의 산화물, 3) 높은 산소 분위기에서 생성되는 metastable한 Ni_2O_3 및 4) 잔존 물 분자에 의한 $Ni(OH)_2$ 등 세가지 다른 원인에 기인함을 알 수 있었다. 또한, 저온에서는 5) ice가 표면에 물리 흡착되어 4 eV high binding 위치에 shoulder가 나타났다. 또한, 다음과 같은 최적 박막 성장 조건을 제시할 수 있었다. 1) 산소 분압은 2 x 10^{-6} Torr.가 적당하고, 2) 물 분압을 10^{-11} Torr. 이하여야 하며 3) Ni_2O_3와 같은 결함을 제거하고 잘 정의된 NiO 구조를 형성하기 위해서는 annealing이 필요하다. 그러나 annealing 온도의 최적화 및 적절한 산소 분위기에서 금속 Ni의 산화를 위한 후처리가 필요하다.

D-21 **Structural and Chemical Characterization of Nickel Oxide Submonolayers on Ag(001) Surface during the Annealing process : Dependence on the oxygen pressure and temperature** 장 영준, 박 수현, 노 태원, 김 재성[1](*산화물전자공학연구단, 서울대학교 물리천문학부. [1]숙명여자대학교 물리학과.*) Since the most electronic devices incorporate the oxide-metal interfaces, systematic investigations on the diverse properties of oxide thin films, especially near the oxide-metal interfaces, are inevitably helpful for developing oxide electronics. In this study, we investigated the structural and chemical properties of the nickel-oxide (Ni-O) ultra-thin films on Ag (001) surface, which were grown by the electron beam evaporation of Ni in the oxygen partial pressures (PO2) of $5*10^{-7}$ – $3*10^{-6}$ torr at room temperature, by using scanning tunneling microscopy (STM) and X-ray photoemission spectroscopy (XPS). It was shown that the growth patterns of the as-grown films have the strong dependence on PO2 during the growth. The annealing effects on the structural and chemical properties were measured for three samples, which showed different surface structures at each as-grown state, annealed at three different temperatures either in an ultra-high vacuum (UHV) or at PO2 in which each film was originally grown.Regardless of the growth patterns of the as-grown states, all three films showed that most of the oxygen atoms were gone from the sample surfaces by UHV annealing at the temperature between 425 – 475 K and remaining Ni transform its state to the metallic phase by checking the shifts of corresponding XPS peaks. We also confirmed that the stoichiometry of the films directly recovered by the annealing at PO2 in which each film was initially grown. Especially for the film grown at PO2 of $5*10^{-7}$ torr, not only the locations but also the shapes of the XPS peaks perfectly recovered. This indicates that the last among three is the most profitable candidate not only for preparing a single-phase interface but also for controlling the oxidation states between Ni-O and Ag (001) surface.We hopefully think that these kinds of studies, which deal with the phase change at the interface in the microscopic regime, are very helpful to the fields such as the application of oxide

thin films to the resistance random access memory by supplying the microscopic physical and chemical information for the control of interface states.

■ SESSION: D [DG2]
10월 18일(목), 14:30 - 16:15
장 소: 탐라홀B

D-22 **Ultrasoft Cantilever with Superconducting Circuit Mounted for Quantum-based Pico-force** 최 재혁, 김 윤원[1], 이 광철, 김 민석, 이 순걸[1](*한국표준과학연구원. [1]고려대학교 물리학과.*) Despite remarkable sensitivity and wide application of force probes, SI-traceable force standard has not been established even at sub-Newton level. Very recently, Choi et al.[1] suggested that stepwise pico-force could be generated by a unit of a single quantum by using a superconducting ring in magnetic field gradient, which traps an integer number of magnetic flux quantums. The magnitude of magnetic force on a single quantum is estimated as ~0.2 pico-Newton in field gradient of 10 T/m. In this work, as a key step to quantum-based pico-Newton force realization the flux-quantum generating ultrasoft cantilevers with a ring-shaped Niobium film mounted on their paddle were micro-fabricated and characterized. The structural and mechanical properties of the devices were measured and compared with requirement and prediction from theoretical analysis, and possible improvements will be discussed.
[1] Jae-Hyuk Choi, Min-Seok Kim, Yon-Kyu Park, and Mahn-Soo Choi, Appl. Phys. Lett. 90, 073117 (2007)

D-23 **Symmetry breaking and breather-assisted electron transport in coupled nanomechanical shuttles** AHN Kang-Hun (*Department of Physics, Chungnam National University, Daejeon 305-764.*) We investigate the charge transport through single, double, and array of nanomechanical shuttles. The nonlinearity given by charge tunneling gives rise to the instability of mechanical motion. The current rectification exists in an asymmetric single shuttle and symmetric (also asymmetric) double shuttles as a result of the instability. When the nanomechanical shuttles form an one-dimensional array, we show a novel charge transport phenomena assisted by 'discrete breather'- highly localized excitation in discrete nonlinear systems.

D-24 **Conditional evolution in an electronic Mach-Zehnder interferometer under continuous weak measurement** 김 경락, 강 기천(*전남대학교 물리학과.*) We study which-path interference, conditional evolution, and current-current correlation in an electronic Mach-Zehnder interferometer under continuous weak measurement by a mesoscopic detector. Transport state in the interferometer conditioned on a particular outcome of the detector undergoes relaxation to a particular path. The direction of the relaxation is affected by which detector outcome is chosen, and is shown to be sensitive only to the change of the current in the detector.

D-25 **Nonlocality of dephasing in a quantum point contact detector** 이 영내, 김 경락, 강 기천(*전남대학교 물리학과.*) We investigate the charge-detection-induced dephasing of a charge qubit interacting with an electronic beam splitter composed of a quantum point contact. When only one input electrode injects electrons in a detector, the qubit suffers the well-known dephasing caused by the state information transferred to the beam splitter. Interestingly, the dephasing is completely suppressed when the two inputs are identically biased so that the electrons collide at the beam splitter. We show that this phenomenon is related to the Fermi statistics, and also argue that it illustrates the peculiar nonlocality of dephasing. We also discuss the case of injecting entangled electron pairs.

D-26 **스핀분극된 이차원 양공계의 홀효과 측정** 노 화용, 이 승조, 천 승현, 김 형찬[1], TSUI D.C.[2], PFEIFFER L.N.[3], WEST K.W.[3](*세종대학교 물리학과. [1]핵융합연구센터. [2]Princeton Univ.. [3]Lucent Technologies.*) GaAs/AlGaAs 이종구조 내의 이차원 양공계에 평행한 고자기장을 가하여 양공이 완전스핀분극된 상태에서의 홀효과를 측정하였다. 이차원 양공계를 평행자기장 하에서 1도 이내의 매우 작은 각도만큼 기울여주면, 평행자기장 성분은 거의 변함이 없고 작은 크기의 수직자기장 성분이 생겨남으로써 홀전압이 나타나게 된다. 따라서, 결과적으로 한 종류의 스핀방향만이 존재하는 상태에서의 홀효과를 측정하게 된다. 이차원 양공계의 밀도로부터 예측되는 홀효과와의 비교 분석을 통해, 스핀분극에 따른 비정상 홀효과의 검출을 시도하였다. 평행자기장이 증가하여 스핀분극의 정도가 커짐에 따라, 예측된 홀효과에 비해 미세한 보정이 생겨남을 확인하였고, 그 극성은 (-)를 나타내었다.

D-27 **Spin Dependent Current in Double-Dot Aharonov-Bohm Interferometer** 서 경철, 홍 종배, 임 국형[1](*서울대학교 물리학과. [1]충남대학교 물리학과.*) We study the spin dependent electronic transport through an Aharonov-Bohm(AB) interferometer containing magnetic quantum structures(MQSs). The transmission probability as functions of electron energy and magnetic flux through the ring shows the characteristic oscillations which are consisted of both transmission resonances and Fano resonances. The spin dependence of the transport is originated from the Zeeman term associated with MQSs and is quite distinctive in our modified interferometer.

D-28 **Study of Particle Trapping Induced by the Interplay between Coherence and Decoherence** YI Sangyong (*Department of Physics, Pusan National University.*) We discuss the possibility for trapping a particle based upon the noble interplay between coherence and decoherence. We consider the following simple scheme; If the position information on a particle is not only acquired (decoherence) when the particle is located in the scattering region but the interference effect (coherence) also takes place so as to destructive interference to vanish the escaping waves, then the particle is trapped in the scattering region. We research whether the above argument is reasonable or not through a physical example, that is a ring attached to a single lead.

■ SESSION: D [DA2]
10월 18일(목), 14:30 - 16:15
장 소: 탐라홀C

D-29 **L자 모양의 Py-wire에서 자기 자벽 이동에 관한 연구** 윤 정범, 박 승영[1], 조 영훈[1], 정 명화[1], 유 천열[2], 이 재철[3], 신 경호[4], 최 석봉[5](*인하대학교, 물리학과; 한국기초과학지원연구원, 양자물성팀. [1]한국기초과학지원연구원, 양자물성팀. [2]인하대학교, 물리학과. [3]한국과학기술원, 스핀트로닉스 연구단; 서울대학교, 물리학과. [4]한국과학기술원, 스핀트로닉스 연구단. [5]서울대학교, 물리학과.*) 자기장으로 자벽을 원하는 위치에 생성시킨 후 자기장과 전류에 의한 자벽의 이동에 대해 연구하기 위해서 L 자 모양의 Py wire를 e-beam 리소그래피를 이용하여 제작하였다. 외부 자기장을 이용해서 L 자 wire의 휘어진 부분에 자벽을 생성시킨 후, 펄스 전류를 인가하여 전류유도 자벽 이동 현상을 관측하였다. 자벽의 이동을 직접적으로 측정하기 위해 MFM (magnetic force microscopy)를 사용하여 자구의 이미지를 얻었다. 폭이 600 nm이며 두께가 20 nm인 Py-wire에서 생성된 자벽은 single vortex 형태를 가진다. 이 자벽은 임계 전류 밀도 5.0 X 10^{11} A/m^2 이상에서 움직임을 확인하였다. 이 조건에서 펄스 전류에 대한 자벽 이동 속도는 약 2 m/sec 를 얻었다. 임계 전류 이상을 인가했을 경우 새로운 자벽이 생기거나 double vortex 형태의 자벽으로 전이하는 현상을 확인할 수 있었다. 또한 AMR (anisotropic magnetoresistance) 을 측정하여 자기장인가 자벽 이동 현상을 확인할 수 있었다. PPMS (physics property measurement system)로 AC모드에서 측정용 전류의 방향에 대한 자기장의 각을 변화시키며 MR을 측정하였다. 급격한 MR의 변화와 MFM 이미지를 확인하여 자기장유도 자벽 이동을 확인하였다.

D-30 **Magnetic Properties of Fe/Ni Thin Films; Magnetic Anisotropy and XMCD** HONG Jisagn, KIM Dongyoo (*Pukyong National University, Department of Physics.*) Using the full potential linearized plane wave method, we have investigated the magnetic properties of Fe/Ni thin films on Cu(001) surface. It has been found that the Fe/Ni films have perpendicular magnetization for pseudomorphic growth. However, the oscillatory magneto-crystalline anisotropy is observed in the presence of strain effect. In addition, we have calculated the X-ray magnetic circular dichroism (XMCD) and X-ray absorption spectroscopy(XAS) spectra. Based on these calculation, the XMCD sum rule has been examined.

D-31 **Coexistence of Two Different Cr Ions by Self-Doping in Half-Metallic CrO_2 Nanorods** SHIM Jeong Hyun, LEE Soonchil, DHO Joonghoe[1], KIM Do-Hyun[1](*Department of Physics, Korea Advanced Institute of Science and Technology. [1]Department of Physics, Kyungpook National University.*) 전도 전자의 스핀이 일정한 방향으로만 정렬되어 있는 절반 금속(half-metal)이라고 불리는 물질들은 스핀트로닉 소자로의 응용 가능성이라는 관점 뿐 아니라, 전도 전자 스핀 정렬의 원인을 규명하고자 하는 순수 고체물리학적 관점에서도 흥미로운 대상이다. 특히, CrO_2는 도핑을 하지 않아도 금속성과 강자성 특성을 가지고 있는 유일한 물질로 이 특이성은 아직까지 명확히 설명되지 않고 있다. CrO_2의 특성을 이해하기 위하여, 우리는 Cr 핵자기 공명법을 사용하여 절반 금속 CrO_2를 조사하였다. 실험결과 Cr들이 단일 원자가를 가지고 있을 때에는 나타날 수 없는 두 개의 핵자기공명 피크가 관찰 되었으며, 불림된 시료와 비교해 보았을 때 두 피크 모두 Cr_2O_3와 관련없이 CrO_2 상에서 나온 것들임을 알 수 있었다. 각각의 핵자기 공명 피크들은 매우 강한 초미세 자기장 특성을 가지고 있으며, 이것은 Cr의 3d 궤도 전자들 중 하나가 국지화된 xy 궤도 상태에 있을 때 잘 설명된다. 각 피크들의 중심 주파수 및 완화 시간 차이로부터 우리는 Cr 이온들이 4.3+/ 3.7+ 두 원자가 상태로 분리되어있다는 결론을 얻었다. 이 결론은 자체 도핑 효과(self-doping effect)가 CrO_2에 나타나며, 이중교환(Double Exchange) 상호작용으로 CrO_2의 금속성과 강자성을 설명할 수 있음을 의미하는 것이다.

D-32 **High magnetic field phase diagram of $LiCu_2O_2$** KIM Jae Wook, PARK S.[1], CHEONG S-W.[1], KIM Kee Hoon(*서울대학교 물리천문학부. [1]Rutgers University.*) Multiferroicty has been recently found in the quasi-1D spin chain compound $LiCu_2O_2$ (S. Park et al., Phys. Rev. Lett. (2007)). The 1D spin chain is realized with Cu^{2+} spins (S=1/2) along the b-axis and competition between the ferromagnetic nearest neighbor coupling and next-nearest neighbor coupling stabilizes the sprial magnetic structure below T_s=23 K with a magnetic propagation vector Q=(0.5, 1-ξ, 0). The ferroelectric polarization (P) appears along the c-axis at T_s. While the spiral plane is reported to be the ab-plane in a recent neutron scattering study (T. Masuda et al., Phys. Rev. Lett. (2004)), the observed P direction along the c-axis and its flip to the a-axis under magnetic field applied along the b-axis are consistent with the spiral ordering with a bc-spiral plane (H. Katsura et al., Phys. Rev. Lett. (2005)). To further understand the multiferroic behaviors of this compound, we have systematically investigated the phase diagram of $LiCu_2O_2$ by polarization and dielectric constant measurements under pulsed and static magnetic fields up to 45 T by use of facilities at NHMFL at Tallahassee and Los Alamos. With enhanced sensitivity in the measurements, we find yet another phase transition occurs at T=24.5 K at zero magnetic field above T_s, which can be attributed ti an amplitude modulated spin-density wave state. Through various combinations of electric and magnetic field directions, we present a complete electric phase diagram in H-T phase space, and discuss whether the evolution of each phaseand its P magnitude is consistent with the predictions of the standard spin-current model.

■ SESSION: D [DT1]
10월 18일(목), 16:30 - 18:15
장 소: 탐라홀C

DT-01 **유기태양전지의 기초원리와 개발현황** 이 광희 (*광주과학기술원 신소재공학과.*) 최근 들어 화석연료의 매장량 한계 및 고유가 문제에 따른 에너지 수급 문제뿐만 아니라 이산화탄소배출 규제와 같은 국제적 환경정책의 실시에 따라 신재생 에너지에 대한 필요성이 급속히 증가하고 있다. 태양전지는 친환경 에너지 원의 관점에서 신재생 에너지 중 가장 큰 잠재력과 높은 상용화 가능성을 가진 것으로 평가 받고 있다. 특히 유기태양전지는 무기물 태양전지에 비해 제작 공정이 간편하며 앞으로 다가올 유

비쿼터스 시대의 특징인 유연하고 휴대 가능한 소자의 에너지 원이라는 점에서 차세대 태양전지로 인정받아 기초 물성부터 응용에 이르기까지 광범위하게 연구되고 있다. 본 강좌에서는 유기태양전지의 기본원리인 공액고분자와 풀러린으로 구성된 유기복합재에서의 '광여기 전하이동' 현상에 대해서 살펴보고 이를 이용한 소자의 제작에 대해 논하고자 한다. 아울러 본 강좌에서는 유기태양전지의 세계적 연구 동향을 분석하고 국내 태양전지 관련 연구의 방향을 제시함으로써, 유기태양전지에 대한 이해 및 관심을 높이고 관련 국내 연구자에게 유용한 정보를 제공하고자 한다.

■ SESSION: D [DD]
10월 19일(금), 09:00 - 10:45
장 소: 한라홀A

D-33 **약물 결정의 상전이 및 유리질 형성** 이 광세(*인제대 나노시스템공학과.*) 물질의 점성 및 유리질 상태는 여러 분야에서의 기술적인 응용 뿐 아니라 일상생활에서도 깊은 관계를 갖고 있다. 어떤 약물들의 경우 결정상태보다 비정질 상태가 용해성이나 치료 등의 실제적인 면에서 유용할 수 있으므로 이점이 있을 수 있다. 일상생활에서 많이 복용, 투약하고 있는 약물들은 유리질이 형성될 수도 있으므로 그 자체로도 흥미로울 수 있다. 본 발표에서는 Differential Scanning Calorimetry (DSC)를 사용하여 약물 결정의 구조상전이, 융해, 응고 현상을 보고한다. 잘 알려진 실험 방법을 Aspirin ($C_9H_3O_4$) 결정과 Anhydrous cholesterol ($C_{27}H_{46}O$) 결정에 적용하여 과냉각 액체 및 유리상태의 가능성을 조사하였다. Aspirin 결정의 경우 용융상태가 냉각될 때 (-5 $^oC\ min^{-1}$) 과냉각 액체로 냉각되었다. Cholesterol 결정의 경우는 가열시 37 ^oC, 냉각시 25 ^oC 부근에서의 구조상전이 현상을 확인하였으며, 강한 열적 이력에서 나타나는 것처럼 구조상전이의 경우도 과냉각과 과열과정은 피할 수 없는 현상이다. Cholesterol 결정의 경우는 용융상태가 냉각될 때 (-5 $^oC\ min^{-1}$) 결정화가 일어나며, 융해과정과 응고과정(결정화)은 시간변화에 대해 (Kinetic한 입장에서 보면) 매우 비대칭적이다. 이러한 결과로부터 잘 알려진 약물 결정의 경우 유리질 상태를 얻기 위한 기초정보를 얻을 수 있었다.

D-34 **Study of Binding Energy between DNA and Carcinogenic Molecules from First-principles Calculations** LEE Geunjung, YOON Young-Gui(*Chung-Ang University, Department of Physics.*) We investigated nanobio structures of biomolecules to which a polycyclic aromatic hydrocarbon (PHA) is attached. Binding between DNA bases such as adenine, cytosine with PHAs is attributed to one of the main mechanisms of carcinogenicity. Each carcinogene has its characteristic carcinogenic activity. We studied relation between carcinogenic activity and physical property change upon binding with a carcinogene. Genes such as DNA and RNA are composed of very complicated base chains. Therefore, we chose adenine for calculation, one of four bases to which a carcinogene is directly attached, and we passivated the part of the base with hydrogen to simulate DNA backbone. From the calculated results, binding energy between adenine and carcinogens, charge transfer, and characteristic HOMO/LUMO molecular energy levels were investigated.

D-35 **Stability of BWYV Pseudoknot Structure using Single-Molecule FRET Spectroscopy** 홍 성철, 윤 정민(*서울대학교 물리천문학부.*) Many pathogenic viruses use programmed -1 ribosomal frameshifting to regulate translation of their structural and enzymatic proteins from mRNAs. Frameshifting is believed to be stimulated by tensile stress generated when the ribosome tries to go through stable pseudoknot (PK) structure located downstream of mRNA. However, the unfolding mechanism of PK, which is required for the translation of downstream sequences, is not understood yet. To address the question, we used single-molecule fluorescence resonance energy transfer (FRET) spectroscopy, an excellent tool for measuring sub-nanometer distance changes between two fluorophores attached to specific sites on PK. Our data clearly show that PK is a dynamic molecule switching between a number of different structures. We will present a model the unfolding process of RNA PK and its relation to frameshifting efficiency.

D-36 **On the Adsorption of Malachite Green on DSPC/DSPG Lipid Bilayer Membranes** MOON Junhyuk, KIM Junheon, SHIN Kwanwoo[1], SHIBAYAMA Mitsuhiro[2], SEO Youngsu[3], KIM Mahnwon(*KAIST, Dep. of Physics. [1]Seogang Univ., Dep. of Chemistry. [2]NSL, ISSP, The University of Tokyo. [3]Sejong Univ., Dep. of Nano Science.*) 이전 Second Hamonic Generation 연구를 통하여 MG의 DSPG로 이루어진 LUV내부로의 transport mechanism이 연구되어왔다.MG과 같은 소수성을 가지고 있는 입자의 생체막 투과시 긴 transport time과 MG의 흡착에 의한 lipids의 sol-gel transition temperature의 변화, 그리고 lipid membranes의 유동성변화에 의한 MG의 transport변화는 소수성을 가지는 입자의 흡착및 투과에 의한 lipid bilayer membranes의 구조 변화의 간접적인 증거로 여겨져왔다.따라서 lipid bilayer membranes의 구조를 가지는 LUV와 supported bilayer membranes을 형성하여 각각 Small Angle Neutron Scattering와 Neutron Reflectivity를 이용하여 MG의 영향에 의한 lipid bilayer의 구조변화를 직접적으로 보았다.

D-37 **Optical Imaging of Quantum Dot Conjugated Protein Chips and their Clinical Applications** GOKARNA Anisha, 김 려화, 김 용환, LERONDEL Gilles[1], 임 영택[2], 정 봉현[2], 조 용훈(*충북대, 물리학과. [1]Universite de Technologie de Troyes, France. [2]생명공학연구원.*) Microarrays of biomolecules such as DNA, RNA and proteins have proven to be a useful high throughput screening tool especially in the field of proteomics and genomics. In this study we have fabricated Quantum Dots (QDs) conjugated protein microarrays and have detected the fluorescence emission arising from these microarray spots by a microchip scanner, confocal microscope and a scanning optical microscope respectively. We also fabricated and characterized cancer protein biochips consisting of microarrays whereby QDs conjugated Prostrate Specific Antigens (PSA) were used as clinical biomarkers for the detection of Prostrate cancer.

D-38 **Structural study of G-quadruplex in C-myc promoter using single-molecule fluorescence resonance energy transfer** SUNG Jaeho, YOON Jeongmin, SUNGCHUL Hohng(*서울대학*

교 물리 천문학부.) The nuclease-hypersensitivity element III (NHE III_1) in the promoter region of C-myc oncogene, which controls ~90% of C-myc transcription, is actively studied as a potential target of an anti-cancer treatment. Recent NMR studies reported that NHE III_1 mainly formed one of the two parallel G-quadruplexes with varying G-stretch combinations. A systematic study of its conformational dynamics, however, has been hindered at ensemble level due to the intrinsic randomness of the biomolecular motion. To address this question, we used single-molecule fluorescence resonance energy transfer (FRET) spectroscopy. By utilizing the advantages of single-molecule measurements combined with systematic mutational studies clearly showed that NHE III_1 exists in dynamic equilibrium among a number of different structures, one of them never predicted before.

D-39 **An Intrinsic DNA Magnetism Induced by a Possible Helical Charge Transport** LEE Chang Hoon, KWON Young-Wan[1], DO Eui Doo[1], CHOI Dong Hoon[1], JIN Jung-Il[1] (*Dept. of Polymer Science &Engineering, Chosun University. [1]Dept. of Chemistry, Korea University.*) Recently, the charge transfer/transport of deoxyribonucleic acids (DNAs) has attracted much attention due to their important roles in various repair activities on the damaged-DNA bases as well as potential applications for nanotechnologies. During the last three decades, although many workers in diverse fields have devoted their endeavors to realize repeatable and reproduceable experimental results, it is still far from complete understanding. From an experimental point of view, it is necessary for fixing this problems to firstly control various external and environmental parameters including conformational degrees of freedom of DNAs, electrical contact between DNAs and metal electrodes, interactions with substrates, pH, water content, types and concentration of counter ions. These are too complex to solve at once. Nevertheless, we challenge here to study the charge transport in DNAs by employing an electron magnetic resonance (EMR) and a SQUID magnetization measurement, that was known to be another appropriate noninvasive methods capable of studying diverse charge transport phenomena. As a result, we succeed in obtaining not only two types of strong EMR signals but also a s-shaped SQUID magnetization-magnetic fields curve from perfectly dried salmon testes dsDNAs. Especially, the extremely broad EMR line at g>10 is identified as a cyclotron orbital motion along the helical path of a single molecular dsDNA. The s-shaped M-H curve in SQUID measurement is explained by considering lateral tunneling and constructive interference of charge carriers experiencing the cyclotron motion, which can exert on the nearest DNA strands an induction current according to the electromagnetic Faraday"s law leading to transverse mesoscopic loop currents with diameter 50 nm.

D-40 **Real-time measurement for a change of the optical property of sensory rhodopsin II thin films using a scanning near-field microwave microscope** KIM Songhui, YOON Youngwoon, CHOI Ahreum, JUNG Kwanghwan, LEE Kiejin (*Sogang university, Department of Physics and interdisciplinary program of integrated biotechnology.*) We studied a real-time measurement for a change of the electro-optical properties of the sensory rhodopsin II (NpSR II) using a scanning near-field microwave microscope (SNMM). In order to research into the optical characterization of NpSR II, first, we measured the absorption spectra and the transients difference of NpSR II from Natronomonas pharaonis using a UV/VIS spectrophotometer with Nd-Yag Laser (532 nm). Second, after applying UV source on surface of NpSR II with Zenon Arc Lamp (68911, 170W), we measured a change of the microwave reflection coefficient(S_{11}) at one-point of NpSR II with the SNMM in real-time. The observed photocycle reaction was confirmed by measuring the microwave reflection coefficient (S_{11}) and compared with the results of a photocycle of NpSR II. The scanning near-field microwave system was constructed by using a high quality dielectric resonator at an opening frequency f=4-5 GHz. The microwave reflection coefficient (S_{11}) for photocyle reaction was observed using a tuning fork distance control system.

■ SESSION: D [DG3]
10월 19일(금), 09:00 - 10:45
장 소: 탐라홀B

D-41 **First-principles study of graphene layers on SiO_2 surfaces** CHANG K. J., KANG Joongoo, KANG Yong-Ju (*Department of Physics, KAIST.*) Among carbon-based materials, graphene has attracted much attentiondue to their unique electronic and transport properties. Since graphene layers are usually deposited and supported on SiO_2 or SiC substrates, their electronic properties are likely to be affected by interactions between graphene layers and substrates. In this work we study the structural and electronic properties of a few graphene layers on SiO_2 substrates through first-principles calculations. We consider both Si- and O-terminated surfaces of α-quartz SiO_2, and find that O-terminated surfaces induce the p-type doping effecton graphene, while Si-terminated surfaces weakly interact with graphene layers. For a bilayer of graphene in AB stacking on O-terminated surfaces, an asymmetric charge distribution between the two layers gives rise to the gapopening at the Dirac point. The electronic structure of graphene layers are severely modified by strong covalent bonds formed between the graphene C and surface O atoms.

D-42 **Ab initio calculation of graphene's band structure with which has doped edge structure** 최 선명, 지 승훈(*포항공과대학교 물리학과.*) Graphenes are the ideal 2D conducting materials yet realized, and they exhibit many interesting physical phenomena such as low energy massless Dirac dispersion, quantum Hall effects, and the orientation-dependent conductivity. One of the unresolved but critical issues in graphene research is the graphene edge structure and its effect on physical properties. The edge structure is extremely hard experimentally to identify and reproduce, and current etching processes that are indispensable to obtain proper graphene shapes are not at a level of atomic scale control. We

have studied the atomic and electronic structure of graphenes with various types of edge structures using the pseudopotential density functional method. Formation energy and band structures of the graphenes are particularly investigated.

D-43 **Optimization of Metal Dispersion and Hydrogen Adsorption Strength in Graphitic Materials for Hydrogen Storages** 김 규봉, 지 승훈, 박 노정[1](*포항공대 물리학과. [1]단국대학교 응용물리학과.*) The non-covalent hydrogen binding on transition metal atoms dispersed on carbon clusters and graphene is studied with the use of the pseudopotential density functional method. It is found that the presence of acceptor-like states in the absorbents is essential for enhancing the metal-absorbent binding strength and for increasing the number of hydrogen molecules attached to the metal atoms. Particular configurations of boron or nitrogen substitutional doping are found to be very efficient for providing such states and thus enhancing storage capacity. Optimal doping conditions are suggested based on our calculations for the binding energy and ratio between metal and hydrogen molecules.

D-44 **Edge States Of Zigzag Bilayer Graphite Nanoribbons** 임 준원, 문 경순(*연세대학교, 물리학과.*) Electronic structures of Z-BGNR(zigzag bilayer graphite nanoribbons) of various ribbon width are investigated within tight binding approximation. Neglecting the band parameter γ_4 there are two fixed Fermi points k^* independent of ribbon width which is also a center of peculiar dispersion $\varepsilon \sim (k-k^*)^N$ for edge states near the band center $\varepsilon = 0$ where N is the ribbon width. We also identify 'a trace of three legs near the Diracpoint of bilayer graphene' by examining a semi-infinite Z-BGNR. Band structures of Z-BGNRs including the band parameter γ_4 are also studied assuming γ_4 is small compared with γ_1 and γ_3. With this small γ_4, theFermi points is not fixed with respect to the ribbon width but move to the vicinity of the Dirac point as the width N grows which is seen by scaling method and the peculiar dispersion is collapsed to parabolic dispersions.

D-45 **Titania nanotube의 oxygen vacancy에 관한 ESR 측정** 조 정민, 이 정한, 이 정근(*전북대 물리학과.*) Titania Nanotube (TNT)를 hydrothermal 방법을 이용하여 합성하였다. Anatase type의 TNT는 약 500 ℃에서 anatase nanocrystal로 바뀌고 약 800 ℃에서 rutile 구조로 변하였다. Single-electron trapped oxygen-vacancy (SETOV)와 관련된 뾰족하고 대칭적인 ESR 신호(g=2.003)가 500 ℃이하의 온도에서 공기 중 열처리된 TNT에서 나타났다. 이 SETOV 신호는 약 400~500 ℃에서 최대값을 갖고, nanotube 구조도 이 온도에서 급격히 부서지기 시작하였다. 한편 진공에서 가열된 TNT는, N_2나 Ar 분위기에서 밀봉될 때, SETOV 신호 외에 다른 ESR 신호들이 나타났다. 폭이 넓고 비대칭적인 g=1.98 ESR 신호는 환원된 TiO_2 matrix에서 Ti^{3+}와 관련된 surface oxygen vacancy에 의해 나타나는 것으로 이해되었다. SETOV ESR 신호와 Ti^{3+}와 ESR 신호는 둘 다 저온 측정에서 Curie 특성을 보이며 localized electron인 것을 보였다. 한편 microwave saturation 특성에서 서로 다른 spin-relaxation time을 가짐을 보여주었다. 이러한 현상은 Ti^{3+} 신호들이 공기 중에 노출되면 점차로 사라지고 SETOV 신호는 오히려 증가하는 결과와 연계되어 있음을 보인다.

D-46 **GaAs 기판 위에 성장한 Epitaxial Ge Nanowires의 성장 방향과 모양에 관한 연구** 송 만석, 정 재훈, 김 유리, 김 용, TAN H. Hoe[1], GAO Qiang[1], JAGADISH Chennupeti[1], WANG Yong[2], GUO Yanan[2], ZOU Jin[2](*동아대학교 물리학과. [1]The Australian National University. [2]The University of Queensland.*) Lamp Heated CVD(Rapid Thermal Chemical Vapour Deposition) 법에 의해 GaAs (001), (111)B, (110) 기판에 각각 Epitaxial한 Ge Nanowires(NWs)를 성장하였다. Ge NWs는 VLS(Vapour-Liquid-Solid) 메커니즘을 통해 성장하며, 촉매로는 지름이 50 nm인 Au colloid 용액을, source gas로는 1% GeH_4를 사용하였다. Au 입자들을 정전기적으로 고정시키기 위해 poly-L-lysine 용액에 기판을 1분간 담근 후, Au colloid 용액을 살포하였다. Au와 Ge의 공융점 온도 근방인 섭씨 300~380도 사이 온도에서 10 Torr 압력에 1시간씩 성장시킨 샘플은 FE-SEM(Field Emission Scaning Microscope)을 이용하여 Ge NWs의 이미지를 관찰하였다. 각 샘플의 평면과 단면 SEM 이미지와 평면 Polar chart를 이용해 기판과 온도에 따른 Ge NWs의 성장 방향과 길이 그리고 그 모양을 분석하였다. 그리고 HRTEM(High Resolution Transmission Electron Microscope)과 EDX(Energy Dispersive X-ray)의 측정으로 통해 Ge NWs Tip, Middle, Bottom 각 부분의 결정성과 조성을 분석해보았다.

■ SESSION: D [DB]
10월 19일(금), 09:00 - 10:45
장 소: 탐라홀C

D-47 **Epitaxial Growth of Terbium Iron Garnet Thin Films with Out of plane Axis of Magnetization** KUMAR Naresh, 김 남건, 박 영안, 허 남정, 정 종훈, 한 강전[1], 이 기주[1](*인하대학교 물리학과. [1]충남대학교 물리학과.*) We fabricate epitaxial terbium-iron-garnet (Tb3Fe5O12, TbIG) thin films on(110) gadolinium-gallium-garnet (Gd3Ga5O12, GGG) substrates using a pulsed laserdeposition technique. High quality (110) oriented epitaxial growth of TbIG thin filmshas been revealed by θ-2θ scans, φ-scans, rocking curves (ω-scans), and reciprocalspace mapping in high resolution x-ray diffraction. Magnetic and magneto-optichysteresis loops, however, demonstrate that the easy axis of magnetization in thesefilms is out of plane, i.e. along [110] instead of [1-11] direction, as sharp contrast tobulk.

D-48 **Transitions in the half-filled ionic Hubbard model** 고 아라, 전 건상(*서울대학교 물리천문학부.*) We consider the ionic Hubbard model in the half-filled caseat zero temperature. It is an extended version of theHubbard model with on-site energies being staggered spatially.In the limit of strong interaction, the system exhibits a Mott insulating phaseas in the Hubbard model. On the other hand, a band insulating phase shows upwhen the interaction is much smaller than the band width.We use the cellular dynamical mean field theory in order to examine thenature of transitions between the two phases in one and two dimensions.Each phase is specified by its characteristic density of states andk-dependent spec-

tral function.We also give discussions on intermediate phases intervening between Mott and band insulating phases.

D-49 **Switching of the Mott Transition Based on Hole-Driven MIT Theory** KIM Hyun-Tak, LEE Yong Wook, KIM Bong-Jun, YUN Sun Jin(*ETRI.*) It has been proved that a strongly correlated Mott first-order metal-insulator transition (MIT) (or Jump) is not accompanying the structural phase transition (SPT) in VO_2 by using femtosecond measurement techniques. According to the hole-driven MIT theory which have predicted that the Mott MIT can occur and be switched by doping and de-doping holes of a low concentration into the valence band, we observes the switching phenomenon by optical method for VO_2-based devices with a narrow width of 3~5 μm and a length of 10~30 μm such as a rod. The switching phenomenon is not explained in terms of Peierls transition (electron-lattice (or phonon) interaction related to the SPT) due to heat. The switching can be applied to nano-level switching devices and power devices.
(Ref: New J. Phys. 6 (2004) 52, Phys. Rev. Lett. 97 (2006) 266401, Appl. Phys. Lett. 90 (2007) 23515.)

D-50 **Effect of Linear Density of States on the Quasi-particle Dynamics and Small Electron-phonon Coupling in Graphite** LEEM Choonshik, KIM Bum Joon[1], KIM Chul, PARK Seung Ryong, OHTA Taisuke[2], BOSTWICK Aaron[2], ROTENBERG Eli[2], KIM Hyeong-Do[3], KIM Min Kook, CHOI Hyeong Jun, KIM Changyoung(*Institute of Physics and Applied Physics, Yonsei University, Seoul, Korea. [1]School of Physics and Center for Strongly Correlated Materials Research, Seoul National University, Seoul, Korea. [2]Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA. [3]Pohang Accelerator Laboratory, Pohang 790-784, Korea.*)
We obtained the spectral function of very high quality natural graphite single crystals using angle resolved photoelectron spectroscopy (ARPES). A clear separation of non-bonding and bonding bandsand asymmetric lineshape are observed. The asymmetric lineshapes are well accounted for by the finite photoelectron escape depth and the band structure. The extracted width of the spectral function (inverse of the photohole life time) near the K point is, beyond the maximum phononenergy, approximately proportional to the energy as expected from the linear density of states nearthe Fermi energy. The upper bound for the electron-phonon coupling constant is about 0.2, a much smaller value than the previously reported one.

D-51 **Magnetic reversal of electric polarization in $MnCr_2O_4$** OH Yoon Seok, KIM Ingyu, CHUN Sae Hwan, KO Kyung-Tae[1], PARK Jae-Hoon[1], KIM Kee Hoon(*CSCMR &FPRD, School of Physics and Astronomy, Seoul National University. [1]eSSC &Department of Physics, Pohang University of Science and Technology.*)
With recent advances in understanding the multiferroic phenomena, researchers have been recognizing the importance of noncollinear spin ordering with spiral or conical patterns to realize a ferroelectric ordering in a magnetic material [1]. The term, "magnetic ferroelectrics", was coined to describe such compounds that develop ferroelectricity as a secondary order parameter induced by a main magnetic order parameter. The spinel chromite MCr_2O_4 (M=Mn, Fe and Co) is another candidate of magnetic ferroelectrics; all the compound are expected to develop a spontaneous electric polarization as they are known to have a conical spin ordering below T_S [2]. Electric polarization was indeed found in $CoCr_2O_4$ below T_S=25K, being also switchable by the magnetic field [3]. Yet, there is no report of ferroelectricity in $MnCr_2O_4$ and $FeCr_2O_4$. Herein, we report our systematic study on the polycrystal synthesis and the single crystal growth of $MnCr_2O_4$ by the flux method. We find that while the polycrystalline sample shows a sharp ferroelectric transition at T_S=18.6 K, the latter does not exhibit any electric polarization except rather a broad magnetic transition indicative of a conical ordering near 20 K. X-ray absorption spectroscopy study reveals that Mn^{2+} and Cr^{3+} sites are partially mixed in the single crystal while the poly-crystal shows the expected electronic configuration of the stoichiometric spinel, explaining absence of ferroelectricity in the single crystal. This result implies that the site disorder is harmful in realizing the multiferroicity in the present spinel compound, and that the standard flux method to grow the spinel chromite, known in the literature [4], can"t produce high quality single crystals. We further report our on-going efforts to grow high quality single crystals.
[1] H. Katsura et al., Phys. Rev. Lett. 95, 057205 (2005). [2] K. Tomiyasu et al., Phys. Rev. B 70, 214434 (2004). [3] Y. Yamasaki et al., Phys. Rev. Lett. 96, 207204 (2006). [4] B. M. Wanklyn et al., J. Matter. Sci. 11, 1607 (1976).

D-52 **Electron Removal Self-energe와 이것의 $Ca_2CuO_2Cl_2$에 적용** 김 창영, 김 철, 박 승룡, 임 춘식, 송 동준, 진 형욱 (*연세대학교, 물리학과.*) 우리는 electron removal Green's Function에 대한 새로운 self-energy를 제안하였다. Electron removal Green's function에서 시작하여, 우리는 single band를 갖고 있는 non-quasi particle photoemission spectral function에도 적용이 가능한 새로운 electron removal self-energy를 추출할 수 있었다. 우리의 방법은 self-energy의 momentum 의존성을 가정하지 않고 전체 momentum-energy 공간에 추출했다. 새로운 방법은 $Ca_2CuO_2Cl_2$ ARPES data에 적용하였고 이것은 peak wdth에서 알 수 있는 self-energy의 값과 비슷했다. Self-energy는 매우 약한 momentum 의존성을 보였고, self-energy의 imaginary part는 1ev에서 최대값을 보였다.

D-53 **Domain-wall Dynamics of Frroelectric Perovskites** 신 영한, 손 종역, 이 병주, GRINBERG Ilya[1], CHEN I-Wei[2], RAPPE Andrew[1](*포항공과대학교, 신소재공학과. [1]University of Pennsylvania, Department of Chemistry. [2]University of Pennsylvania, Department of Materials Science and Engineering.*) Ferroelectric perovskite oxides are key materials in nonvolatile random access memory technology. Important properties for memory materials are a proper working temperature, a long retention time, and a fast read/write speed under a reasonable external field. $PbZr_xTi_{1-x}O_3$ (PZT) has been known as a promising material for this purpose.

However, the intrinsic property of the polarization reversal process in the polycrystalline or thin-film ferroelectrics in the microscopic level is not still unveiled in experiments and computations. In this talk, we will show how this problem can be studied with a multi-scale approach. First, we performed molecular dynamics (MD) simulations which are based on the first-principles calculations. From MD simulations, we could obtain the nucleation and growth rates of the polarization reversal process under an external electric field. Second, we carried out stochastic Monte Carlo simulations with the event rates obtained from the MD simulations. With the potential parameters for $PbTiO_3$, we found that while the overall domain-wall speed from our calculations is an upper bound of the recent experiments, the size of the critical nucleus is much smaller than the prediction from the Miller-Weinreich model. We think that this discrepancy can be explained with the diffuse-boundary model and that the overall wall motion is controlled by both the nucleation and growth processes. Finally, we will suggest a general analytic expression of the free energy change which is based on the Landau-Ginzburg-Devonshire's theory and the diffuse-boundary model, which also can be applied to the ferroelectric perovskite $BaTiO_3$.

■ SESSION: D [DH2]
10월 19일(금), 11:00 - 12:45
장 소: 한라홀A

D-54 **최근 강유전체 연구동향: 신물질을 중심으로** 김 복기, 권 대영, 장 효동(*부산대학교, 물리학과.*) 최근 들어 활발하게 진행되고 있는 강유전체 분야의 연구동향을 종합하여 발표하고자 한다. 강유전체에 관한 최근 연구는 1) 강유전체 메모리 관련 연구분야 (FeRAM 및 DRAM), 2) 압전효과 및 그 응용, 3) Lead Free 강유전체의 개발 및 그 응용분야, 4) 강유전체 이론 및 분극현상 연구, 그리고 5) 기타중요분야 (relaxor, nanoferroelectric, multiferroics) 분야로 정리하여 볼 수 있다. 이러한 분야의 최근 연구동향에 관한 연구방향을 소개하고자 한다. 한편 본인이 관심을 가지고 있는 분야의 최근 연구결과인 1) 강유전 박막에서의 구조연구, 2) 신물질 강유전체(다강체포함)를 찾기 위한 노력과 그 결과에 관한 간단한 소개도 함께 하고자 한다.
관련 publication 1) 오세정 외, 응집물질물리학 발전전략, 한국과학재단 (2007년 출판예정).2) MultiFerroics: Progress and prospects in thin films, Ramesh and Nicolar A. Spaldin, Nature materials, 6, 21(2007).3) Writing Polarization bits on the multiferroics BMO thin film using Kelvin probe force microscope, J. Y. Son, Bog G. Kim, C. H. Kim, and J. H. Cho, APL, 84 4971 (2004), Warren Averbach analysis of coherent domain size in PZT thin film, D. Y. Kwon, X.D. Zhang, and Bog G. Kim, submitted to APL(2007), Structural phase transition of new ferroelectric BZT-PT, X. D. Zhang, D. Y. Kwon, and Bog G. Kim, submitted to APL(2007).

D-55 **Aspects of Inhomogeneous Domain Nucleation in Epitaxial $Pb(Zr,Ti)O_3$ Thin Films, investigated by using Piezoresponse Force Microscopy** KIM Tae Heon, KIM Dong Jik, JO Ji Young, YANG Sang Mo, CHEN Bin, KIM Yong Su, NOH Tae Won(*ReCOE &FPRD, Department of Physics and Astronomy, Seoul National University, Korea.*) Understanding polarization switching dynamics in ferroelectric film is of great importance scientifically and for applications of ferroelectric materials. It is known that the polarization switching occurs via nucleation of reversed polarization domains, their forward growth, and domain wall motion. In electrical measurements, such as hysteresis loops and switching transient, macroscopically averaged switching data has been measured, so it is impossible to separate domain the nucleation process from the domain wall motion. On the other hand, in piezoresponse force microscopy (PFM) studies, the direct images of domain nucleation and growth could be measured distinguishably. However, the detailed studies on the domain nucleation process have been rare, partly due to unstable contact by a moving tip to top electrode in conventional PFM configurations. In this presentation, we will show results of our recent PFM studies for 170 nm thick PZT films, epitaxially grown on $SrRuO_3/SrTiO_3$ (001) using the pulsed laser deposition. We modified PFM configuration such that external probe provides a reliable electric contact to the top electrode and that the PFM cantilever will work only as the scanning probe. By measuring the domain images using this new PFM, we made direct experimental evidences which support the following important facts on the nucleation process. (1) The domain nucleation in our 170nm thick PZT films does not occur by homogeneous process (such as thermal nucleation) but by inhomogeneous process (possible due to defects of the films). (2) The nucleation occurs mostly at the interface, not from the inside of the PZT films. (3) The number of domain nuclei is proportional to the logarithmic of the time during which the electric pulse was applied. This observation might be explained by that the domain nucleation process could be governed by a broad distribution of the barrier energies. (4) With a high electric field, the number of nuclei becomes larger, and the nucleation process becomes the dominating process in the polarization switching. However, as the applied electric field becomes weaker, the domain wall motion starts to play a more important role. We believe that our new PFM approaches can provide us some insights on domain dynamics of numerous ferroelectric thin films. For examples, our new PFM configuration can be also used to investigate domain wall motion in epitaxial ferroelectric films. And, such studies can be also extended to other ferroelectric thin films, including polycrystalline thin films.

D-56 **강유전체 박막의 구역반전 현상** 조 지영, 김 동직, 김 용수, 양 상모, 김 태헌, 최 석봉, 송 태권[1], 윤 종걸[2], 노 태원 (*서울대학교 물리천문학부. [1]창원대학교 나노세라믹공학부. [2]수원대학교 물리학부.*) 최근 강유전체를 이용한 RAM (FeRAM) 등등의 전자기기와 관련하여 강유전체 박막에서 일어나는 전기장 하에서의 구역반전 역학에 대한 연구가 급증하고 있다. 약 50년 전 Landauer가 일반적인 강유전체 박막 (100 나노미터의 두께)에서는 구역 반전에 첫 번째 필수요소인 구역 핵이 발아하는 데 너무 큰 에너지가 필요하여 열역학적으로 구역핵이 발아하기 어렵다고 보고한 바 있다. 그후로 이런 "Landauer의 패러독스"를 해결하기 위해, 많은 학자들은 핵발아가 원자 결함 자리 등에서 비등질적으

로 일어날 수 밖에 없다고 예측해 왔지만 직접적인 실험적 결과는 없었다. 허나, 우리는 압전력 현미경을 이용하여 170 나노미터 두께의 $Pb(Zr,Ti)O_3$박막의 비균질적인 핵발아 현상을 실험적으로 관측하였다. 또한 강유전체 박막이 얇아짐에 따라 강유전체와 전극 사이에서 분극전하가 완전히 차단되지 못하여, 분극의 방향과 반대인 분극소거장이 생겨나며 그 크기는 박막의 두께와 반비례한다. 우리는 30 나노미터 이하의 $BaTiO_3$초박막에서 분극소거장이 구역 핵발아에 필요한 에너지 장벽을 줄여, 구역핵이 등질적으로 일어날 수 있음을 보였다. 강유전체 초박막에서 이렇게 핵 발아가 쉽고 또한 빠르게 일어남에 따라 FeRAM에게 있어 새로운 두께한계를 한정지을 수 있다.

D-58 **Thermal properties of $Gd_2Zr_2O_7$ thin films by RF magnetron sputtering.** YANG Ho-Soon, KANG Jun-Gu (*Department of Physics, Pusan National University.*) Low thermal conductivity is important property for Thermal Barrier Coating (TBC) materials of thermal control devices. Because Ytrria-Stabilized Zirconia (YSZ) which has short phonon mean free path by means of oxygen vacancies has low thermal conductivity, it is generally used for TBC materials. An oxidized substance which constitutes pyrochlore structure without 1/8 oxygen at fluorite is well known that thermal conductivity is smaller than YSZ's. Considering high gas temperature of next generation engine, people pay attention to an oxide as TBC materials instead of YSZ. In this report, $Gd_2Zr_2O_7$ is deposited with RF magnetron sputtering and is investigated about thermal properties. X-ray diffraction (XRD) is used to identify structural crystallization and orientation of thin films. Moreover Atomic Force Microscope (AFM) and Scanning Electron Microscope (SEM) is utilized respectively in order to observe grain size and film thickness. Finally, we make use of the 3 omega method for measuring thermal conductivity of thin film and verifying interfacial effects between substrate and thin film.

D-59 **Spontaneous dissociation of NO on Si(001) and Incorporation of N into the subsruface** 정 석민(*전북대학교, 물리학과.*) We present our first-principles molecular dynamics (MD) simulation of dissociation of a nitric oxide (NO) molecule on the Si(001) surface and subsequent incorporation of the nitrogen atom into the subsurface, which are important in understanding synthesis of oxynitride thin films. We have found that the detailed dissociation processes are sensitive to the substrate temperature and the way of approaching the substrate. In the final stages of MD runs, we have three different configurations where (1) nitrogen and oxygen bridge a Si dimer and backbond, respectively, (2) nitrogen incorporates into the subsurface with formation of $N\text{-}Si_3$ and (3) NO dissociates across two dimers. These structures are obtained through a series of elementary processes that last at most a couple of pico seconds, implying that the corresponding energy barriers are quite small. Nearly spontaneous dissociation of NO and incorporation of N are in agreement with photoemission measurements.

D-60 **STM study on Pb induced one-dimensional structures on Si(557)** MORIKAWA Harumo, KIM KeunSu, YEOM Han Woong(*연세대학교 물리학과 원자선원자막연구단.*) A few semiconductor surface systems with adsorbates have attracted renewed interests as low dimensional electronic systems where exotic phenomena, such as Peierls transitions and Luttinger-Liquid behaviors, can be observed at low temperature (LT). One of the notable recent systems is the Pb nanowires on the stepped Si(557) surface. Deposition of Pb onto Si(557) followed by annealing was reported to yield an 1D chain structure [1]. The surface-state conductivity showed a sudden switching between 1D metal (LT) and 2D insulator [high temperature (HT)] at Tc=78K. This is quite unusual, considering other low-dimensional systems which basically show metal(HT)-to-insulator(LT) transition or power-low conductivity due to the Peierls instability or non-Fermi liquid nature. In the previous scanning tunneling microscopy (STM) study, a disordered chain structure was observed above Tc, which changed to an ordered but modulated one below Tc, indicating a disorder-order transition in relation to the conductivity switching transition [1]. Recently, we established a phase diagram of the Pb/Si(557) system through an electron diffraction and photoemission study, which exhibits two different 1D phases, so called the αX2 and βX2 [2]. Based on the formation condition, the αX2 phase was considered as the 1D chain system shown in the previous STM [1]. In the present study, we have performed a detailed STM study for the αX2 phase from 140K to 4K, which are far above and below the reported Tc. We have found that this phase consists of a chain structure formed on the (223) terrace, whose misorientation from the (557) direction is compensated by narrow (111) terraces. However, contrary to the previous study, our high-resolution STM images have shown that the αX2 phase is completely commensurate with the underlying lattice with a clear x2 modulation along the chain direction above and below Tc. No indication of the long-period modulation is found in each chain even at 4K. This rules out the order-disorder and the commensurate-incommensurate transition suggested before.
References [1] C.Tegenkamp et al., PRL 95,176804(2005). [2] K.S. Kim et al.PRB 75,195324(2007).

D-61 **실리콘 (001) 표면의 초기 산화 과정에 대한 원자 구조 연구** 장 윤희, 황 은경, 구 자용, 김 한철(*한국표준과학연구원.*) 실리콘 표면에서의 산화에 대한 연구는 학문적으로나 기술적으로 중요하고 흥미로운 주제이다. 실리콘을 기반으로 한 반도체 소자의 소형화 기술이 발전하면서, 표면에서 원자 몇 개의 층을 정밀하게 조절할 수 있는 기술이 요구되고, 따라서, 실리콘 표면의 산화 과정에 대한 미시적인 이해가 더욱 중요해지고 있다. 지난 수 십년 동안 실리콘 표면에서의 산화에 대한 광범위한 실험 및 이론 연구가 진행되어 왔지만, 산화 메카니즘에 대한 원자 수준에서의 이해는 잘 되어있지 않은 상태이다. 산소 원자 1개가 실리콘 (001) 표면과 반응하는 경우에는 back-bond 에 산소 원자가 침투한 구조가 에너지 적으로 안정하다는 사실이 이론 계산을 통해 잘 알려져 있지만, 산소 분자의 경우에는 일치된 견해 없이 여러 가지 서로 다른 구조 모델들이 제안되고 있다. 또한, 이런 이론적인 연구들은 표면 아래로 두 번 째 층까지만 산소의 침투를 고려하여 일정 정도의 한계가 있을 수도 있다.이 발표에서는 실리콘 (001) 표

면의 초기 산화 과정에 대한 제일원리계산 연구 결과를 소개한다. 산소 분자들의 여러 가지 분해 흡착/혼입 구조들과 분해되지 않고 분자 상태로 흡착된 구조들의 에너지 안정성을 비교하였다. 특히, 표면에서 두 번째 층보다 더 깊은 층까지 산소 원자가 침투된 구조들도 고려하였다. 이 구조들에 대해 scanning tunneling microscopy 이미지를 모사하고, 실험 이미지와 비교 분석하였다.

■ SESSION: D [DG4]
10월 19일(금), 11:00 - 12:45
장 소: 탐라홀B

D-62 **Relativistic Theory of Spin Current** LEE Soo-Yong, LEE Hyun-Woo(*POSTECH, Dept. of Physics.*) The spin current has been one of main concerns in the field of the spintronics. Recently, the spin Hall effect using the spin current has attracted great interest. However, when conventionally defined spin current, which is a symmetric product of the Pauli spin and the velocity operators, is taken into account, several questions still remained relevant to spin transport. First, the spin current does not satisfy the continuity equation for a spin because spin is not conserved unlike charge. Second, Rashba [PRB 68, 241315 (2003)] pointed out that in certain nonmagnetic systems with the spin-orbit coupling, the conventional definition of the spin current leads to a rather strange prediction, namely a nonzero spin current should flow even without external biases. Though the nonvanishing equilibrium spin current does not violate the time reversal symmetry, it still led many scientists to reexamine the definition of the spin current. Recalling that the spin-orbit coupling arises due to the relativistic effects, we examine in this work properties of the conventionally-defined spin current for a Dirac electron subject to an electrostatic potential V(r). Interestingly it is found that in this fully relativistic treatment, the equilibrium spin current vanishes for a wide class of V(r) including those representing the zincblende structure and the asymmetric quantum well, which is in clear contrast with the nonvanishing equilibrium spin current obtained from some effective non-relativistic Hamiltonians. To understand the origin of this discrepancy, we examine the non-relativistic limit of several operators in view of the Foldy-Wouthuysen(FW) transformation which is rigorous transformation from the Dirac Hamiltonian to the Schrödinger-Pauli Hamiltonian. It is found that non-relativistic operators obtained by FW transformation is altered from their relativistic forms. In particular, the transformed non-relativistic spin current is quite different from its conventional form, spin times velocity. This difference of the spin current stems from the fact that there are additional relativistic corrections even in leading order. The electron-electron interaction effect on the spin current is also discussed.

D-63 **Magnetostatic Interactions in Patterned Ferromagnetic Dot Arrays** KUK YOUNG, SEO JUNGPIL, KIM T.-H.[1], CHOI J.H.[2](*Department of Physics and Astronomy, ykuk Lab., Seoul National University, Seoul, Korea. [1]Condensed Matter Sciences Division, Oak Ridge National Laboratory, Oak Ridge, USA. [2]National NanoFab Center.*) For a single magnetic dot, the magnetic phase is determined by competitions between exchange energies and crystalline anisotropy energies. In a patterned media, however, the magnetostatic energy also plays important roles in ordering the magnetic phase of the dots. It lowers the system energy by ordering the dot in special manners. Home built spin polarized scanning tunneling microscope (SPSTM) is used to investigate the magnetic properties of patterned ferromagnetic dot arrays. We fabricated well-ordered rectangular Fe dot arrays on a W(110) substrate with alumina shadow mask. The Fe dot on W(110) has fixed uniaxial easy axis by substrate and the direction is toward [1-10] direction. Contrast to the easy axis, the direction of Fe dot arrays is easily controlled by the direction of the shadow mask. The magnetostatic energies among the dots depend on the angle between the easy axis and the direction of the Fe dot arrays. This experiment revealed parallel coupling, antiparallel coupling among the dots by the angle and the direction of magnetic coupling.

D-64 **Pair tunneling and shot noise through a single molecule in a strong electron-phonon coupling regime** HWANG Myung-Joong, CHOI Mahn-Soo[1], LOPEZ Rosa[2](*Pohang University of Science and Technology. [1]Korea University. [2]Universitat de les Illes Balears.*) We investigate the electronic transport through a single molecule in a strong electron-phonon coupling regime. In this regime, it has been shown that a pair of electrons can simultaneously tunnel into molecule from normal leads. Based on a particle-hole transformation which is made suitable for non-equilibrium situation, we treat the pair tunneling and cotunneling on an equal footing. We also study Franck-Condon effect on both pair tunneling and co-tunneling and show that a pair tunneling contribution is exponential suppressed in typical experimental situations. We propose an experimental setup to enhance the visibility of pair tunneling, which has no Franck-Condon suppression. We also discuss the shot noise characteristics.

D-65 **Strain and Defect engineering: Room-temperature ferroelectricity in tetragonal $SrTiO_3$ thin films on $SrTiO_3$ (001) substrates** 김 용수, 김 동직, 김 태헌, 문 순재, 최 우석, 장 영준, 김 지연[1], 이 준희[1], 최 진식[2], 박 배호[2], 윤 종걸[3], 노 태원(*ReCOE &FPRD, Department of Physics and Astronomy, Seoul National University. [1]CSCMR &FPRD, Department of Physics and Astronomy, Seoul National University. [2]Department of Physics, Konkuk University. [3]Department of Physics, University of Suwon.*) SrTiO3 (STO) is known well as incipient ferroelectric (FE) material: The ferroelectric transition seems to be hindered by competing interactions, such as quantum fluctuation, and/or the antiferrodistortion, down to 0K. Such a sharp balance could be easily broken by external parameters. For examples, other studies have reported ferroelectricity in $SrTiO_3$ by doping with other cations, substituting oxygen isotopes, applying electric field, or using strain engineering techniques.In this presentation, we will report the room-temperature ferroelectricity of tetragonal STO thin films on $SrTiO_3$ (001) substrates with $SrRuO_3$ electrodes. From x-ray reciprocal space mapping, we found that the STO layer is co-

herently grown on the $SrTiO_3$ substrate without in-plane lattice relaxation, but its out-of-plane lattice constant increased with a decrease in oxygen pressure during deposition. This expansion of the unit cell volume was attributable to formation of defects, such as oxygen and strontium vacancies inside the STO layer, during deposition and resulted in tetragonality greater than that of ferroelectric $BaTiO_3$. We substantiated that our tetragonal STO films possess room-temperature ferroelectricity using piezoresponse force microscopy and P-V measurements. In our tetragonal STO films, we expected that the strain and defects should be possible candidates for the origins of the room-temperature ferroelectricity. We will discuss that the roles of strain and defects in the observed ferroelectricity. This interesting experimental finding is very easy to implement when making ferroelectric STO films and could have significant practical implications.

D-66 **Quantitative Measurement of Nonoscale Dynamic Interfacial Interactions in Air** 이 만희(*서울대학교 물리천문학부.*) 진공에서 두 입자의 상호작용에 대해서는 잘 연구가 되어 있을 지라도, 공기중에서 두 입자의 상호작용을 연구하기는 매우 어려웠다. 왜냐하면, 이를 연구하기에 적합한 실험적-이론적 도구가 부재했기 때문이다. 그러나, 우리는 튜닝포크를 이용한 Amplitude-Modulation AFM과 이를 해석할 수 있는 이론적 도구를 이용하여 반데어발스힘, dynamic capillary force, indentation force를 관측할 뿐만아니라, 이를 0.1nm 이하의 정밀한 분해능으로 정량적인 측정을 하였다. 여기에서, 우리는 그동안 알려져있던 attractive static capillary force와는 다른 repulsive dynamic capillary force를 나노영역에서 최초로 보고하고, 공기중에서 습도에 의존하는 dissipation energy를 관찰하였다. 이러한 연구는 나노 마찰 및 윤활, MEMS, 그리고 생명현상의 공통된 문제를 푸는 열쇠가 된다.

D-67 **Directed-Assembly of Robust Single Nanoparticle-Attached AFM Tip for Stable Imaging, Contact Force Measurement and Dip-Pen Nanolithography** KIM Taekyeong, MYUNG Sung, HONG Seunghun(*Seoul National University, Physics and Astronomy.*) In previous works, single nanoparticle (NP) attached Atomic Force Microscope (AFM) tips have been utilized for optical imaging and non-contact mode surface force research. However, the NP tip was not strong enough to survive during the AFM imaging and contact force curve study. Herein, we present a directed-assembly method to mass-produce robust single Au nanoparticle attached AFM tip which enables stable tapping mode imaging of carbon nanotubes (CNTs) and contact force curve measurements under ambient conditions. In this method, the end of the AFM tip was functionalized with amine-terminated molecular layers, while other regions passivated by methyl-terminated layer. Then, the assembly of a negatively-charged single Au NP was directed to the end of the AFM tip via electrostatic interaction in solution. We successfully achieved repeated tapping mode imaging of CNTs using the Au NP tip, and verified that the Au NP was still firmly attached at the end of the tip after the imaging process. The tapping mode AFM image of CNTs showed the expected tip convolution effect from the flattened Au NP. As far as we know, this is the first report on stable AFM imaging using a single NP tip. Furthermore, we performed contact force curve measurement on the flat surface using our robust Au NP tip and measured about the contact deformation of the tip-end with the Au NP. It confirmed that our Au NP tip is also strong enough for contact force curve measurement. The tip was also utilized to perform molecular deposition via dip-pen nanolithography. Since we can precisely control the shape and chemical groups of our NP tips, these tips could be utilized for various nanoscale researches such as surface force study, nano-SERS imaging, and etc.

D-68 **Tunneling Properties Of Ultra-thin SiO_2 Barriers: a First-principles Study** KO Eunjung, CHOI Hyoung Joon(*Yonsei University, Department of Physics and IPAP.*) As the size of the metal-oxide-semiconductor field effect transistor decreases, the thickness of the gate oxide approaches 1 nm scale. In such cases the quantum-mechanical tunneling through ultra-thin gate oxides becomes a very important source of the gate leakage current. In this work, we performed first-principles simulations of the electron tunneling through ultra-thin SiO_2 barriers in $Si(100)/SiO_2/Si(100)$ structures. The atomic structures of the Si/SiO_2 interfaces are generated by considering various silicon suboxide states observed in photoemission studies. For comparison, we also consider sharp Si/SiO_2 interfaces with dangling bonds. For each atomic structure, the tunneling conductance is calculated by a first-principles scattering-state method based on the ab-initio pseudopotentials and the density functional theory within the local density approximation. As a result we obtained the dependence of the tunneling probabilities on the oxide thickness and on the interfacial structures. Effects of the dangling bonds on the tunneling probabilities will also be discussed. Computational resource for this work is provided by KISTI under the 8th Strategic Supercomputing Support Program.

■ SESSION: D [DC]
10월 19일(금), 11:00 - 12:45
장 소: 탐라홀C

D-69 **고온초전도체의 "짝짓기보존"을 찾아서** 최 한용, 윤 재현, VARMA Chandra[1], KAMINSKI Adam[2], KONDO Takeshi[2](*성균관대 물리학과. [1]UC Riverside. [2]Iowa State Univ.*) We plan to report the current progress of extracting the "pairing glue" spectra of high Tc superconductors. An underlying assumption is that the Eliashberg type equation is valid for the high Tc. This is an extension of the celebrated McMillan-Rowell analysis of the tunneling conductance for conventional s-wave superconductors. A major difference from the McMillan-Rowell analysis is that there are two distinct "α^2F" functions for the d-wave Eliashberg equation. Consequently, we need twice more experimental inputs to perform this analysis; the pairing function $\Delta(\omega)$ and self-energy $\sum(\omega)$. Since this experimental information is currently not available for high Tc superconductors, we first generated and theoretically using the marginal Fermi liquid like glue spectra to test this approach. Then, using the generated Δ and $\sum$ as "experimental inputs" we inverted

the Eliashberg equation to extract the glue spectra. We will compare the input and extracted glue spectra to demonstrate the applicability of the approach. Then, we will describe how to obtain the experimental inputs $\Delta(\omega)$ and $\sum(\omega)$ from ARPES experiments.

D-70 **Magnetization Hysteresis Loops of Coated Conductors Calculated Using Field Profile Data Measured** YOO Jaeun, LEE Jaeyoung[1], YOUM Dojun(*KAIST, department of Physics. [1]PaiChai University, department of Physics.*) The hysteretic magnetization loops of superconducting $ReBa_2Cu_3O_7$ (RE: Y, Sm) films were investigated. The YBCO and SmBCO films were grown on ion beam assisted deposition (IBAD) templates by using pulsed laser deposition (PLD) and coevaporation method (EDDC), respectively. The field profiles near the surfaces of the films under external fields, H_a, were measured using a scanning Hall probe method. The external field, H_a, was applied normal to the film surface, and increased monotonically up to 4000 Oe. The corresponding sheet current profiles, $J(x, H_a)$, in the superconducting thin films were obtained by a numerically iterative inversion of the measured field profile data. Using the values of $J(x,H_a)$, the negative magnetic moments, $M(H_a)$, per unit length were estimated by integrating xMdx over the film width. It is found out that the magnetization hysteresis loops for SmBCO (EDDC) sample are similar to those calculated using the Kim model, while the loops for YBCO (PLD) sample are more like those calculated using the Bean model.

D-71 **헬륨-4 비열의 불연속과 상호작용과의 관계** 김 상훈(*목포해양대학교, 교양학부.*) 액체 헬륨-4는 약 2.2K의 온도에서 람다전이라 부르는 상전이를 하며, 이는 비열이 큰 불연속을 보이는 것을 측정함으로써 쉽게 알 수 있다. 하지만 이 비열의 불연속을 이론적으로 구명하기는 쉽지 않다. 이 연구에서는 비열의 불연속이 상호작용에 의하여 발생하며 그 불연속의 크기 역시 상호작용의 크기에 따름을 보였다.

D-72 **Growth of MgB_2 Thin Films by Novel Technique of LACVD** 강 원남, 정 순길, 이 남훈(*성균관대학교 물리학과.*) For the first time in the world, we have fabricated superconducting MgB_2 thin films by using laser assisted-chemical vapor deposition (LACVD) technique. For the in situ LACVD process, we used the Mg target and a mixture of 5% B_2H_6 gas in H_2. The Mg and the B sources were obtained from pulsed laser ablation and inlet gas, respectively. The MgB_2 thin films were grown on the Al_2O_3 (0001) substrate at various temperature ranges of 220 − 400℃ under about 0.2 Torr. These samples showed a superconducting transition temperature (T_c) of about 19 − 40 K. When the B_2H_6 gas flow rate was 20 sccm and substrate temperature was 400℃, we have obtained the best quality films of the maximum T_c ($T_{c,onset}$ ~ 40.15 K, $T_{c,0}$ ~ 39.31 K). The residual resistivity ratio (RRR) of this sample is about 4.4. MgB_2 thin films by LACVD method is looking forward to the electronic applications, Josephson junctions and circuits, because of low growth temperature and good surface morphology.

D-73 **Non-Hermitian Quantum Mechanics in the Presence of Quasiperiodic Potentials** 조 영권, 김 기홍(*아주대 에너지시스템학부.*) We study the localization transition in 1D non-Hermitian vortex systems with quasiperiodic potentials given by one of the well-known quasiperiodic sequences; Fibonacci, Thue-Morse (TM), Rudin-Shapiro (RS), Paper-folding (PF), Period-doubling (PD) or hybrid. The eigenenergy spectrum consists of bubbles of different sizes in the complex plane and shows a Cantor set structure where small bubbles merge with each other as the strength of the non-Hermitian field increases. A complicated fluctuating behavior appears in the spectrum of the participation ratio. Localized and delocalized states determined using the participation ratio calculation are interspersed together forming a multifractal structure, even when the energy spectrum and winding number calculations suggest that all those states are delocalized

■ SESSION: D [DG5]
10월 19일(금), 13:00 - 14:30
장 소: 탐라홀B

D-74 **Tunable resonant Raman scattering of highly purified single-walled carbon nanotubes** 민 경인, 김 서군[1], 정 문석[2], 변 지수[2], 김 종수[2], 노 희석, 이 영희[3](*전북대학교, 물리학과. [1]전북대학교, 반도체과학기술학과. [2]광주과학기술원, 고등광기술연구소. [3]성균관대학교, 물리학과.*) 열처리와 산처리를 통해 95% 이상의 순도를 가지는 single-walled carbon nanotubes(SWCNT)를 580~900 nm 사이에서 파장변조가 가능한 Dye laser와 cw-Ti: Sapphire 레이저를 이용해 Resonant Raman scattering 실험을 실시하였다. Resonant Raman scattering 실험 결과 150~200 cm^{-1}, 1340 cm^{-1}, 1600cm^{-1} 부근에서 각각 Radial breathing mode(RBM), D-band, G-band가 관측되었다. 레이저 파장에 따른 RBM 의 변화를 측정하여 CNT powder 내에 존재하는 SWCNT들의 직경과 chirality를 측정하였으며 이를 pristine SWCNT와 열처리 전 SWCNT 및 산처리 전 SWCNT 시료와 비교하여 열처리와 산처리가 SWCNT에 미치는 영향을 조사하였다.

D-75 **Micro-Raman Spectroscopy of Single Nanowires and Nanosheets** 이 경연, 노 희석, 최 영진[1], 최 경진[1], 박 재관[1](*전북대학교, 물리학과. [1]한국과학기술연구원, 나노재료연구센터.*) 마이크로-라만 산란 실험을 통해서 단일 CdS 나노선과 나노시트에 대한 분광 특성을 연구하였다. 단일 나노선에서 얻은 라만 스펙트럼에서는 first-order longitudinal optical (1LO) phonon의 세기가 가장 큰 반면, 단일 나노시트에서 얻은 라만 스펙트럼에서는 multiphonon의 세기가 단일 나노선에 비해 현격하게 증가됨이 관측되었다. Multiphonon 세기의 증가는 시료의 결정성이나 exciton-LO phonon coupling과 관련이 있다. 라만 산란 실험 결과에서 주목할 만한 특징은 나노선에서 나노시트로 시료의 측면 폭이 증가할수록 1LO phonon 에너지가 증가함을 확인할 수 있었다. 이러한 1LO phonon 에너지의 증가는 나노시트 성장과정에서 생기는 표면장력에 의한 c 축 방향으로의 격자수축과 밀접한 관련이 있다. 단일 나노시트의 여러 지점으로부터 얻어진 라만 산란을 통해 미세한 스트레스의 변화를 관측하였다.
*이 논문은 2006년 정부(교육인적자원부)의 재원으로 한국학술진흥재단의 지원을 받아 수행된 연구임 (KRF-2006-005-J00302).

KIST에서의 연구는 KIST-CNRS LIA 프로그램(2U03450)과 KIST 프로젝트 (2E19770)의 지원을 받아 수행되었음.

D-76 **Improvement of field emission properties in plasma-treated CNT emitters** LEE Kyu, LEE Ilha[1], KIM Eun Sung[2], GÜNEŞ FETHULLAH[1], LEE Young Hee[3](*Sungkyunkwan university, Department of Physics, Center of Nanotubes and Nanostructured Composites. [1]Sungkyunkwan university, SKKU Advanced Institute of Nanotechnology. [2]Sungkyunkwan university, Department of Physics. [3]Sungkyunkwan university, Department of Physics, Center of Nanotubes and Nanostructured Composites, SKKU Advanced Institute of Nanotechnology.*) Using thermal chemical vapor deposition (CVD), we synthesized the vertically aligned multi-walled carbon nanotubes (MWCNT) emitter. After argon (Ar) plasma treatment on CNT emitters, emitters' surface was flatted and we characterized emitters. Plasma treatment etched emitter's protruding CNT, and then field enhancement factor β value decreased. In spite of reduction in β, field emission characteristics were improved. The improvement in emission properties might be caused that plasma etching sharpened CNT emitter's edge and modified to flavor for field emission. These combination are assumed to reduce the effective field emission barrier.

D-77 **High Voltage Characteristics of Double-wall Carbon Nanotubes** MOON Sunkyung, SONG Woon[1], KIM Nam[1], LEE Joon Sung[1], LEE Soon-Gul, PARK Jongwan[2], JUNG Myung-Hwa[3], LEE Hyun-Woo[4], KANG Kicheon[5], LEE Cheol Jin[6], KIM Jinhee[1](*Korea University, Applied Physics. [1]Korea Research Institute of Standards and Science. [2]National Nanofab. Center. [3]Korea Basic Sicence Institute. [4]Pohang University of Science and Technology. [5]Chonnam National University. [6]Korea University, School of Electrical Engineering.*) We have fabricated and studied the electric transport characteristics of individual double-wall carbon nanotubes (DWNT) under high bias voltage. As the bias voltage applied to the carbon nanotubes increases, the outermost shell of the DWNTs broke down sequentially and we could determine the maximum current-carrying capacity and the electronic properties of each shell. The maximum current-carrying capacity per shell was about 150mA, well above that of any other previous reports, which is about twice as large as that of a single-wall carbon nanotube (SWNT).

D-78 **Effect of Chemical Treatment on Conductivity of Carbon Nanotubes Based Transparent Conducting Films** GENG Hong Zhang, KIM Ki Kang[1], LEE Dae Sik[1], SO Kang Pyu, LEE Young Hee[1](*Department of Nanoscience and Nanotechnology, and Center for Nanotubes and Nanostructured Composites, Sungkyunkwan Advanced Institute of Nanotechnology, Sungkyunkwan University, Suwon 440-746, Korea. [1]Department of Physics, and Center for Nanotubes and Nanostructured Composites, Sungkyunkwan Advanced Institute of Nanotechnology, Sungkyunkwan University, Suwon 440-746, Korea.*) Single-walled carbon nanotubes (SWCNTs) dispersed with sodium dodecyl sulfate into deionized water was sprayed on a poly(ethylene terephthalate) substrate to fabricate flexible transparent conducting films (TCFs). These films were further modified by chemical treatment. This process involved a chemical doping and removal of the remaining dispersant on the CNT surface. The properties of CNTs, the degree of dispersion, film morphology and the performance of TCFs were characterized by scanning electron microscopy, transmission electron microscopy, thermogravimetric analysis, optical spectra, four-point probe measurements, Raman, and x-ray photoelectron spectroscopy. The film conductivity was enhanced by a factor of ~4 with a negligible change in the transmittance in the visible range. This enhancement was attributed to the removal of remaining SDS and the subsequent densified film formation to improve the cross-junction resistance between SWCNT networks and enhanced metallicity of SWCNTs.

D-79 **Controllable CNT cutting using saccharide molecules by grinding method** PARK Kyung Ah, LEE Dae Sik, KIM Ki Kang, LEE Young Hee(*Department of Physics, Sungkyunkwan University.*) Carbon Nanotubes (CNTs) have long length up to few micrometer scale after synthesis. Depend on the application purpose, sometimes it is necessary to control the length of CNTs. Several reports for the cutting of the CNTs in mass scale using chemical treatment were reported. For example, strong acid treatment, harsh sonication treatment, and ball milling method using various materials. We succeeded to control the length of the CNTs using saccharide molecules by simple grinding method.We used thin-mulltiwall carbon nanotube (t-MWCNT) in this experiment. For the saccharide molecules, the glucose, sucrose (sugar) and b-cyclodextrin were admitted with different size of the molecule. We used general table handing muller for the grinding method and SEM, TEM, Raman spectroscopy and DLS (dynamic light scattering) were used for the analysis before and after the cutting procedure. Further detailed studies will be presented.

■ SESSION: E [E1]
10월 18일(목), 12:30 - 14:15
장 소: 한라홀B

E-01 **A first-principles study of the crystal stability of Fe_2Al_5 structure** KIM InGee, JANG Jae-hoon, PARK Jae-sung[1] (*포항공대, 철강대학원. [1]한양대학교, 재료공학과.*) In Al coated layers on low carbon steels, Al, $FeAl_3$ and Fe_2Al_5 phases were detected from the external topcoat to the steel. In order to understand the mechanism of the compound formation for Fe_2Al_5, the total energy of Fe_2Al_5 is calculated using the all-electron full potential linearized augmented plane-wave method (FLAPW) implemented in the QMD-FLAPW within the generalized gradient approximation (GGA). The crystal structure of Fe_2Al_5 is the orthorhombic with the space group of Cmcm. Fe atom and Al atom are fully occupied on 4c and 8g sites, on the other hand, Al atoms are occupied partially on 4b and 8f sites with the 0.32 and 0.24 occupancies, respectively. The total energy of ferromagnetic case in 4b and 8f sites are about 0.032 eV and 0.01 eV lower then paramagnetic case, respectively. The total energy of 4b site is about 0.27 eV lower then 8f site for both paramagnetic and ferromagnetic cases. These facts imply that ferromagnetic case is more stable and Al atoms prefer to locate 4b site. Energetics, electronic structure, magnetic structure are described and discussed.

E-02 **Observation of the domain wall motion using secondary electron microscope with polarization analysis (SEMPA)** 이 상선, 김 원동, 이 도현, 황 찬용(*한국표준과학연구원.*) 최근에 자구벽이동을 이용한 race track memory 에 대한 관심이 집중되고 있다. 용량은 하드디스크의 크기를 가지며 속도는 SRAM, 집적도는 DRAM에 필적하는 새로운 메모리의 실현은 지금까지 이용되는 대부분의 메모리를 대체할 가능성이 있다. 이러한 메모리의 개발에 가장 기본이 되는 측정기술은 나노크기의 자성 구조체에서 자구벽 이동을 측정하는 기술이다. 또한 이기술은 자기적으로 비파괴적인 방법이어야 한다. 본 연구원에서 개발된 SEMPA기술은 일반적으로 널리 사용되고 있는 이차전자 현미경(SEM)에 전자의 스핀을 분해할 수 있는 전자스핀 편향기를 추가하여 나노스케일에서 자구를 효율적으로 측정할 수 있는 방법이다. 본 발표에서는 이 방법을 이용하여 여러가지의 구조를 갖는 나노체의 자구측정 결과를 제시하고자 한다. 이를 이용하여 현재 발표된 나노 자성구조체에서 전류에 의한 자구벽 이동을 측정하여 주로 MFM을 이용하여 발표된 기존의 결과를 비교할 예정이다.

E-03 **Preparation and properties of ferritin embedded in nanofiber** HYUN YoungHoon, PARK SangYoon, LEE YoungPak, SHIN MinKyoon[1], KIM SeonJeong[1](*q-Psi and Department of Physics, Hanyang University. [1]Center for Bio-Artificial Muscle and Department of Biomedical Engineering, Hanyang University.*) The magnetic properties of ferritin embedded into polyvinyl alcohol (PVA) fibers with a diameter of about 100 nm were investigated as a function of process temperature (T_P) of the mixed PVA-ferritin solution. The ferritin-embedded PVA fibers were fabricated by electrospinning at room temperature. The dependences of ferritin size and size distribution on T_P were determined by transmission electron microscopy. Depending on T_P, it was found that the monodispersed ferritin (MF) and the clustered one (CF) were embedded into the PVA fiber. The magnetic properties of MF and CF were analyzed by using a superconducting quantum interference magnetometer. The obtained results provide us a possibility to manipulate the size and the magnetic ordering inside a biocompatible superparamagnet and to realize the biomedical electric devices.

E-04 **Butt-end fiber coupling to a surface-emitting gamma-point photonic crystal band edge laser** 김 성환, 박 연상, 문 채영(*서울대학교 물리학부.*) 광결정 레이저는 그 크기가 작고 효율이 높아 차세대 레이저 광원으로 각광을 받고 있다. 그러나 집적의 어려움과 커플링의 어려움 등으로 인해 그 응용에 제약이 있었다. 여기서는 1 X 2 광섬유 커플러를 이용하여 간단하고 소형의 광섬유 커플링 구조를 제안한다. 이를 위해 수직방향으로 발진하고 결함이 없는 패턴을 가진 Γ-point 광결정 밴드에지 레이저를 제작하였고 PL장비를 이용 레이징을 확인하였다. 더불어 광섬유 커플러를 통해 펌핑과 레이저 수집을 동시에 할 수 있었고 그 효율성은 일반적인 PL장비보다 우수함을 확인하였다.

E-05 **Laterally Graded pPorous Silicon Optical Filter Fabricated By Diffusion-Limited Etch Process** 전 헌수, 황 경욱, 김 시한, 박 연상, 정 재욱[1](*서울대학교, 물리천문학부. [1]서울대학교, 전기컴퓨터 공학부.*) 전기화학 식각을 이용하여 제작되는 다공질 실리콘의 얇은 박막에 선형적인 식각 차이를 유도하는 방법을 고안하였다. 전기적인 유도로 인한 홀 전류를 이용하는 기존의 방법과는 달리 우리는 식각 용액 속의 이온의 확산 현상을 이용하였다. 제작된 다공질 실리콘의 식각 차이는 실리콘 표면 위에 제작된 테이퍼 모양의 식각 마스크에 따라 결정된다. 이러한 방법을 통해서 우리는 1550nm 부근에서 동작하는 선형 변환 광학 필터를 제작하였다. 이 필터는 일반적인 다공질 실리콘 제작 장비를 이용하였으며, 제작된 필터는 3nm 의 단측폭과 테이퍼 패턴 방향으로 60nm 정도의 변환율을 가지는 것을 확인하였다. 이 현상을 설명하기 위해 시도된 시뮬레이션 결과는 테이퍼 패턴 방향으로 일어난 식각율의 차이가 전류에 의한 차이가 아닌 것을 보여준다. 이는 용액 속에서 일어나는 이온의 확산 제한 식각 과정이 중요한 역할을 했음을 보여준다.

E-06 **Waveguiding and optical switching properties of Au/SiO_2 nanocomposite waveguide films using prism coupler method** LEE Kyeong-Seok, CHO Sunghun[1], LEE Soonil[2], LEE Taek Sung, KIM Won Mok(*Korea Institute of Science and Technology, Thin Film Materials Research Center. [1]Ajou University, Department of Physics. [2]Ajou University, Division of Energy Systems Research.*) Since nanocomposite films which consist of metal nanoparticles dispersed in dielectric matrices exhibit a variety of interesting optical properties, they have received considerable attention as a promising candidate for future all-optical switching devices. Because the applications of nanocomposite films are primarily based on the planar waveguide-type devices, it is important to analyze the refractive index, film thickness, waveguiding mode and loss of nanocomposite films not to mention the size, shape, and volume fraction of metal

nanoparticles. In this study, we report an analysis and a theoretical modeling on the optical waveguide mode properties and the switching properties of a cross-modulation of signal by a pump-probe technique of NC films fabricated by alternating deposition. We prepared slab waveguide composed of Au(1 vol.%)/SiO_2 NC films of about 3000 nm thickness by radio frequency (RF) magnetron sputtering directly onto SF10 prism basal plane with pre-coated MgF_2 layer and investigated their optical waveguiding and switching properties in near-IR (NIR) region using prism coupler method. The probe beam of NIR wavelength of 1550 nm and the cw pump beam of 532 nm close to the SPR wavelength were used. We observed the optical waveguide modes at the NIR probe beam and the theoretical analysis based on multi-layer thin film optics could reproduce the measured mode profiles successfully. Also, from the pump-probe switching experiments, we observed shifts of the mode. It was found that the index change induced by the pump beam irradiation was purely refractive in nature, and that the magnitude of index change was large enough to yield a full signal modulation of probe light. Our subsequent work now in progress with using the pulsed-laser pump beam and optimization by designing the material system and structure are under way.
(This research was supported by a grant (code #: 07K1501-02110) from 'Center for Nanostructured Materials Technology' under '21st Century Frontier R&D Program' of the Ministry of Science and Technology, Korea and this work has been supported by the ABRL Program of KOSEF through Grant No. R14-2002-062-01000-0.)

E-07 **Coherent X-ray Diffraction Studies of Quantum Dots in Zeolite Microcrystals.** 변 영석, 정 낙천[1], 윤 경병[1], HARDER Ross[2], ROBINSON I.K.[2], 김 현정(*서강대학교, 물리학과. [1]서강대학교, 화학과. [2]Department of Physics &Astronomy, University College London, UK.*) Coherent x-ray diffraction imaging(CXDI)은 coherent한 x-ray의 회절된 패턴을 phase reconstruction algorithm을 이용하여 결정 내부의 전자 밀도를 포함한 3D image를 얻는 측정기술이다. 본 연구에서는 zeolite microcrystal의 나노세공에 quantum dot을 형성시키고, 화학적 자기조립법을 이용하여 zeolite microcrystal을 기판에 부착하였다. Zeolite microcrystal에 CXDI를 적용하여 내부 구조를 측정했으며, 결정 내부의 복원된 위상 정보를 바탕으로 분석한 결과를 논의하고자 한다.
*This research was supported by the Korea Science and Engineering Foundation, Seoul Research and Business Develpoement Program (10816), Sogang University Grant (2007).

■ SESSION: E [E2]
10월 18일(목), 12:30 - 14:15
장 소: 303호

E-08 **Structure of Lipid Membranes on Solid Support** 엄 대용, 변 영석, 김 현정(*서강대학교, 물리학과 &바이오 융합.*) We study the structure of lipid membranes deposited on silicon at the solid-liquid interface by x-ray reflectivity. X-ray reflectivity measurements were done with the energy of 20 KeV at the Pohang Light Source. The samples investigated are composed of the bilayers of single phospholipids on the substrate with various surface conditions. We confirmed the bilayer formulation and found a water layer between the lipids and the substrate by the analysis of X-ray reflectivity. The results will be discussed with the effect of different surface conditions to the water layer and the lipid bilayer system with electron density, thickness, and roughness.
*This research was supported by the Korea Science and Engineering Foundation, Seoul Research and Business Development Program (10816), Sogang University Grant (2007).

E-09 **Patterning on sputter-eroded surface by dual ion beams** 조 민웅, 최 철호, 강 병남, 김 재성[1](*서울대, 물리천문학부. [1]숙명여대, 물리학과.*) The pattern formation on Au(001) by dual-ion-beam sputtering (DIBS) is studied. During DIBS, two ion beams simultaneously project onto the sample surface at a grazing incidence, and cross perpendicular in azimuth. In contrast with a ripple structure induced by single-ion-beam sputtering (SIBS), two-dimensional (2-D) pattern of nanodots or nanoholes is formed by the DIBS according to the beam flux and the ion energy conditions. The spatial order of the nanopatterns has long-range and square symmetric correlation. Slope asymmetry in the nanohole formation and modulated ripple patterns in the nanodot formation clearly show how two crossing ion beams in the DIBS influence the surface morphology. We provide a superposed Kuramoto-Sivashinsky (KS) equation to describe the patter formation by the DIBS. It, however, lacks linear instability to explain the experimental results. The DIBS process is beyond the scope of the kinetics under the existing KS equation.

E-10 **Photoluminescence and Raman Spectroscopic Study of Single-Walled Carbon Nanotubes Dispersed and Sonicated in Aqueous Sodium Dodecyl Sulfate (SDS) Solutions** PARK June, SEONG Maeng-Je(*Chung-Ang University.*) The dispersion of single-walled carbon nanotubes (SWCNTs) in aqueous surfactant solution has recently become an important method of getting isolate SWCNTs. In this work we studied, using photoluminescence and Raman spectroscopy, material property change of SWCNTs in 1wt% sodium dodecyl sulfate(SDS) solution as a function of sonication time and power. We have observed an increase of CNT photoluminescence intensity and a relative enhancement of the radial breathing mode (RBM) Raman signals of metallic CNTs with respect to those of semiconducting CNTs under 514.5nm laser excitations, with increasing sonication time to some extent.

E-11 **근접장 분광학을 이용한 InAs/GaAs 양자점의 광학 특성 연구** 노 한얼, 유 영준, 제 원호(*서울대학교, 물리천문학부.*) 반도체 양자점은 0차원 나노구조로서 델타함수 모양의 에너지 상태밀도를 가진다. 이로 말미암아 인공적인 원자(artifical atom)로 불리우고 있으며, 작은 선폭과 높은 효율을 이용하여 양자점 레이저, 단일 광자 광원, 양자정보처리와 같은 분야에 응용하기 위한 노력들이 진행되고 있다. 본 연구에서는 반도체 양자점의 이러한 광학적 응용을 위한 기초연구로써, 근접장 현미경을 이용

한 단일 양자점 분광학에 대한 발표를 하고자 한다. 근접장 현미경을 이용하여 InAs/GaAs 양자점을 각각 구분해서 관찰하였으며 가까운 두양자점간의 결합상태와 상호작용 가능성에 대해 언급할 것이다.

E-12 **Electrical Resistance Switching Behavior in Magnetite Nanoparticles** KIM Tae Hee, JANG Eun Young, JANG Jungtak[1], CHOI Deung Jang, CHOI Jinsil[1], CHEON Jinwoo[1](*Department of Physics, Ewha Womans University. [1]Department of Chemistry, Yonsei University.*) Understanding size effect in ferromagnetism and ferroelectricity, combined with the size reduction constraints imposed by the semiconductor industry, raises a lot of interests to researchers. For the last decade, many studies of magnetic and electric properties have been carried out on small magnetic particles in order to study an intrinsic magnetic and electric dependence on sample size because a different degree of ordering is expected to our near surface or interfaces. However, the understanding of the correlation between magnetic properties and particle size is incomplete. Magnetite (Fe_3O_4) is currently one of key materials for applications in magnetic storage devices due to its nearly full spin polarization at room temperature (RT)[1]. In this work, Fe_3O_4 nanoparticles with different sizes ranging from 7 to 17 nm were prepared in a well-controlled manner by a nonhydrolytic synthetic method. The size dependence in magnetoelectric effect has been investigated in Fe_3O_4 nanoparticle pellets. Superparamagnetic (SPM) behavior was clearly shown for the magnetites of size smaller than 10 nm. As the particle size decreases, the variability in the electrical properties of the nanoparticles, ranging from semiconducting to insulating behavior was observed. We observed also the resistive switching behavior by the application of an appropriate electric field. From our results, we will discuss the size dependence of magnetoelectric effect linking the magnetic and electric effect for composite oxide materials, such as Fe_3O_4 nanoparticles.
*This work is supported by the Basic Research Program of the Korea Science &Engineering Foundation (No.R01-2006-000-11227-0) and a Korea Research Foundation (KRF-2006-531-C00026).
*Corresponding author : taehee@ewha.ac.kr [1] J. M. D. Coey et al., (1998) Appl. Phys. Lett. 72, 734.

E-13 **카본 나노튜브를 이용한 고성능 flexible 전자소자 및 카본 나노튜브 super structure** 강 성준, ROGERS John A.[1], KOCABAS Coskun[1](*한국표준과학연구원. [1]UIUC.*) Carbon Nanotube (CNT)는 현존하는 반도체 물질 중 최고의 성능을 갖고 있는 반도체 물질중의 하나이며, 경제성에서는 GaAs보다 뛰어난 이점이 있는 반도체 물질이다. 이와 같은 CNT의 특성은 single CNT를 사용하였을 때의 (즉, 분자수준의) 디바이스 특성이며, 이와 같은 뛰어난 CNT의 특성을 디바이스 scale에서도 실현 할 수 있는 기술은 현재 매우 중요한 연구 분야이다. 이를 위해서 CNT를 Chemical Vapor Deposition 기술을 이용하여 기판과 평행한 방향으로 배열시키는 기술을 개발하였으며, 이를 이용하여 device scale 에서 고성능의 CNT 트랜지스터 제작에 성공하였다. 또한, flexible 소자를 제작하기 위해 카본나노튜브를 플라스틱 기판에 옮기는 기술을 개발하여 CNT를 이용한 다양한 소자를 개발하였다. 본 발표에서는 CNT를 이용한 고성능 소자를 제작하는 과정과 CNT transfer기술을 이용한 카본 나노튜브 super structure제작에 관해 발표할 예정이다.

E-14 **Field emission properties of CNTs-emitters on conducting films/Si with thermal treatment** RYU Dong Heon, LEE Seung Youb, SONG Woo Seok, HONG Jun Yong, PARK Chong-Yun(*성균관대학교 물리학과.*) Since carbon nanotubes (CNTs) have been discovered, they showed unique electrical, mechanical, and geometric properties for nanoelectronic devices such as field emitters, interconnects, and field effect transistors. We have investigated field emission properties of the sprayed CNTs on the conducting films/Nb/Si substrate. To improve the adhesion between the conducting films and Si wafer, the Nb(thickness : ~30㎚) has been deposited on Si wafer by using magnetron sputtering system. Then, the conducting films(thickness : ~500㎚) have been deposited on the substrate by using magnetron sputtering system. The solutions with thin-CNTs(ILJIN : CMP-310F) have mixed 1,2-dichloroethane (DCE). The dispersion process consists of the sonication and centrifugation to remove the undissloved CNTs and some amorphous carbon. After this solutions were blown into the substrate by the spray method, the sample was annealed with ambient Ar at ~700℃. As the CNTs on the conducting films were heated, they have been penetrated into the molten conducting films. As a result of the heating process, the CNTs were tightly combined with the conducting films. Moreover, the conducting films are provided with characteristics as a electrode, high electrical conductivity, low contact resistance. Then, we measured the field emission current, turn-on voltage, I-V curve and field emission stability. Furthermore, we observed the morphology of the embedded CNTs by scanning electron microscopy (SEM).

E-15 **Selective band gap engineering of singlewalled carbon nanotubes by nitronium hexafluoroantimonate** KIM Ki Kang, BAE Jung Jun, PARK Hyun Gi, KIM Su Min, BAE Dong Jae, AN Kay Hyeok[1], LEE Young Hee(*Department of Physics, Center for Nanotubes and Nanostructured Composites, Institute of Basic Sciences, Sungkyunkwan University, Suwon 440-746, Republic of Korea. [1]Material &Development Department, Jeonju Machinery Research Center, Jeonju, 561-844, Republic of Korea.*) Band gap engineering of singlewalled carbon nanotubes (SWCNTs) is an important issue for the application of nanoelectronic devices. We have introduced the selective band gap engineering of SWCNTs by nitronium hexafluoroantimonate (NHFA) treatment. We found that a selective band gap engineering of both metallic and semiconducting nanotubes depends strongly on the concentration of NHFA. The pi electrons of metallic nanotubes near the Fermi level were selectively suppressed initially at low concentration, followed by the subsequent removal of semiconducting subband E11 and E22 level. With increasing the concentration further, E11 of metallic nanotubes was suppressed and with longer treatment time, the metallic nanotubes were disintegrated, similar to previous report by An et al., JACS, 127 (2005) 5196. These were characterized by

UV-Vis-NIR and Raman spectra.

■ SESSION: E [E3]
10월 18일(목), 14:30 - 16:15
장 소: 한라홀B

E

E-16 **Galvanizing Behavior and Selective Oxidation of B-bearing Interstitial Free (IF) Steel** 김 태철(*POSCO Technical Research Laboratories, Automotive Steel Products Research Group.*) In order to improve mechanical properties and cold work embrittlement of interstitial free (IF) steels, B is added to steels, by replacing P at the grain boundaries. However, surface segregation of B can deteriorate in galvanizing reaction between liquid Zn and solid IF steel due to selective oxidation on steel surface. To examine the effect of B in galvanizabilty and surface morphology, we investigate the influence of the dew point and soaking temperature in reducing atmosphere. At high dew point (-40 °C) and high soaking temperature (835 °C), the steel surface is covered with B oxide and appears poor wettability with Zn. In contrast, at low dew point (0 °C) and low soaking temperature (775 °C), the steel surface is dramatically changed with faceting and the amount of boron oxide is considerably reduced on steel surface. Therefore, the galvanizability is appropriately improved with internal oxidation of B.

E-17 **Interfacial morphology and interdiffusion of LiF between aluminium cathode and Alq_3 in organic light emitting devices** LEE Young Joo, LI Xiaolong, KANG Da-Yeon, PARK Seong-Sik[1], KIM Jinwoo[2], CHOI Jeong-Woo, KIM Hyunjung (*Sogang University. [1]Samsung Corning Co., Ltd. [2]Gwangju Institute Science and Technology.*) We studied morphology of LiF interface between aluminum (Al) cathode and tris-(8-hydroxyquinoline) aluminum (Alq_3) by synchrotron X-ray scattering, atomic force microscope (AFM), and scanning electron microscope (SEM) as a function of thickness of LiF and the order of deposition of the layers [i.e., Al/LiF/Alq_3 and Alq_3/LiF/Al]. Interdiffusion of LiF into aluminum and Alq_3 was observed as a function of annealing temperature and thickness of LiF. We found that LiF diffuses into Al more actively than into Alq_3 by thermal agitation. LiF on Alq_3 induces the ordering of Al to (111) direction strongly with increasing thickness of LiF.
*This research was supported by the Korea Science and Engineering Foundation, Seoul Research and Business Development Program (10816), Sogang University Grant (2007).

E-18 **Atomic model for interface defects in Si oxynitride** LEE Eun-Cheol(*경원대학교, 바이오나노학과.*) Based on first-principles density-functional calculations, we propose an atomic model for interface defects at Si/SiON interface. We find that the defects involving a N interstitial have defect levels lying in the broad range, from the mid-gap to the conduction band edge of Si, depending on local oxidation status near the N. Our results provide a mechanism for the enhancement of degradations related to interface defects, such as negative-bias temperature instability (NBTI) and low-voltage stress-induced leakage current (LV-SILC).

E-19 **Dynamics and Structure of Block Copolymer Films** LEE Heeju, LEE Young Joo, SONG Sanghoon[1], KIM Hyunjung[1], JIANG Zhang[2], SINHA S. K.[2], RUEHM A.[3](*Sogang University, Dept. of Physics. [1]Sogang University, Dept. of Physics and Interdisciplinary Program of Integrated Biotechnology. [2]UC San Diego and LANSCE, Dept. of Physics. [3]MPI, Metallforschung.*) The surface and bulk dynamics of the block copolymer films of poly(styrene)-b-poly(dimethylsiloxane) with various thickness were investigated by surface sensitive x-ray photon correlation spectroscopy (XPCS) in grazing angle geometry. The incident angles were chosen at 0.14° and 0.2° for studying selectively dynamics from surface and micelles in films, respectively. The thickness of the film were from 400 Å to 5900 Å. We obtained the surface tension and the viscosity of block copolymer films as a function of temperature. We found that the surface tension of film is close to that of PDMS. We verified that the PDMS preferentially located on the surface by x-ray photoelectron spectroscopy.
*This research was supported by the Korea Science and Engineering Foundation, Seoul Research and Business Development Program (10816), Sogang University Grant (2007).

E-20 **Atomic Layer Deposition of ZrO_2 Using Tetrakis (ethylmethylamino)zirconium and H_2O** 신 웅철, 류 상욱[1](*NCD technology. [1]단국대학교, 전자공학과.*) In the last few years, zirconium dioxide (ZrO_2), one of promising high-k materials is attracting for use as a SiO_2 replacement in microelectronic devices due to its excellent properties, such as a relatively wide band gap, a high refractive index and a high dielectric constant. ALD (Atomic Layer Deposition) as an ideal method can be recommended for the complementary metal oxide semiconductor (CMOS) application. To date the study of ZrO_2 thin films in ALD process that uses $ZrCl_4$or $Zr[OC(CH_3)_3]_4$ has been reported. However, the investigation of ZrO_2 film with TEMA-Zr (Tetrakis(ethylmethylamino) zirconium)-based ALD process has been rarely published. In this work, the deposition and characteristics of ZrO_2 thin film with TEMA-Zr –based ALD process are addressed. The ZrO_2 films were deposited onto p-type Si (100) substrates with/without SiO_2 surface grown by UV/ozone for 3min with 1.5nm thick by ALD (Lucida-D200, NCD Technology). The reactants used are TEMA-Zr, Tetrakis(ethylmethylamino)zirconium [$Zr(NMeEt)_4$], which is prepared by DNF solution, and de-ionized water, respectively. Each cycle consisted of 0.1~1 sec for precursor pulse, 5~10 sec purging time with N_2. The temperature of the substrate and the precursor were chosen at 150~350°C and 70~120°C, respectively. As-deposited samples were annealed at various temperature in a RTP (rapid thermal process) chamber. The deposited ZrO_2 films were characterized by GIXRD, XPS, HRTEM, C-V, I-V, and Dit.

E-21 **Enhanced photoluminescent properties of laser-ablated $Y_{1-x}Gd_xVO_4:Eu^{3+}$ thin films by Li-doping** SHIM Kyoo Sung, JUNG Ye Ran, FU Zuo Ling, MOON Byung Kee, CHOI Byung

Chun, JEONG Jung Hyun, YI Soung Soo[1], KIM Jung Hwan[2](*부경대학교 물리학과. [1]신라대학교 전자재료공학과. [2]동의대학교 물리학과.*) $Y_{1-x}Gd_xVO_4:Eu^{3+}$ and Li-doped $Y_{1-x}Gd_xVO_4:Eu^{3+}$ phosphor films have been grown on Al_2O_3(0001) substrate using a pulsed laser(PLD) technique. The films grown under different deposition conditions have been characterized using microstructural and luminescent measurements. The crystallinity, surface morphology, and photoluminescence (PL) of the films are highly dependent on the amount of Gd and Li. As the substrate temperature was increased, the $YVO_4:Eu^{3+}$ and $GdVO_4:Eu^{3+}$ thin films deposited on Al_2O_3 (0001) substrates at the oxygen pressure of 350 mTorr have shown the improved crystallinity and the increased grain size. The PL intensity increases linearly with substrate temperature and a surface roughness for the both $YVO_4:Eu^{3+}$ and $GdVO_4:Eu^{3+}$ thin films have a strong effect on the PL response of the films. For the $Y_{1-x}Gd_xVO_4:Eu^{3+}$ luminescent films, the PL brightness is more dependent on the surface roughness than the crystallinity of the films. The PL intensity and surface roughness have similar behavior as a function of Gd concentration. In particular, the incorporation of Gd into YVO_4 lattice could induce a remarkable increase of PL. The highest emission intensity was observed with $Y_{0.57}Gd_{0.40}Eu_{0.03}VO_4$ thin film whose brightness was increased by a factor of 2.5 and 1.9 in comparison with that of $YVO_4:Eu^{3+}$ and $GdVO_4:Eu^{3+}$ films, respectively. The effect of Li^+ ion on the crystallization behavior, morphology, and luminescence property of $Y_{1-x}Gd_xVO_4:Eu^{3+}$ films were also investigated. The incorporation of Li^+ ion into $YVO_4:Eu^{3+}$ and $GdVO_4:Eu^{3+}$ films could lead to a remarkable increase of photoluminescence and the intensity at 619 ㎚ was increased by a factor of 1.5 and 1.7 in comparison with that of $YVO_4:Eu^{3+}$ and $GdVO_4:Eu^{3+}$ films, respectively. The enhanced luminescence was regarded as the results in the change of crystal field surrounding the activator Eu^{3+} ions owing to the incorporation Li^+ ions into interstitial sites and the flux effect of Li^+ ions.

E-22 **Characterization of titanium films deposited by dc magnetron sputtering** BOJAN Karunagaran, SUH E.-K (*Semiconductor Physics Research Center and School of Semiconductor and Chemical Engineering, Chonbuk National University.*) The structural and microstructural characteristics of titanium (Ti) films have been studied as the function of deposition condition and/or chemical composition. Ti films of thickness in the range of 35 – 138 nm were deposited by direct current magnetron sputtering at conventional conditions of cathode power, sputtering pressure and base pressure. The sputter discharge characteristics were studied using optical emission spectroscopy technique. X-ray diffraction, scanning electron microscopy and atomic force microscopy techniques were used to investigate the structural and microstructural properties. Independent of the deposition conditions the Ti films exhibited void free, uniform and smooth surface morphology. The rms surface roughness of the films was around 2.6 nm with a variation of ± 0.3 nm between different Ti films. Amorphous nature and crystallinity are observed in the Ti films with respect to the deposition condition/composition. X-ray photoelectron spectroscopy, spectroscopic ellipsometry and optical transmission measurements were used to identify the composition of the Ti films. In the crystalline Ti films the crystallites were found to be densely packed and oriented along the c-axis of the hcp structure. The structural parameters such as crystallite size, micro strain and stress were evaluated for the crystalline films. The crystallite size was found to be in the range of 7 to 16 nm as evaluated from XRD using Voight fuction and Scherrer relation. The structure - deposition condition - composition relation for the Ti films has been derived.

*This work was supported by the Korea Research Foundation Grant funded by the Korean Government (MOEHRD) (KRF-2005-005-J07501).

E-23 **Luminescent characteristics of $YVO_4:Eu^{3+}$ thin film phosphors by Li^+ ion concentration** YANG Hyun Kyoung, FU Zuoling, MOON Byung Kee, JEONG Jung Hyun, YI Soung Soo[1], KIM Jung Hwan[2](*부경대학교, 물리학과. [1]신라대학교, 전자재료공학과. [2]동의대학교, 물리학과.*) Li-doped $YVO_4:Eu^{3+}$ luminescent thin films have been grown on Al_2O_3 (0001) substrate using a pulsed laser deposition technique at oxygen pressure of 300 mTorr substrate temperature of 700 °C. The Li^+ ion concentration was varied from 1 to 4 wt.%. The crystallinity and surface morphology of the films were investigated using X-ray diffraction (XRD) and atomic force microscope (AFM), respectively. Crystalline phase and surface morphology of thin films have been very important factors to determine luminescent characteristics of thin films. The crystallinity of $YVO_4:Eu^{3+}$ films was improved by Li-doping as shown the relatively intense and sharp peaks in the X-ray diffraction pattern. As Li^+ content increases from 1 wt.% to 2 wt.%, the crystallinity improved, but as Li^+ content increases to 3 wt.%, the crystallinity of films was decreased. Photoluminescence (PL) spectra have been measured at room temperature using a luminescence spectrometer and excitation by a broadband incoherent ultraviolet light source with a dominant excitation wavelength of 312 nm. The emitted radiation was dominated by the red emission peak at 620 nm radiated from the transition of $^5D_0$-$^7F_2$ of Eu^{3+} ions. The PL brightness of Li (2 wt.%)-doped $YVO_4:Eu^{3+}$ thin film was increased by a factor of 1.43 in comparison with that of $YVO_4:Eu^{3+}$ thin film. In particular, the incorporation of Li^+ ions into YVO_4 lattice could induce an increase of photoluminescence. The enhanced luminescence results not only from the improved crystallinity but also from the reduced internal reflections caused by rougher surfaces. The luminescent intensity and surface roughness exhibited similar behavior as a function of Li^+ ion concentration.

■ SESSION: E [E4]
10월 19일(금), 09:00 - 10:45
장 소: 한라홀B

E-24 **GaN-based Light-emitting Diode Integrated With Photonic Crystal Patterns And Sidewall Deflectors For Improved Light Extraction** 이 준희, 김 동욱[1], 김 시한, 안 성모(*서울대학교 물리천문학부. [1]서울대학교 나노협동과정.*) GaN를 기반으로 하

는 발광소자는 미래의 조명을 대체 할 수 있는 등 많은 응용 가능성이 있는 물질로 많은 관심을 받고 여러 연구진들이 연구를 하여왔다. 그러나 이러한 장점을 가진 GaN는 공기와의 큰 굴절률 차이에 의해 대부분의 빛들이 전반사에 의해 나오지 못하고 갇혀있게 된다. 이러한 문제를 해결하기 위해 지금까지 많은 연구들이 진행되어 왔고 본 연구진은 두가지 다른 형태의 LED구조를 개발하여 광자추출의 효율을 증가시킨 바 있다. 첫째로 홀로그래피 방법을 통해 만든 2차원 광자결정으로 만든 구조이고 두번째는 LED의 옆면을 각지게 만들어서 옆방향으로 흐르는 광자를 수직방향으로 편향시키는 구조이다. 이 구조를 이용해 LED의 수직방향으로의 광자추출 효율을 2배 이상으로 향상시킬 수 있었다. 본 연구에서는 이 두 가지 구조를 하나의 LED 칩 위에 함께 만들어서 그 결과를 알아보았다. 홀로그래피를 이용하여 2차원 광자결정을 사파이어 기판위에 만들고 그 위에다 MOCVD를 이용하여 일반적인 LED 구조를 기른 다음 옆면을 각지게 식각을 하였다. 이렇게 만들어진 LED구조는 평평한 기판위에 만들어진 레퍼런스 LED에 비해 내부 양자 효율이 떨어짐에도 불구하고 수직방향으로의 광자추출 효율이 약 3배정도가 향상되었음을 확인하였다. 이는 기존에 연구된 두가지 구조가 합쳐져서 추가적인 광자 효율 향상에 도움이 될 수 있음을 보인 것이다.

E-25 **Dynamic of Magnetic Vortex Core Switching in NiFe Nanodisks by Applying In-plane Magnetic Field Pulse**
CHOI B. C., HONG Yang-Ki[1], DONOHOE G. W.[2], NAM I. T.[3](*Department of Physics and Astronomy, University of Victoria, Canada.* [1]*Department of Electrical and Computer Engineering, University of Alabama, Tuscaloosa, AL 35847, U.S.A.* [2]*Department of Electrical and Computer Engineering, University of Idaho, Moscow, ID 83844, U.S.A..* [3]*Department of Advanced Materials Engineering, Kangwon National University, Chunchon, Korea.*) We investigated the influence of the magnetic field pulse parameters and the size of NiFe element to the vortex core switching by micromagnetic modeling. When the magnetic field pulse with an appropriate strength and duration is applied to circular disks with diameters between 100 nm and 1 mm, the vortex configuration is perturbed away from the equilibrium state, and the circular symmetric distribution of the in-plane magnetization around the vortex core deforms. This leads to the creation of a new vortex core with the opposite polarity and an antivortex. With increasing time, the vortex-antivortex pair annihilates. As a result of the annihilation, a single vortex core with opposite polarity remains and a vortex core switch is realized. The process of core switching, however, strongly depends on the amplitude and duration of the magnetic pulse.

E-26 **T-DMB Internal Antenna with Ferrite Substrate**
BAE Seok, HONG Yang-Ki, GEE Sung-Hoon, NAM In-Tak[1], SUNG Won-Mo[2], PARK Sang-Hoon[2](*Department of Electrical and Computer Engineering, University of Alabama, Tuscaloosa, AL 35847, U.S.A..* [1]*Department of Advanced Materials Engineering, Kangwon National University, Chunchon, Korea.* [2]*E.M.W. Antenna Co., Limited.*) Miniaturization of T-DMB antenna is an emerging issue due to demand of multi-functions of mobile phone. Ferrite is a promising material as an antenna substrate to miniaturize the antenna size because of its permeability and permittivity characteristics. Lossy ferrite materials have been known as electromagnetic wave absorbers. However, by making the permeability of ferrite equal to its permittivity, then input impedance is matched to that of the surrounding free space or air. Therefore, electromagnetic wave is transmitted into the ferrite without insertion loss. By embedding a radiating element in such a ferrite, the physical size of the elements may be substantially reduced without appreciable performance loss.In this paper, the effects of ferrite substrate on central frequency and azimuth gain of an inverted F type double helical antenna (IFDHA) was investigated by 3D FEM simulation. 32 turn-helix antenna with the size of 6 mm x 35 mm x 0.6 mm and volume of 0.108 cm^3 was used for our simulation. We successfully achieved the central frequency of 193 MHz and the azimuth gain of about -26.52 dBi that are suitable properties for T-DMB internal antenna applications.

E-27 **An Investigation of Geiger-mode Solid-state Photomultipliers for Simultaneous PET and MRI Acquisition**
HONG Seong Jong, SONG In Chan[1], ITO Mikiko[2], KWON Sun Il[3], LEE Geon Song[4], SIM Kwang-Souk[2], PARK Kwang Suk[4], RHEE June Tak[5], LEE Jae Sung[3](*서울대학교 의학연구원 방사선의학연구소.* [1]*서울대학교 진단방사선과.* [2]*고려대학교 물리학과.* [3]*서울대학교 핵의학과.* [4]*서울대학교 의공학과.* [5]*건국대학교 물리학과.*) Photon detecting Geiger-mode solid-state devices are being actively researched and developed because, unlike photomultiplier tubes (PMT), they can be used in high-magnetic-field and radio-frequency environments, such as, in magnetic resonance imaging (MRI) scanners. In addition, some Geiger-mode solid-state devices have higher particle detection efficiencies than PMTs and higher gains than avalanche photo-diodes (APD). We tested Geiger-mode solid-state photomultipliers (SSPM) inside aunder a 3-T MRI to study the possibility of using them in combined PET/MRI scanners. Approximately 16% energy resolutions and ~1.3-ns coincidence time resolutions with ^{22}Na and lutetium yttrium oxyorthosilicate (LYSO) were obtained for full-width at half maximum (FWHM) for T1, T2, and gradient echo $T2^*$ MRI pulse sequences with little MR image degradation. The study shows that SSPMs have excellent potential for use in combined PET/MRI scanners.

E-28 **Mechanism of the Droplet Motions Induced by Laser Heating**
SONG Chaeyeon, MOON Jong Kyun, LEE Kyuyong(*연체물리연구실, 물리학과.*) We experimentally investigated the motion of micro-liter oil droplets on the surface of an aqueous solution induced by laser heating. The droplets exhibit two types of motion, directed movement parallel to the laser beam and periodic pumping – oscillation of the contact line. The directed movement of the droplet can be switched between forward and backward by changing the optical path of the laser through the droplet. We can also control the onset of the pumping and its frequency by changing the laser intensity and the heating point on the droplet. We show that the mechanism of both types of motion can be explained in terms of the contact angle adjustment, the resulting force imbalance at the contact line of the droplet, and the con-

vective flow in the droplet.

E-29 **Resistive Memory Switching in Epitaxially Grown NiO** LEE Seung Ran, CHAR Kookrin, KIM D. C.[1], JUNG R. J.[1], SEO S[1], LI X. S.[1], PARK G. -S.[1], YOO I. K.[1](*Seoul N. Univ., Department of Physics &Astronomy. [1]Samsung Advanced Institute of Technology.*) Recently NiO has attracted great attention due to its potential applications for nonvolatile resistive random-access memory (ReRAM) devices. However, the mechanism of resistance switching has not been clearly elucidated and it still remains controversial. To understand the phenomena in resistance switching, epitaxial thin films can serve as a good model system. We have fabricated successfully epitaxial NiO films on $SrRuO_3$ films on $SrTiO_3$ single-crystal substrates by the pulsed laser deposition system. The I-V measurements of epitaxial NiO show the resistive memory switching behavior with a change in the polarity of the bias voltage, in contrast with the switching behavior of polycrystalline NiO due to a single polarity. The I-V characteristics and memory switching property of epitaxial NiO prepared under various synthesis conditions and electrodes are presented. The interface between epitaxial NiO and the electrode appears to play an important role in the resistive switching behavior with a change in the bias voltage polarity.

E-30 **Applications of DROS to Biomagnetic Measurement** KANG Chan Seok, LEE Yong-Ho[1], KWON Hyukchan[1], KIM Jin-Mok[1], YU Kown-Kyu[1], PARK Yong-Ki[1], LEE Soon-Gul[2] (*Korea university,Korea Research Institute of Standards and Science. [1]Korea Research Institute of Standards and Science. [2]Korea university.*) We developed SQUID magnetometer and gradiometer were based on double relaxation oscillation SQUIDs (DROS) for applying to the biomagnetic studies, such as magnetoencephalogram (MEG) and magnetocardiogram(MCG). The DROS consisted of a hysteretic dc SQUID and a reference junction, and shunted by a relaxation circuit of a resistor and an inductor. Since DROS has about 10 times lager flux-to-voltage transfer coefficient than dc SQUID, we can use simple flux-locked loop electronics for SQUID operation. The measured noise at 100 Hz was 3 $fT/Hz^{0.5}$ for the magnetometer and 4 $fT/Hz^{0.5}$ for the gradiometer, which are low enough for biomagnetic applications. We constructed multichannel systems by using the DROS magnetometer and gradiometer to cover whole signal area. Using these systems, we measured various signals were generated from the brain and the myocardium, analyzed the characteristics through the techniques of source localization and mapping.

E-31 **Spin Transport Studies through Spin Filter and Organic Semiconductor Hybrid Tunnel Barriers** KIM TaeHee, CHOI DeungJang, SANTOS Tiffany.S.[1], VENKATARAMAN Karthik[1], SHIM Jenny[1], MIAO Guo-xing[1], MOODERA Jagadeesh. S.[1](*Department of Physics, Ewha Womans University. [1]Francis Bitter Magnet Laboratory, MIT.*.) Organic spintronics is a new area that is rapidly growing in interest. Tunneling transport of spin polarized carriers through a hybrid tunnel barrier of spin filter EuO magnetic semiconductor and an organic semiconductor Rubrene was investigated. Quasi-magnetic tunnel junction structures such as Co/Rubrene/EuO/Al or Cu were utilized for this and successful spin tunneling was observed. Various thicknesses of Rubrene and EuO were investigated. We observed a magnetoresistance (MR) of up to 8.5%, whereas from the junction resistance versus temperature data, we deduced a possible spin polarization (P) of up to 99%. The inconsistency of seeing a low MR and a high P has been attributed to spin scattering by defects at interfaces, EuO and Rubrene interfacial intermixing and nonstoichiometry. This needs further studies to optimize defects and hence raise MR to reflect the high P. This study demonstrates the possibility of combining organic and spin filter materials as tunnel barriers. In addition, Rubrene also serves to magnetically decouple the ferromagnetic electrode from EuO which is important to make large MR. Significant outcome of this study is showing the possibility to inject spins into organic materials via spin filter barriers. This work was performed at Francis Bitter Magnet Lab, MIT. The research at MIT is supported by NSF and ONR funds.

*The research at Ewha Womans University is supported by the Korea Research Foundation (KRF-2006-531-C00026). One of the authors, DJC thanks the Global Affairs Office of Ewha Womans University for the financial support Ewha-MIT Phoenix program 2007 to visit MIT and carry out this work.

■ SESSION: E [E5]
10월 19일(금), 09:00 - 10:45
장 소: 303호

E-32 **Effects of Surface Plasmon Resonances Induced by Various Metal Nanostrucutres in Organic Light Emitting Devices** 김 동유, 박 홍주, 김 석순, 변 지수[1](*광주과학기술원, 신소재공학과. [1]광주과학기술원, 고등광기술연구소.*) The collective response of electrons in surface of conductor to optical fields, so-called surface plasmon resonance (SPR), strongly affects the spectroscopy of nearby molecules. The frequency and intensity of the SP absorption bands are characteristic of the type of material, and are highly sensitive to the size, size distribution, and shape of the nanostructures, as well as to the environments which surround them. Of great significance is the opportunity of tuning the wavelength of SPs, which is highly desirable for various applications of metallic nanoparticles such as single molecule detection using surface-enhanced Raman scattering and near-field microscopy. However, due to the quenching of emission by SPs in the light emitting device, only few attempts have so far been made for SPs to be applied for organic light emitting devices. In our presentation, we demonstrate enhanced photoluminescence intensity of organic fluorophores, as well as, enhanced OLED performance by using the coupling of the SPs, induced by the silver and gold nanostructures, with organic fluorophores. Metal nanostructures fabricated by thermal evaporation method, co-sputtering method and pulse-current electrodeposition method were located between the indium tin ox-

ide substrate and hole tranport layer as a spacer, to prevent the quenching of emission. The thickness of this spacer layer affects the enhancement of emission ratios because SPs are evanescent waves that decay exponentially with distance from the metal surface. An OLEDs using various metal nanostructures fabricated by thermal deposition method and spin coating method. As a result, the maximum intensity of the electroluminescence of light emitting materials enhanced compared to the reference sample. To find out the mechanism for the enhancement, we measured emission lifetime by Time-correlated single photon counting method.

E-33 **Directed percolation approach to the resistance random access memory** LEE Sinbum, CHAE Seongcheol, CHANG seohyoung, KIM Dongwook[1], JUNG Changuk[2], PARK Seongyoung[3], JUNG Myounghwa[3], NOH Taewon(*ReCOE &FPRD, Department of Physics and Astronomy, Seoul National University, Seoul 151-747, Korea. [1]Department of Applied Physics, Hanyang University, Ansan, Gyeonggi-do 426-791, Korea. [2]Department of Physics, Hankuk University of Foreign Studies, Yongin, Gyeonggi-do 449-791, Korea. [3]Quantum material Research Team, Korea Basic Science Institute, Daejeon 305-333, Korea.*) The reversible resistance switching behavior has attracted considerable research attention due to its potential for application in nonvolatile resistance random access memory (RRAM). Even though the origin of switching behavior looks unclear, many researchers have reported the resistance switching behavior at various ternary and binary transition metal oxides. Especially for the unipolar resistance switching which shows the resistance switching along the single bias voltage, the filamentary model has been proposed. Some people think that abrupt resistance change from high resistance state (HRS) to low resistance state (LRS), vice versa, is attributed to forming or rupturing of filament as like as behavior near the percolation threshold. Empirical bias voltage independence and commonly observed voltage distribution for each resistance switching could also give a clue that the mechanism governing the unipolar resistance switching might be related to the percolation model. In this work, characteristic features of percolative system, using the high frequency impedance spectroscopy and 1/f noise analysis, were investigated. NiO thin films were made by ex-situ oxidation of Ni films, which were deposited using e-beam evaporation. The former experiment results showed that the percolation threshold existed during the resistance switching process. Near the percolation threshold, $G \sim f^m$, $C \sim f^n$, $0.9<m<1$, $0<n<0.1$ indicated that RRAM behavior could be explained by 3-D directed percolation. The latter reflected that conduction mechanism of each state was determined by competition between continuous metallic conduction and thermally assisted tunneling. In as-grown state and HRS, thermally assisted tunneling was more dominant but in LRS, metallic conduction was. Our results support that the dominant conduction and switching mechanism can be understood by the filamentary model which can be governed by the directed percolative nature.

E-35 **Random Circuit Breaker Network Model for Unipolar Resistance Switching** CHAE Seung Chul, LEE Jae Sung[1], KIM Se-jin[2], LEE Sinbum, CHANG Seo Hyoung, LIU Chunli, KAHNG Byoungnam[1], SHIN Hyunjung[2], KIM Dong-Wook[3], JUNG Chang Uk[4], NOH Tae Won(*ReCOE &FPRD, Department of Physics and Astronomy, Seoul National University, Seoul 151-747, Korea. [1]Department of Physics and Astronomy, Seoul National University, Seoul 151-747, Korea. [2]Center for Materials and Processes of Self-Assembly, School of Advanced Materials Engineering, Kookmin University, Seoul 146-702, Korea. [3]Department of Applied Physics, Hanyang University, Ansan, Gyeonggi-do 426-791, Korea. [4]Department of Physics, Hankuk University of Foreign Studies, Yongin, Gyeonggi-do 449-791, Korea.*) The unipolar resistance switching behaviors of binary oxide thin films have attracted attention due to the possibility for the memory device application. An issue of considerable attention, for both application and mechanism, is what parameters determine the resistance switching behavior and how it works. Their microscopic understand for resistance switching is still unveiled and debated enormously. Even though the understand of microscopic origin for switching mechanism is not clear, the characteristic feature of resistance switching behavior, i.e., voltage or current driven resistance switching and current compliance dependence, can be understood in the percolation point of view. We report on the comprehension of characteristic feature of unipolar resistance switching behavior in the percolation point of view. Experimentally, the unipolar resistance switching was observed in the TiO_2 thin film prepared by the thermal oxidation. Characteristic features of unipolar resistance switching were simulated in the random circuit breaker network. The circuit breaker network is composed with the element which can have two bistable resistance states according to the bias voltage value on both ends of unit in the random circuit-breaker network. The simulation of characteristic features in unipolar resistance switching behavior was achieved well. The current compliance dependence and deviation of switching voltages were simulated. The coincidence of experimental and simulation results suggest that the mechanism of unipolar resistance switching behavior can be the percolative system which has simultaneously two kinds of breakdown phenomena.

E-36 **비파괴 검사용 탄소나노튜브 기반의 신개념 엑스선 광원 개발** 최 해영, 김 종욱(*한국전기연구원.*) Carbon nanotube (i.e., CNT) has been extensively studied because of its physical, chemical, and mechanical merits and it has been applied instantly for many fields such as field emission display (FED), nano scale bio-sensor, vacuum electronic devices, and so on. Recently, CNT has been applied for x-ray source as a cold emitter. In this study, we report a new CNT based field emission x-ray source for non destructive inspection system in which CNT emitter can be applied as cold electrode in the x-ray tube. The main advantage of this is that the CNT electron emitter can be easily replaced with new one without any big efforts when CNTs are damaged in the x-ray tube. Detailed descriptions of it and some preliminary x-ray images obtained in this study are reported.

E-37 **Array of Smart Mirror for MEMS Space Telescope for Extreme Lightning (MTEL) using MEMS(Micro-Electro-Mechanical Systems) Technology** 전 진아, 박 일흥, 남 신우, 박 재형, 양 종만, 이 직, 나 고운, 김 지은, 문 경화, ARTICOVA S., 오 세지, GARIPOV G.[1], KHRENOV B.[1], KLIMOV P.[1], 박 용선[2], 유 형준[2], 김 용권[3], 유 병욱[3], 김 민수[3](*이화여자대학교,물리학과. [1]DV Skobeltsyn Institute of Nuclear Physics, Moscow State University. [2]서울대학교, 물리천문부. [3]서울대학교, 전기컴퓨터공학부.*) MEMS (Micro-Electro-Mechanical Systems) 기술을 응용한 마이크로미러 어레이는 극한 대기 현상을 관측하게 될 MTEL(MEMS Telescope for Extreme Lightning) 우주 망원경의 핵심 부품이다. 이 망원경은 광전증배관을 이용한 검출기와 작고 빠르게 움직이는 두 부분의 마이크로미러로 구성되어 있다. 광 시야각을 이용하여 지구상에 극한 대기현상이 발생하는 위치를 파악하기 위한 디지털 미러와, 위치의 파악 후 극한 대기 현상을 고해상도로 측정하기 위한 아날로그 미러가 사용된다. 마이크로미러는 넓은 영역을 고속으로 관측하기 위해 10 ㎑ 이상의 고유 진동수를 가지고 전압에 비례하여 6°까지 정전력 구동이 가능하게 하였다. MTEL을 위해 설계된 마이크로미러는 350 ㎛의 크기를 가지며 8×8 개의 미러 어레이로 배열되었다. 이번 한국 우주인 임무 중 하나인 KAMTEL(Korean Astronaut MEMS Telescope for Extreme Lightning)은 MEMS우주 망원경의 극소형 시작품이며, 특히 마이크로미러 기술의 첫 우주 응용사례가 될 것이다.

E-38 **Characteristics of the CNT based X-ray Source and its Applications** 김 종욱, 최 해영(*한국전기연구원.*) Recently, medical device studies become very popular. Specially, medical instruments using nano materials are being extensively developed. Studies on the electronic structure of carbon nanotube (CNT) are of much importance because of its efficient utilization in electronic vacuum devices and so on. For example, CNTs have many applications such as field emission display (FED), LCD back light units, microwave amplifiers, lighting lamps, and so on. One of potential applications is the electron emitter for x-ray source. In order to obtain x-ray images of relatively hard material or components, high quantity of x-ray current is generally required. In this study, we report that the current density of x-ray source can be greatly enhanced by using the CNT emitter as a cathode. In general, the emission current of CNT emitter is very sensitive to gap distance between CNT emitter and grid metal mesh, and so on. Detailed parameters and corresponding results were presented and some preliminary characteristics of the x-ray source were reported in this study.

■ SESSION: E [E6]
10월 19일(금), 11:00 - 12:45
장 소: 한라홀B

E-40 **Observation of the local pair correlation function at the free surface of a dielectric liquid** 유 청종, 이 동렬(*포항가속기연구소, 빔라인부.*) The local pair correlation function at the free surface of a Lennard-Jones liquid is thought to be hidden due to the broad surface width. Liquid metals, however, show the function because their free surfaces are atomically smooth resulting from high surface tensions. This smooth surface works as a well-defined liquid layer and reveals the function as the prominent surface layering. We used a dielectric liquid whose molecules are spherical, nonpolar, and nonentangling. We prepared nanoscopically thin films by the dipping method and measured the internal structure normal to the surface using synchrotron x-ray reflectivity at 5A HFXS of Pohang Light Source. We found that the electron density profiles show slowly decreasing molecular oscillations which is expected to be the hidden pair correlation function. The interfacial liquid layer worked as the well-defined layer and reveals the function.

E-41 **Study of the Silicon Photomultiplier in Geiger Photon Counter Mode** 이 혜영, 나 고운, 김 지은, 남 신우, 이 직, 박 일흥, 박 재형, 최 용[1], 홍 기조[1](*이화여자대학교. [1]성균관대.*) The Silicon Photomultiplier (SiPM) is a multipixel semiconductor photodiode. All multipixels of SiPM are joined on common substrate. The Gain is the same level as conventional photomultiplier tubes(PMT). The micropixels on the same substrate are electrically isolated from each other by poly silicon resistors and trench. Each micropixel is working in limited Geiger mode as "binary" devices. The pixel's signals are ganged together by aluminum strips. We will present the simulation, design and first fabrication of SiPM made in Korea.

E-42 **Design, Fabrication and Performance of Silicon Stripixel Sensors and Pad Sensors** 이 혜영, 이 직, 남 신우, 박 일흥, 박 재형(*이화여자대학교.*) Silicon stripixel sensors are capable of 2-dimensional position detection of charged particles utilizing a novel design of comb-type pixels intertwining with each other. We present the simulation, design and fabrication of stripixel sensors, and their performance obtained from a radiation source test. We also present the design, fabrication and performance of the silicon pad sensors. The prototype of silicon-tungsten sandwich calorimeter is built with silicon pad sensors. The calorimeter can include a layer of stripixel sensors located forefront as a presampler, and the other layer in the middle as a show maximum detector. The beam test of such configuration is carried out at CERN in September for 10 days, and the preliminary results are presented.

E-43 **Continuous Injection and Reporter-Quantifying Method for In Vivo Fluorescence Imaging** KIM Minsoo, SUNG Baeckkyoung, WON Nayoung[1], KIM Sungjee[1], SOH Kwang-Sup (*Biomedical Physics Laboratory, Department of Physics, Seoul National University, Seoul, Korea. [1]Department of Chemistry, Pohang University of Science and Technology, Gyungbuk, Korea.*) In vivo fluorescence imaging is broadening its applications from micro to macro and from plane to stereo with the development of the reporter technology. The imaging technique has mapped sentinel lymph nodes, detected cancers and tumors, and revealed biological mechanisms in small animals. In this study, we focused on developing tracing system for in vivo fluorescence imaging from skin to organs. To trace the flow of circulatory system, a continuous injection system of reporter was made of a syringe pump, a PTFE tubing and a

33-gauge removable needle. The injection rate was adjustable from 0.01 μL/min up to about 300 μL/min depending on the syringe type. The type-II CdTe/CdSe (core/shell) quantum dots (QDs) capped with dihydrolipoic acid for its water stability (or biocompatibility) were used as a tracer. We used the near-infrared emitting QDs (max. at 800 nm), because depth penetration of visible light is limited by absorption and autofluorescence of the tissue. And to quantify the concentration of the QDs that flowed or accumulated in tissues, the intensity of the QDs was referenced and examined by varying the concentration of QDs, thicknesses of the skin, and exposure time. Injecting the QDs into the abdominal skin of hairless mice, we could trace the QDs that flowed and measure the concentration of the QDs in the tissue. With further studies, this system is expected to take images of flows and concentration changes of the reporters in real time.

E-44 **Effect of Compton Scattering to the Performance of the Four-Layer Animal PET made of Small Crystals** ITO Mikiko, 권 순일[1], 심 광숙, 이 경세, 이 석재[2], 이 재성[1], 이 준택[3], 홍 병식, 홍 성종[4](*고려대학교 물리학과. [1]서울대학교 핵의학과. [2]서남대학교 의료공학과. [3]건국대학교 물리학과. [4]서울대학교 의학연구원 방사선의학연구소.*) For an animal PET system with high sensitivity and resolution, we have proposed the four-layer configuration, which is expected to provide a good DOI (depth of interaction) information. To achieve the best resolution in this configuration, it is desirable to use crystals with small size. However, the small size of the crystals makes the peak-to-valley ratio of the signals deteriorate due to Compton scattering. We have performed the detailed Monte-Carlo simulation of the Compton scattering to the performance of the four-layer PET system made of small-size crystals by using the GATE. The dimensions of crystals defined in the simulation were 1.5 * 1.5 * 7.0 mm^3 and 2.0 * 2.0 * 7.0 mm^3. In this presentation, we describe the results from the simulation in comparison with the experimental data.

■ SESSION: F [F1]
10월 18일(목), 12:30 - 14:00
장 소: 401호

F-01 **Emergence of collective group intelligence** 김 범준(*성균관대학교, 물리학과.*) We numerically investigate how collective group wisdom can emerge out of irrationality in individual levels by using the framework of the path findings in complex networks. Agents in our model randomly search the final target node without the knowledge of the network structure, leaving traces behind. In analogy to the formation of ant trails where pheromone left behind by preceding ants guides the following ants, the accumulated traces in our model are used to form collective group knowledge in path findings. The collectively found path is compared with the shortest path and the condition for the formation of successful group wisdom is discussed.

F-02 **Interior and Exterior of Modules in Scale-Free Networks** 김 진섭, 강 병남, 김 두철(*서울대학교 물리-천문학부.*) Many complex networks in real world consist of modules inside which the connection is compactly interwoven. While the existence and identification methodology of such module structure have been extensively studied, little attention has been paid on the internal structure of modules and connections between modules. Here we first investigate the distribution of module sizes using several module detection algorithms, finding that the module sizes are heterogeneous. Several physical quantities describing the internal structure of modules are investigated. To study the connections between modules, we investigate the coarse-grained network regarding the modules as supernodes. The renormalized degrees of the supernodes scale with their module sizes in a power law fashion. Such power-law scalings determine the scale invariance of the degree distribution under coarse graining. We also study the dependency of a transport dynamics on complex networks to the internal structure of modules.

F-03 **Module Identifcation of Complex Networks in the Frame of Synchronization** KAHNG Byungnam, OH Eulsik[1], CHOI Chulho, KIM Doochul(*Seoul National University, Department of Physics and Astronomy. [1]KIST.*) We introduce a modified Kuramoto model for synchronization and apply it to a modular complex network. The model contains a gauge term depending on the betweenness centrality(BC) of the link between two nodes, which drives the phase difference between the two nodes from 0 to as the BC increases from minimum to maximum. The system exhibits a phase synchronization within each module, however, the average velocities of each module are different. Because such a behavior is found in the steady state and maintained in large coupling constant limit, the overall system is not synchronized in spite of the phase synchronization within each module. This result enables us to use the modified Kuramoto model to identify modules in the system with the phase discordancy between modules due to the different group velocities.

F-04 **Dynamics of The Collaboration Networks** LEE Deokjae, GOH KWANG-IL[1], KAHNG Byungnam[2], KIM Doochul[2](*Dapartment of Physics And Astronomy, Seoul National University. [1]Department of Physics, Korea University. [2]Department of Physics And Astronomy, Seoul National University.*) Many complex networks contain modular structure within them. Understanding of the formation and evolution of such modular networks is a key issue in the current research. We study the evolution of the collaboration network working on complex network which contain modular structure. The data are downloaded from the web of science, which provide us the evolution information from the beginning. we also introduce a model associated with this network evolution. Implication of the evolution is discussed in the perspective of social sciences.

F-05 **Reaction-Diffusion Processes on Sparse Complex Networks** 윤 창근, 강 병남, 김 두철(*서울대, 물리천문학부.*) Reaction-diffusion models are important tools to understand various dynamic processes such as epidemic spreading, chemical reactions, etc. Here we study the reaction-diffusion processes of A + B -> 0 on scale-free networks, in particular, where scale-free networks are tree. In this case, owing to the simplicity of reaction pathways, survived particle density decays slowly than the mean-field result, while it decays faster than the mean-field result for scale-free networks with loops. Such slow decaying behavior can be observed in modular scale-free networks with loops as well. In early time regime, particle density decays in the mean-field fashion, but in the intermediate time regime, it shows the behaviors occurring on scale-free tree. In long time regime, it decays fast as observed in scale-free networks without modular structure.

F-06 **Transport in Jamming States with Priority-based Protocol** KIM Kanghun, KAHNG Byungnam, KIM Doochul (*Department of Physics and Astronomy, Seoul National University.*) We study the packet transport on a scale-free network using priority-based protocol. The priority is given to f fraction of all generated packets, not to others. A priority assigned packet is treated firstly in each queue. We find that when number of generated packet n is small, mean travel time between every pair of nodes is the same irrespective of whether priority is assigned or not. However, it is significantly different when n is large beyond the jamming transition point. The mean travel time is reduced drastically for priority-assigned packets for arrived packets, however, it is increased fast for those with non-priority. By controlling the fraction parameter f, we can broaden freely flow states in phase diagram, which is jamming states when priority-based protocol does not use. The new protocol based on the priority enhances capability of packet transport in the Internet and could be applied to commercial download services or paid mail delivery system and so on.

■ SESSION: F [F2]
10월 18일(목), 16:30 - 18:30
장 소: 401호

F

F-08(초) **From structure to dynamics of complex bio-networks** JEONG Hawoong(*Dept. of Physics, KAIST.*) It was found that many biological systems like cells, have common internal structure showing heterogeneous connectivity distribution. Like many other complex systems in nature, this inhomogeneous connectivity distribution has unique dynamical properties, such that it is very robust to internal and/or environmental changes on all levels of organization. In this lecture, we will review recent findings on the structure of biological systems and corresponding dynamical properties of the cellular systems, including protein interaction network of budding yeast and metabolic network of E. coli. [2007 Yong-Bong Prize Lecture]

F-09(초) **DNA-inspired physics: theory and biological relevance** HA BAE-YEUN(*Dept. of Physics and Astronomy, University of Waterloo.*) DNA is not only a passive storage of life's information but also a fascinating physical object, actively participating in many biological processes of vital importance (e.g., DNA replication/ organization). In aqueous solution, DNA is a highly-charged molecular spring. DNA strands resist bending, twisting, stretching, and confinement; by themselves, they would repel each other. In a living cell, however, DNA is packaged and organized into higher-order structures. In this talk, I will present a simple physical picture of how the charge and elastic properties of DNA influence DNA organization in a confined space.

F-10 **Metabolite essentiality elucidates robustness of Escherichia coli metabolism** 김 판준, 이 동엽[1], 김 태용[2], 이 광호[3], 정 하웅, 이 상엽[2], 박 선원[2](*한국과학기술원, 물리학과. [1]싱가포르 국립대학, 생명화학공학과. [2]한국과학기술원, 생명화학공학과. [3]CJ주식회사, BIO연구소.*) Complex biological systems are very robust to genetic and environmental changes at all levels of organization. Many biological functions of Escherichia coli metabolism can be sustained against single-gene or even multiple-gene mutations by using redundant or alternative pathways. Thus, only a limited number of genes have been identified to be lethal to the cell. In this regard, the reaction-centric gene deletion study has a limitation in understanding the metabolic robustness. Here, we report the use of flux-sum, which is the summation of all incoming or outgoing fluxes around a particular metabolite under pseudo-steady state conditions, as a good conserved property for elucidating such robustness of E. coli from the metabolite point of view. The functional behavior, as well as the structural and evolutionary properties of metabolites essential to the cell survival, was investigated by means of a constraints-based flux analysis under perturbed conditions. The essential metabolites are capable of maintaining a steady flux-sum even against severe perturbation by actively redistributing the relevant fluxes. Disrupting the flux-sum maintenance was found to suppress cell growth. This approach of analyzing metabolite essentiality provides insight into cellular robustness and concomitant fragility, which can be used for several applications, including the development of new drugs for treating pathogens.

F-11 **Selection of Checkpoints in The Cell-cycle Regulatory Network with Topological Properties** OH EULSIK, LEE JONG SANG[1], KAHNG BYUNGNAM[1](*Korea Institute of Science and Technology. [1]Department of Physics &Astronomy, Seoul National University.*) Recently, an increasing number of researches are performed on the interplay between the global structure of molecular cellular network and their functional roles. Cellular networks are robustly designed to perform their biological functions against changing environmental perturbations. The checkpoints in cell cycle play such a role of the robustness in the reproduction and growth of a cell. We construct a network composed of the Boolean states of 14 key proteins involving the cell cycle. In the network, directed links represent the temporal evolution of Boolean dynamics. We measure the basin size of an attractor in two ways, (i) the basin size with the on-state of a given protein and (ii) that with the off-state of the protein. The difference between the two basin sizes turns out to be meaningful. It becomes extreme when the given protein is associated with the checkpoints. Reversely, using this method, we can identify key elements playing a major role in regulating a network.

F-12 **Drugome: A Complex Network Approach to Drugs and Their Targets** 고 광일, YILDIRIM Muhammed[1], CUSICK Michael[2], BARABASI Laszlo[3], VIDAL Marc[2](*고려대학교. [1]Havard University and Dana-Farber Cancer Institute. [2]Dana-Farber Cancer Institute. [3]University of Notre Dame.*) Interrelationships between drugs, their molecular targets, disease gene products and phenotypes in the context of interactome network is important for better understanding of human physiology and pathology. Toward this goal, as a continuing effort to the recent curation and analyses of the human diseasome, here we introduce the concept of "drugome", a bipartite graph composed of FDA-approved drugs and proteins linked by drug-target binary associations. The resulting network connects most drugs into a highly interlinked giant component, with clustering of drugs of similar types. Analyses of the constructed network uncover a number of observations such as the over-abundance of “follow-on” drugs, a trend towards improving polypharmacology for experimental drugs, and differences in locations in the interactome for etiological and palliative drugs.

F-13 **The Roadmap For The Protein Folding Pathway; A Complex Network Analysis** JINHONG Kim, JIYONG Park, JONGSANG Lee, BYUNGNAM Kahng, DOOCHUL Kim(*서울대학교 자연과학대학 물리천문학부.*) Many classical approaches to understand the kinetics and thermodynamics of protein folding have been suggested, but they have their own limits because many degrees of freedom of proteins make it difficult to analyse folding mechanism. Here, we apply the complex network analysis to the protein of Trp-cage and Alanine dipeptide by constructing a protein

folding network. In the network, a node represents a conformation state of protein structure, and two states are linked with direction when the two states are consecutive from one to another in the dynamics. We introduce a new coarse-graining method for analysing the complex kinetic network by clustering nodes. After clustering, we find that the distribution of the connection numbers between states follows a power law. The network-based approach allows for determining free energy basins and barriers. We can also calculate the probability to reach the native structure, and identify the folding pathways in the conformation space.

■ SESSION: F [F3]
10월 19일(금), 09:00 - 10:45
장 소: 401호

F-14 **Ferromagnetic Transitions in Correlated Networks** 노 재동, 이 상훈[1], 정 하웅[1](*서울시립대학교, 물리학과. [1]KAIST, 물리학과.*) We investigate the universality class of ferromagnetic phase transitions in correlated complex networks. It is known that structural inhomogeneity encoded in the degree distribution is one of the essential ingredients determining the universality class. In this work, we present Monte Carlo simulation results for ferromagnetic phase transitions in the Ising model in complex networks with/without strucutral correlation. The results show that the universality class also depends on structural correlation of underlying networks as well as the degree distribution.

F-15 **Nonequilibrium phase transitions in the annealed version of scale-free networks** HA Meesoon(*KAIST 물리학과.*) The heterogeneous mean-field (MF) theory is discussed for two nonequilibrium models on the random-neighbor (annealed) version of scale-free networks, where all MF results work. To establish scaling properties, finite-size scaling (FSS), and the cutoff dependence on the FSS exponents, we perform both static and dynamic simulations. It is found that the proper MF conjecture for the annealed case is different from one for the quenched (conventional) case.

F-16 **Percolation transition on hyperbolic tessellations** 백 승기, 김 범준(*성균관대학교 물리학과.*) A surface with a constant negative curvature can be decomposed of regular polygons by the method of hyperbolic tessellation. We study percolation phenomena on various lattices generated by this method and find some universal features. The finite size scaling technique indicates the critical exponents far away from the mean-field ones. Moreover, the intrinsic length scale, the curvature of the lattice, makes the scale invariance property violated, and a percolating cluster may appear without occupying a finite fraction of the system due to the short average path length. The geometrical effects will be discussed in viewpoint of the thermodynamic limit and the critical phenomena.

F-17 **Kosterlitz-Thouless transition of the triangular Ising antiferromagnet in a magnetic field** 황 치옥, 김 승연[1], 강 대승[2], 김 진민[3](*국가수리과학연구소. [1]국립충주대학교, 교양학부. [2]숭실대학교, 전기공학과. [3]숭실대학교, 물리학과.*) The Kosterlitz-Thouless (KT) transition of the triangular Ising antiferromagnet in a magnetic field has not been directly shown for a long time due to the computational difficulty of Monte Carlo simulations. In this paper, the transition was confirmed by means of the density of states of the ground state of the antiferromagnet and a simple order parameter p. The density of the states was obtained via the exact enumeration method for a small system (9x9) and the two-dimensional random walk of the Wang-Landau method for a large system (30x30). The usual magnetic order parameter was multiplied by three to get the order parameter $0 \le p \le 1$ of the ground state.

F-18 **Kinetic Roughening and Multifractality in Vapor Deposition Polymerization Growth** SON Seung-Woo, HA Meesoon, JEONG Hawoong(*Korea Advanced Institute of Science and Technology, Dept. Physics.*) Recent experiments of vapor deposition polymerization (VDP) growth show quite different kinetic roughening with multifractality compared to molecular-beam epitaxial (MBE) growth cases. To understand what the key ingredients of multifractality in VDP growth are, we propose a polymer thin film growth model by VDP processes, which is based on monomer diffusion, shadowing effects, and limited active end bonding. Our simulation results are compared with earlier results in the ballistic deposition growth model with power-law decaying noise, where anomalous kinetic roughening with multifractality has also been observed. We argue the possible origin of multifractality in VDP growth, and check whether it is consistent with recent experimental observations.

F-19 **Increasing market efficiency in the stock markets** YANG Jae-Suk, KWAK Wooseop[1], KAIZOJI Taisei[2], KIM In-mook(*Korea University. [1]ChosunUniversity. [2]International Christian Univeristy.*) We study the temporal evolutions of three stock-markets; Standard and Poor"s 500 index, Nikkei stock averageindex, and Korean composition stock price index. We observe thatthe probability distribution function has a fat tail but the tailindex is increased rather than fixed. We have also found that thevariance of the autocorrelation function, the scaling exponent ofthe standard deviation, and the statistical complexity decreases,but the entropy density increases as times goes. We introduce amodified microscopic spin model and simulate the model to confirmsuch increasing and decreasing tendencies. All findings indicatethat three stock markets become more efficient.

F-20 **Non-Gaussian 옵션 가격결정 모델을 이용한 이색옵션 가격결정** 박 상남, 박 동수(*서울시립대 물리학과.*) 주식시장에서의 주가의 움직임이 통상적으로 사용되고 있는 로그-정규분포와 많이 다르다는 것이 잘 알려져 있고 이를 이용한 옵션 가격 모형인 블랙-솔즈 모형은 실무에서 다른 방식으로 이용되고 있다. 나아가 이 표준모형은 피팅 파라미터에 대해 가격이 너무나 민감하기 때문에 장외에서 주로 거래되는 이색옵션들의 가격결정이나 헷징에는 사용할 수가 없다. 이를 개선하기 위해서 여러방면

에서 새로운 모델들이 제시되었는데 이 중에 최근에 연구된 generalized Fokker-Plank 방정식에 기초한 Non-Gaussian 주가 모형을 이용하여 이색옵션인 콤파운드 옵션과 배리어 옵션의 가격을 전산모사하고 이를 최근에 널리 이용되고 있는 stochastic volitility 모형과 비교하였다.

■ SESSION: F [F4]
10월 19일(금), 11:00 - 12:30
장 소: 401호

F

F-21 **Study of a Brownian Motion of Gas-Fluidized Ellipsoid Particles.** PARK Youngah, DANIELS Lynn[1], LUBENSKY Tom C.[1], DURIAN Douglas[1](*Myongji University, Department of Physics. [1]University of Pennsylvania,Department of Physics and Astronomy.*) We studied the Brownian motion of ellipsoidal particles placed on a fine sieve inan upward flow of gas and investigated the effect of dissipative coupling of translationalto rotational motion. By using digital video microscopy, we quantifiedthe positions and orientations of individual particles. We found that angularcorrelations decay approximately exponentially in time and that single-particlevelocity correlations decay approximately algebraically in time with different exponentsfor directions perpendicular and parallel to the particles long axes. Weinterpret our measurements using a Langevin theory with frequency-dependent(colored) noise sources in which the dependence of the anisotropic friction tensoron angle is responsible for coupling between orientation and displacement.

F-22 **Nanoscale Fluid Flows on a Helically Patterned Cylindrical Surfaces** JEON Chanil, JEONG Hawoong, JUNG Youngkyun[1](*KAIST. [1]KISTI.*) We investigate the behavior of the nanoscale flows in a cylindrical channel whose surface is helically patterned with different wettability. Density and velocity fields are computed from molecular dynamics simulations. We also study the behavior of spherical nanoparticles through a fluid-filled patterned channel with varying the interaction between the fluid and the channel wall. We will present the helical patterning effect on the flows in the nanoscale channel.

F-23 **배양된 아교세포 네트워크의 발달 과정에서 출현하는 칼슘파의 동적 특성에 관한 연구** 박 진성, 정 병하, 고 태욱, 권 오규, 민 철홍, 이 경진(*고려대학교 물리학과 세포동역학 연구센터.*) 뇌 세포의 대부분을 구성하고 있는 아교세포(glia)의 기능에 관한 이해는 주로 신경세포(neuron)를 감싸서 보호하는 단순한 역할에 국한되어 있었다. 그러나, 최근에 이러한 아교세포가 그 주위에 있는 신경세포와의 상호작용을 통해서 뇌의 다양한 기작에 직접적으로 관여한다는 사실이 밝혀지면서부터, 아교세포의 능동적 역할을 이해하고자 하는 새로운 시도가 광범위하게 진행되고 있는 상황이다. 일반적으로 신경세포들은 시냅스 네트워크를 통한 전기적 신호 전달을 통해, 빠르고 강하게 동기화된 발화 양상을 나타내는 반면, 아교세포는 칼슘을 매개로 한 파동 형태로 비교적 느리게 전파되는 신호전달체계를 갖는다. 본 연구에서는 배양된 아교세포의 장시간에 걸친 실시간 관측을 통하여, 이들의 네트워크 구조의 형성과 발달 과정에 관여하는 칼슘파의 시공간 동적 특성에 관한 이해를 시도한다. 아교세포들의 교신활동은 이들 세포들 사이에 직접적인 연결이 형성되어 있지 않은 배양 초기 단계에서부터 이루어진다. 시간이 지남에 따라, 아교세포들 간의 네트워크는 주위 세포들과의 직접적인 연결을 통해서, 그리고 세포 분열을 통한 개체수의 증가를 통해서 발달하게 된다. 칼슘파는 이러한 단계에서부터 자발적으로 출현하기 시작하는데, 본 연구진은 이러한 칼슘파의 동역학이 세포 네트워크 구조의 형성에 있어서 매우 중요한 역할을 수행하고 있음을 보인다. 또한, 약물 실험을 통해서 이러한 칼슘파의 전파 메카니즘에 다양한 경로가 있음을 밝힌다.

F-24 **Stochastic Oscillator Death in Globally Coupled Neurons** LIM Woochang, KIM Sang-Yoon[1](*아주대 의과학연구소. [1]강원대 물리학과.*) We consider a large population of globally coupled subthreshold Morris-Lecar neurons. By varying the coupling strength J, stochastic spiking coherence (i.e., noise-induced coherence between neural spikings) is numerically investigated. As J passes a threshold, a transition to stochastic spiking coherence, which is described in terms of the order parameter, occurs because the coupling stimulates collective coherence between noise-induced spikings. However, for sufficiently large J, the coupling induces "stochastic oscillator death" (i.e., quenching of noise-induced spikings). As a result of the coupling-induced stochastic oscillator death, nonfiring states appear because each neuron is attracted to a noisy equilibrium state. Such a nonfiring transition may be well described in terms of the average firing probability $\overline{P_f}$. For a nonfiring state, $\overline{P_f}$ tends to zero in the thermodynamic limit. Through competition of these two different roles of coupling, stochastic spiking coherence is found to occur in a large range of intermediate coupling strength.

F-25 **Equalization of synaptic efficacy by synchronous neural activity** 조 명원, 최 무영(*서울대학교 물리학과.*) It is commonly believed that spike timings of a postsynaptic neuron tend to follow those of the presynaptic neuron.Such orthodromic firing may, however, cause a conflict with the functional integrity of complex neuronal networks due to asymmetric temporal Hebbian plasticity. We argue that reversed spike timing in a synapse is a typical phenomenon in the cortex, which has a stabilizing effect on the neuronal network structure. We further demonstrate how the firing causality in a synapse is perturbed by synchronous neural activity and how the equilibrium property of spike-timing dependent plasticity is determined principally by the degree of synchronization. Remarkably, even noise-induced activity and synchrony of neurons can result in equalization of synaptic efficacy.

■ SESSION: K [K1]
10월 18일(목), 12:30 - 14:30
장 소: 한라홀A

K-01 **Investigation of structural and optical properties of AlGaN/InGaN MQWs for application to ultra violet emitter** 전성란, 정 태훈, 이 승재, 정 성훈, 이 상헌, 백 종협, 차 옥환[1], 정 문석[2](*한국광기술원. [1]전북대학교. [2]한국고등광기술원.*) Recently, nitride-based multiple quantum well (MQW) structures are of interest due to their application in blue-violet light emitting diodes (LEDs) and lasers. In particular, AlGaN/(In)GaN MQWs are considered as a most favorable system for UV LEDs, including white lightning, sterilization, and decontamination. However, the performance of UV LED is still quite low compared to a blue LED due to the defects act as non-radiative centers which attributed to poor material quality. In this work, we have investigated V-shaped defect formation and surface morphological evolution of AlGaN/(In)GaN MQW structure grown by different growth conditions and demonstrate the characteristics of the fabticated UV LEDs. Morphological and optical examination of AlGaN/(In)GaN MQWs were carried out with Atomic force microscope (AFM), Cathodoluminescence (CL), and Photoluminescence (PL). Our findings indicate that the V-defect formation and performance of device are depending upon not only the growth condition of InGaN well but also on the AlGaN barrier.

K-02 **Growth and characterization of InAlGaN/GaN heterostructures** SUBRAMANIYAM nagarajan, MUTHUSAMY Senthil Kumar, CHUNG S.J., HONG C.-H., SUH E.-K. (*Semiconductor Physics Research Center and School of Semiconductor and Chemical Engineering, Chonbuk National University, Chonju 561-756.*) AlGaN/GaN heterostructures are attractive for high electron mobility transistors due to large band offset and effective electron confinement. However, AlGaN/GaN heterostructures with high aluminium content encounter misfit dislocations and cracks due to large lattice mismatch. To solve the above problem, InAlGaN quaternary layers have been introduced due to the wide tunability of the lattice constant, and also, the critical thickness of the AlGaN barrier can be increased. In this study, InAlGaN/GaN heterostructures with various Al compositions have been grown on sapphire substrate using metal organic chemical vapor deposition technique. The growth rate of InAlGaN layer decreases with increase of TMAl flow and the gas-to-solid ratio indicates a high Al incorporation efficiency. Atomic force microscopy reveals a smooth surface with formation of hexagonal pits. The size and the density of hexagonal pit increase with increasing Al mole fraction. Formation of Two-Dimensional Electron Gas (2DEG) at InAlGaN/GaN interface has been observed by using C-V and Hall effect. The 2DEG density decreases with increasing Al composition that might be due to the degradation of hetero-interface by the hexagonal pit.
*Acknowledgements: This work was supported by the Korea Research Foundation Grant funded by the Korean Government (MOEHRD) (KRF- 2005-005-J07501).

K-03 **Effect of carrier confinement and optical properties of two-dimensional electrons in single and multiple AlGaN/GaN heterostructures** 곽 호상, 김 선모, 조 현익[1], 이 정희[1], 조 용훈(*충북대, 물리학과. [1]경북대, 전기전자.*) The optical properties of two-dimentional electron gas emissions in single and multiple AlxGa1–xN/GaN heterostructures grown by MOCVD were investigated by high-resolution X-ray diffraction, and photoluminescence (PL) measurements. A strong GaN Band edge emission and its longitudinal optical phonon replicas were observed for all the samples.At 14 K, a 2DEG-related PL peak located at ~ 3.45 eV was observed for sample (a), while two 2DEG peaks at ~ 3.425 and ~ 3.450 eV were observed for samples (c) due to the additional Al0.15Ga0.85N layers. Moreover, the emission intensity of the 2DEG peak was higher in sample (c) than in sample (a) probably due to an effective confinement of the photoexcited holes by the additional Al0.15Ga0.85N layers. The 2DEG-related emission intensity decreased with increasing temperature and disappeared at temperatures above 150 K. In CL measurement with increasing an accelerating voltage, 2DEG peaks show to blue-shift and red-shift. These results are can be explained in terms of the screening effect of carriers on the bending of the conduction band at the AlxGa1-xN/GaN hetero-interface with an increase in accelerating voltage because of the changing of total energy-dose intensity with depth.

K-04 **Single crystalline Cu doped GaN nanowires and their magnetism** SEONG Han-Kyu, KIM Ungkil, PARK Tae-Eon, KIM Jae-Young[1], KIM Ju-Jin[2], LEE Seung-Chul[3], CHOI Heon-Jin(*School of Advanced Materials Science and Engineering, Yonsei University. [1]Pohang Accelerator Laboratory, Pohang University of Science and Technology. [2]Department of Physics, Chon-buk National University. [3]Future Technology Research Division, Korea Institute of Science and Technology.*) The concept of simultaneously manipulating both charge and spin in a single semiconductor medium leads to the exciting area of spintronics. Semiconductors doped with transition metal, so called diluted magnetic semiconductors (DMSs), are the most promising candidates for such applications. Room temperature ferromagnetism has been reported from Cr, Mn, Fe and Co doped GaN, ZnO, and TiO_2. However, these transition metals with local magnetic moments may not be the best choice for the doping elements. Magnetic secondary clusters have been shown to be ferromagnetic, arguing the motivation that the ferromagnetism of the DMSs arises from magnetic secondary clusters. Namely, the origin of ferromagnetism in these DMSs is still controversial, due to the possibility of magnetic secondary phases and uncertainty of magnetic interactions. We report magnetism in nonmagnetic Cu doped single crystalline GaN nanowires. The typical diameter and the length of the $Ga_{1-x}Cu_xN$ nanowires (x = 0.01, 0.024) are 10-100 nm and tens of micrometers, respectively. The saturation magnetic moments are measured to be higher than 0.86 m_B at 300 K and the Curie temperatures are far above room temperature. Anomalous x-ray scattering and x-ray diffraction measurement make it clear that Cu atoms substitute the Ga sites and they largely take part in

the wurtzite network of host GaN. X-ray absorption and x-ray magnetic circular dichroism spectra at Cu $L_{2,3}$-edges show that doped Cu has local magnetic moment and the electronic configuration of doped Cu is mainly $3d^9$ with a small portion of $3d^8$ component. It seems that the iono-covalent bonding nature of Cu 3d orbital with surrounding semiconductor medium makes Cu atom a mixed electron configuration and local magnetic moments. These outcomes suggest that the $Ga_{1-x}Cu_xN$ system is a room temperature ferromagnetic semiconductor.

K-05 **Quantum Coherent Control in Multiple GaAs/AlGaAs Quantum Wells Using EIT** 정 경복, XU Hua[1], 박 용주[2], 함 병승[1](*인하대학교 광양자정보처리연구단. [1]인하대학교 정보통신대학원/광양자정보처리연구단. [2]한국과학기술연구원 나노과학연구본부 스핀트로닉스연구단.*) 3개의 에너지준위를 갖는 시스템에서 dipole-coupling이 금지된 두 준위에서의 coherent non-radiative superposition은 전자기유도투과 (Electromagneticlly Induded Transparency; EIT), 밀도전이없는 레이저, 느린빛, 멈춤빛과 같은 다양한 비선형광학현상의 연구에 매우 중요하다. 이러한 연구는 초기에 기체를 중심으로 연구되어 왔으면, 90년대 중반에 고체에서 실험적으로 증명되어 활발한 연구가 진행되어왔다. 최근에는 반도체를 이용한 연구결과가 제시되어 실생활의 응용에 더욱더 기대되고 있다. 하지만, 이러한 비약적인 연구에도 불구하고 반도체 매질에서는 디코히런스 시간이 매우 짧아서 EIT현상에 제한이 있으며, EIT를 이용한 느린빛 현상은 아직까지 보고 되지 않은 상황이다. 본 연구는 반도체 매질에서의 느린빛 실현을 목적으로 한다. 라만코히런스 현상은 EIT 및 EIT를 이용한 느린빛과 같은 코히런트 비선형광학현상을 규명하는데 중요한 통로가 된다. GaAs-based 양자우물에서, 라만코히런스는 light-hole(lh)과 heavy-hole(hh)의 엑시톤 상태들의 nonradiative phase coherence를 말한다.본 발표에서는GaAs/AlGaAs 다중양자우물에서 사광파혼합을 이용하여 Light- hole과 heavy-hole 사이의 라만코히런스에 관한 연구결과를 보고한다. 광원으로는 mode-locked Ti:sapphire laser (80Mhz repetition rate, 1~790 nm)를 사용하였으며, 3개의 펄스빔을 이용해서 사광파혼합을 시행하였다. 샘플은 9 nm GaAs well, 20 nm $Al_{0.25}Ga_{0.75}As$ barrier로 구성된 20-period GaAs/$Al_{0.25}Ga_{0.75}As$ 다중양자우물 구조이다.

K-06 **고밀도 GaAs 양자점의 광학적특성 연구** 김 종수, 변 지수, 정 문석, 강 훈수, 고 도경, 이 종민, 조 남기[1], 박 성준[1], 송 진동[1], 최 원준[1], 이 정일[1], 김 진수[2], 임 재영[3](*광주과학기술원 고등광기술연구소. [1]한국과학기술연구원 나노소자연구센타. [2]전북대학교 신소재공학부. [3]인제대학교 나노공학부.*) 본 연구에서는 최근 연구되고 있는 droplet 방식으로 AlGaAs (100) 및 (111)A 면위에 성장된 저밀도 및 고밀도 GaAs 양자점의 광학적 특성을 photoluminescence (PL)와 시분해-PL 방법으로 연구하였다. 양자점의 밀도변화에 따른 광학적 특성을 비교분석하기 위하여 밀도가 2×10^9 와 $2\times10^{11}/cm^2$ 인 시료를 사용하였다. 저밀도와 고밀도 양자점은 8 K에서 각각 1.660과 1.648 eV에서 강한 발광을 보여주었으며 FWHM은 각각 60 과 50 meV이었다. 온도의존성 PL 측정을 통하여 고밀도와 저밀도 양자점의 발광에너지변화를 비교분석 하였다. 아울러 온도에 따른 케리어수명시간을 측정하고 비교 분석하였다. 고밀도 양자점에서 나타난 광학적 특성은 양자점간의 커플링에 기인한 것으로 해석하였으며 기존의 InAs 양자점에 적용된 모델과 비교하였다.

K-07 **Chemical states of N doped $Ge_2Sb_2Te_5$ by using NEXAFS and HRXPS with the synchrotron** 정 민철, 신 현준, 김 기홍[1], 송 세안[1], 정 홍식[2], 이 영미[3], 고 창훈[4], 한 문섭[4](*포항가속기연구소. [1]삼성종기원. [2]삼성전자. [3]경희대 물리학과. [4]서울시립대 물리학과.*) 차세대 비휘발성 메모리 소자의 핵심 물질로 연구되고 있는 질소를 doping한 비정질 $Ge_2Sb_2Te_5$ (Na-GST)박막에 대한 화학적 상태를 분석하기 위하여 방사광을 이용한 HRXPS와 NEXAFS를 수행하였다. Sputter 기법으로 제작된 Na-GST 박막은 질소의 도핑량에 따라 저항값이 100 MΩ/sq. 보다 높게 측정되었으며, XRD에서는 비정질로 나타났다. NEXAFS기법을 이용한 N K-edge의 측정에서 N_2 분자에 의한 vibration mode가 나타나는 것으로 보아, 도핑된 질소의 일부는 N_2 분자 상태로 박막 안에 있는 것으로 보인다. Ne^+ sputtering을 통하여 표면 산화막을 제거한 Na-GST 박막에 대한 HRXPS 실험에서는 Te 4d와 Sb 4d core-level spectrum에 변화는 질소의 doping 양에 따라 나타나지 않으나, Ge 3d의 경우 높은 binding energy쪽에 새로운 화학적 상태가 나타난다. 이는 N의 doping이 주도적으로 Ge nitride을 형성하는 것으로 추측된다. 본 연구에서는 이러한 박막내의 질소 역할에 대하여 논의할 것이다.

K-08 **Electron Quantum Tunneling through Ultrathin HfO_2 Layers** RYU Byungki, KANG Joongoo, KIM Yong-Hoon[1], CHANG Kee Joo(*Department of Physics, Korea Advanced Institude of Science and Technology. [1]Department of Material Science and Engineering, University of Seoul.*) Among high-k dielectric materials, hafnium oxide (HfO_2) is considered as a promising replacement for SiO_2 in nanoscale devices due to its high dielectric constant, large band gap, and low leakage current. In this study we investigate the tunneling properties of electrons through ultrathin HfO_2 layers using non-equilibrium Green"s function calculations within the density functional framework. Using atomic orbital basis functions, we calculate the transmission function and examine the gate leakage current. We use a device model, where strained HfO_2 layers in the monoclinic structure are sandwiched between two semi-infinite Si(001) electrodes, with oxide thicknesses ranging from 15 to 50 Å. We find that hole leakage current densities increase with decreasing of the oxide thickness, similar to the case of SiO_2. However, the leakage current density is found to be larger than that for the device utilizing SiO_2 layers.

K-09 **Optical properties of $GeTe$-Sb_2Te_3 thin films studied with spectroscopic ellipsometry** 이 호선, 강 태동, 백 승호, 강 윤선[1], 이 태연[1], 서 동석[1], 김 기준[1], 김 철규[1], 강 윤호[1](*경희대학교 물리학과. [1]삼성종합기술원 반도체 소자 및 재료 연구실.*) We measured the dielectric functions of phase-change-random-access-memory (PRAM) materials - GeTe, $Ge_2Te_2Sb_5$, $Ge_1Te_2Sb_4$, $Ge_1Te_4Sb_7$, Sb_2Te_3 – by using spectroscopic ellipsometry. According to x-ray diffraction, the as-grown thin films were amorphous and the 200^0C-annealed films had FCC phase. In the case of the as-grown thin films, the amplitudes of the dielectric functions in-

creased as Sb/Ge ratio increases. In the case of the annealed thin films, the amplitudes of 124 and 147 thin films increased significantly compared to those of the as-grown films, whereas that of Sb_2Te_3 increased slightly. Therefore, the amplitudes of 124 and 147 were the largest and that of GeTe was the smallest. The optical gap energy of the amorphous thin films was estimated by the equation whereas the interband gap energy of the FCC films was estimated by. As Sb/Ge ratio increased, the optical gap energy decreased from 0.8eV to 0.5 eV and the interband gap energy decreased from 2.2eV to 1.5eV. Standard critical point fitting showed several band gaps and the corresponding electronic band structures are discussed.

K-10 **Thermal conductivity of phase-change material Ge2Sb2Te5** 여 호기, CAHILL David[1], LEE Bong-Sub[1], ABELSON John[1], 김 기범[2], 권 민호[2], BISHOP Stephen[3], 정 병기[4] (*한국표준과학연구원, 기반표준부. [1]University of Illinois, Materials. [2] 서울대학교, 재료공학. [3]University of Illinois, Electrical. [4]KIST.*) $Ge_2Sb_2Te_5$ (GST), a material that can change structural phases between an amorphous and two crystalline states, undergoes phase transformations by optical absorption or joule heating. Practical utilization of this material associated with the phase change at a small scale depends crucially on the thermal transport in GST and between GST and surrounding materials. We hereby explore the relationship between the phase transformations and the thermal conductivity of $Ge_2Sb_2Te_5$ films (Λ_{GST}). The thermal conductivity of GST films is measured using time-domain thermoreflectance. First, we measure the thermal conductivity Λ_{GST} for three films that include an as-deposited amorphous (a-GST) film; the other two films are annealed for 20 min at fixed temperatures of 180 °C and 360 °C to form the cubic f.c.c. (c-GST) and hexagonal (h-GST) phases, respectively. For the three films, we obtain the values of $\Lambda_{a\text{-}GST} \approx 0.19$ $Wm^{-1}K^{-1}$, $\Lambda_{c\text{-}GST} \approx 0.57$ $Wm^{-1}K^{-1}$, and $\Lambda_{h\text{-}GST} \approx 1.58$ $Wm^{-1}K^{-1}$. We then measure the thermal conductivity as a function of the film temperature when the film is heated at a rate of 3 K/min. The measured conductivity Λ_{GST} undergoes a discontinuous increase at T ≈ 130 °C and a smooth change at ≈ 340 °C. The first abrupt change appears upon crystallization, i.e. a- to c-GST transformation, and the second change appears with c- to h-GST transformation. The values of $\Lambda_{c\text{-}GST}$ encompass the range of 0.45 - 0.95 $Wm^{-1}K^{-1}$ at 130 °C <T <310 °C. Similarly, $\Lambda_{h\text{-}GST}$ includes the range of 1.4 - 1.53 $Wm^{-1}K^{-1}$ at 340 °C <T <400 °C while the values of $\Lambda_{a\text{-}GST}$ are essentially constant. The thermal transport at a- and the early c-GST phases can be explained by a random walk of vibrational energy (minimum thermal conductivity). By contrast, in the h-GST phase, the thermal conduction is largely due to electronic contribution; the contribution deduced from the Wiedemann-Franz law accounts for ~70% of the measured $\Lambda_{h\text{-}GST}$. Finally, we measure the thermal conductivity of spots crystallized by laser processing as functions of the energy density and the number of applied laser pulses. The measured thermal conductivity of the rapidly transformed spots induced by laser pulses is lower and closer to the minimum thermal conductivity than that of the thermally annealed one. This implies that the rapid crystallization leads to a more disordered crystalline structure than the annealed one does.

■ SESSION: K [KF1]/[DF1]
10월 18일(목), 16:30 - 18:10
장 소: 탐라홀B

KF-01(초) **Physics of graphene nanoribbons** SON Young-Woo(*Dept. of Physics, Konkuk University, Seoul 143-701.*) The recent fabrication of a single graphite layer opens a new possibility in the area of nanoelectronics. These experimental findings motivated us to study a novel one dimensional nanomaterial - a graphene nanoribbon (GNR). Based on a first-principles approach, we have established the scaling rules for electronic energy bandgaps as a function of ribbon width [1]. Both armchair and zigzag edged GNRs, with homogeneous edges passivated with hydrogen, are shown to have bandgaps, differing from the results of simple tight-binding calculations or solutions of the Dirac's equation based on them. Our ab initio calculations show that the origin of energy gaps for GNRs with armchair shaped edges arises from both quantum confinement and the crucial effect of the edges. For GNRs with zigzag shaped edges, gaps appear because of a staggered sublattice potential on the hexagonal lattice due to edge magnetizations. Our calculations also show that the magnetic properties of nanoribbons can be controlled by electric fields [2]. In particular, half-metallicity is predicted in GNRs if in-plane homogeneous electric fields are applied across zigzag shaped edges of these systems. Such asymmetric electronic structure for each spin originates from the fact that the spatially separated spin polarized states with opposite spin orientations in the semiconducting GNRs are shifted oppositely in energy by the applied fields [3]. This closes the gap associated with one spin orientation and widens the other. The spin precession due to the spin-orbit interaction in the transverse electric fields is shown to be completely suppressed by the spin gap asymmetry so that the predicted half-metallic behavior in these organic materials can be measured in transport experiments with split-gates. This work has been collaborated with M. L. Cohen and S. G. Louie at UC Berkeley.
[1] Y.-W. Son, M. L. Cohen and S. G. Louie, Phys. Rev. Lett. 97, 216803 (2006). [2] Y.-W. Son, M. L. Cohen and S. G. Louie, Nature 444, 347 (2006). [3] Y.-W. Son et al, Phys. Rev. Lett. 95, 216602 (2005).

KF-02(초) **Roles of Edge States in Electronic Heat Capacity of Doped Graphene Ribbons** YI K. S., KIM D., PARK K.-S.(*Department of Physics, Pusan National University, Busan 609-735.*) We report a study on the role of edge states in the electronic heat capacity of doped graphene ribbons. We consider a lattice model Hamiltonian of graphene in ribbon geometries, which includes nearest neighbor (NN) hopping and particle-hole symmetry breaking next nearest neighbor (NNN) hopping on the lattice [1]. The band structure and density of states are calculated in graphene ribbons and explore the temperature behavior of the electronic specific heat for both ribbons with zigzag and armchair edges. We will report the low temperature behavior of the heat capacity in doped gra-

phene ribbons. The low temperature heat capacity shows unconventional temperature behavior. In addition, unusual strong enhancement is observed in the heat capacity for zigzag ribbons at low temperatures due to the localized edge states of the ribbon, the contribution of which depends strongly on the width of the ribbon. As the level of carrier doping is increased, the unusual low-temperature power-law behavior of the massless fermions turns into that of usual 2D electron gas.

[1]. G. W. Semenoff, Phys. Rev. Lett. 53, 2449 (1984); F. D. M. Haldane, Phys. Rev. Lett. 61, 2015 (1988).

KF-03(초) **Nano magnetism in graphene composite** 황 찬용 (*한국표준과학연구원.*) 최근 2-3년간 그래핀에 관한 연구가 매우 활발하게 진행되고 있다. 단원자층의 벌집모양의 탄소 구조체에 해당하는 그래핀은 기존의 응집물질계와는 다른 고유한 특성이 기대되고 있다. 왜냐하면 실질적인 전자의 속도는 광속에 훨씬 못 미치지만 전자 서로간의 상호작용으로 인하여 질량이 0인 입자와 유사하게 행동하기 때문이다. 순수한 물리학적 관심이외에 그래핀에 관한 연구가 활성화되는 이유중의 하나는 CNT보다 월등한 나노 소자로서의 응용가능성 때문이다. 최근 전기장을 이용하여 그래핀띠에서 전자의 스핀을 분리할 수 있는 방법이 예측이 되고 있지만 그 폭이 매우 작아야 한다. 이러한 폭에 상관없이 그래핀내부에서 움직이는 전자의 스핀을 제어할 수 있다면 그래핀이 스핀트로닉스의 물질계로 사용될 가능성이 있다. 본 발표에서는 최근 흑연(graphite)에서 발견되는 강자성의 원인에 대한 연구결과를 이용하여 그래핀에서의 결함(defect)을 제어하여 얻어지는 강자성 그래핀에 관한 연구결과를 발표하고자 한다. * 이도현, 김원동(표준원), N. Hung, 김효진(충남대), 양정화, 홍지상(부경대) 공동연구로 수행.

KF-04(초) **Quantum Transport Properties and Fabrication for Graphene Nano-devices** CHOI Jae-Hyun, JEONG Dongchan, KI Dong-Keun, LEE Hu-Jong(*Department of Physics, Pohang University of Science and Technology, Korea.*) Graphene is a single atomic-layer graphite sheet, containing truly two-dimensional electrons or masslessDirac fermions. Its hexagonal lattice structure consists of two independent base lattices with different chiral symmetries. The linear energy dispersion relation of the system in k space at the Dirac points, in conjunction with two different chiral symmetries, exhibits a wealth of quantum transport phenomena. In this presentation, I will first introduce firsthand technique of preparing graphene sheets out of bulk graphite, making ohmic contact, e-beam patterning, back-gating and local gating, etc., for studies of fundamental electrical transport properties as well as for electronic nano-device applications. Presentation will then touch on the minimal conductance at a Dirac point and half-integer quantum Hall effect (or relativistic Landau levels) we observed. I will then discuss other fundamental quantum transport properties of the system, such as conductance quantization (in units of $4e^2/h$), electronic coherence effect including the weak localization and Aharonov-Bohm effect, superconducting proximity effect, etc. Nano-electronic device applications using graphene p-n junctions realized by using local gating will also be discussed.

■ SESSION: K [KT1]
10월 18일(목), 18:30 - 20:00
장 소: 한라홀B

KT-01(초) **분자선 결정성장 기술을 이용한 나노 반도체의 최근 연구동향** 오 재응, 김 문덕[1](*한양대학교 공학대학 전자컴퓨터공학부. [1]충남대학교 자연과학대학 물리학과.*) 분자선 결정성장 기술(Molecular Beam Epitaxy : MBE)은 70년대를 기점으로 quantum Hall effect, resonant tunneling, modulation-doped 구조 등, 양자영역의 반도체 물리 및 소자에 대한 실험적 연구가 가능하도록 한 견인차로서, 반도체 물리에 새로운 차원에 대한 가능성을 제공하여 왔다. 그러나 초고진공 및 복잡한 유지보수 등 여러 요인으로 인하여, 궁극적인 양산 장비 및 기술로의 가능성에 대해서는 항상 의문시되어 왔으며, 이러한 이유로 인하여 기술의 성숙단계에서는 항상 더욱 높은 생산성을 갖는 기술로의 전환을 위한 연구개발 기술로서 역할이 대부분 제한되었다. 반면에 단원자층 성장이 가능하고 낮은 성장 온도로 인하여 metastable 성장이 가능하고 그리고 RHEED를 이용한 실시간 성장상태 관찰이 가능하다는 모든 장점은 새로운 반도체 연구 개발의 선봉장으로서의 이 기술의 역할의 중요성을 더욱 강조하고 있다. 반도체 시장의 대부분을 차지하는 Si CMOS 는 high-k 게이트 절연막과 metal gate를 사용하여 현존 기술 및 물리적 한계를 극복하고 있으나, 그마저도 25 nm node를 기점으로 새로운 channel 물질로 대체 될 것이라는 기술 예측은 기존의 Si 반도체 기술과 우월한 물리적 특성을 갖는 화합물 반도체의 궁극적인 결합이라는 80년대 반도체 연구의 화두를 다시 한 번 고려하는 계기가 되고 있다. 나노 영역의 반도체 물리의 한계를 극복하고자 하는 움직임은 분자선 결정 성장 기술의 장점과 어우러져 현재 새로운 나노 반도체 기술의 르네상스를 이루고 있으며, 이 시점에서 다시 한 번 기술의 한계 및 가능성을 점검하는 노력이 필요하다고 판단된다. 본 발표에서는 beyond 25 nm 시대를 대비한 여러 선진 연구진의 연구방향 및 결과를 분자선 결정 성장 기술의 관점으로 정리하였고, 또한 가능성과 함께 극복해야할 기술적 관점을 열거하여 새로운 기술 영역에 대한 준비에 도움이 되고자 하였다.

KT-02(초) **MOCVD에 의한 나노구조 성장; 초격자에서 나노선까지** 김 용, TAN H. H.[1], JAGADISH C.[1](*부산광역시 사하구 하단동 동아대학교 신소재물리학과. [1]Department of Electronic Materials Engineering, Research School of Physical Sciences and Engineering, Australian National University, Canberra, ACT0200, Australia.*) 1968년 Manasevit (1) 가 MOCVD 장치를 발명한 이래 그 후 40 여년간 MOCVD 장치는 진화에 진화를 거듭하여 현대의 MOCVD 장치가 되었다. 최초의 MOCVD 장치는 단순한 박막성장을 목적으로 하였으나 현대의 MOCVD 장치는 단분자층의 급준성을 가진 초고순도 양자구조를 자유롭게 성장할 수 있다. 이런 현대적인 MOCVD 장치의 발전 배경에는 수많은 MOCVD 과학자들의 노력이 숨어있다. 초기의 MOCVD 과학자들은 run/vent 개념, residence time 조절 개념, 반응관의 설계, dead space가 없는 manifold valve 개발, satellite rotation susceptor 개발, 초음파를 이용한 고체소스 유량조절 장치, bubbler 의 dilution, bypass, 및 make-up line 개념 등 여러 가지 개념을 제안하였고 이런 개념들이 현대의 MOCVD 장치에 그대로 반영이 되어 있다. 본 발표에서는 현대적인 MOCVD 장치의 숨어있는 여러 가지 개념을 실용적인

측면에서 다각도로 검토하고 아울러 이런 현대적인 MOCVD 장치로 성장한 초격자, 양자우물, 양자선, 양자점, 나노선의 여러 성공 사례를 보일 것이다. 아울러 이런 나노구조를 구현하기 위하여 어떤 문제들이 검토되고 극복되어 왔는지 논의를 할 것이다.

(1) H. M. Manasevit, Appl. Phys. Lett. 12, 156 (1968).

■ SESSION: K [K2]
10월 19일(금), 09:00 - 10:56
장 소: 삼다홀A

K-11(초) **Poly Si TFT on Thin Glass** 원 성환(*서울시립대학교 서울시 동대문구 전농동.*) We have fabricated poly silicon (poly-Si) thin film transistors (TFT's) on flexible thin glass. Currently, most of the flexible displays adopt amorphous Si:H as an active layer, deposited at temperatures below 300 °C and a-Si:H based active matrix LCD's have been fabricated on many plastics substrates. In this study, we used thin flexible glass of 75 um in average thickness as a substrate to fabricate poly-Si TFT's. Glass substrates are so thin that they can be bent to radius of curvature as small as 3 inch. Glass substrate, we used, is borosilicate glass, thus barrier layers, SiN_x fooled by a SiO_2 layer, were deposited on both sides of glass substrate to suppress the out-migration of unwanted glass constituents from the glass into the semiconductor during processing. Especially, the latter provides for a very low recombination velocity and this minimizes any potential back channel leakage. For fabrication of TFT's on glass, a few challenges were performed such as anodic bonding, metal alloy assisted bonding and Si-frame assisted bonding which was to fabricate Si supporting wafers that contains "pockets" in which the thin glass substrates could be inserted. These were based on the idea of using Si wafer as a handling wafer. That is once glass is bonded to Si handling wafer successfully then, poly-Si TFT's could be fabricated on the glass over Si wafer. As results, the Si-frame assisted bonding turned out very effective to fabricate poly-Si TFT's because cracks were observed on the glass with two previous methods. These "pocket carriers" were made by combination of micro-machining and electrostatic bonding of Si to Si via a pyrex "glue" layer. The flexible glass can easily be removed from the carrier for wet etching, but is mechanically supported by the Si wafer during high temperature processing steps such as poly-Si deposition, LTO (low temperature oxide) deposition, and implant activation anneal.

K-13 **Nonvolatile charge storage in single and multiple layers of Ge nanodots/SiO_2 fabricated without annealing** 홍 승휘, 황 성원, 정 필성, 김 민철, 김 혜룡, 최 석호, 김 경중[1](*경희대학교 전자정보대학 물리 및 응용물리 전공. [1]한국표준과학연구원 전략기술부 첨단산업측정그룹.*) Si 이나 Ge 과 같은 4족 원소의 나노 결정이나 나노점을 포함한 구조는 최근 다음 세대의 비휘발성 메모리 소자로서 각광을 받고 있다. 이를 위해서 여러 가지 제작방법이 제안되고 있으나 각각의 방법은 나름대로의 장, 단점을 가지고 있다. Ion Beam Sputtering Deposition (IBSD) 방법은 기존의 방법들보다 낮은 온도에서 성장할 수 있다는 점과 수소를 포함하는 가스를 사용하지 않으면서 초고진공에서 성장하기 때문에 임의의 잔류 원소나 defect states를 줄일 수 있다는 장점으로 주목을 받고 있다. 본 연구에서는 IBSD 방법을 사용하여 상온에서 Ge nanodot/SiO_2 의 단층 및 다층을 포함한 MOS 구조를 동일한 챔버 내에서 성장하여 비휘발성 메모리 소자로서의 특성을 연구하였다. Ge 층과 SiO_2 층의 두께는 각각 TEM과 X-ray Photoelectron Spectroscopy (XPS)를 이용하여 그 성장 비율을 결정하였다. 또한 TEM 측정 결과 control 및 tunnel SiO_2 층 사이에 3-5nm 크기의 Ge nanodot이 형성되었음을 확인할 수 있었다. control oxide와 tunnel oxide의 두께는 각각 20 nm, 3 nm로 고정하였으며 성장 후 MOS 구조를 완성하기 위해 100 um 크기의 Al 전극을 thermal evaporator를 이용하여 증착하였다. C-V hysteresis 측정으로 메모리 특성을 조사하였으며 열처리 과정을 거친 시료와 거치지 않은 시료와의 비교가 진행되었다. 또한 Ge nanodot의 변화에 따른 결과를 알아보기 위해 (Ge/SiO_2)의 주기와 Ge의 두께 등을 변화시켰다. 실험 결과, memory window인 hysteresis의 전압 범위가 이러한 변수들에 크게 의존한다는 것을 관찰할 수 있었으며 SiO_2 만을 성장한 시료와의 비교를 통해 메모리 효과가 Ge nanodot의 존재에 의한 것이라는 것을 확인할 수 있었다.

K-14 **Control of size and density of self-assembled germanium quantum dots (QDs) on Si(001) by carbon-induced strain engineering** 황 성원, 김 성, 홍 승휘, 최 석호, 김 원동[1], 지 승묵[1], 구 자용[1](*경희대학교 전자정보대학 물리 및 응용물리 전공. [1]표준과학연구원 이종성장제어단.*) The self-assembled Ge QDs are fabricated on the strain-controlled Si(001) surface by carbon incorporation. We have investigated the influence of carbon on Ge quantum dots growth on Si(100) substrates with ultra high vacuum scanning tunneling microscopy (UHV-STM) and scanning electron microscopy(SEM) . For carbon incorporation, we utilized the process of thermal dissociation of C_2H_2 gas molecules adsorbed on the Si(001) surface. We confirmed the successful formation of flat carbon-incorporated Si(001) surface by directly observing carbon-induced 2×n and c(4×4) reconstruction with UHV-STM. SEM images obtained after deposition of Ge on these C-incorporated Si(001) surfaces showed that Ge QDs had a bimodal shape distribution of domes and pyramids, and the increase of the amount of the incorporated C atoms lead to the decrease of the Ge QDs average diameter and the increase of their density. The results from SEM can be used to explain the observed PL data showing a red shift of the Ge QDs related PL with an increase in the carbon-incorporation. The two major emission bands observed in the PL spectra are attributed to no-phonon (NP) and transverse-optical (TO) phonon replica of the Ge QDs and they are blue-shifted with decreasing size of the Ge quantum dots. These results suggest that the size and density of Ge QDs can be controlled by only a dose of submonolayer carbon.

K-15 **Enhanced Electron Emission Current of as grown CNT by Post-Treatments** 유 제황, 김 기서[1], 이 창석, 민 경우, 정 일옥, MANIVANNAN S, 장 진, 박 규창(*경희대학교, 정보디스플레이학과, 차세대디스플레이연구센터. [1]경희대학교, 물리학과, 차세대디스플레이연구센터.*) 탄소나노튜브(CNTs) 는 다양한 형태와 물성을 지닌 특성으로 인하여 나노전자 산업분야로 활발하

게 응용되고 있다. 그 중에서도 낮은 임계전계에서의 높은 전자방출 특성으로 인하여 다양한 전자방출소자로의 연구가 활발히 이루어지고 있다.본 연구팀에서는 기 연구된 레지스트패터닝법 (resist assisted patterning, RAP) 을 이용하여, CNTs 의 선택적 위치제어로 다양한 전자소자로의 응용 가능성을 확인하였다. RAP 법으로 성장되어진 CNT 는 몇가지 후처리를 진행하여 전자방출 특성의 향상에 초점을 두었다. 후처리 방법으로는 일정한 전압을 인가하여 나노튜브의 탄소 결합력을 증가시킨 에이징(bias-aging treatment) 방법, CNT 를 희석된 HF 용액에 일정시간 동안 담구어 플루오르 (fluorine) 의 도핑 효과를 얻은 방법, 마지막으로 CNT 를 1000 ^{o}C 에서 CNT 를 열처리하였다. 이와 같은 방법을 이용하여 전자방출 특성을 약 200 μA/cm^2 에서 약 1 A/cm^2 로 50만 배 향상하였다. 분석방법으로는 CNT 형상의 변화를 알아보기 위하여, SEM(scanning electron microscope)과 TEM(transmission electron microcope)을 이용하였고 각각의 구성 원자의 결합력 변화를 알아보기 위하여 XPS (x-ray photoemission spectroscope)를 이용하였다.

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K-16 **Fano Formula Extended with Non-uniform Density of Continuum States in Quantum Well Super-lattices** LIM Jongseok, JANG Kyeong-jin, AHN Jaewook(*Korea Advnaced Institute of Science and Technology.*) Fano formula describes the quantum mechanical coupling of a discrete energy state with a continuum energy band. We consider the effect ofnon-uniformity of the density of states of the continuum energy bandupon the change of the Fano formula. By re-examining the experiments on Fano resonances in biased semiconductor super-lattices, of which the the density of energy states of excitonic mini-bands sharply modified by an applied Stark field, we obtain a new coupling regime of the excitonic Wannier-Stark ladder transitions.

K-17 **Role of Hydrogen and O-vacancy in n-type Conductivity in ZnO** BANG Junhyeok, LEE Woo-Jin, RYU Byungki, CHOI Eun-Ae, CHANG Kee Joo(*Department of Physics, Korea Advanced Institute of Science and Technology.*) Undoped zinc oxide (ZnO) usually exhibits n-type conductivity. The origin of n-type conductivity is attributed to Zn interstitials, O-vacancies, and hydrogen. Even in annealed samples, where hydrogen atoms are removed, n-type conductivity still remains. Thus, O-vacancies are thought to play a rolein the residual conduction, although these defects were threoretically predicted to be deep donors. In this study we investigate the role of hydrogen and O-vacancy in the n-type-conductivity observed in ZnO through first-principles local-density-functional calculations. We examine the diffusion pathway and migration energy of substitutional hydrogen for different charge states, the electronic structure of O-vacancy, and the annealing effect on the n-type conductivity.

K-18 **Optical investigation of p-type ZnO epilayers doped with phosphor by radio-frequency magnetron sputtering** 권 봉준, 곽 호상, 이 선균, 황 대규[1], 박 성주[1], 조 용훈(*충북대, 물리학과. [1]광주과기원.*) Optical properties of p-type ZnO epilayers doped with different amounts of phosphorus by radio-frequency magnetron sputtering are investigated by x-ray diffraction, temperature dependent photoluminescence PL, and time-resolved PL techniques. Bound exciton, free electrons-to-acceptors, donor-to-acceptor pair, and deep-level emissions are observed. These results show that phosphorus doping plays an important role both in reducing native defects and in generating shallow acceptors in ZnO, leading to a good p-type conductivity in ZnO.

K-19 **Enhancement of ultraviolet photoluminescence emission from ZnO films by Ge doping** 김 성, 이 도규, 김 민철, 황 성원, 엄 승환, 최 석호, 황 한나[1], 황 찬국[1](*경희대학교 전자정보대학 물리 및 응용물리 전공. [1]포항가속기연구소 빔라인부.*) Ge-doped ZnO films have been grown on Si wafers by RF-magnetron sputtering and optically characterized by photoluminescence (PL) spectroscopy. A new PL line is found at 3.324 eV by Ge doping and named as G line, which is thought to be originated from Ge suboxide states including GeO color centers. With increasing Ge concentration (n_{Ge}), the intensities of free-exciton-, and neutral-donor-bound-exciton-, two-electron-satellite-, and G- PL lines increase, whilst those of their phonon replicas decrease. The Ge doping also enhances no-phonon (NP) line deconvoluted from the near-band edge (NBE) PL at 300 K, but reduces its LO phonon replicas, responsible for the enhancement of the NBE PL with its reduced bandwidth. It is proposed that these results are attributed to the increase of the Ge suboxide states with increasing n_{Ge}, which is also confirmed by the analysis of the Ge 3d core-level spectra by X-ray photoelectron spectroscopy.

■ SESSION: K [KF2]
10월 19일(금), 11:10 - 12:50
장 소: 삼다홀A

KF-05(초) **Fabrication of I-element doped p-ZnO** KIM J.B., CHOI W.K.(*Korea Institute of Science and Technology, Materials Technology and Research Division, Cheongryang P.O Box 131, Seoul 130-650, Korea.*) Cu(Ib)-doped ZnO was epitaxially grown on Al2O3(1000) by plasma-assisted molecular beam epitaxy. Cu cell temperature was varied from 700-900oC and grown at 720oC. When they were annealed in O plasma, the as-deposited film was electrically converted into p-type property. Based upon four point probe measurement, the hole concentration and mobility were in the range of 1.8-5.9x1016/cm3 and mobility 3.5-7.9 cm2/Vs. From the low temperature photoluminescence, the peaks both around 2.4 eV and 2.87 eV were found besides the near band edge emission (NBE). p-Cu:ZnO on n-6H SiC and n-GaN heterostrutured LED was fabricated. After p-ohmic contact using Ti/Ni/Ti/Au, greenish-blue electroluminescene centered on 477 nm and 520 nm was clearly observed and coincident with PL spectra, and very reproducible. In this presentation, we would like to discuss the doping mechanism of I-element for producing p-ZnO instead of ususal V-element doping.

KF-06(초) **The origin of n-type conductivity in ZnO** KIM

Yong-Sung(*Korea Research Institute of Standards and Science.*) ZnO istypically grown in O-deficient conditionand it shows almost always n-type conductivity. The n-type conductivity has been attributed for a long time to the presence of O-vacancies (V_O). However, a number of recent theoretical calculations on native defects in ZnO have suggested that the O-vacancy should be a deep donor. Thereafter, the O-vacancy as a shallow donor has been severely challenged and the other defect, hydrogen, has been proposed for the source of the n-type conductivity H interstitial (H_i) and H substitutional at the O site (H_O). In this talk, I present the microscopic behaviors of the V_O, hydrogen, and their interactions in ZnO, based on the density-functional theory calculations. I suggest that, in addition to the H_i and H_O, hydrogen can form a V_O-H_2 complex in an H-rich condition, which is an electrically inactive H species in ZnO. More importantly, a probability for the shallow donor formation without H will be discussed. Other impurities, such as the group-III and the group-VII, are also discussed as the sources for the n-type conductivity in ZnO.

KF-07(초) **Growth and Characterization of high-quality undoped, n-type and p-type ZnO thin films using RF magnetron sputtering** JEONG Sang-Hun, KIM Tae-Hwan[1], KIM Il-Soo[1], KUMAR Manoj[1], LEE Byung-Teak[1](*Gwangju center, Korea Basic Science Institute, Gwangju 500–757, Republic of Korea. [1]Photonic and electronic Thin Film Laboratory, Department of Materials Science and Engineering, Chonnam National University, 300 Yong-bong dong, Gwangju 500–757, Republic of Korea.*) High quality undoped, Ga-doped and Ga-N co-doped ZnO films were deposited on Al_2O_3 and ZnO wafers, using high temperature r.f. magnetron sputtering technique. Structural, optical, and electrical properties of the films were characterized by high resolution x-ray diffraction (XRD), photoluminescence (PL), and Hall measurement. Undoped ZnO films deposited at a substrate temperature of 800°C were single crystalline and exhibited full-width at half-maximum (FWHM) of (0002) XRD rocking curve value as narrow as 280 arcsec (on Al_2O_3) and 10 arcsec (on ZnO), revealing excellent crystallinity of the ZnO films. PL spectra of the films showed a sharp and strong UV peak. Single crystal ZnO films doped with about 1wt% Ga, grown at 700°C, showed n-type behaviour with typical electron concentration and mobility of 2 x 10^{18} cm^{-3} and 17 cm^2/vs. Ga-N co-doped ZnO thin films were also grown, using Ga_2O_3-doped ZnO targets to supply Ga and N_2O plasma source to incorporate N atoms into the ZnO. The Ga-N codoped films grown at 550°C showed p-type conduction, with typical hole concentration and mobility of 3.9 x 10^{17} cm^{-3} and 0.4 cm^2/vs. The ZnO/ZnO p-n diodes fabricated on Al_2O_3 wafer show characteristic retifying I-V curves. Further details of the electrical, structural and optical properties of the films will be discussed during the presentation.

KF-08(초) **A study of electric, magnetic and optical properties of impurity doped ZnO** 조 용찬(Yong-Chan Cho), 김 성진(Sung-Jin Kim), 이 현준(Su-Young Cha), 조 채룡(Chae-Ryong Cho), 정 세영(Se-Young Jeong)(*부산대학교 나노융합기술학과 (Pusan National University, Dept. of Nano fusion technology).*) 다기능을 갖는 물질을 찾기위한 방대한 연구와 이론적 접근이 이루어져 왔지만 ZnO 만큼 다양한 분야에서 활용되는 물질을 많지 않다. ZnO는 LED, LD 용은 물론이고 투명전극용 소재로서, 자성반도체에서 상온 자상을 얻기 위한 좋은 물질로서 아주 많은 연구의 대상이 되고 있다. 본 연구에서는 이 ZnO에 Al을 첨가하여 상온에서 투명전극을 만드는 연구를 진행해 왔으며 특히 무기물 기판이 아닌 유기물 기판위에 AZO를 증착하여 투명전극으로 활용하는 연구에 대한 결과를 발표한다. 또한 자성반도체의 origin에 대한 실험적, 이론적 연구결과들이 일관적이지 못한 시점에서 수소를 통한 자성의 효과를 체계적으로 보임으로써 ZnO가 자성반도체를 구현하는 굳건한 기본 물질임을 확인하고자 한다. ZnCoO에 수소를 임의로 주입하고 추출함으로써 자성에 대한 변화가 가역적이며 수소의 양의 조절에 의해 자성의 크기가 최대 100배까지 증가할 수 있다는 결과는 앞으로 이분야의 연구에 좀 더 관심을 가져야 할 필요성을 제시할 것이다.

■ SESSION P1
10월 18일(목), 14:30 - 16:15
장 소: 5층 포이어

Dp-001 **Significant increase of the ferroelectric phase transition temperature in partially deuterated KH_2PO_4 by proton-irradiation** KIM SE-HUN, LEE KYU WON[1], LEE CHEOL EUI[1](*Faculty of Science Education and Educational Research Institute, Cheju National University, Cheju 690-756, Korea. [1]Department of Physics and Institute for Nano Science, Korea University, Seoul 136-713, Korea.*) The ferroelectric phase transition temperature was significantly raised by 5 K in partially deuterated KH_2PO_4 (DKDP) irradiated by a proton beam. Increase in the hydrogen bond length was indicated by the dielectric constant analysis. Deuteron (^{2}H) nuclear magnetic resonance (NMR) measurements of the electric field gradient (EFG) tensor showed atomic displacement after the proton irradiation, and ^{31}P NMR measurements of the chemical shift tensor revealed phosphorous displacement in the hydrogen-bonded direction and the PO_4 tetrahedral distortion. Increase of the phase transition temperature can be closely related to the structural modification involving the hydrogen-bond geometry.

Dp-002 **^{1}H NMR spin–spin relaxation in TlH_2PO_4 undergoing separated antiferroelectric and ferroelastic phase transitions** KIM SE-HUN, LEE K-S.[1], LEE KYU WON[2], LEE CHEOL EUI[2](*Faculty of Science Education and Educational Research Institute, Cheju National University, Cheju 690-756, Korea. [1]School of Nano Engineering, Inje University, Gimhae 621-749, Korea. [2]Department of Physics and Institute for Nano Science, Korea University, Seoul 136-713, Korea.*) We have investigated hydrogen-bonded TlH_2PO_4 (TDP), undergoing separated antiferroelectric and ferroelastic phase transitions, by means of ^{1}H nuclear magnetic resonance (NMR) spin–spin relaxation, which gave two distinct decay constants attributed to the lattice diffusion and dynamically disordered hydrogen bonds. A frustrated proton dynamics of the H-bond defects, with an increased activation energy, was identified in association with the ferroelastic phase transition in the system, throwing new light onto the microscopic nature of the phase transitions in the KH_2PO_4 (KDP)-type crystals.

Dp-003 **Raman spectra of cholesterol** 이 수경, 박 치영, 김 금채, 전 민현, 이 광세(*인제대 나노시스템공학과.*) A Raman spectroscopic study has been carried out on cholesterol in the crystalline state, in order to obtain some empirical correlations between the Raman spectra and structure of each cholesterol form. Although the Raman spectra of cholesterol are highly complex, it was found that three regions of the spectrum yield considerable information about the crystalline chain packing in each form. They are: (1) the low frequency region below 300 cm-1, giving information on the inter- and intra-molecular vibrations in the cholesteryl moiety; (2) the methylene rocking/deformation region between 1400 and 1500 cm-1 giving information on chain packing in the crystalline state, and (3) the C-H stretching region between 2700 and 3100 cm-1 which appears to indicate that there is a correlation between branching in the side chains of the cholesterols, polarity of the substituent groups and relative chain order in the packing arrangements in the crystalline state. A study of two branched chain aerosol derivatives, bis(di2-octyl) sodium sulphosuccinate and its isomer bis(di-2-ethylhexyl) sodium sulphosuccinate, indicate that branched chain amphiphiles are good Raman spectroscopic models for the cholesterols, similar to previous Raman spectroscopic studies which have found straight chain amphiphiles to be good models for more complex phospholipids.

Dp-004 **X선 소각산란장치용 2차원 검출기의 개발과 시험** 천 종규, 문 명국[1], 이 창희[1], 최 영현[1], 정 봉근[1], 박 태원[1], 송 현훈[2], 전 혜진[2](*경북대학교 물리학과/한국원자력연구원. [1]한국원자력연구원. [2]한남대학교.*) 한국원자력연구원은 X선 소각산란용 2차원 검출기를 개발하여, 한남대학교 송현훈 교수 그룹과 함께 일반 X-선원 (conventional X-ray)을 이용하여 소각산란장치를 구성, 그 특성을 평가하였다. 광학장치는 집속 거울을 사용하였으며 본 연구원에서 개발한 검출기와 계측계통은 자체적으로 설계, 제작한 것으로서 일반 X-선원에서도 고감도의 결과를 얻을 수 있는 고성능 소각산란장치를 경제적으로 구성할 수 있게 할 것이다. 본 검출기는 기체 충진형 2차원 다중선 비례계수기 (MWPC: Multi-Wire Proportional Counter) 구조로서, 검출 유효면적 120 mm x 120 mm, 검출기 창 두께가 0.4 mm의 탄소섬유판을 사용하여 최대 5기압까지 견딜 수 있고, 8 keV X선에 대해 약 80%의 투과율을 갖는다. 본 발표는 제작된 검출기의 동작 특성과 실험실 X선 소각산란장치에 적용한 초기 결과를 보고한다.

Dp-005 **Polymerization of Conducting Polymers inside Carbon Nanotubes** NAM Youngwoo(*School of Physics and Astronomy, Seoul National University.*) There has been a intense study on the impregnation of carbon nanotubes with various subsutances. We are also attempting to impregnate conductiong polymers such as polyacetylene, polypyrrole, and poly N-vinyl into the carbon nanotubes using supercritical carbon dioxide. To make sure that these conducting polymers are truly inserted, we make characterizations by means of analysis techniques. Furthermore we are plannning to make a measurement on it's low dimensional properties.

Dp-006 **Quasiclassical Approach on Smooth or Sharp Crossover of the Escape rate in Nanomangetic Systems with Higher-Order Symmetry** KIM Gwang-Hee(*Sejong Univ., Dept. of Physics.*) Smooth or sharp crossover of the escape rate is studied in nanomagnetic systems with truly axial symmetry and a large spin within the framework of the quasiclassical approach. The nonlinear perturbation method is employed to obtain the crossover diagram for first- and second-order crossovers. It is found that the regime for the first-order crossover is greatly enhanced or suppressed depending on the sign of the higher-order axial term, while it is greatly suppressed by the external magnetic field. These features can be tested experimentally in nanomagnetic systems.

Dp-007 **Observation of Fabry-Perot interference with anomalous conductance steps in a single-walled carbon nanotube** 김 소라, 김 종기, 우 병칠, 김 진희, 김 남, 김 주진[1](*한국표준과학연구원, 전략기술연구부. [1]전북대학교, 물리학과.*) We made transport measurements on a single walled carbon nanotube (CNT) at low temperatures. The CNT had been grown by the conventional CVD technique. The length of the CNT was about 3 micrometer. We attached four Pd electrodes with different length of segments in order to check the length dependence of the transport characteristics. The CNT showed p-type characteristics. We also observed Fabry-Perot interference superposed on large conductance oscillations which evolved into anomalous conductance steps as temperature increased. Those features were observed irrespective of the length of the CNT but the threshold voltage of V_g moved to negative bias direction as the length increased.

Dp-008 **Mechanical Test and Properties of Multi Walled Carbon Nanotube** JANG hoon-sik, LEE Yun-hee, BAEK Un-Bong, PARK Jong-seo, NAHM seung-Hoon(*한국표준과학연구원.*) Tensile test of an individual multi walled carbon nanotube (MWCNT) was carried out by means of nano-manipulation system inside a scanning electron microscope and then the strength characteristics of MWCNT were evaluated. The force sensor was cantilever type and was mounted on the nano-manipulator. The nano-manipulator was controlled by personal computer. An individual MWNT was attached on the rigid support and the tip of force sensor using electron beam and then tensile test was performed. After tensile test, the fractured area of a MWCNT was also observed by transmission electron microscope (TEM). The tensile strength of a MWNT was 41.01 GPa and the elastic modulus of a MWNT was obtained at 0.98 TPa.And also, the response of MWCNT to mechanical strain, applied using a tungsten tip via a nano-manipulator controlled by a personal computer, was investigated inside a scanning electron microscope. The contact resistance between a MWCNT and the tungsten tip decreased during exposure to the electron beam. The electrical resistance was significantly changed until fracture occurred. When the nanotube was fully elongated, the value of resistance increased to ~1.79 times as the initial value was measured. It was also observed that the resistance increased abruptly in the beginning of tube fracture. As the nanotube was further fractured, the electrical resistance was finally measured to be infinite. Besides, the value of the electrical resistance was maintained in stable during the elongated state of the tube, and then the resistance value completely recovered to initial value of resistance after the tube length recovered to initial state.

Dp-009 **ZnO 박막을 이용한 ZnO 나노선의 합성 및 특성조사** 최 석철, 이 창민, SAKET asthana[1], 도 중회[1], 손 상호[1](*경북대학교 나노과학기술학과. [1]경북대학교 물리학과.*) ZnO는 다양한 형태의 나노 물질로 제작하기 쉽고, 다양한 기능성을 가지기 때문에 많은 관심을 끌고 있다. VLS 방법을 이용하여 ZnO 박막이 증착된 ZnO/Si 기판 위에 ZnO 나노선을 성장시키고 특성을 조사하여 ZnO나노선의 응용 가능성을 조사해보았다. 스퍼터링 방법으로 Si 기판위에 ZnO 박막을 증착시켰다. ZnO박막의 두께는 약 100nm이고 SEM 이미지 측정 결과 두께가 비교적 균일함을 알 수 있었다. 그리고 전기로를 이용하여 VLS방법으로 ZnO박막 위에 ZnO 나노선을 성장시켰다. 시작물질은 Zn 금속 분말 또는 ZnO분말와 탄소 나노분말을 1:1 비율로 혼합한 분말을 이용하였고, ZnO/Si 기판과 시료와의 간격은 수직으로 4mm 정도이다. 성장온도는 800-1000°C이고, Ar+O_2 혼합가스를 30-40 sccm으로 흘렸으며, 성장 시간은 20-60분이다. 이러한 조건으로 성장시켰더니, ZnO박막에 부분적으로 수직 정렬된 나노선이 성장되었음을 확인하였다. XRD 측정결과 ZnO(00l) 피크가 가장 강한 피크임을 확인하였다.

Dp-010 **Controlled growth of multi-walled carbon nanotubes using Ninanoparticle arrays** 지 승묵, 방 재호, 홍 영규, 김 한철[1], 김 창수[1], 하 동한[1], 이 태진[2], 구 자용[3](*한국표준과학연구원 이종성장제어연구단. [1]한국표준과학연구원 첨단산업측정그룹. [2]강원대학교 물리학과. [3]표준과학연구원 이종성장제어연구단.*) For the controlled growth of a single carbon nanotube (CNT) from a single catalytic nanoparticle over wide area of the substrate, the optimal growth conditions are investigated. Nano-sized Ni particles, C_2H_4 gas, and mixture of H_2 and Ar gases are used as the catalytic seed, carbon feedstock, and carrier gases, respectively. To make Nano-sized Ni particle array, we used the e-beam lithography and ion milling technique. The position and size of Ni particles can be controlled continuously by using this techniques. The diameter of the CNT can be controlled down to below 20 nm by changing the size of Ni particle. Under optimal growth conditions of temperature, C2H4, and H2/Ar composition, a single CNT can be grown from each Ni nanoparticle with controlled position, diameter, and, wall thickness with almost 100% probability over wide area of SiO2/Si wafer.

Dp-011 **Spontaneous growth of single-crystalline Ge nanowires using Ni seed layers** KIM Sung-Kyu, KANG Kibum[1], JO Moon-Ho[1](*POSTECH, Department of Materials Science and Engineering, Center for Information Materials. [1]POSTECH, Department of Materials Science and Engineering.*) We report a spontaneous growth of single-crystalline Ge nanowires seeded on Ni/SiO_2/Si substrate by chemical vapor deposition (CVD) of GeH_4. We found that the nanowires grow preferentially on the Ni film thickness below 2nm without the presence of Ni-Ge alloy tips at the end of Ge nanowires. Our observation of spontaneous growth of Ge nanowires is qualitatively different from the so-called vapor-liquid-solid mechanism that uses a liquid alloy droplet as a growth template. We discuss our observations based on a base-growth model, where Ni thin films play as solid-phase seeds on the growth of single-crystalline Ge nanowires. *This work was supported by the Korean Research Foundation Grant from the Korean Government (KRF-2005-005-J13103)

Dp-012 **Growth of Ultra-long Carbon Nanotubes** SO Hye-Mi, JEON Eun-Kyoung, CHANG Hyunju, KONG Jing[1], HOFMANN Mario[1], LEE Jeong-O(*한국화학연구원, 융합바이오*

기술연구센터. [1]Massachusetts Institute of Technology.) We report the growth of ultra-long carbon nanotubes by chemical vapor deposition method. Both methane and ethanol could be used as a carbon source, and low feeding rate below 50 sccm was crucial in the case of methane growth. In both cases, ultra-long nanotubes ranging from several hundreds of microns to several millimeters can be easily reproduced, while only short nanotubes can be produced with patterned growth technique, at the same growth conditions. Our results suggest that there exist a strong relationship between the catalyst size and the length of the nanotubes, and we will discuss the details.

Dp-013 **Micro-crystals of proton conductor CsH_2PO_4 : a first step toward nano-crystals** 이 수연, 이 지수, 황보 수정, 전 민현, 이 광세(*인제대 나노시스템공학과.*) Crystalline proton conductor CsH_2PO_4 (CDP) exhibits high conductivity (more than 10^{-2} Ω^{-1} cm^{-1}) as a cubic phase ($T > T_{sp}$=503 K). Recently, the possibility of using CDP in a fuel cell operating at moderate temperature was demonstrated. Despite good cell performance, long-term stability is strongly influenced by thermal decomposition and subsequent formation of the low-conductive meta-phosphate phase. To improve performance and thermal stability, it is important to understand the origin of the physical-chemical processes and their influence on the protonic conductivity. The results of the previous studies showed that these phenomena are very sensitive to the temperature, quality of the material and preparation technique (mechanical and thermal treatment during the synthesis, atmospheric humidity). Thus, detailed investigations need to be completed in order to improve the CDP performance. In the first place, it demands the separation of the bulk and surface phenomena occurring in the material at working temperatures. A study concerned with controlling particle morphology and size of CsH_2PO_4 was conducted by modifying the precipitation method and varying the types of adding solvents to aqueous solutions of Cs_2CO_3 and H_3PO_4. Polyols of ethylene glycol were mixed with methanol and added into the solution. The obtained samples were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM) and Raman spectroscopy. The possible agglomeration is discussed compared to bulk with their morphologies.

Dp-014 **Raman Scattering from Digital Alloy InGaAs/InAlAs** 민 경인, 노 희석, 송 진동[1], 최 원준[1](*전북대학교, 물리학과. [1]한국과학기술연구원, 나노소자연구센터.*) InGaAs/InAlAs 디지털 초격자 구조에 대한 라만 산란 결과를 보고한다. InGaAs 층과 InAlAs 층의 두께 및 비율 변화에 의한 격자진동 에너지의 변화를 연구하였다. 라만 산란 실험을 통해 InAs-like, GaAs-like, AlAs-like longitudinal optical (LO) phonon 모드를 235, 265, 368 cm^{-1} 근처에서 각각 관측하였다. InGaAs 층의 두께를 점점 감소시킴에 따라 GaAs-like LO phonon 에너지가 점점 줄어들었다. 이와 대조적으로, AlAs-like LO phonon 에너지는 두께나 비율 변화에 영향을 받지 않고 거의 일정하였다. 이러한 결과는 디지털 초격자 구조에서 나타나는 속박 효과와 층 사이의 계면 형성과 연관이 있는 것으로 보인다.

*이 논문은 2006년 정부(교육인적자원부)의 재원으로 한국학술진흥재단의 지원을 받아 수행된 연구임 (KRF-2006-005-J00302).

Dp-015 **Raman Studies of GaN Structure grown by Epitaxial Lateral Overgrowth Technique** 송 지선, 이 경연, 노 희석, 주 진우[1], 장 이운[1], 이 인환[1](*전북대학교, 물리학과. [1]전북대학교, 신소재공학부.*) Epitaxial lateral overgrowth (ELOG) 기법을 이용해 성장시킨 GaN 구조에 대한 라만 산란 실험 결과를 보고한다. (0001) 사파이어 기판 위에 성장된 GaN 완충 층 위에 일정 간격의 SiO_2 줄무늬를 제작한 후 ELOG GaN 층을 성장시켰다. 라만 산란 실험으로부터 567 cm^{-1}와 734 cm^{-1}에서 강한 E_2와 A_1(LO) 격자진동 모드를 확인하였다. E_2 격자진동 모드의 낮은 에너지 영역과 A_1(LO) 격자진동 모드의 높은 에너지 영역에 부가적인 산란이 관측되었다. 이외에도 532cm^{-1}에서 약한 라만 산란 반응이 관측되었는데 이는 TO 또는 LO phonon-plasmon 결합 모드와 연관이 있는 것으로 생각된다. ELOG GaN 구조의 위치나 운반자 농도의 변화에 따라 phonon 에너지의 변화가 있음을 확인하였다.

*이 논문은 정부(교육인적자원부)의 재원으로 한국학술진흥재단의 지원을 받아 수행된 연구임 (KRF-2006-005-J00302, KRF-2007-521-D00296).

Dp-016 **Tuning Double-Walled Nanotube Devices with Self-Assembled Monolayer of Molecules** 전 은경, 김 효숙[1], 김 병계[1], 소 혜미, 박 동원, 황 재호, 부 경호, 공 기정, 장 현주, 김 주진, 이 정오(*한국화학연구원. [1]전북대학교.*) The electrical transports of double-walled carbon nanotube field effect transistors (DWCNT-FETs) with modified contacts have been investigated. Source and Drain contact electrodes of DWCNT-FETs were irreversibly modified with self-assembled monolayer (SAM) of 2-aminoethanethiol molecules. In ambient, contact-modified DWCNT-FETs show decreased conductance in the p-channel (negative gate voltages) and small increase in the n-channel (positive gate voltages), while the original device shows clearly p-type transport both in air and in vacuum. In vacuum, n-channel current in contact-modified DWCNT-FET started to rise, and clear n-type transport observed in high vacuum. Almost no change of gate threshold voltages was observed by contact-modification with SAM. While semiconducting DWCNT-FET shows clear transition from p-type to n-type transistor with contact modification, no apparent changes observed in metallic DWCNT devices. We suggest the tuning of contact schottky barrier by SAM as an effective method to tune the device characteristics of DWCNT-FETs.

Dp-017 **Formation of Quasicrystals as a Function of Cooling Rate in Ti-based Alloys** 김 남혁, 전 재균, 이 윤만, 손 성우[1], 김 도향[1](*한양대학교 물리학과. [1]연세대학교 금속시스템공학과.*) Contrary to crystals, quasicrystals are quasi-periodic and long range ordered materials showing 5-fold rotational symmetry which is forbidden in solid state physics. Since the first discovery by Shechtman in 1984, the reasons for the formation of quasicrystals have been puzzled. Although most of the quasicrystals are found in Al-based alloys, Ti-based quasicrystals are actively studied because of many potential technical applications. We successively synthe-

sized quasicrystals by rapidly quenching a molten alloy of Ti-Zr-Ni on a high speed rotation stainless steel wheel in an Ar atmosphere. X-ray diffraction (XRD) and transmission electron microscopy (TEM) investigations confirmed that qasicrystals are formed in a large variation of Ti from 33 to 50 at. % when Ni concentration was fixed to 17 at. %. This observation suggests that the Ti and Zr are exchangeable in quasicrystals because of the similar structural and electrical properties. The phase stability of the alloys from the metallic glass to the solid state phase were investigated as changing the cooling rate, and the results will be presented.

Dp-018 **Electrical property modification of 1-dim nanochannel with in-situ metal cluster coatings** 김 효숙, 김 병계, 정 두원, 김 주진, 이 정오[1](*전북대 물리학과. [1]화학연구원.*) The electrical transport of 1 dimensional nanochannel such as nanotube and nanowire coated with metal clusters have been investigated. To avoid contact effect, we prepared contact-covered devices. It has been demonstrated that the use of metal cluster coatings on nanoscale structures can deplete or populate carriers locally, thereby making the device either sensitized or ineffective toward molecular adsorption. Here, we apply this concept to nanotube and nanowire based field effect transistor, and investigate the effect of different metal clusters on their electrical transport and chemical sensing properties. Metal clusters with different work functions, namely Pd, Au, Co and Al, have been used as typical metal clusters with high and low work function metals. Metal nano-particle decoration in a high vacuum caused the devices to change carrier concentrations, or even carrier types, depending on work function of metals. We will present the gate transfer characteristics of nanotube and nanowire devices before and after metal coatings with different work functions.

Dp-019 **Electron beam pattern generation on KrF and ArF photoresist for surfactant-aided supercritical carbon dioxide drying** 노 영섭, 김 주진, 이 민영[1], 임 권택[1](*전북대 물리학과. [1]부경대학교.*) Nanostructures in the range less than 150 nm require the formation of patterns with high aspect ratio (line height/line width) which tend to collapse during fabrication steps. The pattern collapse generally refers to the deformation, fracture, and/or peeling of resist from the substrate mainly due to the surface tension of the rinse liquid. To prevent pattern collapse, a rinse solution with smaller surface tension should be used in the drying stage. Supercritical CO_2 drying has been proposed as a viable option to resolve this issue because the surface tensionof saturated liquid CO_2 is only 1.5 mN/m at 25 C and reaches zero at the critical point. To pattern nanostructures on hybrid type KrF and ARF photoresist, we used electron beam expose technique. SEM images confirmed that the positive resist patterns with line spacing 100 nm were preserved without any deformation or damage by rinsing with de-ionized water followed by surfactants-aided $scCO_2$ drying.

Dp-020 **Controlled modifications of electrical properties in ZnO nanowire field effect transistors by gas molecular adsorption** 노 영섭, 오 황유, 김 주진, 이 정오[1](*전북대학교 물리학과. [1]화학연구원.*) To explore the effect of gas molecular adsorption on the electrical properties of ZnO nanowires, we measured the I-V_g characteristics under various pressures at room temperature. As the pressure is lowered from the atmosphere to a high vacuum ~ 10^{-6} torr, the channel current increases and the threshold voltage (V_t) in the I-V_g curve shifts to the negative V_g direction from -5 V to below -20 V. The negative shift of V_t correspond to desorption of gas molecules especially, OH or O_2 from the surface of nanowire during pumping. Rapid change in threshhold voltage in high vacuum region has been observed reproducibly, which suggests the different adsorption mechanism in low (P >10^{-3} torr) and high vacuum (P <10^{-3} torr) regions. One is the weak form of chemi-sorption (or physi-sorption) and the other the strong form of chemi-sorption, respectively. By adjusting the amount of the adsorbed gas molecules, we could tune the carrier concentrations, that is, doping level in ZnO nanowire devices.

Dp-021 **극성이 다른 용액에서 ZnO 나노결정 성장** 문 병기, 박 진영, 정 홍채, 정 종원, 정 중현, 최 병춘, 전 병억, 이 성수[1], 김 중환[2], 김 청식[3](*부경대학교 물리학과. [1]신라대학교 전자재료공학과. [2]동의대학교 물리학과. [3]부산대학교 물리학과.*) ZnO 는 bandgap 에너지가 3.37eV인 n형 반도체이며, 투명전극으로 사용하고 있고, spintronics에 응용이 가능한 물질로 기대되고 있으며, 격자상수가 3.249Å, 5.201Å인 hexagonal(wurzite) 결정구조이다. 본 연구에서는 극성이 다른 여러 용액에서 solvothermal 방법으로 ZnO 나노결정을 성장하였으며, 결정의 성장속도와 ZnO의 morphology가 용액의 극성에 따라 달라짐을 연구하였다. Cyclohexane, benzene, toluene 등 비극성 용매에서 성장한 ZnO 나노결정은 길이 250-300nm, 굵기 70nm인 육각기둥의 모양으로 c-축 방향으로 성장하였으며, ethanol, 2-propanol, 2-methoxyethanol 등 alcohol 용매에서 성장한 ZnO 나노결정은 굵기 10nm, 길이 100nm의 육각기둥들이 다발로 성장한 모양이었다. Acetone, water, chlorobenzene 등 극성이 큰 용매에서 성장한 나노결정은 길이 1-2um, aspect ratio가 10 이상이고, 양끝이 잘 발달한 긴 육각기둥의 형태로 성장하였다.

Dp-022 **용액의 극성에 따른 Zno 나노결정의 morphology 제어** 문 병기, 박 진영, 정 홍채, 정 종원, 정 중현, 최 병춘, 전 병억, 이 성수[1], 김 중환[2], 김 청식[3](*부경대학교 물리학과. [1]신라대학교 전자재료공학과. [2]동의대학교 물리학과. [3]부산대학교 물리학과.*) 나노물질은 크기에 따른 효과와 표면에 의한 효과가 크게 나타나며, 나노결정의 형상과 크기를 제어하는 것은 나노기술의 한 과제이다. 본 연구에서는 극성이 다른 두가지 용매를 여러 비율로 혼합한 용액에서 solvothermal 방법으로 ZnO 나노결정을 성장하였으며, 용액의 혼합비율에 따라 ZnO 나노결정의 크기와 형상을 조절하였다. Toluene과 2-propanol의 혼합용액에서는 ZnO의 a축과 c축의 길이 비와 크기를 조절하는 것이 가능하였으며 2-propanol의 양이 많을수록 결정의 두께는 줄어들고 aspect ratio는 증가하였다. Toluene과 THF의 혼합용액에서는 ZnO 나노결정의 크기를 조절하였고 THF의 양이 증가할수록 크기가 작아졌다. 물과 2-propanol 혼합용액에서는 결정의 형상이 조절 가능하였고 물의 양을 증가시켰을 때 ZnO의 모양이 육각기둥의 다발이 점차 없어

지고 육각 기둥의 모양을 나타내었다.

Dp-023 **The effect of dispersants in dispersing carbon nanotubes for flexible transparent conducting film** PARK Hyeon-ki, KIM Ki Kang, KIM Soo Min, BEA Jung Jun, GENG Hong Zhang, LEE Young Hee(*성균관대학교 물리학과.*) Abstract- Carbon nanotubes (CNTs) were dispersed by using different dispersants in aqueous solution; anionic sodium dodecylbenzene sulfonate (NaDDBS), non-ionic triton X-100 (TX-100), and cationic cetyltrimethylammonium bromide (CTAB). The flexible transparent conducting films (TCFs) were prepared by using the prepared CNT solution with spray method. The TCFs were then immersed in acidic solution (HNO_3) for some time. The variation of the sheet resistance by acid treatment depend on the interaction energy between dispersant and CNTs. The interaction nature was characterized by UV-Vis-NIR, Raman spectrum, electrophoretic light scattering and scanning electron microscopy.

Dp-024 **Tailoring Electronic Structures of Carbon Nanotubes by Solvent with Electron-Donating and Withdrawing Groups** SHIN HYEON-JIN, KIM SOO MIN[1], YOON SEON-MI, BENAYAD Anass, KIM KI KANG[2], KIM SUNG JIN[2], PARK HYUN KI[2], CHOI JAE YOUNG, LEE YOUNG HEE[2](*Samsung Advanced Institute of Technology. [1]SKKU Advanced Institute of Nanotechnology. [2]성균관대학교 물리학과.*) Various dispersants and solvents have been utilized to disperse carbon nanotubes. This often involves a serious modification of the electronic structures of carbon nanotubes. The presence of functional groups may induce a permanent or an induced dipole moment in molecular solvent. This presumably involves a charge transfer between absorbates and carbon nanotubes, modifying the electronic structures of carbon nanotubes. Various electron donating and with-drawing groups in aromatic and aliphatic backbones of solvent were introduced to tailor the electronic structures of single-walled carbon nanotubes (SWCNTs). In case of solvent with a withdrawing group, electrons were extracted mainly from metallic SWCNTs, whereas small charge transfer was also observed in semiconducting SWCNTs. On the other hand, in case of solvent with a donating group, electrons were donated to both metallic and semiconducting SWCNTs. This effect was less prominent in solvent with an aliphatic backbone than that with an aromatic backbone. The change of the sheet resistance of the SWCNT film under various solvent treatments was explained by the modulation of Schottky barrier height at the junction between metallic and semiconducting carbon nanotubes that resulted from the modification of electronic structures of nanotube networks by solvent.

Dp-025 **Synthesis of Vertically Aligned Carbon Nanotubes Using Remote Plasma-enhanced Chemical Vapor Deposition** LEE ILHA, HAN GANGHEE[1], KIM EUNSUNG[1], LEE YOUNGHEE[2](*BK21 Physics Division, Department of Nanoscience and Nanotechnology, SKKU Advanced Institute of Nanotechnology. [1]BK21 Physics Division, Department of Physics, SKKU. [2]BK21 Physics Division, Department of Physics, CNNC, SKKU Advanced Institute of Nanotechnology.*) Vertically aligned carbon nanotubes (CNTs) have been successfully grown by remote rf plasma-enhanced chemical vapor deposition (PECVD) with the gas mixtures of Ar, C_2H_4, H_2, and O_2. It is known that the remote PECVD is one of the possible CVDs that can make long and large quantity single-walled CNTs (SWCNTs) with highly active gas species. Catalysts have been prepared with the deposition of Fe/Al by e-beam and thermal evaporator. We have changed the distance between plasma and catalyst samples and observed the effect of distance. The length of CNTs gets longer from scanning electron microscopy (SEM) and the quality of CNTs looks getting worse from Raman spectroscopy as catalyst samples come close to plasma.

Dp-026 **Mass Production of Thin-multiwalled Carbon Nanotubes in High Yield** KIM Eunsung, LEE Ilha[1], HAN Ganghee, KIM Taehyung, BAE Jungjun, LEE Younghee[2](*BK21 Physics Division, Department of Physics, Sungkyunkwan Univ.. [1]BK21 Physics Division, Department of Nanoscience and Nanotechnology, SKKU Advanced Institute of Nanotechnology(SAINT), Sungkyunkwan Univ.. [2]BK21 Physics Division, Department of Physics, SKKU Advanced Institute of Nanotechnology(SAINT), Center for Nanotubes and Nanostructured Composites(CNNC), Sungkyunkwan Univ..*) We have synthesized thin-multiwalled carbon nanotubes (t-MWCNTs) by catalytic chemical vapor deposition (CCVD). Various catalysts such as FeMoMgO with microwave treatment were used. The large-capacity CVD system of a quartz tube with the diameter of 25 cm and the length of 150 cm was designed for mass production. Methane (CH_4), Hydrogen (H_2), and Ethylene (C_2H_4) gases have been used for the growth of t-MWCNTs. In previous paper (J. Phys. Chem. B, 108(46), 17695, 2004), we observed that the yield of t-MWCNTs greatly increased with an addition of small amount of ethylene (C_2H_4) gas. T-MWCNTs were characterized by high-resolution transmission electron microscopy (HRTEM), Raman analysis, field-emission scanning electron microscope (FESEM), and thermo gravimetric analysis (TGA).

Dp-027 **Single-walled Carbon Nanotubes Growth by Plasma Enhanced CVD with Oxygen Gas** LEE younghee, HAN ganghee[1], LEE ilha[2], KIM eunsung[1](*BK21 physics division, Department of Physics, Sungkyunkwan Advanced Institute of Nanotechnology, Center for Nanotubes and Nanostructured Composites, Sungkyunkwan Univ.. [1]BK21 physics division,Department of Physics, Sungkyunkwan Univ.. [2]BK21 physics division,Department of Physics, SKKU Advanced Institute of Nanotechnology.*) We have studied the growth of single-walled carbon nanotubes (SWCNTs) and the effect of oxygen by cold wall PECVD. It is known that the presence of small amount of oxygen species act as an etching agent and increases the yield of carbon nanotubes. Aluminum and Iron were deposited on the SiO_2 wafer by electron beam evaporator as a catalyst. We have optimized conditions for vertically aligned carbon nanotubes. Furthermore, less than 1 sccm of oxygen gas was fed during the SWCNT growth. It was confirmed that oxygen gas is "fully" effective to remove amor-

phous carbon-like residue. RAMAN spectroscopy and Tunneling Electron Microscopy (TEM) data were also discussed.

Dp-028 **Improvement of interfacial strength between alumina and carbon nanotube for the highly reinforced ceramic composite** LEE younghee, KIM taehyung, SO kangpyo, KIM sungjin, SONG cheolho(*BK21 Physics Division, Department of Physics, Center for Nanotubes and Nanostructured Composites, Sungkyunkwan Advanced Institute of Nanotechnology, Sungkyunkwan University, Suwon 440-746, Republic of Korea.*) The Multiwalled carbon nanotube(MWCNT) and alumina composite were fabricated by sol-gel method. For increasing interfacial adhesion between MWCNT and alumina, poly(styrene sulfornic acid) were introduced as an intermediate precursor. The formation of robust aluminum carbide at the interface between alumina and nanotubes was confirmed by X-ray diffraction(XRD). The well dispersed ceramic particles on the MWCNT were clearly seen in the scanning electro microscope (SEM). The morphology of the composite and the quantity of carbide and alumina were confirmed in terms of transmission electro microscope(TEM) and thermogravimetric analysis(TGA)

Dp-029 **Effect of Chemical and Plasma Treatment on Carbon Nanotube-based Flexible Transparent Conducting Films** LEE DaeSik, GENG Hong Zhang[1], KIM TaeHyung[2], KIM KiKang[2], LEE YoungHee[2](*BK21 Physics Division, Department of Physics, Center for Nanotubes and Nanostructured Composites, Sungkyunkwan University. [1]BK21 Physics Division, Department of Nanotechnology and Nanoscience, Center for Nanotubes and Nanostructured Composites, Sungkyunkwan Advanced Institute of Nanotechnology, Sungkyunkwan University, Suwon 440-746, Republic of Korea. [2]BK21 Physics Division, Department of Physics, Center for Nanotubes and Nanostructured Composites, Sungkyunkwan Advanced Institute of Nanotechnology, Sungkyunkwan University.*) Single-walled carbon nanotube (SWCNT)-based transparent conducting films were fabricated by using a spray method. These TCFs were further treated by acids and atmospheric plasma to investigate the film performance. We found that the adhesion between the CNT film and substrate was improved during repetition of these treatments, while the sheet resistance decreased with a negligible change in the transmittance in the visible range. The change of conductivity was also confirmed by the BWF line in Raman G-band.

Dp-030 **A study on the electrical characterization of nano-floating gate capacitor with the multi-layer of SiC nano-particles** LEE Tae Hee, LEE Dong Uk, KIM Seon Pil, KIM Eun Kyu(*Quantum-Function Spinics Laboratory and Department of Physics, Hanyang University.*) Silicon carbide (SiC) is the compound-semiconductor of group Ⅳ and has many kinds of polytypes. It has attracted much attentions about the high-power electronic devices, optical devices. Because the energy band gap and work function are 2.0~3.2 eV and 4.0~4.5 eV, respectively. In this study, we fabricated the nano-floating gate capacitor with the multi-layer of SiC nano-particles embedded in silicon dioxide (SiO_2) layer. SiC nano-particles can display due to the quantum confinement effect at nano-scale. At fabrication process, the nano-floating gate capacitors were fabricated on p-type silicon wafers. After cleaning process of wafer, the growth of 4.5 ㎚ tunnel oxide layer by wet oxidation. Next the SiC layer with a thickness of 8 ㎚ was deposited on the tunnel oxide layer by RF magnetron sputtering. And the additional SiO_2 with a thickness of 50 ㎚ was deposited at 300 ℃. The post-annealing process of samples was carried at 700~900 ℃ for 3 minutes in N_2 ambient by using rapid thermal process (RTP) system. The control oxide layer with 30 ㎚ was deposited at room temperature. Finally, the 150 ㎚-thickness of aluminum gate electrode was evaporated by using thermal evaporator system. The morphology of SiC nano-particles was appeared by using high-resolution transmission electron microscopy (HR-TEM). Also, the electrical characterization of these capacitors was used Boonton 7200 capacitance meter. In summary, we fabricated and characterized the electrical property of nano-floating gate capacitors with the multi-layer of SiC nano-particles. Also, we showed a capability of this structure to application of the nonvolatile memory device.

Dp-031 **Fabricating of Flexible Transparent Conducting Films by Using Nafion-Dispersed Carbon Nanotubes** GENG Hong Zhang, KIM Ki Kang[1], SONG Chulho[1], XUYEN Nguyen Thi, KIM So Min, PARK Kyung Ah[1], LEE Dae Sik[1], AN Kay Hyeok[1], LEE Young Hee[1](*Department of Nanoscience and Nanotechnology, and Center for Nanotubes and Nanostructured Composites, Sungkyunkwan Advanced Institute of Nanotechnology, Sungkyunkwan University, Suwon 440-746, South Korea. [1]Department of Physics, and Center for Nanotubes and Nanostructured Composites, Sungkyunkwan Advanced Institute of Nanotechnology, Sungkyunkwan University, Suwon 440-746, South Korea.*) Flexible transparent conducting films (TCFs) were fabricated on poly(ethylene terephthalate) substrate by a spray method. Single-walled carbon nanotubes (SWCNTs) were dispersed with Nafion as a dispersant in a mixture of deionized water and 1-propanol solvent (bisolvent). Different ratios of SWCNTs to Nafion were used to disperse SWCNTs in bisolvent to optimize the film performance. The quality of CNTs, the degree of dispersion, film morphology and the performance of TCFs were characterized by scanning electron microscopy, transmission electron microscopy, thermogravimetric analysis, Raman spectra, optical spectra, and four-point probe measurements. We found that 1:1 mixing ratio of SWCNTs to Nafion was an optimum value to give rise to the minimum resistance with maximum transmittance. These TCFs with high flexibility and strong adhesion open a room in various fields of applications.

Dp-032 **Many-body states near quantum point contact in a quantum ring** SONG Taegeun, PARK Hee Chul, AHN Kang-Hun(*Department of Physics, Chungnam National University, Daejeon 305-764.*) We investigate the many-body states in a quantum ring which has a quantum point contact using exact diagonalization method. We calculate the ground state energy and wavefunctions as well as those for the excited states. We calculate the

compressibility as a function of the size of the constriction in the ring and discuss the spin-charge relation in the system.

Dp-033 **Chirality-Specific Transport Phenomena of Isolated Singlwalled Carbon Nanotube** LEE young hee, YUN Minhee[1], JEONG Seung Yol[2], PERELLO David[3], KIM Sung Jin[2], JANG Jin Ho[2], KANG Bo Ram, YU Woo Jong, BAE Dong Jae[2] (*Sungkyunkwan Advanced Institute of Nanotechnology. [1]Department of Electrical and Computer Engineering, University of Pittsburgh,. [2]Department of Physics, Center for Nanotubes and Nanostructured Composites. [3]Department of Electrical and Computer Engineering, University of Pittsburgh.*) Singlewalled carbon nanotube-field effect transistors (SWCNT-FETs) have been fabricated using in situ thermal chemical vapor deposition (T-CVD). For isolated devices, the resonant Raman spectra confirmed that the full width at half maximum (FWHM) of the radial breathing mode (RBM) peaks was about 4 cm^{-1}, consistent with atomic force microscopy (AFM) images that clearly revealed the individually isolated SWCNTs on the patterned substrate with a diameter of 1.3 nm. Subsequent I-V measurements of the SWCNT-FET revealed a clear gating effect for samples with semiconducting SWCNTs. The transport phenomena of a device with mixed metallic and semiconducting SWCNTs network were governed by the metallic nanotube with severely suppressed gate modulation. Identification of the chirality of SWCNTs by resonant Raman spectroscopy prior to the I-V characteristics guarantees the validity of working FET devices.

Dp-034 **Intensity Ratio of D/G Band in Ar+ Bombarded Carbon Nanotubes and Their Electrical and Optical Properties.** JANG Jin ho, LIM Seong Chu, CHAI Seung jin[1], LEE Dae sik, PARK Hyeon ki, LEE Young Hee[2](*BK21 Physics division, Department of Physics, Sungkyunkwan Univ.. [1]BK21 Physics division, SKKU Advanced Institute of Nanotechnology, Sungkyunkwan Univ.. [2]BK21 Physics division, Department of Physics, SKKU Advanced Institute of Nanotechnology, Sungkyunkwan Univ..*) Films of single walled carbon nanotubes (SWCNTs) are exposed to Ar ions with different energies and dosages. The dosage of Ar ions was monitored by ion currents and exposure times. On the exposed film, we used Raman spectra to probe indirectly the generation of defect sites on CNTs by comparing the D/G-band intensity. In-situ I-V measurement was employed to monitor the degree of defect creations. The variations of electrical properties of CNT films upon D/G-band ratio were studied.

Dp-035 **The Periodicity of Shubnikov de-Haas Oscillations in an Individual Single-Crystalline Bismuth Nanowire** KIM Jeongmin, SHIM Wooyoung, HAM Jinhee, LEE Wooyoung (*Department of Materials Science and Engineering, Yonsei University, Seoul, Korea.*) Bismuth (Bi) is a particularly favorable material with which to study the electronic properties of quantum wires due to the small effective mass of carriers, low carrier concentrations and the anisotropic Fermi surface. These characteristics and the resonance of Landau levels lead to prominent Shubnikov-de Haas (SdH) oscillations that are periodic 1/H. The period of SdH oscillations are required to obtain quantitative information such as the charge density and the anisotropy of Fermi surface. However, it is expected that the period of oscillations can be varied by the spatial confinement in one-dimension. The electrostatic-field-effect (EFE) also modulates the charge carrier concentrations and the Fermi surface, resulting in change of period of SdH oscillations [1]. In the present work, we report the observation of the modulated period of oscillations by the spatial confinement and EFE in an individual single-crystalline Bi nanowire. The SdH oscillations are periodic in 1/H with period of $\Delta(1/H) = 2\pi/\hbar cA$, which is inversely proportional to the extremal cross-sectional area A of the Fermi surface in the plane normal to H. We observed that the period of SdH oscillations in transverse (T) geometry is $\Delta(1/H)_{T,h} = 0.074\ T^{-1}$, $\Delta(1/H)_{T,e1} = 0.16\ T^{-1}$, and $\Delta(1/H)_{T,e2} = 0.77\ T^{-1}$, which is in good agreement with those of Bi thin film and bulk Bi [2]. It is due to that there are three different A: $A_{T,h}$ from the holes, and $A_{T,e1}$, $A_{T,e2}$ from the electrons. In longitudinal (L) geometry, however all three electron ellipsoids are equivalent, there are only two extremal cross sections $A_{L,h}$ and $A_{L,e}$, and these are nearly the same, resulting in only one period similar to that of bulk was expected. However, it was found that the period of SdH oscillation in L geometry is $\Delta(1/H)_{L,h} = \Delta(1/H)_{L,e} = 0.24\ T^{-1}$, which is larger than the value of $0.16\ T^{-1}$ and $0.24\ T^{-1}$ reported for bulk Bi [2]. The deviation may be attributable to the spatial confinement arising from scattering at the nanowire boundary. The energy of the Landau level $E_L = (n+1/2)\hbar\omega_c$ ($\omega_c = eH/m^*c$) is expected to highly increase due to the strong spatial confinement [3], since the cyclotron radius is large in L geometry. Thus, it leads to decrease effective mass m* and increase the period due to the period of SdH oscillations can be written as, $\Delta(1/H) = \hbar e/m^*cE_F$. Further description of the deviation of the period in L geometry and the electric field modulation of the period of SdH oscillations will be discussed in detail.

Reference [1] Yuanbo Zhang, J. P. Small, M. E. S. Amori, and P. Kim, Phys. Rev. Lett. 94, 176803 (2005). [2] F.Y. Yang, K. Liu, K. Hong, D.H. Reich, P. C. Searson, and C. L. Chien, Science 284, 1335 (1999). [3] H. Ibach and H. Luth, Solid-State Physics (Springer Verlag, Berlin, 2003).

Dp-036 **Schottky Barrier Engineering in Carbon Nanotube with Various Metal Electrodes** YUN Minhee, LEE Young Hee[1], PERELLO David, KIM Moon J[2], CHA DongKyu[2], HAN Gang Hee[1], BAE Dong Jae[1], JEONG Seung Yol[1], KANG Bo Ram[3] (*Department of Electrical and Computer Engineering, University of Pittsburgh, USA. [1]Department of Physics, Sungkyunkwan University, Republic of Korea. [2]Department of Electrical Engineering, University of Texas at Dallas, USA. [3]Sungkyunkwan Advanced Institute of Nanotechnology (SAINT).*) We investigated carbon nanotube field effect transistors (CNT FET) utilizing semiconducting single-walled carbon nanotubes (SWCNTs). Multiple devices, each of different metal source and drain contacts, were fabricated on long (~11 micron) SWCNT. Large contact resistances around four MΩ were observed at room temperature. Low termperature measurements yielded varying con-

tact resistances for these same devices. Transport properties of the devices follow to the Schottky contact and Poole-Frenkel model with measured 25 – 41 meV barriers for the devices.

Dp-037 **^{1}H NMR spin-lattice study on the phase transition of single crystal $(NH_4)_3H(SO_4)_2$** CHOI S. H., HAN Kee Sung, KANG K. H., MEAN B. J., KIM S. H., KWON D. J, KWON S. G., NAM S. K., CHOI H. H, SUNG S. J, LEE Moohee, LIM Ae Ran[1](*Konkuk University, Department of Physics. [1]Jeonju University, Department of Science Education.*) The ^{1}H NMR experiment has been performed to investigate phase dependent nature of dynamic network of hydrogen bonds of the single crystal $(NH_4)_3H(SO_4)_2$ in the temperature range from 30 to 300 K at 7 Tesla. The crystal has six phases denoted as Ⅰ, Ⅱ, Ⅲ, Ⅳ, Ⅴ, and Ⅵ which is a superionic conductor, ferroelastic, antiferroelectric, incommensurate, antiferroelectric, and ferroelectric, respectively, with the transition temperature of 413, 256, 139, 133, and 63 K in order of the phases. The measured values of T_1 of ammonium and hydrogen-bond are similar to each other in all range of experimental temperature. As temperature decreased the spin-lattice relaxation time, T_1 of ammonium proton and hydrogen-bond proton are linearly decreased and re-increased until the temperature down to 120 K and 70 K, respectively and abruptly decreased at about 60 K, which temperature is ferroelectric phase transition occurring. Although the similar T_1 value, the spectrum obtained at 70 K shows no hydrogen-bond peak and the linewidth is broader than the spectrum obtained at 300 K. In this presentation, the origin of this temperature dependent behavior of T_1 will be discussed.

Dp-038 **Efficient Synthesis of Individual Single-Walled Carbon Nanotube by Water-Based Catalyst with Polyvinylpyrrolidone** JEONG Seung Yol, CHAI Seung jin[1], JEON Sang Hyun[2], HAN Gang Hee[2], AN Kay Hyeok[2], BAE Dong Jae[2], LIM Seuong Chu[2], HWANG Ha Ryong[3], HAN Chang Soo[4], YUN Minhee[5], LEE Young Hee[6](*Department of Physics, Institute of Basic Science, Sungkyunkwan University. [1]BK21 Physics division, Sungkyunkwan Advanced Institute of Nanotechnology (SAINT). [2]Department of Physics, Center for Nanotubes and Nanostructured Composites (CNNC). [3]Woojin Instrument &System Engineering Control. [4]Nanomechanisms Groups, Korea Institute of Machinery &Materials. [5]e Department of Electrical and Computer Engineering, University of Pittsburgh. [6]Department of Physics, Center for Nanotubes and Nanostructured Composites (CNNC), Sungkyunkwan Advanced Institute of Nanotechnology (SAINT).*) Individual single-walled carbon nanotubes (SWCNTs) were synthesized on the patterned water-soluble catalyst by thermal chemical vapor deposition. The individual SWCNTs were obtained by introducing polyvinylpyrrolidone (PVP) as a dispersant. The number of SWCNTs between two electrodes were approximately 1~2 with an average diameter of about 1.7 nm and a yield of forming electrodes of nearly 70 %. The PVP played an important role in dispersing catalysts and suppressing the active sites to limit the number of SWCNTs during synthesis, which is a critical condition for fabrication of field effect transistors (FETs). The measured I-V characteristics of the over layer-deposited electrodes revealed a clear gating effect in large portion, in good agreement with Raman observations in several excitation energies. The patterning procedure, catalyst preparation, and growth condition for fabrication of the SWCNT-FET were further discussed.

Dp-039 **Poly sodium 4-styrenesulfonate (PSS) intercalated graphite oxide** JIN Mei Hua, LEE Yun Pyo, JEONG Hae Kyung, AN Kay Hyeok[1], LEE Young Hee[2](*Department of Physic, Sungkyunkwan University. [1]Jeonju Machinery Research Center, Jeonju. [2]Department of Physic, Center for Nanotubes and Nanostructured Composites, Sungkyunkwan Advanced Institute of Nanotechnology, Sungkyunkwan University.*) Graphite oxide (GO) has been revisioned recently due to possible applications to energy storage devices and a possible use for graphene layers by reduction. However, the interlayer distance can be expanded/contracted during charge/discharge cycles. Thus it is necessary to keep the interlayer distance irrespective of the charging conditions. We present here that Poly sodium 4-styrenesulfonate (PSS) intercalated graphite oxide has expanded interlayer distance further, which is larger than that of GO, confirmed by X-ray diffraction. In addition, the PSS-intercalated graphite oxide shows stable interlayer structure after annealing at 200 °C.

Dp-040 **이온조사를 이용한 전계방출원의 특성 분석** 김 창득, 강 준태, 김 홍정, 이 성엽[1], 신 병욱, 류 현우, 박 선미, 김 상훈, 이 의완, 이 형락(*경북대학교 물리학과 나노물리연구실. [1]경북대학교 나노과학기술학과 나노물리연구실.*) 탄소나노튜브는 전계방출원으로 몇가지 문제를 가지고 있지만 현재 알려진 물질들 중에서는 가장 안정적인 전계방출원 재료로 이야기되고 연구되어지고 있다. 효율적 전계방출원이 만들어 질 경우 많은 분야에서의 적용이 기대되어 지고 있다. 본 연구에서는 스크린 프린트법을 이용하여 제작되어진 탄소나노튜브 전계방출원을 이온조사 시켜 그 특성을 확인하였다. 전계방출 개시 전압과 전계방출량, 전계방출 균일도 등의 확인을 통하여 다양한 분야로의 적용가능성을 확인 하였다.

Dp-041 **Impedance Spectroscopy of composites of TlH2PO4 and single-walled carbon nanotubes** LEE Cheol Eui, HAN Jun Hee(*Department of physics, Korea University.*) Composites of TlH2PO4 and single-walled carbon nanotubes (SWNTs) were studied by impedance spectroscopy. The changes in the electrical properties of the dielectric system introduced by the metallic SWNTs were manifested by the equivalent circuit analysis.

Dp-042 **Manipulation of Nano particles by indentation and dielectrophoresis** 신 채호, 전 인수[1], 전 승희[1], 김 정구[1](*서울대학교 자연과학대학 나노과학기술전공. [1]서울대학교 자연과학대학 물리천문학부.*) 오늘날 소자의 소형화 추세에 따라 반도체 공정으로 미세 소자를 만드는 기술과 함께 Self assembly 된 molecule 또는 nano particle을 이용한 집적 소자 개발이 중요하게 되었다.특히 Self assembly 된 molecule을 이용한 집적 소자 개발 시 molecule을 원하는 위치로 조정하고 배열할 수 있는 기술이 필요로 하게 된

다. 또한 nano particle의 위치를 옮기거나 nano particle 제거 시, particle과 substrate간의 adhesion force를 측정하고 정량화 시키는 것이 중요하게 된다. 본 연구에서는 AFM indentation을 이용하여 다양한 모양과 간격의 dent를 만들기 위한 조건을 확립하였으며, 이를 이용하여 40nm bead를 원하는 위치에 정렬시키는 연구를 수행하였다. 이러한 방법을 사용하여 다양한 molecule 또는 particle의 물리적 특성 연구 및 집적 소자 개발에 도움이 될 것으로 기대한다.

Dp-043 **기계적 변형에 의한 탄소나노튜브의 전자구조 변화에 대한 멀티스케일 전산모사 연구** 박 찬현, 공 기정, 장 현주, 김 병계, 박 종연[1], 임 세영[1](*한국화학연구원. [1]KAIST.*) 시료의 전처리가 필요 없는, label-free sensing의 가능성으로 인해 바이러스, DNA 등의 바이오분자의 고감도 검출에 MEMS/NEMS (Micro-/Nano Electro-mechanical System) 기술을 이용한 micro-cantilever를 이용하려는 시도가 최근에 들어 많은 주목을 받고 있다. 통상적인 cantilever sensor의 경우 검출 대상 분자와의 상호작용에 의한 cantiveler의 기계적 변형을 광학장비를 이용하여 확인하기 때문에 소형화가 어렵다는 단점이 있는데 전자소자를 마이크로 캔틸레버와 결합하여 기계적 변위를 전기적 신호로 바꾸어 고감도 검출에 이용하려는 연구가 많이 진행되고 있다. 최근 본 연구실에서는 SiN으로 마이크로 캔틸레버(cantilever)를 제작하여 단일겹 탄소나노튜브(SWNT)를 채널로 이용하는 전계효과 트랜지스터와 결합한 소자를 제작하였다. 이 때 캔틸레버의 기계적 변형에 따라 탄소나노튜브 채널에 흐르는 전류가 증가함이 관찰되었다. 그래서 우리는 멀티스케일 전산모사를 이용하여 탄소나노튜브가 휠 때, 전자구조가 어떻게 변화하는지 알아보고 이 결과를 실험과 비교하였다. 우선 Quasi Continuum modeling을 이용하여 탄소나노튜브의 기계적 변형을 탐구하고 나노튜브가 휘어짐에 따라 변형되는 나노튜브 부위를 모델화하여 제일원리계산으로 전자구조를 구하였다. (10, 0) 반도체 탄소나노튜브의 경우, 변형이 심해질수록 단면이 만들어내는 타원의 이심률이 커지고, 그에 따라 띠틈(band gap)이 작아짐을 확인하였다. 즉, 캔틸레버의 변화가 클수록 탄소나노튜브의 변형이 커지고 이러한 변형은 나노튜브의 전자구조, 특히 띠틈의 크기를 변하게 한다. 이러한 전자구조의 변화가 실험에서 관측된 디바이스에 흐르는 전류의 변화의 원인으로 판단된다.

Dp-046 **Nonclassical shot noise in fractional quantum hall liquid** CHUNG Yunchul, YEO Ina(*물리학과.*) We present numerical simulations and measurements of shot noise through a quantum point contact defined by a gate in the fractional quantum Hall (FQH) regime. We measured quantum shot noise and conductance in a weak backscattering regime at filling factor 1/3. Tunneling of electron rather than a 1/3e quasi-particle has been observed. The results were understood by considering irrelevant operators in hamiltonian. The partitioned noise for a week backscattering regime was correctly predicted in whole voltage range by emplyoing the theroy mentioned above.

Dp-047 **Interaction between single-wall carbon nanotube and various liquid crystal molecules** PARK Kyung Ah, LEE Seung Mi[1], LEE Seung Hee[2], LEE Young Hee(*Department of Physics, Sungkyunkwan University. [1]2Research Institute of Standards and Science. [2]3BK-21 Polymer BIN Fusion Research Team, Research Center of Industrial Technology, Chonbuk National University.*) The carbon nanotube (CNT) is the most fascinating matter for many application area to reinforce the material property. Recently, the experimental studies for the CNTs in the liquid crystal (LC) medium were abruptly increased but the nature of the interaction between CNTs and LC molecule is not well known. Thus the plentiful theoretical studies are demanded.In this presentation, we will introduce the interaction between single-wall carbon nanotube (SWCNT) and various types of LC molecules, for example positive- and negative- fluorinated LC molecule and cyano-LC molecule. The LC molecules are anchored on the (5,5) SWCNT surface with different anchoring angle and the each end of SWCNT were functionalized by none, hydrogen and oxygen atoms. We used $DMol^3$ program for the density functional theory calculation within local density approximation (LDA) and the generalized gradient approximation (GGA). We used a double numeric polarized basis set for the atomic basis set. Further detailed study will be posted.

Dp-048 **Control of Nonlinear Effect in Carbon Nanotube Network Encapsulated in a Metallic Nanoelectromechanical system (NEMS) Resonator.** 김 영덕, 박 정훈, 홍 승새, 이 병양, 홍 승훈, 박 윤(*서울대학교 물리 천문학과.*) Metallic based nano-electromechanical systems (NEMS) resonator structures are of interest due to higher optical reflectivity, ductility, and conductivity compared to insulator- and semiconductor- based NEMS structures. And Carbon nanotubes have been spotlighted for its great potential as a promising material as well as the future candidate for nano-electronics, with CNT's unique electrical and mechanical properties. We present NEMS resonator structures fabricated from aluminum-carbon nanotube (CNT) composites. Comparing equivalent Al and Al-CNT composite double clamped beam resonators, we find the dynamic response of composite structures to exhibit resonant frequency of the first flexural mode to be much larger than similar Al structures. Such observation can be attributed to an increase in the effective Young's modulus. Furthermore, we find the onset of the nonlinearity to be retarded in Al-CNT structures consistent with increased Young's modulus. Such structures effectively increase the dynamic range of metallic NEMS resonators for ultra-small force and displacement applications.

Dp-049 **Thermal Conductance Measurement of Metal-CNT Composites using Micro-Sized Suspended Structure** 서 기성, 박 정훈, 이 병양, 홍 승훈, 박 윤(*서울대학교 물리천문학부.*) As CNTs have a unique structure and remarkable physical properties, CNT composites have attracted much attention from many researchers. Especially the thermal properties of CNTs and their composite materials have been studied intensively, because CNT has very good thermal transport properties [1-5]. For example, thermal conductivity of CNT is known to be much larger than that of metals like Ag, Au, Cu and Al. To verify the enhancement of thermal conductance of metals due to adding of small amount of CNTs,

we have fabricated the micro-sized suspended structures based on the GaAs/InGaP heterostructure. By using e-beam lithography and metallization, thermometers have been patterned on the GaAs paddle structures. Thermal links made of metal or metal-CNT composite have been patterned between the two GaAs paddle structure. We will show the fabrication methods and measurement scheme using these microstructures.

†parkyd@phya.snu.ac.kr [1] R. Ramasubramaniam et al., Appl. Phys. Lett. 80, 4647 (2003). [2] J.A. Eastman et al., Appl. Phys. Lett. 78, 718 (2001). [3] M.J. Biercuk et al., Appl. Phys. Lett. 80, 2767 (2002). [4] S.U.S. Choi et al., Appl. Phys. Lett. 79, 2252 (2001). [5] H.Q.. Xia et al., Appl. Phys. Lett. 94, 4967 (2003).

Dp-050 **Large-scale Silicon Nitride Membrane Resonator to Mimic Adaptation Mechanism of Inner Ear Vestibular Hair Cell** 조 성완, 서 기성, 조 성운, 안 강헌[1], 박 윤(*서울대학교 물리천문학부. [1]충남대학교 물리학과.*) We report on the development of a silicon nitride based membrane resonator to investigate the proposed adaptation mechanism of the inner ear vestibular hair cell. By using well-known MEMS fabrication techniques, we fabricated the free-standing silicon nitride membrane of ~ 4.3mm x 4.3mm, and the electrodes for driving and sensing were integrated on the membrane. The resonant frequency of this resonator is expected to be ~ 100 kHz. By applying adaptation force generated by feed-back mechanism, it is expected that the resulting sensor to have high sensitivities even in noisy environments. We also present the fabrication of nano-sized cantilever structure to realize the adaptation mechanism in the NEMS sensor. † parkyd@phya.snu.ac.kr

Dp-051 **Dedoping of acid-treated single-walled carbon nanotubes by reducing agents** BAE Jung Jun, KIM Su Min, KIM Ki Kang, PARK Hyun Gi, AN Kay Hyeok[1], CHOI Jae Young[2], LEE Young Hee(*BK21 Department of Physics, Center for Nanotubes and Nanostructured Composites, Institute of Basic Sciences, Sungkyunkwan University, Suwon 440-746, Republic of Korea. [1]Material &Development Department, Jeonju Machinery Research Center, Jeonju, 561-844, Republic of Korea. [2]Display Device &Material Laboratory, AE Center Samsung Advanced Institute of Technology.*) Carbon nanotubes (CNTs) are usually p-type doped in ambient condition. These are further doped by a strong oxidants such as nitric acids and nitronium ions. We report the recovery of intrinsic electronic structures of CNTs by the treatment of reducing agents; super hydride, lithium ammonium borohydride (LAH). The effect of reducing agent was characterized by UV-Vis-NIR and Raman spectra. The correlation to electronic band structures will be further discussed.

Dp-052 **Electrical Spin Injection and Detection in InAs Channels with Various Widths** HAN DongSeok, KIM Eun Kyu, EOM JongHwa[1], CHANG Joon yeon[2](*Hanyang University, Quantum-Function Spinics Lab. &Department of Physics. [1]Sejong University, Department of Physics. [2]Korea Institute of Science and Technology, Spintronics Research Center.*) We have investigated spin injection and detection in a two-dimensional electron gas (2-DEG) based on InAs heterostructure by measuring a chemical potential which originates from spin accumulation. The device consists of two ferromagnetic electrodes and a transport channel made of the InAs heterostructure. In the first fabrication process, a 15-μm-wide InAs channel of 2-DEG was defined by photolithography and Ar-milling. In the subsequent step, ferromagnetic film (NiFe) was deposited to make spin injector and detector after cleaning the surface of the InAs channel by oxygen plasma and Ar-milling. Fabricated devices have various channel width, but the distance between NiFe electrodes and the shape of NiFe electrodes remain same. The effect of channel width on the spin transport has been studied at low temperature

Dp-053 **Scanning Tunneling Microscopy Study of Azobenzene-Derivatives** KIM HYO WON, KUK YOUNG (*Department of Physics and Astronomy, ykuk Lab., Seoul National University, Seoul, Korea.*) Conjugated molecular chains exhibit good conductivity with π bondings for the carrier transport. If two disconnected parts of a conducting molecular chain are bonded, i.e. the bond is represented by two coupled potential energy surfaces with two degrees of freedom, the resulting chain will reveal non-linear characteristics. It was recently reported that azobenzene can be utilized as a nanomolecular switch which can be triggered by transmitting electrons above threshold biases[1)]. We studied geometric and electronic structures of azobenzene derivative molecules with alkyl chains on Au (111) surface by with scanning tunneling microscopy; EtO-Az-C_{10}. The result can be explained by the existing azobenzene data.

1) Byoung-Young Choi, et al., Phys. Rev. Lett. 96, 156106 (2006).

Dp-054 **The Quantization of Current Induced by Surface Acoustic Wave Through a Etched Mesa Type Quantum Point Contact** 김 남, 우 병칠, 김 진희, 서 민기[1], 정 윤철[1](*한국표준과학연구원. [1]부산대학교 물리학과.*) The acousto-electric current through a quantum point contact induced by surface acoustic waves was observed. It has been found that the current is quantized at integer multiples of ef, where f is the frequency of surface wave. By using the interdigitated transducer with 500nm spacing between the gates, we produced the surface acoustic waves at 2.456GHz. The results in 1.18nA of quantized current when 3 electrons are transferring from source to drain at a time. Also, it has been found that the quantization is related with a presence of a static quantum dot unintentionally formed in a quantum point contact.

Dp-055 **Long Range Scanning System Using Slip-stick Step Motion For Scanning Probe Microscopy** PARK Tae Young, HAN Won Hee, SHIM Ee Le, KANG C.J., CHOI Y.J.(*Department of physics, Myongji University.*) For the study of field emission properties of carbon nanotubes (CNTs) which are dispersed in metallic paste, we have developed new scanning probe microscopy (SPM) named as scanning field emission current microscopy (SFECM). It requires both high vacuum system for the stable field emission of CNTs and long range scanner for the observation of spatial varia-

tion of field emission in sub-mm scale with sub-um resolution. While flexure-type scanners are generally used in SPM for long-range scanning, its adoption to the high vacuum SPM system requires high throughput pumping system due to its large volume. In our SFECM system, we used a small size commercial slip-stick positioning system (attocube ANP series) as a step-by-step. Since the slip-stick motion uses frictional force and inertial movement, it is hardly believed that the step size of slip-stick motion is reproducible. However, we devised a novel method, so called training program for scanner, and we were able to obtain reproducible step size. As a result, we could SFECM images with low distortion.

Dp-056 **Theoretical study of the solvent effect for Pt adsorption on grahene surface** PARK SORA, DAM Hieu Chi[1], CUONG Nguyen Thanh[1], SUGIYAMA Ayumu[1], AHN Jeung Sun[2](*Dept. of Physics, Kyung Hee Univ. [1]Materials Science School, Japan Advanced Institute of Science and Technology. [2]Dept. of Physics, Kyung Hee Univ.*.) A structural study for the adsorption of Pt atom and Pt clusters on graphene surface (Pt_n/graphene) in solvent was investigated using theoretical calculation within Density Functional Theory and Conductor-like Screening Model (COSMO) method. We propose water as a continuous dielectric medium which has influence on the total energies of Pt_n/graphene. The charge transfer from Pt clusters to graphene is found to be promoted in water, compared with that in vacuum. The observed solvent effects suggest a different in the gas adsorption behaviors and therefore the catalytic activities of the system. The stability of Pt clusters on graphene using the binding energy will be also discussed at the meeting.

Dp-057 **이차원 전자계를 이용한 저주파용 circulator 특성 분석** CHUNG Y.C., KIM H.N., YEO Ina, SEO M.K.(*Dept. of Physics, Pusan National Unicersity, Pusan 609-785.*) 이차원 전자계인 GaAs/AlGaAs heterostructure로 Y-circulator device를 제작하여 직류 전류와 외부 자기장하에서 전류 수송 특성을 관측하였다. 전류의 세기를 변화시켜가면서 Y-circulator terminal 각각에 위치한 detector의 전류 세기 변화를 관측하고 그 응답 특성을 온도 변화에 따라 관측하였다. 이를 통해 이차원 전자계를 이용한 저주파수 영역에서의 Y-circulator의 가능성을 검토해 보았다.

Dp-058 **Enhanced catalyst efficiency of Pt atom on a vacancy in the carbon nanotube** PARK YONGJIN, KIM Gunn, LEE Young Hee(*Department of Physics, Sungkyunkwan University.*) Density functional calculations have been performed in estimating the catalyst efficiency of a Pt atom on a defective carbon nanotube. The Pt atom binds more strongly on the vacancy than on the Stone-Wales and on the pure carbon nanotube, independent of the metallicity of the nanotube. The binding energy of a hydrogen molecule on the vacancy is significantly reduced to 0.68 eV from 1.26 eV of pure (5,5) but still sufficient enough to maintain a minimum bond strength on a Pt atom. Moreover, the H-H distance was separated to 2.16 Å. The feasibility of fuel cell with hydrogen gas that is operable at moderate temperature is further discussed.

Dp-059 **Ink jet-printing for the fabrication of a cold cathode** LEE YoungHee, LIM Seong Chu[1], LEE Dae Sik[2], KIM Ki Kang[2] (*성균관대물리학과. [1]Department of Physics, Center of Nanotubes and Nanostructured Composites, Sungkyunkwan University. [2]BK21 Division, Department of Physics, Sungkyunkwan University.*) Single walled-carbon nanotubes (SWCNTs) were dispersed in a water using nafion and NADDBS. We have sprayed the aqueous CNT solution on an Indium-Tin oxides (ITO) glass substrate using ink jet-printer that is equipped with a nozzle of 50 mm in a diameter. After an activation process, the jet-printed CNTs were under electric field and their emission properties were studied. In this jet-printing approach, the CNT concentration and position of emitter arrays are accurately controllable. Unlike a conventional method like screen-printing, enlarging and re-patterning cathode only requires a transferring a blueprint for a new cathode to a printer

Dp-060 **Implementation Of Spin-Orbit Coupling In First-Principles LCAO Calculations** LEE Hyungjun, CHOI Hyoung Joon(*Department of Physics and IPAP, Yonsei University.*) The spin-orbit coupling is an important factor which can affect electron and spin transport in nanometer-scale structures. It can be easily taken into account in first-principles pseudopotential methods by use of relativistically generated pseudopotentials. In particular, when linear combinations of atomic orbitals (LCAO) are used to represent the electronic wavefunctions, the on-site approximation can be used (Fernandez-Seivane et al., J. Phys.: Condens. Matter 18, 7999 (2006)). We have implemented the spin-orbit interaction term to the SIESTA code using the on-site approximation and confirmed the valence band splitting in silicon and the 5d band dispersion in gold. Computational resource for this work is provided by KISTI under the 10th Strategic Supercomputing Support Program.

Dp-061 **Transport properties in patterned few-layer graphene sheets** CHOI jae-hyun, JEONG Dongchan, KI Dong-Keun, LEE Hu-Jong(*포항공과대학교, 물리학과.*) Graphene, a single-layer graphite sheet, is an ideal realization of a truly two-dimensional electron system, which consists of zero-rest-mass Dirac fermions. Although this effect reveals itself only in a single-layer graphite sheet, many other interesting quantum transport effects take place even in a few-layer graphite sheet. In this study, we adopted optical microscope distinction method using substrate brightness difference (SiO_2 thickness 300nm or 500nm) for the selection of mono- and bi-layer graphite sheets out of either natural graphite or highly oriented pyrolytic graphite(HOPG). Electron-beam writing technique was employed to pattern graphene sheets into diverse geometries for various transport measurements. Much effort was made to make good ohmic contact. We present our preliminary observation of the minimal conductance ($4e^2/h$), gate-controlled conversion between hole and electron carrier states, conventional Hall behavior in few-layer graphene sheets, etc.. We also present the observed enhancement of the Dirac-point resistance with increasing external magnetic fields.

Dp-062 **Study of Local Electronic Structure in Si nanowire Device with Atomic Force Mocroscope(AFM)** 국 양, 박 용대, 오 영택, 하 정훈, 채 중석(*서울대학교 물리학과.*) Si nanowire is considered as an outstanding candidate for nanoscale electronics building block. It works as a good field effect transistor at room temperature and also as a quantum device at low temperature. Moreover Si nanowire devices can be fabricated with conventional Si processes. However the appropriate parameters for transistor device are not determined so far. Various studies have shown that parameters like contact resistance with metal electrodes, scattering by local defects and interface sharpness with dielectric layer may determine the device charcteristics. In this study, we adopted atomic force microscope (AFM) to elucidate the correlation between the local structure and the electronic structure. We prepare several samples with ion implantation and thermal anealing. Contanct characteristics and potential variation is studied by electrostatic force microscope (EFM) and Kelvin probe force microscope (KFM).

Dp-063 **Super growth of vertically aligned carbon nanotubes using MPCVD with oxygen injection** 박 종윤, 김 유석, 송 우석, 이 승엽, 최 원철(*나노튜브 및 나노복합구조 연구센터, BK21 물리연구단, 성균관대학교, 수원 440-776.*) 탄소나노튜브(Carbon nanotubes ; CNTs)는 뛰어난 전기적 특성과 화학적 안전성으로 인해 여러 분야의 활용을 위한 차세대 물질로써 주목받고 있다. 또한 길이 대 직경의 비(aspect ratio)가 매우 크기 때문에 큰 비표면적을 이용한 수소 저장물질이나, 전계방출소자 등의 활용 가능성이 높고, 뛰어난 기계적 강도를 가지기고 있어 나노섬유 등의 활용이 가능하다. 이러한 이유로 mm이상의 길이를 가진 수직 성장한 탄소나노튜브를 합성할 경우 길이 대 직경의 비가 비약적으로 증가하여 위에 언급한 분야로의 활용이 더욱 유리하며, 나노전자 소자로의 활용에 극히 유용하다. 최근에는 화학기상증착법(Chemical Vapor Deposition ; CVD)을 이용하여 합성된 탄소나노튜브의 길이를 증가시키기 위해 성장 과정 중 탄소공급원 이외에 물, 알코올 등을 넣어주어 활성화된 촉매금속의 반응시간을 향상시켜 성장을 가능하게 한 방법 등이 보고된 바 있다.[1,2] 본 연구에서는 Si 기판 위에 금속 촉매로 사용된 Fe을 증착한 후 마이크로웨이브 플라즈마 화학기상증착법(Microwave Plasma Chemical Vapor Deposition : MPCVD)을 이용하여 탄소나노튜브를 합성하는 과정에서 주기적으로 산소를 공급해 줌으로써 길이가 1mm 이상의 얇은 다중벽 탄소나노튜브(Thin multi-walled CNTs)를 합성하였다. 실험결과, 약 30 μm/min.의 뛰어난 성장률을 가진 탄소나노튜브를 합성하였으며, 이러한 원인은 적절한 시간에 공급해준 산소에 의해 촉매금속에 흡착된 비정질 탄소(amorphous carbon)를 제거하여 활성화된 촉매로서의 역할을 지속시켜주어 같은 시간에 산소를 공급해주지 않은 것에 비하여 길이가 증가된 것이라 생각된다. 또한 기판에 촉매금속을 patterning 하여 합성시킨 경우는 탄소 공급이 더욱 원활하게 이루어져 그렇지 않은 것에 비하여 향상된 성장률을 보였다. 성장된 탄소나노튜브의 표면 형상과 내부의 구조를 주사전자 현미경(Scanning Electron Microscopy ; SEM)과 투과전자현미경(Transmission Electron Microscopy ; TEM)으로 확인하였고, 결정성의 향상을 라만 분광법(Raman spectroscopy)을 통해 측정하였다.

[참고문헌] 1. Guofang Zhong et al, J. Phys. Chem. B, 111, 1907-1910 (2007) 2. Kenji Hata et al., Science, 306, 1362-1364 (2004)

Dp-064 **Wide band-gap material 을 이용한 탄소나노튜브 전계 방출 특성의 향상** 박 종윤, 권 영택, 최 원철, 이 승엽(*나노튜브 및 나노복합구조 연구센터, BK21 물리연구단, 성균관대학교, 수원 440-776.*) 탄소나노튜브가 가지는 높은 전기 전도도 와 큰 aspect ratio 등은 전계 방출 디스플레이(FED), Back Light Unit(BLU) 및 램프(Lamp) 등의 평판 디스플레이 장치에 사용하기에 매우 적합하여 그 응용에 많은 연구들이 진행되고 있다. 하지만 방전 시에 발생하는 잔류가스에 의한 공격으로 탄소나노튜브가 많이 손상되어 emission 특성이 저하되는 문제점이 발견되어 이를 극복하기 위한 노력들이 발표되고 있다[1,2]. 또한 성장된 탄소나노튜브의 길이가 일정하지 않기 때문에 전계 방출시 사이드효과(side effect)에 의해 손실되는 전류가 많이 발생하여 고효율의 전계 방출 소자를 기대하기가 어려운 실정이다. 본 연구에서는 큰 밴드 갭(wide band-gap)의 물질을 탄소나노튜브 위에 증착함으로서 탄소나노튜브의 수명 연장 및 전계 방출 효율의 극대화를 이루고자 하였다. 플라즈마 화학기상 증착(Plasma Enhanced Chemical Vapor Deposition : PECVD)법을 이용하여 탄소나노튜브를 합성하였다. 합성된 탄소나노튜브 위에 RF sputter를 사용하여 큰 밴드 갭(wide band-gap)물질(SiO_2 &MgO)을 증착하였다. 증착 후, 여러 가지 방법(건식 에칭, 습식 에칭, 기계식 에칭 등)을 이용하여 탄소나노튜브의 팁 부분만이 노출되도록 조절함으로서 전계 방출시 전류의 흐름 방향 및 면적을 조절하여 효율을 극대화하였다. 준비된 시료의 표면형상 변화는 주사전자 현미경(scanning electron microscope)을 사용하여 관찰하였고, 큰 밴드 갭 물질 증착 전·후의 시료에 대한 전계 방출 효율을 측정·비교하였다.

Dp-065 **Carbon Nanotube as Schottky Barrier in Crossed Junction.** BAEK seungjae, LEE dongsu, PARK seungjoo, SVENSSON johannes[1], PARK yungwoo, ELEANOR campbell[1] (*서울대학교. [1]Goteborg University.*) Over the past decades, the semiconductor device has continually been scaled down in size. The reduction of the dimensions of a semiconductor device is important reasons such as fabrication cost. But in case of MOSFET, the channel length is smaller and smaller, some problems are arising. Diffusion areas will no longer be separated by a low doped channel region. The solution is using CNT for channel. Carbon nanotubes show great promise for nanoscale field-effect transistors. But the operation of a CNTFET differs from a conventional MOSFET because of the Schottky barriers formed at the metal-CNT interface at the source and the drain contacts. So I focused the impact of this Schottky barrier and mechanism of current injection such as thermally assisted tunneling and thermionic emission.

Dp-066 **Electrical transport properties under the magnetic field and I-AFM study of single walled carbon nanotube device.** 이 윤희, 노 지영(*고려대학교 물리학과.*) 단일벽 탄소나노튜브는 1차원의 나노 물질로서, 저차원계에서의 물리적 특성 및 전자기적 수송물성을 연구하는데 있어서 여전히 좋은 대상이 되고 있다. 본 연구에서는 표준 사진 식각 공정으로 패턴을 정의하고, 자성이온이 저농도로 첨가된 산화물 박막을 증착하여 화학적 기상

증착법으로 단일벽 탄소나노튜브를 수평성장 시켰다. 수평성장시킨 단일벽 탄소나노튜브 양 끝에 자성 전극을 형성 하여 자성전극-단일벽 탄소나노튜브-자성전극 접합을 제작하였다. 3.8K에서 전기적 특성 및 자기저항을 측정하였으며, 상온에서 국소탐침법을 이용하여 소자의 표면형상과 전류 분포특성를 동시에 측정 및 분석하여 보았다.

Dp-067 **다중 벽 카본 나노튜브(MWCNT) 분산된 Core-Shell 나노섬유 생성** 박 종윤, 이 미현, 최 원철, 홍 준용(*나노튜브 및 나노복합 구조 연구센터,BK21 물리연구단 성균관대학교,수원440-776.*) 나노섬유(nanofiber)는 용도에 따라 다양한 폴리머(polymer)를 원료로 사용하며 전기 방사법을 통해 생성한다. 전기방사법은 비교적 낮은 점도의 폴리머를 전기장을 이용해 순간적으로 방사하여 섬유형태를 얻는 방법이다. 이 때 섬유의 굵기는 전기장의 세기, 폴리머의 점도 및 후속 처리에 의해서 결정된다. 전기방사를 통해 생성된 나노섬유는 수십 나노에서 수 마이크로에 불과한 초극사로 인장강도, 굴곡강도, 전기적 특징이 우수하여 방탄복, 인조피부, 의료용 붕대, 반도체 첨단 제조시설에 필요한 클린룸용 의류를 비롯해 광화학 센서 소재, 차세대 전지 소재, 방탄복 군복 방독면 및 나노 수준 반도체 개발등 많은 분야에 이용되고 있다. 최근 Kumar등은 나노섬유에 CNTs를 첨가함으로써 기존의 나노섬유보다 인장강도, 굴곡강도, 전기적 특성등이 매우 향상되었다는 결과를 발표하였다.[1] 하지만 일반적으로 CNTs는 표면의 소수성 때문에 용액에 분산시키기가 어려워 다양한 공정을 통해 친수성으로 만드는 과정이 필요하다.[2] 본 연구에서는 CNTs중 상대적으로 분산이 잘되는 MWCNTs를 친수성을 향상시키는 과정을 통해 polyacrylonitrile(PAN)에 분산시킨 후, 나노섬유를 제조하여 그 전기적 기계적 특성을 향상시키고자 하였다. 분산이 되지 않은 MWCNTs를 첨가하게 되면 나노섬유의 중앙에 CNTs가 균일하게 분포하지 않아 첨가제로써의 특성의 변화를 보이지 못하는 반면, 강산(strong acid)에 의해 카르복실기를 붙여 소수성(hydrophobic)에서 친수성(hydrophilic)으로 바꾼 후 필터링을 통하여 직경과 길이를 균일하게 한 CNTs의 경우는 나노섬유의 중앙에 균일하게 분포하여 기존의 나노섬유보다 특성이 더욱 향상됨을 확인할 수 있었다. 이렇게 나노섬유의 중앙에 CNTs를 균일하게 분산시키기 위해 이중노즐을 사용하여, 안쪽 노즐에는 농도가 낮은 PAN과 CNTs 혼합 용액을 주입하였고, 바깥 노즐에는 이 보다 농도가 높은 PAN 용액만을 주입하여 전기방사를 통하여 섬유를 생성하였다. 이렇게 생성된 나노섬유는 직경이 감소하였고 인장강도와 굴곡강도 또한 향상되었음을 Universal Test Machine (UTM), 주사전자현미경 및 투과전자현미경으로 확인할 수 있었다.

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Dp-069 **Size effects in organic nanocrystals** RIM MinHo, YOON ChoonSup(*KAIST.*) Quantum size effect in inorganic nanocrystals has been studied extensively and is now well understood. However, the existence of quantum size effect in organic nanocrystals is much in dispute. To investigate the size effect in organic nanocrystals, two different organic crystals, 3-methyl-4-methoxy-4'-nitrostilbene (MMONS) and benzophenone were chosen. High quality nanocrystals of both materials were fabricated using the sonification method in the size range of 2 ~ 200 nm. The absorption spectrum shows that only MMONS nanocrystals showed size effect, while benzophenone nanocrystals did not. By comparing molecular structures and unit cell structures of both MMONS and benzophenone, it was found that the p-electron stacking configuration of MMONS crystals may be responsible for the size effect due to exciton confinement.

Dp-070 **열분해를 이용한 고순도 이중벽 탄소나노튜브의 구조 분석** 류 승철, 강 하나[1], 김 의환[2], 맹 인희[2], 손 주혁[2], 홍 완식[3], 박 경완[3], 석 중현[3](*서울시립대학교 나노공학과. [1]서울시립대학교 나노과학기술학과. [2]서울시립대학교 물리학과. [3]서울시립대학교 나노공학과, 나노과학기술학과.*) 나노 과학기술이 발달됨에 따라 나노소재 및 나노소자에 대한 관심이 증가되고 있다. 또한 최근에는 이러한 우수한 물성을 갖는 나노소재를 이용하여 각종 디스플레이, 바이오 센서, 전자 소자등 다양한 분야에서 응용연구가 활발히 진행 중이다. 탄소나노튜브의 전자방출 특성을 이용한 디스플레이 응용 및 분산 및 기능화를 시켜 바이오 센서로의 응용 연구에 대한 초점이 모여지고 있다. 본 연구에서는 이러한 탄소나노튜브의 전자방출 및 기능화 특성에 적합한 고품질의 이중벽 구조 탄소나노튜브를 저비용으로 대량 합성하는 연구를 진행하였다. 본 연구에서는 탄화수소 공급원으로 Tetra Hydro Furan(THF)을 800℃에서 열분해 하여 다공성 물질인 MgO에 Fe-Mo 금속을 담지시켜 만든 촉매와 반응시켜 이중벽 탄소나노튜브를 대량으로 합성하였다. SEM 분석 결과 비정질 탄소 파티클이 거의 존재하지 않는 고순도의 탄소나노튜브가 합성되었음을 확인 할 수 있었다. 탄소나노튜브 다발의 직경은 10-20 nm 로 균일한 직경분포를 보이고 있으며, 길이는 수십 마이크로 미터였다. TEM 분석결과 Catalytic CVD 방법으로 합성된 대부분 탄소나노튜브는 이중벽 구조의 탄소나노튜브 다발로 구성되어 있는 것을 확인 할 수 있었으며, 내경 1.1 - 4.6 nm 외경 2.8 - 5.6 nm로 구성된 이중벽 구조의 탄소나노튜브 10-20 가닥이 다발로 뭉쳐 있는 형상을 보였다. 또한 일부 이중벽 구조의 탄소나노튜브는 탄소 육각 고리의 결함으로 인해 꺽여 있는 구조의 이중벽 탄소나노튜브도 관찰이 되었다.Raman spectrum 분석결과 합성된 탄소나노튜브의 직경분포는 0.8 - 3.6 nm로 이중벽 구조를 확인 할 수 있었다. 이러한 결과는 TEM 구조 분석 결과와 유사함을 확인 할 수 있다.

Dp-071 **Electro static force enhanced micro cleavage method for graphene** 박 영우, 유 재승, 추 승완(*서울대학교 자연과학대학 물리천문학부.*) Graphene is a single layer of graphite which consist of c-axis directional stacking layers, honeycomb lattice structures. There are many interesting physical properties in two dimensional system such as quantum hall effect, electrical conductivity,gate dependece of electron-phonon interaction and so on. We need to get single layer rather than bulk or few layers in order to study on device characteristics and intrinsic physicalproperties of graphite. For the purpose of that, we are trying to another new method to obtaining graphene single layer. that is electro static forceenhanced micro cleavage method. In this method, we apply the electric field to enhance adhesive force between graphite film and substrate.This micro cleavage method has several advantages.It

does not need any high vacuum facilities and any chemical processing.Moreover, it is relatively easy to locate single or few graphite layer on the pre-patterned substrates and does not depend on the qualitiesof HOPG(HIghly Ordered Pyrolytic Graphite).After this, we can identify the number of layers by Raman spectroscopy and AFM(Atomic Force Microscopy).Electrical Transport experiment also can be confirmed in high magnetic field and low temperature environment.

Dp-072 **편극중성자 이용 PNR 기법 개발 현황** 이 정수, 김 기연, 김 학노(*한국원자력연구원.*) PNR(Polarized Neutron Reflectometry) 기법은 최근 활발하게 연구가 진행되고 있는 첨단 스핀트로닉스 분야의 자성 박막 또는 초전도 박막 등과 같은 다양한 분야의 박막 시료의 수직 및 수평 방향의 자화 밀도 분포를 비파괴적으로 평가할 수 있는 방법이다. 이러한 PNR 기법의 구현을 위해서는 박막 시료의 반사율을 측정 및 해석할 수 있도록 하는 중성자 반사율 측정장치의 유지가 필수적이며 시료 및 검출기 입사 중성자의 효율적인 편극을 위한 편극기, 해석기 및 편극 중성자의 방향을 반전하기 위한 스핀반전기 등이 필요하다. 또한 측정 박막 시료에 자기장 인가를 위한 전자석 및 극저온 시료 환경이 가능하도록 하는 극저온 시료환경장치의 유지가 필수적이다. 이를 위하여 최대 출력 0.7T의 전자석, Mezei type 스핀반전기 및 10K 이하 성능의 극저온시료환경장치(CCR) 등을 준비하고 그 성능을 시험하였으며 기존 하나로의 중성자 반사율 측정장치(REF-V)의 조건에 부합하도록 일부 수정 작업을 진행 중에 있다. PNR 기법을 이용한 박막 시료의 반사율을 효율적으로 측정하기 위해서는 중성자 편극 및 반전, 자기장 및 온도변화 등의 복잡한 구동 변수들을 효율적으로 제어할 수 있도록 하는 통합 ICP(Instrument Control Program)가 요구된다. 현재 PNR 구현을 위한 각 구성 요소의 제어 가능성을 확인하였으며 전체 구성요소의 종합적인 성능 구현을 위한 통합 ICP 모듈을 개발 중에 있다.
*본 연구는 과학기술부 원자력연구개발사업의 일환으로 수행되었습니다.

Dp-073 **Ferroelectric Properties of $CaBi_4Ti_4O_{15}$ Thin Films Prepared by a Chemical Solution Deposition** 김 상수, 김 진원, 박 문흠, 조 현경, 이 승우, 정 보희(*창원대학교 물리학과.*) Bi-층 구조형 강유전체인 $CaBi_4Ti_4O_{15}$ (CBT)는 높은 큐리 온도 (T_c=790℃)와 강유전성, 압전성 등의 특성으로 (Pb,Zr)TiO_3 (PZT)를 대체하기 위한 물질로 연구되어 지고있다. CBT 박막은 여러 가지 물리, 화학적인 방법으로 제작되어 지는데 이중에서 화학용액 증착법(chemical solution deposition method; CSD)은 화학 당량의 조절이 쉽고 저온에서 비교적 균질의 박막을 저렴하게 생산할 수 있다는 장점 때문에 많이 연구되고 있다. 본 연구에서는 CSD법으로 Pt(111)/Ti/SiO_2/Si(100) 기판 위에 순수한 CBT 박막을 성장시켰으며 박막의 결정화는 rapid thermal annealing 장치를 이용해서 500℃와 650℃의 산소 분위기에서 각각 3분 동안 열처리하였다. 제조된 박막의 미세구조와 표면상태 및 박막의 두께 등은 각각 x-ray diffraction (XRD)과 scanning electron microscopy (SEM)를 이용하여 관찰하였으며 CBT 박막 축전기의 전기적 특성은 강유전성 측정장치 (Radiant LC-precision)와 미소 전류계(Keithley 6517A), LF impedance analyzer (HP 4192A)를 사용하여 측정, 분석하였다.

Dp-074 **Multiferroic Properties of $BiFeO_3/Bi_{3.25}La_{0.75}Ti_3O_{12}$ Multi-layered Thin Films** 김 상수, 박 문흠, 김 진원, 조 현경, 이 승우, 정 보희(*창원대학교 물리학과.*) 다강체는 강유전성 및 강자성, 강탄성 등의 특성 중에서 두 개 이상의 특성을 동시에 가지는 물질로써 새로운 기억장치 등에 응용할 수 있는 가능성뿐만 아니라 흥미 있는 물리적 특성들을 가지고 있는 물질이다. 그 중에서 $BiFeO_3$(BFO) 는 큐리 온도(830℃) 와 닐 온도(370℃) 가 상온 이상에서 존재하여 그 활용 가능성이 다른 다강체 물질들에 비해 높다. 그러나 BFO물질을 활용하기 위해서는 여러 가지 해결해야 할 문제들이 있으며 낮은 잔류 분극과 높은 누설 전류가 그 대표적인 예이다. 그 원인으로는 Fe^{+3} 이온이 Fe^{+2}이온으로 천이 되기 쉬워서 일어나는 화학 양론적 불균형에 의한 산소 빈자리가 주원인으로 알려져 있으며, 이를 해결하기 위해 Fe^{+3}이온을 일부 다른 물질로 치환하는 방법, 다른 다강체 물질을 활용 하는 방법 등 많은 연구들이 진행되고 있다. 본 연구에서는 BFO 박막과 강유전체 물질인 $Bi_{3.25}La_{0.75}Ti_3O_{12}$ 박막을 다층으로 성장시켜 그 특성 향상을 시도하였다. 이렇게 만들어진 박막을 미세구조, 잔류 분극, 누설 전류 및 자기 특성 등 여러 가지 특성을 측정, 분석해 보았다. 미세구조 및 결정성 변화는 x-ray diffraction (XRD)과 scanning electron microscopy (SEM)을 통해 관찰하였다. 또 박막의 잔류 분극과 누설 전류 특성은 강유전성 측정장치 (Radiant LC-precision)와 미소 전류계 (Keithley 6517A)를 사용하여 각각 측정하였고, 자기특성 측정장치 (Magnetic Property Measurement System)로 박막의 자기적 특성을 측정, 분석하였다.

Dp-075 **화학 용액 증착법으로 Si(100) 기판 위에 성장시킨 $Bi_{3.54}Nd_{0.46}Ti_3O_{12}$ 박막의 성장 축에 따른 전기적 특성** 김 상수, 이 승우, 박 문흠, 김 진원, 조 현경, 정 보희(*창원대학교 물리학과.*) Bi-층 구조형 강유전체 박막은 dynamic random access memory (DRAM)와 ferroelectric random access memory (FeRAM) 등의 응용을 위해서 많은 연구가 진행되어 왔다. FeRAM 소자로의 응용에 있어서 metal-ferroelectrics-semiconductor field effect transistor (MFS-FET) 형이 metal-ferroelectrics-metal (MFM) 구조의 축전기를 사용할 때와 비교해서 비휘발성 데이터 저장과 non-destructive readout, 단일 Tr형 cell 구조 등의 장점으로 인해 주목을 받고 있지만, 강유전체 박막을 Si 기판 위에 직접 성장시킬 경우 Si 기판으로의 원소들의 확산과 강유전체-Si 기판 경계에서의 결함 등은 개선되어져야 할 과제들이다. Bi-층 구조형 강유전체 박막 중에서 란탄계열 (La, Nd, Sm, etc.)의 원소들이 치환된 $Bi_4Ti_3O_{12}$ (BTO) 박막은 상대적으로 큰 잔류 분극 및 낮은 공정 온도, 안정적인 피로 특성 등의 전기적 특성들로 인해서 많은 주목을 받고 있다. 본 연구에서는 화학 용액 증착법(chemical solution deposition)을 이용하여 p-형 Si (100) 기판 위에 Nd가 일부 치환된 BTO ($Bi_{3.54}Nd_{0.46}Ti_3O_{12}$) 박막을 성장시켰다. 코팅과정에서 열처리 방법을 달리하여 박막의 성장 방향을 random 및 c-축으로 제어하였으며, XRD 패턴으로부터 이를 확인하였다. 또한, 주파수와 전압에 따른 C-V 특성을 측정 분석하였고 온도에 따른 J-E 곡선을 통해서 누설전류 메커니즘을 규명하였다.

Dp-076 **Structure of ZnO thin films determined by X-ray diffraction and X-ray absorption spectroscopy** 이 익재, 유 청종, 성 낙언, 김 형국[1](*포스텍, 포항가속기연구소. [1]부산대학교, 나노학부.*) The epitaxial growth of ZnO thin films on Al_2O_3 (0001) sub-

strates has been achieved at a low substrate temperature of 200℃ using a dc reactive sputtering technique. The structures and crystallographic orientations of zinc oxide films with different thicknesses on sapphire (0001) were investigated using X-ray diffraction (XRD), angle-dependent X-ray absorption near-edge structure (XANES) spectroscopy, and extended X-ray absorption fine structure (EXAFS) with linearly polarized X-rays. The XRD data show that the crystallinity of the film is improved as the film thickness increases. The Zn K-edge XANES spectra of the ZnO films are strongly angle dependent, indicating preferred c-axis orientation. The dependence of the peak intensity on the incident angle for the Zn K-edge results from an anisotropy in the p states or the wurtzite crystal phase in ZnO in consistence with our previous XRD results. The EXAFS signals for in-plane and for out-of-plane were separately measured with linearly polarized X-rays. The best fit result shows that the Debye-Waller factor from in-plane is larger than that from out-of-plane.

Dp-077 **The crystalline and Photoluminescent properties of Eu activated $A_{1-x}VO_4$ (A= Y, Gd, La) phosphor powders.** BAE Jong-Seong, HAN Ok Sik[1], AHN Won Ahn, KIM Jong Pil, PARK Sungkyun, PAK Hyuk Kyu[1], SHIM Kyoo Sung[2], JEONG Jung Hyun[2](*Busan Center, Korea Basic Science Institute. [1]Department of Physics, Pusan National University. [2]Department of Physics, Pukyong National University.*) Yttrium orthovanadates has been extensively used a red phosphor with Eu^{3+} as dopant in color television and cathode ray tubes in its powder form. $A_{1-x}VO_4 : Eu^{3+}{}_x$ (A= Y, Gd, La) oxide phosphor powders were synthesized by solid state reaction process. The powder calcined at 1000℃ for 4 hours, and Eu^{3+} ion was replaced with A, x= 0.03. Surface morphology and crystalline structure of phosphor powders have influenced on the photoluminescence (PL) characteristics. In this paper, we studied the dependence between the PL and host material. The crystallinity and surface morphology of the powders were investigated using X-ray diffraction (XRD) and scanning electron microscopy (SEM), respectively. In the XRD measurement, $GdVO_4$ and YVO_4 powders showed tetragonal structure, $LaVO_4$ was monoclinic structure. The luminescent characteristics of powder samples presented that the PL spectra depended not only on the crystal structure but also host materials. The PL spectra were measured at room temperature using a luminescence spectrometer and the emitted radiation was dominated by the red emission peak at 620 nm radiated from the transition of $^5D_0$-$^7F_2$. Due to the shielding effect of 4f electrons by 5s and 5p electrons at the europium ion, narrow emission peaks are expected, consistent with the sharp peak in powder samples. The $GdVO_4:Eu^{3+}$ powder have maximum PL intensity in comparison with that other powder samples.
*(This work was supported by KBSI grant N27078 to PI initial)

Dp-078 **Surface analysis and luminescent properties of $Y_2O_3:Eu^{3+}$ thin film phosphor grown on Si (100) substrate by Li-doping** BAE Jong-Seong, HONG Tae Eun, KIM Jong Pil, PARK Sungkyun, JEONG Jung Hyun[1], YI Soung Soo[2](*Busan Center, Korea Basic Science Institute. [1]Department of Physics, Pukyong National University. [2]Department of Electronic Material Engineering, Silla University.*) The influence of lithium doping on the crystallization, the surface morphology, chemical states, ion distribution and the luminescent properties of pulsed laser ablated $Y_2O_3:Eu^{3+}$ thin film phosphors grown on Si (100) substrate were investigated. The structural, surface morphology characteristics, ion distribution and chemical states of the phosphors were analyzed by using X-ray diffraction (XRD), scanning electron microscope (SEM), secondary ion mass spectroscopy (SIMS) and X-ray photoelectron spectroscopy (XPS), respectively. The crystallinity, the surface morphology, and the photoluminescence (PL) of phosphors depended highly on the Li-doping and deposition condition, in particular, a deposition temperature and oxygen pressure. The relationship between the crystalline and morphological structures and the luminescent properties was studied, and Li^+-doping was found to effectively not only the enhanced crystallinity but also the luminescent brightness of $Y_2O_3:Eu^{3+}$ thin film phosphors. In particular, the incorporation of Li^+ ion into the Y_2O_3 lattice could induce remarkable increase in the PL intensity. The enhanced photoluminescence brightness with Li doping may result not only from the improved crystallinity leading to higher oscillating strengths for the optical transitions, but also the enhanced the surface area due to the larger grain sizes
*(This work was supported by KBSI grant N27078 to PI initial)

Dp-079 **Study of micro-structural properties in epitaxial $PbZr_{0.2}Ti_{0.8}O_3$ thin film by using synchrotron x-ray grazing incident diffraction (GID)** 권 대영, 장 효동, 장 창환[1], 김 복기(*부산대학교 물리학과. [1]산업과학 기술연구소(RIST) 특성평가팀.*) In order to analyze the micro-structure of epitaxial $PbZr_{0.2}Ti_{0.8}O_3$(PZT) thin films, we have carried out synchrotron x-ray scattering measurements in Beamline 8C1 at the Pohang Light Source (PLS). The epitaxial film of the PZT with thickness of 30 – 97 nm prepared using off-axis RF magnetron sputtering method on Nb:STO(100) substrate. Grazing incident diffraction (GID) techniques have been employed to study in-plane structure of the thin films. We found that the strain relaxation occurs about 50nm thickness of PZT thin film along the out-of plane direction. While coherent domain size of c-axis shows definitive saturation behavior about 50 nm, that of a-axis shows thickness-independent behavior, which results from in-plane strain of the substrate.

Dp-080 **HREELS investigation of graphene layers on 6H-SiC(0001) surface** 신 선영, 황 춘규, 엄 상훈, 김 남동, 정 진욱 (*Postech.*) The peculiar features of electronic properties of two dimensional (2D) graphene layers arising from so-called Dirac electrons have attracted much research efforts in recent years. These include the linear dispersion of graphene band, zero effective mass, and vanishing density of states at the Dirac point. Since the elementary excitations from these Dirac electrons are also of scientific interest to understand such features, we have performed high-resolution electron-energy-loss spectroscopy (HREELS) study for the graphene layers formed on 6H-SiC(0001) surface at room

temperature. We find a unique loss feature of which the loss energy shifts towards higher energy with increasing thickness of the graphene layers. We discuss possible origin of the loss feature.

Dp-081 **6H-SiC(0001) 표면위에서의 graphene layer 형성 조건에 관한 연구** 김 일유, 조 은진, 황 찬용[1], 김 원동[1](*전남대 물리학과. [1]한국표준과학연구원.*) 6H-SiC(0001)표면에서 graphene layer가 어떻게 형성되는지에 대하여 다양한 조건하에서 연구하였다. 시료의 온도를 단계적으로 상승시키면서 저에너지 전자회절(LEED) 실험과 Auger Electron Spectroscopy(AES) 실험을 수행하였고, 이로부터 관찰된 LEED 패턴과 측정된 Si과 C의 AES 신호세기의 비를 통해 온도에 따른 graphene layer의 형성 과정과 layer의 두께를 알 수 있었다. 또한 이렇게 형성된 graphene layer에 대하여 Scanning Tunneling Microscopy(STM)을 실험을 수행하여 graphene layer의 수에 따라 표면 구조가 어떻게 변화하는지에 대해 살펴보았고, 이로부터 최근에 보고된 바와 유사한 complex scattering pattern을 보여주는 STM 원자 분해능 영상을 볼 수 있었다[1]. 초기 산화층 제거 단계에서 Si flux의 사용 여부에 따른 형성 조건의 변화와 기울어진 6H-SiC(0001) 표면에서의 형성 조건에 대해서도 조사하였다.

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Dp-082 **X-ray reflectivity studies of InGaN/GaN multi-quantum well structure with conformal rough interfaces** LEE SUNG PYO, NOH DO YOUNG(*Department of Materials Science and Engineering, Gwangju Institute of Science and Technology, Gwangju 500-712, Korea.*) InⅢ-nitride based light emitting diodes(LEDs), the chemical and structural characteristics of the InGaN/GaN multi-quantum well(MQW) used as the active layer affect their optical properties greatly. X-ray reflectivity measurement is a powerful and nondestructive method for analyzing structure of thin films and multilayers. However, it is often difficult to extract the structural information of typical semiconductor MQW structures from the reflectivity measurement, since the specularly component of the reflection is often dominated by the diffuse scattering . In this study, we investigated local density profiles of InGaN/GaN MQWs with conformal rough interfaces using synchrotron x-ray diffuse reflectivity. The specular reflection from the MQWs was dominated by the diffuse intensity, which is confirmed by the diffuse scattering profile including the lateral momentum transfer. The diffuse reflectivity profile, integrated over the inplane transverse directions, is analyzed in terms of kinematic Born approximation. We present the vertical density profile statistically averaged over the film plane obtained from the analysis.

Dp-083 **A Study of Surface Morphology in Epitaxial ZnO Grown by Plasma Assisted Molecular Beam Epitaxy** CHA Su-Young, CHO Yong Chan, KIM Tae Hoon, CHO Chae Ryong, JEONG Se-Young(*Department of Nano Fusion Technology, College of Nanoscience and Nanotechnology, Pusan National University, Miryang, 627-706, Korea.*) Due to the a wide band gap of 3.37 eV and a large exciton binding energy of 60 meV at room temperature, ZnO has attracted attention as a promising material for short-wavelength optoelectronic devices. And the great potentials of diluted magnetic semiconductors (DMSs) in spintronics have brought the much world-wide research efforts into this field. Especially in II–VI semiconductors ZnO, transition metals including cobalt and manganese ions have been examined as dopants in semiconductor for introducing ferromagnetism. The origins of ferromagnetism in ZnO are now on debating. To verify the ferromagnetic origin more clearly, the several possibilities such as magnetic ion clustering and unexpected impurities should be excluded from sample. In this work, high-quality ZnO were grown on Al_2O_3 (0001) substrates by plasma-assisted molecular beam epitaxy (PAMBE). The base pressure of the chamber was 5.0×10^{-10} Torr. And Al_2O_3 substrates were thermal cleaned in high-temperature of 850°C. Subsequently, the ZnO crystal was grown whit only Zn beam flux of 3.6×10^{-7} Torr at 750°C at fixed O_2 flow rate of 2.0 sccm. Also, ZnO nanorod was grown Zn flux of 1.2×10^{-6} Torr at O_2 flow rate of 15 sccm. All samples were systematically investigated by in-situ reflection high energy electron diffraction (RHEED) and ex-situ atomic force microscopy (AFM) as a function of Zn beam flux intensity and substrate temperature. The preferential orientation and epitaxy of ZnO films were examined in the XRD spectra. And we have measured wetability of ZnO for study of the surface morphologies.

Dp-084 **Effect of Surface Pretreatment of Metal Oxides Probed by Gas Molecules** KIM EUIKWOUN, LEE JUNG-GIL, LEE YUNMAN(*한양대학교, 물리학과.*) Although the metal oxides are sensitive to the surface contamination such as oxygen and carbon related organic materials, the identification and the mechanism of the pre-existed surface-bond molecules on surface structure are not well understood.To address these questions, MgO nanoparticles were synthesized by using a combustion method in quartz using RF power in air, and gas adsorption properties were investigated by using methane for the heat-treated samples. The results were compared with the non-treated ones. After a set of powers were heat treated at 750℃ for 48hours keeping the vacuum lower than 10^{-7} torr, methane isotherms were immediately measured below 77K. The results revealed that heat treated samples showed additional isotherm steps, indicating the cleaner surface than the non-treated MgO powders. The species of protecting molecules on the surface were identified by using a residual gas analyzer (RGA) as a function of temperature. Our data are expected to provide key information for defining interaction of gas molecules on MgO surfaces aims at understanding the surface adsorption isotherm properties on metal oxide surfaces.

Dp-085 **Revisit to the satellite structure in a C 1s core-level spectrum of CO adsorbed on Cu(100) surface** KIM Hyeong-Do, KIM Hanchul[1](*Pohang Accelerator Laboratory. [1]Korea Research Institute of Standards and Science.*) When carbon monoxide is adsorbed on a Cu(100) surface, a carbon 1s core-level photoemission spectrum shows a prominent satellite structure, which was explained by a spinless hamiltonian for the unoccupied CO π^*-antibonding level

pushed down below the Fermi level by strong attractive Coulomb potential [Gunnarsson and Schoenhammer, Phys. Rev. Lett. 41, 1608 (1978)]. This model is reexamined by considering not only the full degeneracy of the π* level but also the occupied σ-bonding level with hybridization matrix elements obtained from ab initio band calculations.

Dp-086 **Atomic And Electronic Structures Of Silicon Surface With Defects: A First-Principles Study** KIM Min-Kook, CHOI Hyoung Joon(*Department of Physics and IPAP, Yonsei University.*) We present electronic structure and total energy calculations of reconstructed silicon surface with defects, using an ab-initio pseudopotential density functional method. We used the local density approximation to the density functional theory and pseudo-atomic orbitals to expand the electronic wavefunctions. The p(2×1), p(2×2), and c(4×2) reconstructions on Si (100) surface are considered, and their optimized atomic geometries are obtained by minimizing the total energy. Our results show that the c(4×2) reconstruction has the lowest total energy, with the c(4×2) and the p(2×2) structures being very close in energy and substantially lower than the p(2×1) structure. Surface electronic structures are obtained and they are compared with reported experimental results. We also studied defects on the silicon surface to investigate their effects on the surface electronic structure. Computational resource for this work is provided by KISTI under the 8th Strategic Supercomputing Support Program.

Dp-087 **First-principles study of atomic and electronic structures of graphene-metal contacts** GOH JUNGSUK, CHOI HYOUNGJOON(*Department of Physics and IPAP, Yonsei University.*) Graphene-metal contacts are of great importance in all applications of graphenes as nanometer-scale electronic devices. We investigated graphene-metal contacts with a ab-initio pseudopotential density functional method. We employed both the local density approximation and the generalized gradient approximation to the density functional theory. The electronic wavefunctions are expanded with pseudo-atomic orbitals. We determined atomic structures of graphene-metal contacts and analyzed their electronic structures to find out contact properties. Computational resource for this work is provided by KISTI under the 10th Strategic Supercomputing Support Program.

Dp-088 **Oxidation Of Ni Thin Film By Dc Reactive Magnetron Sputtering** LEE Yun-man, JEON Jae-kyun, KIM Nam-hyuk(*한양대학교 물리학과.*) The nickel oxide (NiO) thin films on Si (100) substrate were prepared by a dc-reactive magnetron sputtering method using a Ni target in a partially filled with mixture of oxygen and argon gases, and the surface structure was investigated by using X-ray diffraction. The effect of process parameters including O_2/Ar ratio, partial gas pressure, substrate temperature, and applied power were systematically investigated in terms of crystallographic structures. The emphasis was placed on the influences of the discharge parameters such as the applied voltage and current in a dc system.

Dp-089 **Defect-Induced Pendulum Motion of an Adatom on Si(111)-7X7** LEE Jinwoo, CHO Doohee, LYO In-Whan (*Institute of Physics and Applied Physics, Yonsei University, Seoul 120-749, Republic of Korea.*) We investigated the dynamics of thermal motion of Si adatom-like features on Si(111)-7x7 using scanning tunneling microscopy at room temperature, which were produced by dosing a small amount of oxygen onto a clean surface. A series of STM images show a pendulum-like motion of a center adatom with a pivot point located at an adjacent vacant center adatom site. Or, equivalently, this motion gives an appearance of double vacancy defects located on two adjacent center adatom sites swinging about a particular vacancy site. However, a detailed analysis of the voltage-dependent images shows that this feature is not identical to typical double vacancy defects found on this surface. No reversal of the roles among the sites was ever observed. Possible models for the pendulum structures will be discussed.

Dp-090 **Observation of Inelastic tunneling spectroscopy of hydrogen atoms on Pt(110)-(1x2) surface at low temperature using STM** CHOI Eunyeoung, LYO In-whan(*Institute of Physics and Applied Physics, Yonsei University.*) Scanning tunneling microscopy (STM) is fascinating equipment for the study of properties of single molecules or atoms using inelastic electron tunneling. The tunneling current from scanning tunneling microscopy was used to image single H atoms on Pt(110)-(1x2) surface in the temperature range of 25K to 300K. At low temperature, H atoms made the Pt atoms in the row buckled and were observed as protrusions on the Pt rows. The vibrations of individual H atoms on the surface were excited and detected by inelastic tunneling spectroscopy. Further IETS results of single H atoms obtained will be discussed during the talk.

Dp-091 **Inelastic-Electron Scattering Cross Section from Model Dielectric Function for Fe, Ni and Fe-Ni Alloys** LEE Eun Kyoung, TAHIR Dahlang, KWON Hyuk Lan, PARK Kwang Ho, KANG Hee Jae(*Chungbuk National University, Department of Physics.*) A comparison of quantitative surface analyses of Fe–Ni alloy thin films by various methods has been proposed for a pilot study by the Surface Analysis Working Group of the Consultative Committee for Amount of Substance (CCQM). The alloy compositions measured with X-ray photoelectron spectroscopy (XPS) and Auger electron spectroscopy (AES) using sensitivity factors, determined from pure Fe and Ni metal films, agreed with the certified mean values to better than 2%. These results indicate that the quantification of the Fe–Ni alloy is a good method for a CCQM pilot study because matrix effects and ion-sputtering effects are small for these analytical methods. [1]. In this work, Inelastic scattering cross section of 0.5, 0.8, 1, 1.5 and 2 keV electrons in Fe, Ni and Fe-Ni alloys have been investigated theoretically and experimentally. The product of the inelastic mean free path (IMFP) and the cross section were determined theoretically based on Tougaard-Yubero QUEELS-ε(k, ω)-REELS software [2]. Theoretical cross sections

were determined through a dielectric-response description of the solid interaction using Drude-Lindhard model dielectric function. The theoretical cross section and IMFPs were in a good agreement with those obtained with TTP-2M formula.
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Dp-092 **Electronic Structures of 1D and 2D Surface Reconstructions of Au/Si(110)** *강 세훈, 김 근수, 염 한웅(연세대학교 물리및응용물리사업단 원자선원자막연구단.)* Abstract The properties of electrons become more exotic in a lower dimension than three dimension since the correlated electrons in one-dimensional (1D) would exhibit various intriguing ground states and low-energy excitations. In recent years the self-assembled atomic wires with the 1D band structures have been observed for Au and In on flat and vicinal Si surfaces, making them model systems to investigate Peierls-type phase transitions [1, 2, 3]. On the other hand, it was recently reported that Au atomic wires on Si(110) have metallic electronic structures with a half and a third electron filling down to around 200 K [4]. In the present work, we systematically investigate the Au induced surface reconstructions on Si(110) by low-energy-electron diffraction (LEED) and angle-resolved photoelectron spectroscopy. This system reveals 1×2, 2×5 and (4,0)×(-1,3)+(4,0)×(-3,3) structures, depending on the amount of Au as in the earlier reflection-high-energy-electron diffraction study [2]. The 1×2 surface does not show any dispersive band structures, which suggests that this phase correspondings to a disorder one. Complicated surface-state bands found on the mixed phase of (4,0)×(-1,3)+ (4,0)×(-3,3). The 2×5 surface shows two surface-state bands, which disperse one-dimensionally along the wire direction ([-110]) with the electron fillings of a half and a quarter, respectively. In contrast to the previous study, the half-filled band has a small gap at ×2 zone boundary with a band backfolding. However the quarter-filled band is metallic with the effective mass close to that of a free electron down to 90 K. This metallic surface would be a nice candidate to observe the 1D physics of correlated electrons physics like non-Fermi liquid behavior.
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Dp-093 **광방출 STM을 이용한 Ag를 증착한 Si(111)표면의 광방출 스펙트럼 측정** *이 근섭, 우 정석, 심 형준(인하대학교, 물리학과.)* STM 투과틈에서 나오는 빛의 검출은 국소분광기법으로 표면의 광학적인 성질을 연구하는 방법 중의 하나로 개발되어 왔다. 본 실험에서는 투과틈에서 나오는 빛을 검출하기 위하여 투과틈 부근에 광섬유를 이용한 빛 수집장치를 상온 STM에 설치하여 광방출 STM을 구성하였으며 Si(111)-7x7표면에 평탄한 모양으로 성장한 Ag표면과 H/Si(111)-1x1표면에 다양한 크기의 클러스터로 성장한 Ag표면으로부터 광방출 스펙트럼을 얻었는데 방출된 빛의 스펙트럼은 2.3~2.7 eV에 분포했다. 투과 바이어스 전압의 변화에 따른 방출된 빛의 스펙트럼 위치는 변화하지 않았는데 이 결과는 방출된 빛이 전자의 비탄성 투과에 기인한 것을 암시한다. 검출된 빛은 탐침과 시료표면 사이의 탐침에 의해 유도된 플라즈몬(tip-induced plasmon)붕괴에 따른 것으로 분석되며 방출된 빛의 에너지 차이와 증가를 관찰할 수 있었는데 이는 시료표면의 거칠기와 모양의 차이에 따른 결과로 추정한다. 시료표면의 형태에 따라서 방출되는 빛의 스펙트럼에 대해서 앞으로 논의될 것이다.

Dp-094 **Tetra-σ Bonding Adsorption of Pyridine on Si(100)-2x1** *이 한구, 김 기정[1], 강 태희[2], 정 진욱, 김 봉수[3](포항공과대학교. [1]포항가속기연구소, 한국과학기술원 화학과. [2]포항가속기연구소. [3]포항공과대학교, 포항가속기연구소.)* We studied adsorption of Pyridine on Si(100) at room temperature using high resolution photoemission spectroscopy (PES) and near edge x-ray adsorption fine structure (NEXAFS) in the partial electron yield (PEY) mode. The Si 2p, C 1s, N 1s spectra of pyridine on Si(100) showed that pyridine is chemisorbed on Si(100)-2x1 through the formation of the tetra-σ-bonded structure with the N atom and three C atoms. NEXAFS was conducted to characterize the adsorption geometry of pyridine on Si(100). The π* orbital of C=C bond showed a good angle dependence in C K-edge NEXAFS spectra, and we were able to estimate the adsorption angle between chemisorbed pyridine of C=C bond and the Si (100) surface using an analytical solution of NEXAFS intensity. The calculated adsorption angle is ~42±2°

Dp-095 **경면성 나노 다이아몬드 박막 증착에 관한 연구** *이 욱성, 이 학주[1], 전 형탁[1](한국과학기술연구원, 박막재료연구센터. [1]한양대학교, 신소재공학과.)* DC-PACVD로 증착된 4" 직경의 나노 다이아몬드 박막의 표면이 경면과 비경면으로 이루어진 불균일한 표면 상태를 갖는 현상에 대하여 연구하였다. 나노 다이아몬드는 모든 적용분야에 있어 박막의 균일성을 필요로 하기 때문에 전체적으로 균일한 경면성 나노 다이아몬드 박막 증착이 요구된다. 경면과 비경면이 혼재되는 원인으로는 크게 세 가지로, 증착된 다이아몬드 박막 표면조도의 불균일성, 다이아몬드 박막의 결정질의 불균일성, Si-wafer 기판 자체 물리적 특성의 불균일 등으로 예상하였다. 불균일한 박막 증착의 원인을 규명하고, 전체적으로 균일한 4" 직경의 경면성 나노 다이아몬드 박막을 증착하는 것이 본 연구의 목표이다. 나노 다이아몬드 박막 증착은 DC-PACVD를 이용하였으며, 150Torr 압력 하에 수소플라스마 분위기에서 3% 메탄, 0.3% 질소를 첨가하여 800℃ 기판온도를 3시간을 유지하였다. Si wafer 자체 물성의 불균일을 확인하기 위해 Prime grade 와 Test grade를 비교하였으며, 나노 다이아몬드 박막의 결정질의 불균일성을 확인하기 위해 XRD, NEXAFS를 통해 분석하였다. 마지막으로 나노 다이아몬드 박막의 표면조도 및 미세구조에 대한 불균일성을 분석하기 위해 Alpha step, AFM, SEM을 이용하였다. Si-wafer grade 및 나노 다이아몬드 박막 결정질의 차이는 불균일한 표면 상태를 갖는 현상의 원인으로 파악되지 않았다. 경면과 비경면의 차이는 나노 다이아몬드 박막의 표면조도 및 미세구조에 대한 차이로 나타났으며, 이것은 핵생성밀도의 불균일성이 직접적인 원인으로 규명되었다. 메탄올과 5nm diamond

particle이 섞여있는 용매에서 Seeding Process를 1시간에서 3시간으로 늘려주었고, 에탄올을 이용한 Cleaning을 1분씩 3단계에서 30초씩 3단계로 줄이는 변수를 통해 높은 핵생성밀도를 보였으며, 전체적으로 균일한 경면성 나노 다이아몬드 증착이 가능하였다.
*(본 연구는 과학기술부 221세기 프론티어 연구개발사업인 나노소재기술개발 사업단의 지원(과제번호:M105KO010022-07K1501-02210)으로 수행되었음.)

Dp-096 **Characteristics of diamond-like carbon thin films grown by D.C. electrodeposition** 이 종덕, 김 현수, 김 건호, 이 정주, 정 기수, 최 홍수[1], 김 장렬[2], 이 정일[2](*경상대학교 물리학과. [1]경상대학교 물리교육학과. [2]한국원자력연구소.*) Diamond-like carbon (DLC) films were deposited by electrodeposition technique on n-Si(100) substrates by using a mixture of acetonitrile (10% V/V) and deionized water as electrolyte. Electrodeposition of carbon has been carried with the applied potential ranging from 20 V to 100 V. During the deposition in these lower voltage ranges, the reduction current densities increased with increasing the potential but showed different behaviors at the different potential. The films were characterized by Atomic force microscopy (AFM), Field emission scanning electron microscopy (FESEM), Raman spectroscopy and X-ray photoelectron spectroscopy (XPS). In all cases, two broad bands located at 1350 cm^{-1} and 1570 cm^{-1} were confirmed through Raman spectroscopy analysis and these peaks are indicative of presence of DLC. In addition, from FTIR spectroscopy, the characteristic peaks of DLC films were observed at ~2850 cm^{-1}, ~2920 cm^{-1} and ~2955 cm^{-1} which correspond to the symmetric, anti-symmetric stretching vibrations of sp^3 bonded CH_2 group and the anti-symmetric stretching vibrations of sp^3 bonded CH_3 group, respectively. From X-ray diffraction (XRD) measurements we have found that single phase C8 films with cubic structures were preferentially grown on Si(100) substrates in all potential ranges. AFM and FESEM revealed that the surface morphologies of DLC films depend strongly on the applied d.c. voltage but the grain sizes does not. The RMS surface roughness, R_q increased with the increase of the deposition voltage and R_q was about 4.2 nm at 40 V and about 7.6 nm at 100 V, respectively. On the other hand, the grain sizes remained almost the same despite of increasing the deposition voltage and the average grain size was estimated to about 480 nm.

Dp-097 **STM를 이용한 기판 온도에 따른 Si (111))-(7x7) 표면 위의 준단층 Au의 연구** 이 근섭, 임 희철, 심 형준, 김 영훈, 장 레이(*인하대학교 물리학과.*) 다른 기판 온도에서 Si (111) -(7x7) 표면 위의 준단층 Au의 흡착을 STM을 이용하여 연구하였다. 상온 증착에서 Si (111)-(7x7) 위에 흡착된 Au는 일반적으로 두 가지 형태로 나타나게 되는데, 하나는 밝은 삼각형 모양이고 다른 하나는 반단위 격자 안에 국한되어 형성된 클러스터 모양이다. 매우 적은 덮임율에서는 밝은 삼각형들이 많이 관찰되지만 덮임율이 증가함에 따라 다양한 크기의 클러스터들이 많이 관찰된다. 또한 증착하는 동안 150C이하의 약한 온도로 기판을 가열하게 되면 밝은 삼각형들의 수가 줄어든다. 350C 이하의 기판에 증착될 때 대부분 반단위격자에 들어갈 수 있는 크기로 제한된 클러스터들은 기판의 온도가 올라감에 따라 반단위 격자의 경계를 덮으면서 연결된다. 클러스터들 근처에서 빈격자점과 무질서함이 생겨나는데, 이는 가열된 기판의 클러스터들에서 Au-Si 원자들의 강한 결합 과정에서 형성되는 것으로 생각된다. 약 550C에서 Au를 증착시키면 테라스에 특별한 섬-구멍 쌍을 형성하여 (5x2) 재구성 구조를 만들거나 스텝의 끝부분에 (5x2) 섬만을 만든다. 본 발표에서는 증착하는 동안 기판의 온도 변화에 따른 이러한 Au 흡착 표면의 변화에 대하여 자세히 논의되고 상온에서의 증착후 열처리 결과와 비교될 것이다.

■ SESSION P1
10월 18일(목), 14:30 - 16:15
장 소: 5층 포이어

P1
포스터세션

Ep-001 **Voltage-Current Characteristics of Superconductor-Normal Metal Contact Junctions Measured by a Picovoltmeter** 김 완섭, 김 문석, 김 규태, 정 연욱, 박 포규, 김 영균, 유 광민(*대전시 유성구 도룡동 1, 한국표준과학연구원 기반표준부.*) A picovoltmeter based on a DC SQUID has been built to measure low-level voltage in the range of 10^{-12} V. An output-input ratio amplification of 10^{8} is achieved by a proper current feed-back system. A preliminary result analyzed from the Voltage(V)-Current(I) characteristics of a Cu-wire with a diameter of 0.25 mm and a length of 10 mm shows that a voltage resolution of the picovoltmeter is of about 10^{-12} V and a corresponding resistance resolution is tens of μΩ. Possibility of improvement on the voltage resolution of the picovoltmeter will be discussed on the basis of noise spectrum analysis, where the main noise source of the picovoltmeter is the ground frequency (60 Hz) and its higher harmonics (120, 180, 300 Hz, etc.) of the power line. Moreover, the amplitude of the power line noise is attributed to tens of femtovolt (10^{-15} V). In addition, recent results of application related to the picovoltmeter in the measurement of V-I characteristics of thick films consisted of superconductor/normal metal/superconductor contact junctions will be presented and discussed at the conference.

Ep-002 **X-ray Scattering Study of Organic Films Grown by Organic Molecular Beam Deposition** CHA Wonsuk, KIM Hyunjung(*Interdisciplinary Program of Integrated Biotechnology and Department of Physics, Sogang University.*) 본 연구에서는 유기물의 단원자층 제어가 가능한 Organic Molecular Beam Deposition (OMBD) 방법을 이용하여 저분자 유기 박막을 증착하였다. 증착된 박막은 x-ray reflectivity, diffuse scattering의 x-ray 산란을 통하여 초기의 구조와 표면 특성을 측정하였다. 본 실험은 증착 속도와 기판의 온도를 달리하여 수행되었으며 이들 변수에 의한 영향을 논의하고자 한다.
*본 연구는 Korea Science and Engineering Foundation, Seoul Research and Business Development Program(10816), Sogang University Grant의 지원을 받아 수행되었다.

Ep-003 **The Study on Temperature Dependence of Resonance Frequency of PZT Ceramics Near Morphotropic Phase Boundary** LEE Gaemyoung, YANG Jungbo(*제주대학교 공과대학 전기공학과.*) PZT ceramic devices mostly use the substrates with the compositions near morphotropic phase boundary in PZT systems because they have the best piezoelectric property. In most applications, temperature stability of the properties of the PZT ceramic substrate is required strictly.In this study ceramics with the compositions, Zr/Ti=51/49, 52/48, 53/47, 54/46 and 55/45 in binary pure PZT system were fabricated and their X-ray patterns and temperature dependence of resonance frequency were measured. And the effect of thermal aging and poling strength on temperature dependence of resonance frequency was examined

Ep-004 **The Effects of Grain Size on Temperature Dependence of Resonance Frequency of PZT Ceramics** LEE Gaemyoung, HEO Sunghun, YANG Wansuck(*제주대학교 공과대학 전기공학과.*) Piezoelectric ceramic devices such as filters and resonators are used widely in electronic systems. Stability of operating frequency of the devices is very important. If the operating frequency changes, the system using them is not working.In this study ceramics with the compositions, Zr/Ti=51/49, 53/47 and 55/45 in binary pure PZT system were fabricated and grain size of the ceramics were modulated by controlling sintering condition. Their X-ray patterns, piezoelectric properties, grain size and temperature dependence of resonance frequency were measured. And the effects of grain size on temperature dependence of resonance frequency were examined.

Ep-005 **Au 나노로드에 Ag을 이용하여 만든 나노갭의 온도변화에 따른 전기적 특성** 김 길호, 전 병엽(*성균관대학교 정보통신공학부 반도체 나노소자 연구실.*) 알루미늄 양극산화(AAO)는 전압, 용액 농도의 변화를 통해 균일한 크기의 Au 나노로드를 합성 할 수 있다. 이러한 나노로드는 Ag을 이용한 나노갭을 만들 수 있는데 이러한 나노갭은 터널링 현상이 예견된다. 본 연구에서는 AAO를 이용해 나노로드를 만들기 위한 AAO template 제작의 한 과정인 'pore opening &widening'에서, SEM 이미지를 통해 최적화된 결과 값을 찾아내었다. 또한 이러한 과정을 통해 얻어진 AAO template을 이용하여 Au-Ag-Au 나노로드를 합성하고 Ag부분만을 식각 해 내어 생성된 나노 갭을 이용하여 온도변화에 따른 전기적 특성을 측정 하였다.

Ep-006 **Au 나노로드의 이중 나노 갭에서 전기전도특성** 김 길호, 차 영산(*성균관대학교 반도체 나노 소자 연구실.*) 양극산화 알루미나 주형을 이용하여 수십 나노 주기로 잘 정렬된 육각형 구조의 나노 기공을 만들고 전기도금법을 사용하여 Au와 Ag를 반복적으로 증착한 뒤 Ag를 제거하면 수 나노미터 크기의 이중 나노 갭을 갖는 나노 와이어를 만들어 낼 수 있다. 또한 이 나노 갭에서 단전자 트랜지스터에서 볼 수 있는 전기적 특성을 측정할 수 있다. 본 연구에서는 양극산화 알루미나 주형 제작시 1,2차 양극산화 과정과 Pore widening 과정을 통하여 기공의 크기와 길이를 조절하여 합성해낸 Au-Ag-Au-Ag-Au 나노 와이어에서 Ag를 제거한 뒤 이중 나노 갭을 만들고 이 나노 갭에서의 전기전도특성을 관찰 하였다.

Ep-007 **Bias voltage dependence of magnetic tunnel junctions comprising amorphous ferromagnetic CoFeSiB layer with double barriers** 이 장로, 이 선영, 임 혜인, 황 재연[1], 전 병선[2], 김 영근[3], 김 태완[4], 이 상석[5], 황 도근[5], 유 성초[6], 이 희복[7](*숙명여대,물리학과. [1]한국원자력연구소,하나로센터. [2]UCLA, 전자공학과. [3]고려대학교,신소재공학과. [4]세종대학교, 나노신소재 공학과. [5]상지대, 물리학과. [6]충북대, 물리학과. [7]공주대, 물리교육과.*) A double-barrier magnetic tunnel junction (DMTJ) with/without amorphous ferromagnetic material such as CoFeSiB 10, CoFe 5/CoFeSiB 5, and CoFe 10 (nm) were prepared and compared to investigate the bias voltage dependence of tunneling magnetoresistance (TMR) ratio. The typical DMTJ structures were Ta

45/Ru 9.5/IrMn 10/CoFe 7/AlOx / free layer 10/AlOx /CoFe 7/IrMn 10/Ru 60 (in nanometers). The interlayer coupling field and the normalized TMR ratios at the applied voltage of +0.4 and -0.4 V of the amorphous CoFeSiB-used DMTJ offer lower and higher values than that of the polycrystalline CoFe-used one, respectively. An amorphous ferromagnetic CoFeSiB-used DMTJ improve the interface roughness of the free layer/tunnel barrier and result, the interlayer coupling field and bias voltage dependence of the TMR ratio is suppressed at given voltage.

Ep-008 **X-ray Scattering Studies on Ultralow-k Nanoporous Organosilicate Dielectric Films as a Function of Porogen Loading** KIM Jeeun, LEE Heeju, SONG Sanghoon, CHA Wonsuk, KIM Hyunjung, PARK Gunwoo[1], MIN Sungkyu[1], LEE Taehoon[1], RHEE Heewoo[1], KIM Gangwoo[2](*서강대학교 물리학과 &바이오융합과정. [1]서강대학교 화공생명공학과. [2]포항 가속기 연구소.*)
반도체 소자의 층간 절연 물질로서의 나노기공 유기실리케이트 박막은 기계적 물성이 강하면서 저 유전율의 성질을 가져야 한다. 반응성 포라젠은 비 반응성 포라젠 보다 같은 함량에서 더 낮은 유전율과 높은 기계적 강도를 갖는다. 본 연구에서는 반응성 포라젠을 이용한 나노기공 유기실리케이트 박막을 제조하여 포라젠의 함량에 따라 형성된 기공의 크기 비율을 Ellipsometry, X-ray Reflectivity(XRR)와 Grazing Incidence Small Angle X-ray Scattering를 이용하여 측정하였다. 제조된 나노기공 박막의 기공 분포를 후열처리 조건과 시간에 따른 변화에 대해 측정하였다. 또한 포라젠의 함량이 늘어남에 따라서 전자밀도가 감소함을 XRR를 통해 확인하였으며, 포라젠 함량이 10% ~40%에서는 기공의 크기가 매우 작게 균일하게 분포되어 있고 50% 이상에서는 기공의 뭉침 현상이 일어나 기공의 크기가 증가함을 알았다.
*This research was supported by the Korea Science and Engineering Foundation, Seoul Research and Business Development Program (10816), Sogang University Grant (2007).

Ep-009 **Photoluminescence Anisotropy of Randomly Dispersive Zeolite-dye Composites** LIM Hyunjin, CHEONG Hyeonsik, LEE Jin Seok[1], YOON Kyung Byung[1](*Department of Physics, Sogang University. [1]Department of Chemistry, Sogang University.*)
The dynamics of photoluminescence (PL) from dye-containing zeolite rods were studied using polarized photoluminescence spectroscopy. We prepared nanoporous zeolites L and pyronine B dyes molecules as the host and guest materials, respectively. Since zeolites are nanoporous and materials with uniform structures, it can be used as nano-building blocks. We synthesized each zeolites in different lengths of 2.5 μm, 5 μm, and 10 μm, and then inserted dye molecules to the pores of each zeolite. The polarized PL spectra of these composites were obtained and compared with the case of dye molecules in glycerol as the solvent. The dye molecules are hard to move or rotate in glycerol since it is a very viscous solvent. The theoretical anisotropy value of randomly dispersed molecules is 3. As the concentration of dye molecules increases, the anisotropy of the PL from the dye molecules in glycerol decreased, whereas that from the composites increased up to 2.8. In addition we observed that the length of the zeolites affect the anisotropy. From these results we try to understand better the properties of zeolite-dye composites as light-emitting nano-building blocks.

Ep-010 **Single-Crystalline Bi Nanowires Grown by A Stress-Induced Method** HAM Jinhee, SHIM Wooyoung, LEE Minyoung, HONG Eunjin, KANG Joohoon, JEON Kyejin, LEE Wooyoung(*Department of Materials Science and Engineering, Yonsei University, 134 Shinchon, Seoul 120-749, Korea.*) The great interest in Bi nanowires lies in the opportunity for exploring novel low-dimensional phenomena as well as practical application such as thermoelectricity, since the smallest effective mass of all known materials, ~0.001m_e, make it easy to observe the quantum confinement effect [1]. In this work, we present a novel method to grow high-quality, single-crystalline Bi nanowires and the growth mechanism and origin for the Bi nanowire growth. The Bi thin films were sputtered and transferred to a furnace for heat treatment at 270 ˚C for 10 hours. Interestingly, after heat treatment, uniform and straight Bi nanowires with high aspect ratios were found to be extruded from the surface of the as-grown films. The growth of Bi nanowires on the films is attributable to the relaxation of stress, originating from a thermal expansion mismatch between the film and the substrate. This mismatch is due to the large difference in the coefficient of thermal expansion of Bi (13.4×10^{-6}/℃) and Si/SiO2 ($2.4 \times 10^{-6}/0.5 \times 10^{-6}$/℃). The grains of a Bi film grown at 100 W and annealed was found to have preferred orientation, i.e., (003) and (006), while the grains of a Bi film grown at 10 W and annealed were observed to be randomly oriented. We infer that the grains of the Bi film grown at 100 W having the preferred orientation play a role as seeds for Bi nanowires after annealing. We also found that the diameter of Bi nanowires decreased with the mean grain size of the films, indicating that the diameter of the Bi nanowires can be controlled in our method. A detailed discussion of the spontaneous growth of Bi nanowires will be presented. Our new growth method for Bi nanowires provides a motivation for exploring the high-efficiency thermoelectric properties of single-crystalline Bi nanowires. Reference [1] Y. M. Lin, et al., Phys. Rev. B 62, 4610 (2000) [2] D. W. Zheng, et al., J. Mater. Res. 17, 1795 (2002)

Ep-011 **Near-infrared Resonant Multilayer Half-Shell Nanoparticles for Photothermally Controlled Drug Delivery and MRI Enhancement** 박 희열, 양 재문[1], 서 성백[2], 김 규정[2], 함 승주[3], 김 동현[3], 유 경화[3](*연세대학교 나노 메디컬 협동 과정. [1]연세대학교 공과대학. [2]연세대학교 나노메디컬 협동과정. [3]연세대학교 나노 메디컬 센터.*) Polymer-metallic multilayer half-shell nanoparticles (H-S NPs) are developed as multifunctional nanoplatforms for photothermally controlled drug delivery and magnetic resonance imaging (MRI) enhancement. These nanoparticles are fabricated by depositing Mn and Au films onto rhodamine-loaded poly(lactic-co-glycolic) (PLGA) nanoparticles; their surface plasmon-resonance frequency is found to be in the near infrared (NIR) range. Drug release from PLGA nanoparticles is enhanced in response to NIR light which is converted into thermal energy. Additionally, the magnetic properties of the Mn layer allow these

nanoparticles to act as MRI contrast agents.

Ep-012 **Interfacial mixing in double-barrier magnetic tunnel junctions** 임 혜인, 이 선영, 이 장로, 전 병선[1], 황 재연[2], 김 영근[3], 김 태완[4](*숙명여대, 물리학과. [1]UCLA, 전자공학. [2]한국원자력연구소,하나로센터. [3]고려대학교,신소재공학과. [4]세종대학교, 나노신소재 공학과.*) A double-barrier magnetic tunnel junction (DMTJ) requires ultrasmooth and uniform tunnel barriers where, in particular, the top one is more critical but very difficult to fabricate [1]. To resolve this problem, we introduced an amorphous magnetic CoFeSiB to retard the columnar growth resulting in a wavy interface. The basic DMTJ structure consisted of Ta 45/Ru 9.5/IrMn 10/CoFe 7/AlO_x/free layer 7/AlO_x/CoFe 7/IrMn 10/Ru 60 (nm). Various free layers such as CoFe 7, CoFeSiB 7, and CoFe 1.5/CoFeSiB 4/CoFe 1.5 were prepared and compared. The structural and magneto-transport properties of DMTJs depending on the free layer structure are summarized in Table 1. By using an amorphous CoFeSiB layer, the normalized TMR ratio (at +, - 0.4 V) and V_h increased and the interlayer coupling field (H_i) decreased. This result can be attributed to the fact that the upper tunnel barrier of the DMTJ became more uniform with the CoFeSiB layer compared to that with the CoFe layer. For reducing the H_i and suppressing the bias voltage dependence of the TMR ratio, the smooth free layer/tunnel barrier is indispensable.

Ep-013 **Magnetization switching effects of double synthetic antiferromagnet structure consisting of amorphous NiFeSiB layers** 전 병선, 황 재연[1], 이 선영[2], 이 장로[2], 김 영근[3], 김 태완[4] (*UCLA, 전자공학. [1]한국원자력연구소, 하나로센터. [2]숙명여대, 물리학과. [3]고려대학교,신소재공학과. [4]세종대학교, 나노신소재 공학과.*) A synthetic antiferromagnet (SAF) structure comprising of ferromagnetic amorphous $Ni_{16}Fe_{62}Si_8B_{14}$ layer has been devised and employed as a free layer of magnetic tunnel junctions (MTJs) to enhance cell switching performance. Various MTJ structure such as CoFe 7/AlOx/NiFeSiB 7 [normal], CoFe 3.5/Ru 1.0/CoFe 3.5/AlOx/NiFeSiB 7 [single SAF], and CoFe 3.5/Ru 1.0/CoFe 3.5/AlOx/NiFeSiB 4/Ru 1.0/NiFeSiB 3 (nm) [double SAF] were prepared and compared. The magneto-transport properties of MTJs depending on the free and pinned layer structure are summarized in Table 1. The double SAF structure showed lower magnetization switching field (H_{sw}) and interlayer coupling field (H_i) than that of the other structures. This result can be attributed to the fact that the SAF structure can reduce both magnetostatic coupling between the pinned and free layers and magnetostatic energy in the free layer separated by nonmagnetic space layer. The most interesting feature associated with this research is that the NiFeSiB free layered MTJ showed lower H_{sw} than traditional CoFe and NiFe free layered MTJ. And moreover, the H_i can be controlled and reduced by proper structure.

Ep-014 **Photocatalytic property of W-doped $PbBi_2Nb_2O_9$ layered perovskite material under visible light irradiation** 김 현규, 유 성미, 장 지민, 안 창원, 하 명규, 진 종성, 정 의덕(*한국기초과학지원연구원 부산센터.*) The substitution effect of W^{6+} at Nb^{5+} site in PbBi2Nb2O9, a layered Aurivillius-phase perovskite system, has been studied and further optimized to fabricate an efficient photocatalyst. The material doped with electron donor (W^{+6}), $PbBi_2Nb_{2-x}W_xO_9$ with an optimum composition of x=0.15 exhibited a red shifted (0.14eV) band gap, generated two times higher photocurrent, and showed analogous higher quantum yield for photodecomposition of H_2O/CH_3OH solution than undoped $\lambda \geq 420$nm). In contrast, the material doped withlmaterial under visible light (hole donor (Ti^{+4})) revealed deteriorated photochemical properties. The higher electron density by n-type doping seems to be responsible for the more efficient charge separation in $PbBi_2Nb_{2-x}W_xO_9$ ($0 < x < 0.5$).

Ep-015 **Optical property of nanocrystalline $Ca_{1-x}Mg_xFe_2O_4$ synthesized by the polymerized complex method** 김 현규, 유 성미, 김 혜진, 진 종성, 홍 태은, 하 명규, 홍 경수, 정 의덕(*한국기초과학지원연구원 부산센터.*) Perovskite-type oxide materials based on transition metals with d(0) electron configuration such as Nb(V), Ta(V), and Ti(IV) are efficient photocatalysts for overall water splitting with high quantum yields. However, the large band gaps of these materials (ca. 3.8-4.0 eV) are not suitable for the visible light photocatalysis. Very recently we observed that photocatalyst consisting of nanocomposites are efficient in utilization of visible light photons. Hence we report here a study on the synthesis and application of nanocrystalline ternary metal-oxide. Here, we report the new finding that nanocrystalline $Ca_{1-x}Mg_xFe_2O_4$, viz. a p-n type photocatalysts have activity for the photoreaction of water under visible light irradiation. We characterized the optical properties of nanocrystalline $Ca_{1-x}Mg_xFe_2O_4$ by UV-vis diffuse reflectance spectroscopy and X-ray diffraction.

Ep-016 **Photocatalytic activity of Cr and Fe co-doped TiO_2 nanoparticle** 김 현규, 유 성미, 김 혜진, 장 지민, 안 창원, 홍 태은, 홍 경수, 정 의덕(*한국기초과학지원연구원 부산센터.*) We report here the new findings on the visible light photodecomposition activity of gaseous iso-propyl alcohol over Cr and Fe co-doped TiO_2 nanoparticles. High surface area, doped TiO_2 nanoparticles were synthesized hydrothermally and co-dopant effects are investigated. The physico-chemical properties of the co-doped nanoparticles led to efficient photocatalysts. Cr and Fe co-doped TiO_2 nanoparticles exhibited two times higher photocatalytic activity for photodecomposition of gaseous isopropyl alcohol than the individually (Cr/ Fe) doped TiO_2 nanoparticles under visible light irradiation ($\lambda > 420$nm). The activity is mainly correlated to the larger absorptions around 496nm and 563nm wavelengths by co-doped TiO_2 nanoparticles than Fe doped TiO_2 nanoparticles those possibly absorb $\leq$ 496nm.

Ep-017 **Elucidation on the enhancement of magneto-optical diffraction from magnetic gratings** LU YueHui, CHO MinHyung, KIM JinBae, LEE GeonJoon, LEE YoungPak, RHEE JooYull[1](*Quantum Photonic Science Research Center and BK21 Program*

Division of Advanced Research and Education in Physics, Hanyang University. [1]BK21 Physics Research Division and Department of Physics, Sungkyunkwan University.) An enhancement of the magneto-optical effects of the diffracted beams, compared with the specular one, was observed experimentally for Co_2MnSi magnetic gratings made using the interference pattern of two femtosecond-laser beams. In order to analyze it, a rigorous coupled-wave approach is utilized, which is implemented as Airy-like internal-reflection series. The numerical simulations illustrate the relationship between the enhancement and the structural parameters of gratings. This work shows the potential of the theoretical analysis for the control of the magneto-optical properties of magnetic photonic bandgap materials and nanostructures.

Ep-018 **분무법을 이용한 fullerene(C_{60}) cluster 생성 장치 개발에 관한 연구** 여 승준, 안 정선, 류 성원[1], 이 병로[1], 김 화민[1] (*경희대학교 물리학과. [1]대구카톨릭대학 전자공학과.*) 본 연구는 용액 중에서 나노미터 크기의 C_{60} aggregates을 형성하고 C_{60} aggregates내에서의 광중합 반응을 이용하여 C_{60}을 기본단위로 하는 새로운 나노 구조체를 형성하려는 시도로서, 기존의 bulk 물질에서 시도한 방법과는 달리 C_{60} aggregates의 크기 제어를 통해 최종적으로 C_{60} 중합체의 크기제어가 용이할 것으로 기대된다. 지금까지 단일 용매를 이용한 실험에서 톨루엔, 벤젠, CS_2 등에 C_{60}을 용해한 후, 온도 변화에 따른 용액의 PL 스펙트럼 변화를 통해 C_{60}을 기본 단위로 하는 나노미터 크기의 C_{60} aggregates이 형성됨을 보고한 바 있다. 이때 생성된 C_{60} aggregates은 내부의 C_{60}분자 간의 결합력이 약하여, 상온에서는 분자상태로 복귀하는 weakly bound cluster 이다. 이러한 C_{60} aggregates에 UV pulse laser (Nd:YAG laser, 355nm)를 조사하여, 반응 전과 후의 PL 스펙트럼의 변화를 측정하고, High-Resolution TEM image를 이용하여 관측한 결과, 내부의 C_{60} 분자 사이에 광중합 반응이 형성되어 상온에서도 안정한 나노 구조체가 형성되었음을 확인할 수 있었다. 하지만 이러한 방법으로는 생성된 C_{60} cluster의 양이 극히 적다는 문제점이 있다. 거시적으로 나노구조체를 생성할 수 있는 새로운 방법을 찾기 위하여, 본 연구에서는 초음파 분무법을 도입한 C_{60} cluster 생성장치를 설계, 제작하여 거시적인 양의 C_{60} 나노구조체의 생성 가능성을 조사하였다. 본 실험에서 설계한 C_{60} cluster 생성장치는 C_{60} 분자가 포함된 용액 방울(droplet)을 초음파 분무법을 이용하요 마이크로미터 사이즈로 진공 중에서 분무 시켜, 용액 방울이 자연 증발하는 과정에서 C_{60} 용액이 농축되어 나노미터 사이즈의 aggregates이 형성될 가능성이 있으며, 이때 UV 광원을 조사하면 C_{60} aggregates 내부에 공유결합의 network이 형성될 수 있다는 점에 착안하여 설계하였으며, 본 발표에서는 이러한 설계에 의하여 제작된 시작품을 이용하여 C_{60} cluster 생성 가능성을 조사한 결과를 소개할 예정이다.

Ep-019 **Synthesis of High Quality Single Walled Carbon Nanotubes using Fe/Al Multilayer Film as Catalyst** JEON M. H., NOH K. S., LEE S. Y., LEE J. S., LEE K. S., SOHN K. Y. (*Department of Nano Systems Engineering, Center for Nano Manufacturing, InJe University.*) The high quality single walled carbon nanotubes (SWNTs) were synthesized on the Fe/Al multilayer catalyst by thermal chemical vapor deposition (CVD) method. The methane (CH_4) mixed with ethylene (C_2H_4) was fed into a reactor to synthesize SWNTs at a temperature range of 600-900℃. The carbon clusters and MWNTs are produced at low temperatures (~700°C). At 800°C, there were observed the mixing of rare SWNTs and MWNTs. We obtained that the high quality SWNTs were optimally grown at 900°C. According to the increase in the growth temperature, the Al layer appears to increase the surface roughness and prevent the nanoparticles to aggregate at high temperature. As a result, the formation of SWNTs was greatly influenced by the variation of the surface morphology at different growth temperatures. Furthermore, a bridged SWNT was grown between patterned multilayer catalysts at 900°C. Patterns created on SiO_2 substrate were obtained by electron beam lithography techniques. The current-voltage (I-V) characteristics of the bridged SWNT were also investigated.

Ep-020 **Local Piezoelectric and Electrical characterization of PZT thin films by Scanning Probe Microscopy** 조 진형, 민 성식[1], 김 철환[1], 장 윤형[1], 문 학범[1](*부산대학교 유전체 물성연구소. [1]부산대학교 물리학과.*) $PbZr_{0.52}Ti_{0.48}O_3$ (PZT) thin films have been a candidate for new applications including nonvolatile memory devices. In order to understand growth characteristics of PZT thin films, PZT thin films were deposited on $Pt/Ti/SiO_2/Si$ substrate and on $Ir/Ti/SiO_2/Si$ substrate by pulsed laser deposition (PLD). Above all, we focused on two factors to understand ferroelectric domains; firstly, the 3-D orientation of ferroelectric domains in PZT thin films using local piezoelectric properties of these films. In order to find orientation of ferroelectric domains, we investigated PZT thin films by piezoresponse force microscopy (PFM) of both in-plane and out-of-plane directions with respect to the direction of the film growth, where the PFM images show the magnitude and phase of local domains of out-of-plane and in-plane directions. These images show the 3 dimensional ferroelectric domain orientation of PZT thin films. The second factor is a domain switching investigation of PZT thin films using electric force microscopy (EFM) and PFM. From the data, we will report criteria for domain switching without charging effect and will discuss the 3-dimensions orientation and control of domain switching method.

Ep-021 **Studies On Thermal Stability Of Phases In Ti-Zr-Ni Alloys** JEON Jae-kyun, KIM Nam-hyuk, SOHN sung-woo[1], KIM Do-hyang[1](*한양대학교 물리학과. [1]연세대학교 신소재공학과.*) Quasicrystals, discovered by Schectman et al. in 1984, are known to exhibit a feature of 5-fold rotational symmetry that is forbidden in crystalline materials. Their sharp diffraction patterns in X-ray and transmission electron microscopy, however, demonstrate that they differ from amorphous materials. Ti-based quasicrystals form the second largest class, having potential possibilities on hydrogen storage applications. Most of the Ti-based quasicrystals are found by a rapid quenching from molten ingots, suggesting that they are metastable. Ti-Zr-Ni quasicrystals, however, are thermodynamically stable and the phase stabilities were predicted earlier by using a differential scanning calorimetry (DSC) studies. To inves-

tigate the phases stabilities of the quasicrystals, samples made with a broad range of Ti/Zr concentrations, $Ti_{53}Zr_{27}Ni_{20}$ compositions, for example, were prepared by slow, rapid quenching and annealed at high temperatures, and the microstructure, phase information were obtained by using X-ray diffraction and TEM studies. Thermal stability of the phases appearing in Ti-Zr-Ni alloys was investigated by using a differential scanning calorimetry (DSC), and the results will be presented.

Ep-022 **Improvement of Electrical Contact Properties between SWNTs and Metal Electrodes Using Ti Underlayer** JEON M. H., LEE S. Y., NOH K. S., PARK C. Y., LEE K. S., SOHN K. Y.(*Department of Nano Systems Engineering, Center for Nano Manufacturing, Inje University.*.) Single-walled carbon nanotubes (SWNTs) offer great promise for use in functional molecularscale devices because of their remarkable mechanical and electrical properties. To achieve CNT-based devices with the small size, fast speed and low-power dissipation, the sturdy and low-resistance contact is mandatory. Titanium (Ti) is used as ohmic contact electrodes to SWNTs. Compared with other metals such as gold, palladium, iron, aluminum, and lead, Ti has stronger interactions with CNT and the lowest contact resistance. SWNTs were grown on the patterned Fe catalysts by chemical vapor deposition (CVD). In order to improve electrical contact properties between SWNTs and metal electrodes, Ti underlayer was pre-deposited prior to depositing Fe catalysts. Structural properties are investigated by raman spectroscopy, field emission scanning electron microscope (FE-SEM) and atomic force microscope (AFM). Electrical contact properties are measured between SWNT and metal electrodes of Au/Ti/SWNT/Ti/Si substrate and Au/Ti/SWNT/Si substrate through I-V characteristics by two terminal method. We confirm that Au/Ti/SWNT/Ti exhibits lower contact resistance.

Ep-023 **Investigation on Electrochemical Properties Using Rapid Thermal Annealed CNT based Electrodes in DSSC** JEON M.H, MOON J.H, HWANG S.H, LEE S.K, LEE K.S, LEE D.Y[1](*Department of Nano systems engineering, Center for Nano Manufacturing Inje University. [1]Optoelectric Research Group, Korea Electrotechnology Research Institute, Korea.*) Nanocrystalline oxide film, dye molecules and redox electrolyte of dye-sensitized solar cells have been sufficiently carried out until now. In recent years, carbon structures with many advantages have been studied as a new electrochemical electrode materials replacing metal counter electrode. We prepare carbon nanotubes (CNT) as counter electrode material of DSSCs. CNTs on the high doped p-type Si substrate are grown by chemical vapor deposition (CVD) using Fe catalysts. The growth temperature is 900 °C. In order to improve redox reaction, the rapid thermal annealing (RTA) treatments on the CNTs are carried out at the growth temperature. Electrochemical properties of CNTs are measured by electrochemical impedance spectroscopy (EIS). EIS measured that, the frequency of annealed CNT electrode is about 3 kHz and unannealed CNT is about 0.4 kHz. The total resistivity of the annealed electrode has much lower than that of unannealed electrode at the interface and also the electrode reaction occurs easier. In order to measure the electrochemical properties of the CNT electrode itself, we also prepare the CNT paste on F-doped SnO_2 (FTO) glass using CNTs powder, de-ionized water and CMC (Carboxyl Methyl Cellulous). It is found that the annealed CNTs have the better performance than unannealed CNTs as electrode material for dye sensitized solar cells.

Ep-024 **Permalloy 단일 나노선의 자기적 성질.** 이 한석, 김 승호, 황 현미, 이 재용(*연세대학교 물리학과 표면자성연구실.*) 스핀트로닉스는 전자의 고유한 성질인 스핀을 정보처리 및 전달에 이용하고자 하는 시도이다. 이 기술의 장점은 비휘발성, 고밀도 및 빠른 전달속도라는 장점을 가지고 있으며, 미래에 실생활에 이용될 것으로 기대되는 새로운 분야이다. 자성정보는 자성물질에 의하여 전달되고, 이 물질은 단일자구와 잘 정의된 자기이방성을 가져야 한다. 자성 나노선은 이 목적에 부합되는 물질이다. 따라서 우리는 100-2000 nm의 단일 자성 나노선에 대한 자기적 성질을 연구하였다. 자성 나노선은 e-beam lithography와 진공증착 및 lift-off를 거쳐서 길이 100 μm인 permalloy 나노선을 제작하였다. permalloy의 증착률은 0.3 Å/s이었으며, 두께는 200Å으로 고정시켰다. 진공증착 챔버의 base pressure는 4×10^{-9} torr였다. 광자기 Kerr효과(magneto-optic Kerr effect) 장비를 이용하여 자기이력곡선을 측정하였으며, 이때 사용된 HeNe 레이저의 beam 크기는 2.5 μm이하였고, 입사각은 45°를 유지하였다. 또한 비교할 film의 대용으로 같은 두께를 가진 폭 9 μm의 cross를 제작하였다. 자화용이축으로 측정한 2000 nm이하의 나노선은 폭이 작아질수록 보자력(coercivity)이 증가하였으나, 측정할 때마다 보자력이 변하는 것을 관찰하였다. 반면에 박막대용으로 사용하는 9 μm의 시료는 일정한 보자력을 유지하였다. cross의 경우 교차점과 교차되지 않는 지점에서 자기이력곡선을 측정하였다. 비교차 지점에서는 전형적인 easy와 hard axis loop이 관찰되었고, 교차점에서는 100% 이하의 잔류자화가 관찰되었다. cross의 hard axis loop 으로부터 결정된 K_u 값은 1.40×10^4 erg/cm^{3}이었다. 현재 다른 나노선들에 대한 easy 및 hard에 대한 측정을 진행하고 있으며, 외부자기장의 변화에 따른 측정결과를 발표할 예정이다.

Ep-025 **자성 단일나노선의 동역학 연구** 김 승호, 이 한석, 황 현미, 이 재용(*연세대학교 물리학과 표면자성연구실.*) 스핀트로닉스에서의 정보전달은 단일 자구를 가지며, 잘 정의된 자성나노선을 통하여 이루어질 것으로 예상된다. 자성체의 정보전달은 자화반전(magnetic reversal process)에 의하여 구현되는데, 전달이라는 측면에서 이 현상을 이해하는 것은 매우 복잡한 일이다. 나노선에서 부분적인 자구형성(domain nucleation)없이 순수한 자벽의 이동(domain wall motion)에 의하여 이루어지는지 또는 자벽의 운동방향과 자기장의 변화에 따른 보자력의 변화 등등 아직 많은 부분이 이해되지 않고 있다. 따라서 우리는 수 kHz이하로 변하는 자기장의 영향을 받는 자성 단일나노선의 동역학적 성질에 대한 연구를 수행하였다. 일반적으로 자성박막의 경우 자기이력곡선의 면적은 가해준 자기장과 자기장의 변화속도에 영향을 받는다는 power-law($A\propto H^{\alpha}\Omega^{\beta}$)가 잘 알려져 있다. 즉, 가해준 자기장의 크기나 Frequency가 커지면 자기이력곡선의 면적은 그에 따라 넓어진다는 것이다. e-beam lithography와 진공증착 및 lift-off를 이용하여 제작한 permalloy 나노선(선폭:100-2000 nm, 길이:100 μm, 두

께: 20 nm)을 제작하였다. 이러한 나노선에 2000Hz에서부터 0.1 Hz까지 Frequency를 변화 주면서 자기장을 가해주었고, Magneto Optic Kerr Effect (MOKE)와 Oscilloscope를 이용해서 자기이력곡선을 관찰하였다. 일반적으로 자기장이 증가하거나 frequency가 증가하면 자기이력곡선의 보자력이 증가하였다. 또한 같은 두께의 박막을 대신하기 위하여 9 μm의 선폭을 가진 cross를 제작하여 같은 실험을 반복하였다. 현재 실험이 진행 중에 있으며, 상세한 내용은 학회에서 발표할 예정이다.

Ep-026 **Upconversion properites of Er^{3+} doped (Y,Gd)AG and (Y,Gd)AP nanocrystals** 최 혜영, 심 규성[1], 문 병기[2], 정 중현[2], 이 성수[3], 김 중환[1](*동의대 기초과학연구소. [1]동의대 물리학과. [2]부경대 물리학과. [3]신라대 전자재료공학과.*) We report the single photon luminescence and upconversion spectra of 3.0 mole% Er^{3+} doped (yttrium, gadolinium)aluminum garnet((Y,Gd)AG) and (yttrium, gadolinium) aluminum perovoskite ((Y,Gd)AP) nanocrystals. The samples was prepared with solvethermal method. X-ray diffraction(XRD) and scanning electronic microscope(SEM) were measured for the characterizations of nanocrystals. Green emissions were observed under continuous-wave pumping at 980nm ($^4I_{11/2}$) and upconversion dynamics was measured by using pulsed optical parametric oscillator with β-$BaBO_4$ crystal(BBO-OPO). The intensities and spectra of luminescence were dependent on the phases of nanocrystals. The various emissions, energy-transfer upconversion (ETU) and excited-state absorption(ESA), were measured and their energy transfer processes could be explained.

Ep-027 **Fabrication of Au nanoparticles-embedded Silicon oxide nanowires** CHUN Jung Hwan, CHUNG Sang Young, KIM Dong Eon(*Department of Physics, POSTECH, Pohang 790-784, Korea.*) Silicon oxide nanowires(NWs) were fabricated successfully by laser ablation using Au as catalyst. Si wafers were used as the collector. The diameters range from 20 to 150 nm. Different forms of Silicon oxide NWs were observed at different local sites inside a furnace: NWs with a high ratio of length to diameter, NWs with Au nanoparticles being embedded. The characteristics of these nanostructures were investigated using electron microscope. Furthermore, Au nanoparticles that were embedded in Silicon oxide NWs could be removed successfully using KCN solution, creating hollows inside NWs.

Ep-028 **Photoluminescence of Pr^{3+}-doped $CaTiO_3$ Produced by Mechanochemical Alloying** 김 현구, 박 경화(*조선대학교 물리교육과.*) The photoluminescence of the Pr^{3+}-doped $CaTiO_3$ mixture produced by mechanochemical method was investigated by X-ray diffractometry(XRD), scanning electron microscopy(SEM), transmission electron microscopy(TEM) and thermogravimetric/ differential thermalanalysis(TG/DTA). The typical $^1D_2 \rightarrow {}^3H_4$ transition of Pr^{3+}-doped $CaTiO_3$ host by mechanochemical method provided us emission at about 615 nm. When the molar ratio of Pr^{3+} was 0.1, the emission intensity of the Pr^{3+}-doped $CaTiO_3$ mixture was higher than in other molar ratio. The red emission intensity of the Pr^{3+}-doped $CaTiO_3$ mixture was enhanced distinctly by increasing annealing temperature.

Ep-029 **Nanoscale Electricical Properties of NiO Thin films using Scanning Probe Microscopy** 조 진형, 김 철환[1], 문 학범[1], 민 성식[1], 장 윤형[1](*부산대학교, 유전체물성연구소. [1]부산대학교, 물리학과.*) We have studied nanoscale electrical properties of NiO thin films. The electrical properties of NiO thin films are very important for understanding the mechanism of the resistance change effect. NiO thin films were prepared by RF magnetron sputtering method, and nanoscale electrical properties were measured using conducting atomic force microscopy (CAFM) and electric force microscopy (EFM). CAFM and EFM studies showed that the change of resistance states caused by filamentary conducting path in the NiO thin films. We will discussed the experimental results of the resistance change mechanism of NiO thin films.

Ep-030 **Electrochemical Corrosion Behaviors of Amorphous $Co_{69}Fe_{4.5}(Ni, Nb)_{1.5}Si_{10}B_{15}$ Alloys** 김 현구, 박 경화, 김 은선, 명 화남[1](*조선대학교 물리교육과. [1]전남대학교 물리학과.*) This study was undertaken to measure the electrochemical corrosion behaviors of amorphous $Co_{69}Fe_{4.5}Ni_{1.5}Si_{10}B_{15}$(Ni-alloy) and $Co_{69}Fe_{4.5}Nb_{1.5}Si_{10}B_{15}$(Nb-alloy) (at.%) alloy ribbons under various conditions. The corrosion potential (E_{corr}) of the first peaks, under various conditions, exhibited a negative potential at all temperatures. The corrosion current density (I_{corr}) and corrosion rate in general increased with increasing temperature. The values of the I_{corr} and the corrosion rates in 0.001-M H_2SO_4 solution in general were higher than that of 0.07-M NaCl solution of higher concentration. The corrosion resistance for Ni-alloy in general was lower in NaCl solution, higher in H_2SO_4 solution than that of Nb-alloy. The E_{corr} was inversely proportional to the corrosion rate. The corrosion was not proportional perfectly to the oxygenation time within the range of studied times.

Ep-031 **Luminescence behavior of $GdVO_4$: Sm^{3+} powder phosphors by Sm concentration** CHUNG Jong Won, YANG Hyun Kyoung, FU Zuoling, MOON Byung Kee, JEONG Jung Hyun, YI Soung Soo[1](*부경대학교, 물리학과. [1]신라대학교, 전자재료공학과.*) Gadolinium orthovanadate ($GdVO_4$) is an attractive host lattice for several lanthanide ions to produce efficient phosphors emitting a variety of colors. Especially, samarium doping gives a red emission in $GdVO_4$ with two main group of lines at 564 nm ($^5G_{5/2}$-$^6H_{5/2}$), and 603 nm ($^4G_{5/2}$-$^6H_{7/2}$). Recently $GdVO_4$:Sm^{3+} phosphor is considered as a candidate for re phosphor for flat panel displays (FPDs) because of its good color purity. It has been reported that when the Sm ion is located in a host lattice lacking inversion symmetry such as $GdVO_4$, luminescent properties of Sm-activated phosphor are affected by the crystal symmetry of the Sm site. As a result, $GdVO_4$:Sm^{3+} phosphor shows good color purity. Generally, to synthesize ceramic powders, sol-gel been widely adopted. Sm^{3+} doped $GdVO_4$ phosphors were prepared by sol-gel method. The doped concentration of Sm^{3+} was various 0.01, 0.03,

0.05, 0.07, 0.1 and 0.5 mol of Gd^{3+} in $GdVO_4$ host. $Gd(NO_3)_3$, $Sm(NO_3)_3$, and $VO(OR)_3$ were used as starting materials and they were dissolved in 2-MOE. Stoichiometric amounts of above solutions were mixed and the solution was initially heated at 70℃ in air and continuously stirred in a mixture for 80h. The samples were dried at 50℃ in air for 5h, and the as-prepared samples were obtained. The as-prepared samples were annealed to the desired temperature at 700℃ for 2h. The room temperature photoluminescence spectra were dominated by the red emission peak at 603nm radiated from the transition of $^4G_{5/2}$-$^6H_{7/2}$ within Sm^{3+} ions. Their crystalline structures, surface morphologies and phase transitions were investigated according to annealing process by X-ray diffraction(XRD), scanning electron microscopy(SEM), and cathode luminescence(CL).

Ep-032 **Synthesis and luminescent properties of $CaTiO_3$ nanocrystals doped with Pr^{3+} ions** FU Zuoling, MOON Byung Kee, YANG Hyun Kyoung, JEONG Jung Hyun(*부경대학교, 물리학과.*) Calcium titanate, $CaTiO_3$, belongs to the important group of compounds with a perovskite structure and has been widely used in electronic devices as a dielectric material. In recent years, much work has been concentrated on orthorhombic praseodymium-doped calcium titanate, which is known as a red emitting phosphor characterized by a single strong and sharp emission peak at about 610nm. This is attributed to the characteristic $^1D_2$-$^3H_4$ transition of Pr^{3+}. Researchers prepared the kind of materials by conventional solid-state reaction in most reports. However, in order to enhance the luminous properties, many researchers have studied these phosphors by varying the concentration of praseodymium, different charge compensators, and different synthesis methods. It is well known that the effect of grain size on the properties of $CaTiO_3$ phase is strong and manifests itself in changes of all properties: phase transition temperatures, crystal structure and optical properties. In this paper, the bulk $CaTiO_3$:Pr^{3+} were synthesized by high temperature solid-state reaction. Nanocrystal $CaTiO_3$:Pr^{3+} were prepared by solvo-thermal method, using calcium acetylacetonate ($Ca(C_5H_8O_2)_2{\cdot}xH_2O$), titanium(IV) butoxide ($Ti(OCH_2CH_2CH_2CH_3)_4$) and praseodymium acetylacetonate($Pr(C_5H_8O_2)_3{\cdot}xH_2O$) as precursors. The as-grown powders were found to be amorphous, which crystallized to the orthorhombic phase after calcination at 700°C in air for 3 hours. Characterizations of products were performed by XRD, IR, SEM, PL and PLE, the PL spectrum has a peak at 610nm, which is attributed to the intra-4f transition from the excited state $^1D_2$ to the ground state $^3H_4$ of Pr^{3+} ($^1D_2 \rightarrow {}^3H_4$ emission). On the other hand, in the PLE spectra, there is a broad excitation bands centered 330nm and a shoulder at 370nm, respectively. The former corresponds to the absorption of Pr^{3+} 4f5d states and latter is attributed to a low-lying Pr-to-metal (Pr^{3+}-Ti^{4+}) intervalence charge transfer state. However, compared with the bulk material, the broad excitation band of Pr^{3+} 4f5d in nanocrystal shifts to shorter wavelength, but the shoulder at 370nm is not obviously changed. The change mechanism of broad excitation band in bulk and nanocrystal was also discussed.

Ep-033 **Low-temperature preparation and optical properties of Pr^{3+}-doped $SrTiO_3$ by sol-gel method** FU Zuoling, MOON Byung Kee, YANG Hyun Kyoung, JEONG Jung Hyun(*부경대학교, 물리학과.*) $SrTiO_3$ is a perovskite quantum paraelectric where large quantum fluctuations make the ferroelectric state unstable in favor of the paraelectric state. Recently, $SrTiO_3$: Pr^{3+} was developed as a red phosphor for field emission displays (FEDS). Many studies have been made on the preparation of perovskites oxides by the sol-gel method. The use of Sol-gel synthesis is a particularly attractive route for several reasons: (i) better homogeneity because of mixing on the molecular scale, (ii) a potential for higher purity because of purer starting materials and fewer processing steps than in solid-state preparations, (iii) a high degree of control in the stoichiometry of the final product. In this paper, $SrTiO_3$: Pr^{3+} powders were prepared by the sol-gel method. At first, strontium acetylacetonate ($Sr(C_5H_8O_2)_2{\cdot}xH_2O$,) and praseodymium ($Pr(C_5H_8O_2)_3{\cdot}xH_2O$) acetylacetonate were dissolved in 2-methoxyethanol ($CH_3OCH_2CH_2OH$) and stirred for 12h. Titanium (IV) butoxide ($Ti(OCH_2CH_2CH_2CH_3)_4$) was then added to the strontium and praseodymium solutions and stirred for 24h to prepare precursor solutions of $Sr_{1-x}PrTiO_3$(x=0.002). The precursor solutions were amber in color and transparent. Then the solutions were dried at 110°C for 72h in oil bath to obtain gels. The gels were then calcined at 700°C for 3h. Single phase of $SrTiO_3$:Pr^{3+} were confirmed. In addition, the photoluminescent properties were detected. Under 359nm excitation, $SrTiO_3$: Pr phosphor exhibited a strong red emission, peaking at about 617nm, which should be ascribed to $^1D_2$-$^3H_4$ transition.

Ep-034 **분광타원해석기를 이용한 다공성 알루니늄 양극산화막 구조분석** 정 용우, 변 준석, 윤 재진, 김 영동, 우 덕하[1] (*경희대학교 물리학과. [1]한국과학기술연구원.*) 다공성 알루미늄 양극 산화막(Anodized Aluminum Oxide:AAO)은 나노 단위의 패턴 및 구조물 형성 마스크로서 널리 사용되고 있는 물질 중 하나이다. 이러한 폭넓은 응용은 알루미늄을 2차 이상의 양극 산화시 고밀도의 균일한 구멍의 배열을 갖으면서도 물리화학적인 강도가 높은 산화막이 형성되는 특징에 기인한다. 특히 최근에는 다공성 AAO template 자체가 갖는 광결정 특성에 대한 연구가 활발히 진행되고 있다. 빛의 전파를 조절하여 특정 주파수나 파장의 빛을 제어하는 광결정은 디스플레이, 광자 컴퓨팅, 광통신등의 응용에 매력적인 물질이기 때문이다. 다공성 AAO template의 특징 중 하나는 제작공정이 매우 단순하고 AAO template의 구멍 배열이 전압에 의존하기 때문에 원하는 template 제작조건을 찾기가 쉽다. 그러나 문제는 제작된 AAO template의 구멍 크기와 표면상태를 확인하는 방법이 Scanning Electron Microscopy (SEM) 또는 Atomic Force Microscopy (AFM) 에 국한되어 있다는 점이다. 이러한 측정들은 시료의 손상이 필연적이며 많은 시간과 노력이 소요된다. 본 연구는 200-850 nm 분광영역을 갖는 분광타원분석기를 이용하여, 시료 비파괴적인 광학적 접근 방식에 의한 AAO template의 구조분석을 수행하였다. 측정에 사용된 분광타원해석기는 시료에 반사된 빛의 편광상태 변화 (Ψ, Δ) 를 측정하여 물질의 광학적 특성을 분석하는데 널리 사용되고 있으며 다층박막같은 구조물분석에서도 수 Å에 해당하는 분해능을 갖고 있음이 알려져 있다. AAO template는 상부와 하부가 다른 구조를 가지고 있다. 따라서 상부

에서 하부에 이르는 AAO template의 구조를 다층박막으로 가정하였고 각 층을 Effective Medium Approximation (EMA) 방식으로 모델링하여 AAO template의 분광타원분석기 측정결과를 분석하였다.

Ep-035 **Photoluminescence of diamond: Before and after high-pressure, high-temperature treatment** 박 수연, 정 현식, 최 현민[1], 김 영출[1](*서강대학교 물리학과. [1]한미보석감정원.*) 다이아몬드는 본래 탄소 원자만으로 이루어진 다이아몬드 구조로 매우 안정한 물질이다. 하지만 질소 불순물이 미량 첨가되면 질소와 vacancy의 결합에 의해 중성인 NV^0가 defect level로 생성되며, 음극성을 띠는 NV level은 거의 생성되지 않는다. 그러나 이러한 다이아몬드를 천연 생성상태에 가까운 고온고압(HPHT)으로 처리하면, 아직까지 알려지지 않은 메커니즘에 의해 불순물이 재배열되어 defect level의 에너지 구조 변화가 뚜렷하게 일어난다. 본 연구에서는 NV^0 level이 고온고압 처리 과정에서 전자를 얻어 NV level로 치환되며, 단일 level이 고온고압 처리를 거치며 splitting되는 특이한 현상을 photoluminescence와 Raman spectroscopy 방법으로 연구하였다.

Ep-036 **High bias behavior in semiconducting carbon nanotube and carbon nanotube cross junction** 이 동수, SVENSSON Johannes[1], 박 승주[2], 백 승재[2], 김 유경[2], 유 호남, CAMPBELL Eleanor E. B.[1], 박 영우(*서울대학교 물리학부. [1]Gothenburg University, Gothenburg, Sweden. [2]서울대학교 나노응용시스템.*) Current-voltage characteristics of devices of metallic and semiconducting carbon nanotubes were measured. The current saturation behavior was observed at high bias voltage. The behavior was explained by the electron-phonon scattering involving optical and accustic phonons and also in terms of scattering length. In addition, the high bias behavior through the metallic and semiconducting carbon nanotube cross junctions will be presented.

Ep-037 **Postgrowth doping of as-grown silicon nanowires and their electrical transport** 이 윤희, 권 혁상(*고려대학교.*) 실리콘 나노와이어는 나노디바이스와 나노기술분야에서 차세대 물질로 각광받고 있는 1차원 물질이다. 하지만, intrinsic한 실리콘이 가지고 있는 저항이 매우 높기 때문에, 그 자체만으로는 소자로서의 동작이 불가능하다. 실리콘 나노와이어의 전기적 특성을 개선하는 여러가지 방법이 있지만, 우리는 일반적인 도핑을 통하여 N-type &P-type 채널을 형성하였다. 일반적인 VLS(vapor-liquid-solid) 방법으로 intrinsic한 실리콘 나노와이어를 합성한 후, 그 위에 니켈을 전극으로 사용하여 통상적인 I-V 특성을 측정한 결과, intrinsic한 실리콘 나노와이어의 저항은 약 2GΩ으로 측정되었다. P- &N-doping 실험을 위해 PH_3 dopant gas와 스퍼터링 방법을 이용하였다. N-type 채널을 형성하기 위해 PH_3 분위기하에서 열처리를 하였다. 또한, P-type 채널을 형성하기 위해 Boron을 스퍼터링하여 마찬가지로 열처리를 진행하였다. P- &N-doping 후, 전극은 니켈을 사용하였으며, 200nm부터 1um까지 100nm간격으로 양 전극간 채널길이를 형성하여 채널 길이에 따른 전자의 이동도 및 전도도 변화정도를 살펴보았다. 마지막으로, Top-gate와 Back-gate에 따른 charge trap현상과 게이트 응답특성을 조사하였다.

Ep-038 **Sputtering방법으로 제작한 SiOx박막의 발광특성** 한 문섭, 주 지호, 고 창훈, 배 명욱, 장 승훈, 정 기영, 박 경완[1](*서울시립대학교, 물리학과. [1]서울시립대학교, 나노과학기술학과.*) 실리콘 기반의 나노구조물은 전자소자 내부에 광 입출력이 가능하도록 하는 광-전자소자 구현에 큰 가능성을 보여주고 있다. 하지만 아직까지 정확한 발광기제가 밝혀지지 않고, 상용화하기에는 발광효율이 상당히 부족하여(<5%) 많은 연구자들이 발광기제의 이해와, 발광 효율을 높이기 위하여(>10%) 노력하고 있다. 이 실험은 sputtering을 이용하여 증착한 SiOx박막의 광 특성을 연구하는데 그 목적이 있으며, 이미 실리콘 기반의 소자에서 상당한 효율의(눈으로 관측되는) 발광특성을 도출한 바 있다. 실험의 특성을 살펴보면, 실리콘 기판(100, p-type)위에 sputtering 방법을 이용하여 SiOx (x<2) 박막을 제작하고 후열처리를 하여 발광 특성을 높이게 된다. 실험을 통하여 후열처리는 초고진공상태(<~10^{-7} torr)에서 실시하는 것이 발광 효율 증가에 가장 큰 영향을 미치는 것으로 분석되었으며, 증착된 박막 내부의 전자의 화학적 결합상태를 분석함으로써(XPS) 박막 내부의 실리콘과 산소의 함량비를 알 수 있었다. HORIBA® 사의Monochrometer와 CCD로 구성된 Photoluminescence측정장비를 이용하여 발광 특성을 측정하였고, 실리콘과 산소의 함량비가 발광 파장 변화에 많은 영향을 미치는 것으로 분석되었다. 박막 내부의 화학적 함량비는 sputtering시 사용되는 Ar^+ plasma의 power에 의하여 영향을 받는 것으로 분석되었기 때문에, 결과적으로sputtering시의 plasma power를 조절하여 박막의 발광특성(파장)을 조절할 수 있다는 결론을 얻을 수 있다. 여기에 초고진공 열처리를 통하면 높은 발광 효율을 얻을 수 있으므로, 본 연구를 통하여 발광 파장의 조절이 가능하고 높은 발광 효율을 가지는 광소자의 개발이 앞당겨질 것으로 기대된다.

Ep-039 **Density Control of Single-walled Carbon Nanotube Network Synthesized by Ferritin Catalyst** GÜNEŞ Fethullah, JEONG Seung Youl, KIM Ki Kang, LEE Young Hee(*Department of Physics and Center for Nanotubes and Nanostructured Composites, Department of Nanoscience and Nanotechnology, Sungkyunkwan Advanced Institute of Nanotechnology (SAINT), Sungkyunkwan University, Suwon 440-746, South Korea.*) Ferritin catalyst which consists of discrete catalytic Fe particles with diameters in range of 3-7 nm has been recently used for synthesis of single-walled carbon nanotubes (SWCNT) as a random network on SiO_2 substrate. SWCNT growth process from ferritin catalyst includes dilution of catalyst, spin casting of catalyst on a hydrophilic substrate, removal of the protein shell by calcination, and synthesis of SWCNT. We show that the number of SWCNTs in a random network can be controlled by changing the temperature and the time of calcination. Furthermore, we also demonstrate that after hydrophilic treatment, evaporation of "3-aminopropyltriethoxysilane" (APTES) onto the substrate has an effect of increasing the discrete Fe particles on the substrate by changing the surface charge from negative to positive which makes negatively charged ferritin protein to be attached onto the positive APTES on the substrate. Providing more discrete catalyst particles is an essential step for increasing density of SWCNTs in the random network on the substrate.

Ep-040 **Electric and Mechanical Characteristics of Carbon**

Nanotubes Grown on Zn/Ni Multi-catalytic Layers HA Jaehwan, LEE Jonghyun, YOO Jae-eun[1], LEE Naesung[2], HONG Jinpyo(*New Functional Materials and Device Lab, Department of Physics, Hanyang University, Seoul 133-791, KOREA. [1]Iljin Nanotech Co., Ltd., Seoul 157-810, Korea. [2]Faculty of Nanotechnology and Advanced Materials Engineering, Sejong University, Seoul 143-747.*) Multi-wall carbon nanotubes(MWCNTs) were synthesized on glass substrate with Zn/Ni multi-catalytic Layer (MCL) by plasma enhanced chemical vapor deposition (PECVD). Cr(200nm) was deposited as role of buffer layer and then 10-50nm Ni and Zn were successively deposited as parts of MCL. Properties of CNTs (diameter, length, density, etc.) were controlled by varying the thickness of each MCL and repetition number of MCL set. Other experimental parameters were changing mixed ratio of gas (C_2H_2 and H_2), growth temperature, and growth time. TEM and EDX results clearly exhibit to the formation of Zn/Ni MCL. Moreover, the number of wall and the diameter of MWCNT with techniques were smaller than that of MWCNT synthesized on only Ni catalytic layer. Raman spectroscopy shows enhanced G/D ratio of 0.98.

Ep-041 **Opto-electrical Characteristics of ZnO-coated Multiwall Carbon Nanotubes** LEE Jonghyun, HA Jaehwan, HONG Jinpyo, LEE Naesung[1], YOO Jae-eun[2](*New Functional Materials and Device Lab, Department of Physics, Hanyang University, Seoul 133-791, KOREA. [1]Faculty of Nanotechnology and Advanced Materials Engineering, Sejong University, Seoul 143-747. [2]Iljin Nanotech Co., Ltd., Seoul 157-810, Korea.*) ZnO thin film was successfully coated on multiwall carbon nanotubes(MWCNTs) synthesized by a modified dual RF magnetron system. The vertically well aligned MWCNTs were synthesized on glass substrate by plasma enhanced chemical vapor deposition (PECVD) with Ni catalytic layer and Cr buffer layer beneath Ni layer. ZnO thin film was deposited on MWCNTs as a function of thickness at RT, 250, and 400℃, respectively. SEM images show the coated-ZnO layer on top of MWCNT. I-V measurements provide enhanced electrical property than that of non-coated MWCNTs. Furthermore, the life time of MWCNTs as a role of the cathode was also dramatically increased.

Ep-042 **The fabrication of various nanopores using MWNTs embedded in SiO_2** LEE Sang-jun, LYO In-Whan(*National Core Research Center for Nanomedical Technology.*) A new method to fabricate nano-pores using multi-walled nano-tubes(MWNT) in bulk SiO2 is described. MWNT"s dispersed in a solvent aresprayed onto a thickly oxidized Si wafer, and a thick layer of SiO2 isdeposited over the dispersed layer. Subsequent e-beam lithography andetching leave narrow SiO2 walls with MWNT"s protruding from the sides ofthe wall. The embedded MWNT"s were subsequently removed by high-voltagefield emission in oxygen environment. Thus fabricated nanopores wasexamined using transmission electron microscopy, which showswell-resolved nanopores with a variety of diameters possibly reflectingthe diameter of the original MWNT"s that were occupying the pore beforesputtering. Although more involved than the previous method, this methodshows promise of controlled fabrication of nanopores of an arbitrarysize, length and direction.

Ep-043 **Al-Nano Wire Grid를 이용한 Metal Polarization** 박 원훈, 강 동한[1], 안 기완, 오 범석, 오 재환, 장 진, 이 성중[2], 김 상규[2], 이 교현[2](*경희대학교 차세대디스플레이연구센터, 정보디스플레이학과. [1]경희대학교 차세대디스플레이연구센터, 물리학과. [2]파버나인.*) 최근 TFT-LCD 모듈(module)의 가격 인하로 인해 가장 중요하게 대두되고 광학필름의 효율향상과 대체 가능한 새로운 기술 개발에 많은 노력을 집중하고 있다. 따라서 본 연구에서는 디스플레이의 편광필름을 대체할 수 있는 metal polarization에 관한 것으로 미세한 주기를 가지는 알루미늄(Al) 와이어 그리드(wire grid)편광자의 제조 기술과 특성에 대한 내용이다. 전자기파에서 특정 편광만을 편광시키기 위하여 평행한 도전체 선을 배열시키는 평행 전도 전선(parallel cinducting wires)의 어레이를 사용한지는 약 110년이 지나왔다. 이것을 일반적으로는 와이어 그리드(wire grid)라고 하며, 투명한 기판 위에 형성되어 전자기파의 파장 중에서 적외선 영역에서 편광자로 사용된다. 통상적으로 와이어 그리드의 편광자 성능을 결정하는 중요한 요소는 평행한 선과 선 중심간의 거리, 즉, 주기와 입사하는 파의 파장과의 관계이다. 따라서 본 연구에서는 편광자의 주기를 100nm로 사용하였으며, 편광자 물질로는 알루미늄을 사용하였다. 뿐만 아니라, 일반적으로 사용되고 있는 편광 필름(polarizer film)과의 transmittance를 비교 분석하여 유리기판(glass)위에 편광필름을 사용하지 않고 빛을 편광시킬 수 있는 기술을 소개하였다. 투명한 기판(glass)위에 Al-nano wire grid를 형성한 이후에 산화 절연막인 SiO2를 PECVD(Plasma Enhanced Chemical Vapor Deposition) 장비를 이용하여 transmittance와 roughness를 측정하여 metal polarization에 대한 특성을 연구하였다.

Ep-044 **고온초전도 코일의 열적 안정성 연구** 손 명환, 박 해용, 김 석호, 심 기덕, 이 언용, 김 호민, 성 기철, 권 영길(*한국전기연구원 초전도기기연구그룹.*) 오늘날 고온초전도 도체를 이용한 초전도 응용기기들이 속속 개발되고 있다. 많은 경우에 고온초전도체는 코일의 형태로 응용이 되는데, 이 코일의 안정성이 초전도기기의 안정성에 지배적으로 영향을 미친다. 초전도 코일의 열적 안정성을 실험하기 위해 일반적으로 초전도 코일 내부에 히터를 설치하고 이 히터에서 발생한 열의 크기에 따른 퀜치 발생 유무를 측정한다. 초전도 코일에 흐르는 전류가 없을 경우에 퀜치를 발생 시키는 데는 매우 큰 열이 발생하고 초전도기기의 운전시에는 반드시 초전도 코일에는 전류가 흐르기 때문에 초전도 코일의 임계전류(혹은 퀜치전류)의 80% 혹은 90%의 운전전류시에 퀜치 실험을 한다. 본 연구에서는 2가지 형태의 초전도 코일을 제작하였다. 코일 A는 Kapton 테이프가 감긴 고온초전도 도체를 사용하여 wet-winding method로 더블 팬케이크 코일로 권선하였다. 코일 B는 절연이 되지 않은 초전도 도체와 Kapton 테이프를 co-winding &wet-winding method로 역시 더블 팬케이크 코일로 권선하였다. 실험은 액체 질소 속에서 행하였으며, 사용한 히터는 폭 4mm, 두께 40μm, 길이 약 35mm의 stainless steel tape이고 77K에서의 저항은 약 0.25Ω였다. 코일 내부의 온도를 측정하기 위해 여러 곳에 E-type 열전대를 설치하였다. 실험은 히터 동작을 위한 전류 및 시간을 변화 시키면서 퀜치 발생을 관찰하였으며, 이 결과들을 통하여 두 초전도 코일의 안정성에 대하여 논의하고자 한다.

*"본 연구는 산업기술연구회 지원의 한국전기연구원 기본연구사업비로 수행되었습니다."

Ep-045 **Patterning and Electrical Property Measurement of Carotene Molecular Wires using Atomic Force Microscopy** YANG Hyun, KIM S.B., KOO S.H., CHOI Y.J., KIM J.W., KIM Y.S., KANG C.J.(*Myongji University , Nano Science and Engineering.*) To use molecular wire for the nano devices, we studied electrical properties of Carotene molecules. Among the various patterning techniques for the nano size structure, Dip-Pen Lithography (DPL) is one of the most promising method for the molecule patterning. Especially, DPL using Atomic Force Microscope (AFM) is able to control the length, width and shape on the quite small area. Furthermore it is possible to conduct on the not flat surface. We have patterned wires of Carotene molecules on the gold surface covered with octadecane mono layers for making upright alignment of a carotene molecule. Measured electrical properties of Carotenoid by Electrostatic Force Microcopy (EFM) and Scanning Capacitance Microscopy (SCM), shows the possibility of organic molecular wires for the applying nano devices.

Ep-046 **Experimental Evidence of the Surface Layers on BaTiO3 Thin Films by X-ray Reflectivity and Angle-resolved X-ray Photoelectron Spectroscopy** XIAOLONG li, HUIBIN Lu[1], QUANJIE Jia[2], MING Li[1], ZHENHONG Mai[1], KIM Hyunjung[3] (*Sogang university, Physics, Korea. [1]Chinese Academy of Sciences, China. [2]Beijing Synchrotron Radiation Facility, China. [3]Sogang university, Dept. of Physics and Interdisciplinary Program of Integrated Biotechnology.*) The surfaces of epitaxial BaTiO3 (BTO) films grown on SrTiO3 substrate were investigated by x-ray reflectivity and angle-resolved x-ray photoelectron spectroscopy. It was shown by x-ray reflectivity analysis that there exists a water layer of about 5Å and a low-density surface layer (about 85%-94% of the electron density of the underneath BTO layer) of about 15 Å on top of the BTO film. The water layer is removed at 70 °C, whereas the low-density surface layer remains up to 140 °C. No reactive phase with air and loose structure were observed in the near surface region. We consider this layer is caused by surface lattice expansion of the BTO film due mainly to surface relaxation. Furthermore, the angle-resolved x-ray photoelectron spectroscopy results showed a surface core-level shift for barium in layer of 11 Å, a value which is in agreement with the thickness of the low-density surface layer, indicating the surface core-level shift of barium stems from the BTO surface relaxation. The same surface relaxation layers are also present on the surface of ultra-thin BTO film with distorted tetragonal structure. Our results will help to understand the origin of the size effect of the BTO thin films.

Ep-047 **Energy Exchange in Field Emission from Semiconductors** CHUNG Moon Sung, LEE Han Na, BAE Hae Kyung, JANG Yu Jin, KUM Kwan Pil(*University of Ulsan.*) For the usual description of field emission, the replacement of electrons in the emitting region is never mentioned. However, consideration of the replacement process is necessary to evaluate the energy gain or loss of the cathode through field emission. By assuming that the energy levels emptied by electron emission are reoccupied with electrons supplied from the back contact, we calculate the energy difference between the emitted and the replacement electrons. This energy exchange, the so-called Nottingham effect, changes from one of heating to one of cooling at the inversion temperature where the net energy exchange per electron is zero. A formal theory is developed for the replacement process of the injected charge carriers for semiconductors. It leads to analytic expressions for the energy exchange, which exhibit the dependence on field, temperature, and doping concentration in a parametric form. The analytic and numeric results reveal the important feature that the energy exchange is positive for all temperatures. This implies that field emission from semiconductors always produces cooling of an emitter. When Joule heating is included, there is still a net cooling for a wide range of emitted current densities.

Ep-048 **분무열분해법으로 성장된 SnS 박막의 구조와 광전기적 특성** 서 동주, 오 상미, 임 수경, 이 관교, 김 건호[1](*조선대학교. [1]경상대학교.*) SnS 박막을 분무열분해법으로 유리기판 위에 성장시켰다. SnS 박막을 성장시키기 위해 사용한 시약은 tin chloride, thiourea이며, 이차증류수에 이들 시약을 녹여 0.02 mole 수용액을 만든 후 증류수를 혼합하여 분무용액을 만들어 사용하였다. 성장온도 변화에 따른 SnS 박막의 결정구조를 규명하기 위하여 X-선 회절분광기(XRD)를 이용하였으며, SnS 박막의 표면과 미세구조는 주사전자현미경(SEM)을 이용하여 관찰하였다. SnS 박막에 입사한 빛의 파장을 변화시키면서 광투과와 광흡수 스펙트럼을 측정하여 광학적인 특성과 에너지 간격을 구하였다. 시료에 대한 Hall의 효과를 van der Pauw법으로 실온에서 측정하여 비저항, 운반자 농도 등의 전기적 특성을 규명하였다.

Ep-049 **Dependence of Width of Quantum Hall Plateau on Disorder** 김 길호, E. S Kannan, 정 경훈[1](*성균관대학교 정보통신공학부 반도체 나노소자 연구실. [1]성균관대학교 정보통신공학부.*) We investigated the effect of disorder on the width of the quantum Hall plateaus by embedding self assembled InAs quantum dots in the single and double quantum well system. In the single quantum well system the width of the plateau was found to be greatly reduced due to the short range scattering effect of embedded quantum dots. However in the double quantum well system, instead of a plateau an abrupt increase in the Hall resistance is observed at integer filling factor. This phenomenon is attributed to the enhancement in the scattering between the edge states induced by the potential due to the quantum dots.

Ep-050 **나노 박막의 XRR 두께 신뢰성 향상** 박 재환, 신 대근, 김 창수[1], 오 병성[2], 최 용대[3](*한국 표준과학 연구원, 충남대학교 물리학과. [1]한국 표준과학 연구원. [2]충남대학교 물리학과. [3]목원대학교 광.전자 물리학과.*) 오늘 날 반도체 소자의 발전으로 점점 얇은 두께와 고 유전율의 박막이 요구되고 있다. 그 중에서도 실리콘 소자의 고 직접화로 인해 게이트-산화막의 두께는 수 nm 크기로 얇아짐에 따라 정확한 두께 측정을 필요로 하고 있다. Si 기

판위에 성장한 차세대 게이트-산화막 HfO_2 나노 박막 두께를 XRR (X-ray reflectivity)를 이용해 측정 후, TEM, SE, MEIS 방법을 사용하여 측정한 Data와 비교 · 분석 하였다. XRR과 TEM의 측정결과 중간층인 SiO_2-Buried layer를 확인하였다. HfO_2 두께만 결정하는 MEIS 결과와 XRR에서의 HfO_2 단일층의 두께는 잘 일치하였으나 SE의 결과와는 다소 차이가 있었다. 이에 Fourier Transform에 의한 결과를 바탕으로 XRR 반사율을 시뮬레이션 하여 구한 HfO_2, SiO_2 두께 결과는 총 두께를 나타내는 SE 결과와 잘 일치한다. 이는 중간층을 고려 시 두께측정 결과가 향상되었음을 보여준다. 본 연구에서는 박막의 두께를 각 분석 방법으로 측정한 결과를 비교 · 분석하여 특성 평가를 하였다.

Ep-051 **스프레이 방법에 의한 CuInS2 및 ZnS 박막 제조** 김 준호, 윤 병선(*인천대 물리학과.*) 스프레이 방법에 의해 CuInS2와 ZnS 박막을 제조하였다. 각각 박막의 제조에 있어서 CuCl2, InCl3 thiourea 수용액, ZnCl2, thiourea 수용액을 구성성분의 몰비를 바꾸어 가면서 제조하였다. 만들어진 시료는 X-선 회절, 자외선-적외선 스펙트럼 분석, 라만 스펙트럼 분석 등을 통하여 재료의 결정성과 에너지 밴드갭 등을 조사하였다. 분무되는 용액의 분사량, 시료 성장 온도, S의 구성 몰비가 박막 성장에 큰 영향을 미치며, 각각의 변수에 따른 박막 성장 결과를 제시하고 논의한다.

Ep-052 **Hierarchical domain pattern of $Pb(Mn_{1/3}Nb_{2/3})O_3$-33%$PbTiO_3$ single crystal** 이 성호, 이 은주, 박 재현, 구 태영[1], 정 윤희(*포항공대 물리학과. [1]포항가속기연구소.*) A hierarchical macro-/nanoscale domain pattern is revealed on (001)-oriented $Pb(Mn_{1/3}Nb_{2/3})O_3$-33%$PbTiO_3$ single crystal near the morphotropic phase boundary by scanning force microscopy in the piezoresponse mode at room temperature. The hierarchical domain pattern consist of various characterization length scales, ranging from nanometers to millimeters. Hierarchical domain control the effective material properties of multi-domainsystem which exhibit enhanced piezoelectric coefficient. Present study shows that the giant piezoelectric coefficients of PMN-PT are originated from domain configuration, consistent with recent experimental and theoretical results of Wada et.al. on domain-engineered single crystals.

Ep-053 **Ordering of quantum dots in biocompatible polymer films** 송 상훈, 김 현정, 김 보경[1], 정 혜선[1](*서강대, 바이오 융합기술 협동과정. [1]KIST, Center for Chemoinformatics Research.*) 본 연구에서는 생분해성 고분자 물질과 양자점을 혼합하여 박막을 형성하였을 때 기판의 개질에 따른 표면 및 계면 특성과 구조적 특성을 측정하였다. 물질의 조성 비율이 다른 3종류의 pluronics와 양자점을 spin coating 방법으로 10~50A의 박막을 제조하였다. 박막의 나노 구조 특성을 관찰하기 위해서 X-ray reflectivity(XRR)와 Grazing Incidence Small Angle X-ray Scattering(GI-SAXS) 기술을 적용하여 측정하였다. XRR 측정결과 각 박막에서의 표면과 계면의 거칠기, 시료의 전자 밀도 및 두께를 확인하였다, 본 연구 결과로 특정 비율의 pluronics 박막 표면에서 양자점의 정렬이 잘됨을 발견하였고 기판의 개질이 소수성일 때 정렬도가 좋아짐을 확인하였다.
*This research was supported by the Korea Science and Engineering Foundation, Seoul Research and business Development Program (10816), Sogang University Grant (2007)

Ep-054 **전구체 노출 시간을 이용한 원자층 증착 기술** 신 웅철, 류 상욱[1](*NCD Technology. [1]단국대학교, 전자공학과.*) 원자층 증착(Atomic Layer Deposition: ALD) 방법은 반응물질들을 펄스형태로 챔버에 공급하여 기판표면에 반응물질의 표면 포화반응에 의한 화학적 흡착과 탈착을 이용한 박막증착기술이다. ALD 법은 기존의 화학적 기상증착(Chemical Vapor Deposition: CVD)과 달리 자기 제한적 반응(self-limiting reaction) 에 의하여 반응가스가 기판 표면에서만 반응하고 가스와 가스 간에는 반응하지 않는다. 따라서 박막의 조성 정밀제어가 쉽고, 파티클 발생이 없으며, 대면적의 박막 증착시 균일성이 우수하고, 박막 두께의 정밀조절이 용이한 장점이 있다. 이러한 ALD 방식으로 3차원의 반도체 장치 구조물에 산화막 등을 형성하는 공정에서 중요한 요소 중의 하나는 전구체의 충분한 공급이다. 따라서 증기압이 높은 전구체를 선호하는 경향이 있다. 그러나 증기압이 낮은 전구체를 사용할 경우, 공급량이 부족하여 단차 도포성(step coverage)이 떨어지는 문제가 있다. 원자층 증착 공정에서 전구체를 충분히 공급하기 위해전구체 온도를 증가시키거나 전구체의 공급시간을 늘리는 방법을 사용한다. 그러나 전구체 온도를 상승시키는 경우, 전구체의 변질이나 수명을 단축시키는 문제점을 발생시킬 수 있으며. 전구체를 충분히 공급하기 위하여 전구체의 공급시간을 늘이는 방법을 사용하면, 원하는 박막을 형성하기 위하여 소요되는 공정시간과 전구체 사용량이 증가된다. 본 논문에서는 이러한 문제점을 해결하기 위해 반응기 안에서 전구체 노출 시간을 조절하는 새로운 ALD 공정을 소개한다. 본 연구에서 전구체 노출 시간을 조절하기 위하여 사용된 ALD 장비는 Lucida-D200-PL (NCD Technology 사)이며 (TEMA)Zr을 사용하여 ZrO_2 박막을 포리카보네이트와 다공성 알루미나 위에 성장시켰다. 전구체의 노출 시간은 반응기의 Stop 밸브를 이용하여 조절하였으며, SEM, TEM 등을 이용하여 박막의 균일성과 단차피복성 등의 특성을 관찰하였다. 그 결과 낮은 증기압을 가지는 전구체를 이용하여도 우수한 박막의 균일성과 단차피복성을 가지며, 또한 증착속도도 증가하였다.

Ep-055 **Effect Of Thermal NO- And/or NH_3-Treated Silicon Oxynitride Films On Chemical States And Band gaps By Nitrogen Depth Profile** KIM C. Y., YIM C. J.[1], YI Y.[2], WHANG C. N., CHO M. -H.(*Institute of Physics and Applied Physics, Yonsei University. [1]Department of Ceramics Engineering, Yonsei University. [2]Advanced Technology Group, Korea Research Institute of Standard and Science.*) The growth of ultrathin silicon oxynitride films formed by thermal nitridation of SiO_2 films with NO and/or NH_3 gases has been studied to investigate changes of chemical bonding states and band gaps by the distribution of nitrogen incorporation using photoelectron spectroscopy (XPS), medium energy ion-scattering spectroscopy (MEIS), and reflection electron energy loss spectroscopy (REELS). The chemical states in N1s spectra by XPS suggests that there are different chemical states assigned to $N\text{-}Si_3$, $N\text{-}(SiO_x)_3$, and $N\text{-}Si_2\text{-}O$ in the films, revealed that the $N\text{-}Si_2\text{-}O$ bonding state closer to the surface than the $N\text{-}Si_3$ bonding states, and shows the difference of intensities in each chemical states by NO and/or NH_3 treated. To confirm the distinction of intensities in N1s spectra in the films, we also demonstrate the element depth profile by using

MEIS. It is suggested that changes in chemical state closely depends on the distribution of nitrogen content diffused into silicon oxynitride films, which endorses the role of diffused nitrogen that has an effect on the decrease of band gap from general value of 9.2 eV for SiO_2 film up to minimum value of 7.9 eV for silicon oxynitride films.

Ep-056 **AZ91D 합금에서의 Ark-Anodizing 표면처리 시 전압 변화에 따른 MgO 박막두께에 대한 연구** 유 재인, 김 진희, 유 재용, 박 창훈, 임 진환, 김 기홍[1], 김 상엽[1](*(주)태양기전 제2기업부설연구소. [1]경운대학교 안경광학과.*) 보통 마그네슘합금은 산화가 잘되는 금속이므로 전처리 과정인 표면처리공정이 필수적으로 필요하다. 표면처리방법은 소프트(Soft) 및 하드(Hard) 방법으로 크게 2가지로 나눈다. 여기서 소프트 방법은 크로메이트, 3가 쿠로메이트 및 화성처리 방법등이 있으며, 하드 방법은 스파크-아노다이징, 아크 아노다이징, PEO(Plasma Electrolysing Oxcidation) 방법이 있다. 하드 방법의 3가지는 모두 전기를 이용하는 방법이며, 전압에 따라 Mg합금 표면에 형성되는 MgO막의 두께에 영향을 준다고 주장하는 쪽도 있고, 영향을 주지 않는다고 주장하는 쪽도 있다. 본 연구에서는 Ark Anodizing 방법에서 이러한 전압의 변화에 따른 형성되는 MgO 박막의 두께 영향을 규명하고자 한다.

Ep-057 **아크 아노다이징시 표면에 발생되는 기공 감소에 대한 연구** 김 진희, 유 재인, 유 재용, 박 창훈, 한 병하, 김 기홍[1](*(주)태양기전 제2기업부설연구소. [1]경운대학교 안경광학과.*) 마그네슘합금을 사용하기 위해서는 표면처리를 선행적으로 사용한다. 이러한 표면처리 방법중에서 아크 아노다이징 방법을 사용하여 표면에 형성되는 MgO 박막을 연구하고자 한다. 보통 아노다이징 방법으로 표면처리를 하였을 때 표면에 의도하지 않는 기공이 다수 발생하며 이는 표면 내식성 저하의 원인이 된다. 본 연구에서는 이러한 기공을 감소하고자 Burning 방법을 추가하여 기공 감소의 영향을 연구하고자 한다.

Ep-058 **화학용액 적층방법에 의해 성장된 CdS 박막의 annealing 조건 및 전극의 간격에 대한 특성 연구** 김 미정, 정 원호, 오 동훈, 채 영안, 차 덕준, 조 승곤[1], 정 양준[1], 이 기진[2], A. Babajanyan[2](*군산대학교 물리학과. [1]목포대학교 물리학과. [2]서강대학교 물리학과.*) ITO/Glass 기판위에 화학용액 적층(Chemical Bath Deposition)방법으로 CdS 박막을 제조하였다. 제조된 박막에 대해 annealing 온도조건에 따라 XRD, AFM, SEM 및 Near-Field scanning microwave Microscope(NFMM)특성을 조사하였다. 아울러 박막에 50-200μm 이내의 일정한 간격의 Al, Au 금속의 전극을 형성하여 NFMM을 측정하여 전기적 현상을 비교 연구하였다.

Ep-059 **SIMS를 이용한 Si/Ge 다층박막의 조성 깊이 분포 분석 연구** 장 종식, 강 희재, 김 경중[1], 홍 태은[2](*충북대학교 물리학과. [1]한국표준과학연구원 첨단산업측정그룹. [2]한국기초과학지원연구원.*) 실리콘(Si)-게르마늄(Ge) 반도체는 차세대 반도체의 재료중 하나로 최근 각광을 받고 있다. 이러한 반도체 물질의 정량과 깊이분포도를 정확히 측정하는 것은 차세대 반도체 소자 개발에 매우 중요하다. 이 연구는 표면분석 장비에 쓰이는 SIMS로 다층박막을 연구하였다. 이 연구를 위해 Si/Ge 델타 다층 박막, Si/Ge 다층박막, Si/Ge 합금 박막을 IBSD 장비로 제작하였다. Si/Ge 델타다층박막은 SIMS로 다른 크기의 충돌에너지 분석하여 델타 층의 이동을 추적하였고, 깊이 분해능을 살펴보았다. Si/Ge 합금박막은 SIMS와 RBS 데이터를 비교하였고, RBS결과를 인증값으로 하였을 때 Si-Ge 합금박막의 정량비가 50%인 시료를 기준으로 상대적인 농도 량을 계산하여 Si/Ge 다층박막의 SIMS 깊이 분포를 조성깊이분포로 변환하였다. 그리고 Si과 Ge의 에칭속도를 이용하여 조성깊이분포도의 깊이방향을 보정하여 실제박막의 정보와 비슷한 조성깊이분포도를 얻을 수 있었다.

Ep-060 **Ark-Anodizing 시 표면에 형성되는 MgO 박막 표면에 대한 연구** 유 재용, 김 진희, 김 재근[1](*(주)태양기전 제2기업부설연구소. [1](주)태양기전 연구센터.*) 마그네슘합금은 진동감쇄성, 전자차폐성 및 초경량의 특징을 가지는 금속이므로 산업 제반에 많이 이용되고 있다. 하지만 산화가 잘 되는 단점을 가지므로 이를 극복하기 위해 표면처리를 선행적으로 하고 있다. 표면처리 방법중 아크 아노다이징을 이용하면 표면에 보통 MgO형태의 박막이 형성되어진다. 이러한 막의 두게는 보통 10 – 15 §- 정도의 두께를 가진다. 또한 제품으로 제작시 이러한 막위에 도장, 도금 및 증착을 활용하는데 그때 영향을 주는 것이 표면의 거칠기 정도이다. 본 연구에서는 이러한 표면의 조도와 막의 견고성을 향상하기 위한 Si, Na 및 K 계열에 대한 표면에 미치는 영향을 연구하고자 한다.

Ep-061 **Charge Injection in Organic Films and Contact Metallurgy for Organic-Based Electronic Applications** KIM Tae Hee, LEE Nyun Jong, LEE J. H.[1], CHO Hyunduck[2], JANG Eun Young, LEE Changhee[2](*Department of Physics, Ewha Womans University. [1]Microgate, Inc., Anyang, Korea. [2]School of Electrical Engineering and Computer Science Seoul National University.*) Carrier injection, carrier separation at organic/metal (O/M) interfaces and carrier transport in the organic films are key processes in the organic semiconductor(OSC) devices.[1] The understanding of the electrical properties at O/M interfaces is of great importance to improve device performance as well as to design novel organic devices. In our earlier study [2], we reported the variation in the surface potential could be related to a change in the apparent work function of the metal surface. Our results showed that excess holes or electrons displaced from metal electrodes into organic films could be attributed to the electronic structure of the interfacial region of the organic films. In this work, we focused on the investigation of the electrical properties of O/M interfaces by transport measurements. 100-nm-thick pentacene and Cu-phthalocyanine films were doposited on nonmagnetic and magnetic electrodes such as Al and permalloy(Py). Our results show clearly that charge injection at O/M interfaces could depend on not only the metal electrode, but also the effect of magnetic field and light. These results point out the importance of electrical properties at O/M interfaces in the organo-metallic structures for spintronics applications.

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*Corresponding author: taehee@ewha.ac.kr [1] W. R. Salaneck, K. Seki, a. Kahn, J. J. Pireaux(Ed.), Conjugated polymer and molecular interfaces-Science and Technology for photonic and Optoelectronics Applications, Marcel Dekker, 2002. [2] K. J. Lee and T. H. Kim, Korean Phys. Soc. Vol 49, L2226, 2006

Ep-062 **XAFS Study of Temperature-dependent $Mn_{0.3}Ge_{0.7}$ Thin-films** SUNG Nark-Eon, KIM Sung-Kyu[1], JO Moon-Ho[1], JANG M. S.[2], JEONG I. –K.[2], PARK S.[3], HONG Tae Eun[3], KIM Jong-Pil[3], KIM Sung-Kyu[1], JO Moon-Ho[1], JANG M. S.[2](*Pohang Accelerator Laboratory, POSTECH. [1]Department of Materials Science and Engineering, POSTECH. [2]Research Center for Dielectric and Advanced Matter Physics(RCDAMP). [3]Busan center, Korea Basic Science Institute.*) Mn_xGe_{1-x}(x=0.3) thin films were fabricated on Al_2O_3(0001), Si(100) and glass substrates at temperature ranges up to 500°C by an RF magnetron sputtering method. The local structure and electronic states were characterized using X-ray absorption fine structure (XAFS) technique at Mn and Ge K-edges. It was revealed that the electronic states of both atoms were not related so much to the fabrication temperature and kind of substrates. However, the local structures around Mn and Ge atoms show significant changes depending on the fabrication temperature of the thin films. XAFS analysis also showed that the Mn_xGe_{1-x}(x=0.3) thin films of below 300°C were in amorphous state and those had low short range ordering. On the other hand, the other films were crystallized gradually. Those films showed the significant variations in bonding character, as a function of the fabrication temperature.

Ep-063 **Sol-gel synthesis and characterization of sodium potassium niobate films** 김 일원, 안 창원[1], 김 현규[1], 정 의덕[1], 이 해준(*울산대학교, 물리학과. [1]한국기초과학지원연구원.*) The development of lead-free ferroelectric and piezoelectric materials has been required from the viewpoint of environmental preservation. We focused the lead-free sodium potassium niobate [$Na_{0.5}K_{0.5}NbO_3$ (NKN)] system and their precursor solutions were prepared by a sol-gel process. The NKN precursor solutions were prepared using sodium acetate, potassium acetate and niobium ethoxide as starting materials. To compensate the alkaline metals loss during thermal annealing, 0 ~ 40 mol% excess alkaline metals were added to the precursor solutions. The NKN films were fabricated by spin-coating on Pt/Ti/SiO_2/Si substrate. To promote crystallization, the films were annealed in air or O_2 atmosphere at 600 ~ 800 °C. The films were characterization by X-ray diffraction, dielectric and ferroelectric properties. Sample with remarkable dielectric properties and pure perovskite phases were obtain by identifying the ideal amount of alkaline metal excess added to the precursor solution.

Ep-064 **PLD 방법으로 증착된 TiNi 형상기억합금 박막에 Ar 분위기 가스와 기판의 온도가 미치는 영향** 차 정옥, 조 정연, 신 진호[1], 이 광배[2], 안 정선(*경희대 물리학과. [1]한국과학기술연구원. [2]상지대학교 응용물리전자학과.*) Ti-50 at. % Ni 합금 타깃을 이용하여 PLD 방법으로 고진공($5X10^{-6}$)과 Ar 200mTorr 분위기에서 TiNi 형상기억합금 박막을 증착하였다. Ar 200mTorr 분위기에서 증착된 TiNi 박막은 Si (100) 기판의 위치가 가시적으로 보이는 플룸 끝부분에 위치해 있을 때, 고진공에서 증착된 박막보다 더 좋은 증착효율과 타깃의 조성과 근접한 TiNi 박막을 얻을 수 있었다. 또한 Ar 가스 분위기에서 증착할 때, in-situ로 더 낮은 온도(약 100℃)인 400℃에서 결정화된 TiNi 박막을 얻을 수 있었다. 이러한 Ar 가스가 TiNi 박막에 미치는 영향들은 shock front 이론으로 설명이 가능하며, shock front란 상대적으로 높은 가스 분압(Ar 200mTorr)에서 분위기 가스 입자와 방출입자들의 충돌로 생겨나는 분자들의 밀집 지역을 일컫는다. Si (100) 기판의 온도에 따른 증착된 TiNi 박막의 조성 및 두께의 변화를 살펴보았으며, 기판 온도 변화에 따른 박막의 조성 변화는 거의 없었으며, 박막의 두께는 기판의 온도가 600℃일때 큰 증가를 보였으며, 이는 Ti입자의 산화로 인한 TiO_2 입자들의 영향인 것을 XRD 패턴 결과를 통해 알 수 있었다

Ep-065 **Optimization of process conditions for enhanced properties of organic light emitting diodes using TEMAH precursor** SOHN Sunyoung, JUNG Donggeun[1], KIM Hyoungsub[2], LIM Jung-Ran, SON Byungchul, LEE Jouhahn(*Organic Nano Device Team, Jeonju Center, Korea Basic Science Institute. [1]Department of Physics, Institute of Basic Science, and Brain Korea 21 Physics Research Division, Sungkyunkwan University, Suwon 440-746. [2]School of Advanced Materials Science and Engineering, Sungkyunkwan University, Suwon 440-746.*) In order to find the optimum condition for various tetrakis(ethylmethylamino)hafnium (TEMAH, $Hf[N(CH_3)C_2H_5]_4$) treatments, three types of ALCVD treatments on organic light emitting diodes (OLEDs) were studied: only TEMAH treatment at room temperature (RT), TEAMH+O_2 treatment at RT, and TEMAH+O_2 treatment at high temperature (HT). The OLED performance with only TEMAH treatment at RT was deteriorated due to the increased diffusion of electroluminescence (EL)-quenching metal contaminants into the emission layer. While the TEMAH treatment with O_2 at HT resulted in the degradation of the OLED performance probably due to the formation of an electrically insulating HfO_2, the identical treatment at RT significantly enhanced the electrical and optical properties of OLEDs.

Ep-066 **Low-voltage-driven Pentacene Thin-film Transistor With An Organic-inorganic Nano-hybrid Dielectric** IM Seongil, LEE Kwang H, CHOI Jeong M, LEE Byung H[1], IM Kyo K[1], SUNG Myung M[1], LEE Seungjun[2](*연세대학교 물리학과. [1]한양대학교 화학과. [2]이화여자대학교 전자정보통신공학.*) We report on the fabrication of pentacene-based thin-film transistors (TFTs) with a 13 nm-thick nano-hybrid superlattice-type dielectric composed of 10 units of molecular aluminium oxide (AlO_x)–self-assembled multilayer (SAMu) lattice on indium-tin-oxide (ITO) glass or on n^+ - Si substrate. The AlO_x – SAMu nano-hybrid layers showed high dielectric capacitances of 187 and 233 nF/cm^2 on ITO glass and on n^+ - Si substrate, respectively, along with a high dielectric strength of 4 MV/cm in the both cases. Our pentacene-TFTs showed a maximum field effect mobility of 0.92 cm^2/V s, operating at -3 V with an on/off current ratio of ~10^3. Load-resistance inverter using our

pentacene-TFT demonstrated a decent voltage gain of ~5.

Ep-067 **위글러 빔라인 자동화 장치에 대한 성능 분석** 김 경화, 김 경진, 이 흥수(*포항가속기연구소.*) 2005년부터 가동되기 시작한 단백질 결정학 위글러 빔라인의 효율적 운영을 위하여 자동화 장치의 개발은 필수적이다. 자동화 장치 개발에 있어 최우선적으로 고려해야 하는 사안은 단백질 결정의 안전성을 확보하는데 있다. 로봇이 액체질소 속에 있는 단백질 결정을 엑스선 집속 위치로 이동하거나 다시 액체 질소 속에 보관할 때 로봇의 손이 이동하는 중에 발생하는 온도 차에 의해 공기 중 수분이 응결하게 된다. 이 때 생기는 작은 응결수를 결정에 달라 붙지 않도록 하기 위하여 온도를 차단하는 것은 한계가 있으므로 액체 상태의 질소가 기체로 상태 변환 될 때 발생하는 부피 차이를 이용하여 공기에 집적 노출되지 않도록 하는 방법이 고려 되었다. 본 논문을 통하여 상용화를 앞두고 있는 자동화 장치의 성능에 대한 분석과 문제점을 진단하고 이에 대한 해법을 제시 하고자 한다.

Ep-068 **ZrO_2-incorporation effect on the energy band structure and dielectric properties of $(Ba_{0.5}Sr_{0.5})TiO_3$ thin films** CHO Kwang-Hwan, KANG Chong-Yun, YOON Seok-Jin, LEE YoungPak[1](*Thin Film Materials Research Center, KIST. [1]q-psi and Dept. of Physics, Hanyang Univ.,.*) We have investigated the effect of ZrO_2- incorporation on the microstructure, microwave properties and of $Ba_{0.5}Sr_{0.5}TiO_3$ (BST) thin films grown on $LaAlO_3$ (100) substrates by co-sputtering. The structural properties were examined by x-ray diffraction (XRD), atomic force microscope (AFM), and scanning electron microscope (SEM). The transmission spectra of these BST thin films measured by ultraviolet-visible (UV-VIS) spectrophotometer show that the band-gap energies are strongly dependent on ZrO_2- incorporation. The variation of the band-gap energies and the dielectric constant can be attributed to the combined effects of ZrO_2 doped BST thin films.

Ep-069 **Fabrication of quantized electron pump device on quarz substrate by combining surface acoustic wave transducers with carbon nanotube transistors on quarz substrate** 김 종기, 김 소라, 우 병칠, 김 진희, 김 남(*한국표준과학연구원, 전략기술연구부.*) Quantized electron pump has drawn much attention for decades because of its potential applications for quantum current standard as well as single photon source. We manufactured the quantized electron pump device consisting of a carbon nanotube transistor and SAW transducers on quarz substrate. Carbon nanotubes were grown on quartz substrate by the conventional chemical vapor deposition (CVD) technique. Using high piezo-electric effects of the quarz substrate we designed to inject SAW-generated travelling potential waves through the carbon nanotubes resulting in quantized electron current of nef where n is the number of quantized electrons, e is the charge of electron and f is the frequency of the SAW. The wave length of the SAW was about 1 ㎛ corresponding to a frequency of 3.1 GHz. Measurements were performed below 2 K.

Ep-070 **The Aging effect of Inter-digit Structure TFT based on ZnO** 임 성일, 김 기태, 이 기문, 오 민석, 황 도경(*연세대학교 물리 및 응용물리학과.*) ZnO comes into the spotlight because the relatively successful electrical performance such as LCD switching thin film transistor (TFT), ultraviolet (UV) detector, transparent electronics and solar-cell etc. To apply these properties to above mentioned industrial fields, it is very important to examine if the device can maintain its stable in air. Until now, many researchers mainly focused on the superior electrical performance of ZnO-TFTs, but the ambient aging effects of ZnO-TFT device have rarely been reported. In the present work, we thus report on the aging effect of ZnO-TFT in air ambient. To observe the aging effect, we fabricated the ZnO-TFT with inter-digit structure electrode (IDE). ZnO active thin film channel was deposited at 400℃ on the substrate (of SiO_2/p^+-Si). And then, IDE as source-drain (Al) was evaporated on the ZnO layer. Because the IDE structure exposes large surfaces of high-temperature-deposited ZnO channel, we expected to sensitively observe the aging effect as the variation of electrical signal in more detail with the IDE than with a conventional unit device of ZnO-TFT. After all the device fabrication processes was finished, we kept the device samples in a dessicator (~1 Torr) in the dark.As time elapses, the threshold voltage of our IDE ZnO-TFTs deceased from 27.6V to 15V ($\triangle V_T$~12.6V). Since other researchers reported on surface adsorption of ZnO films, we suspect the aging effect is related to the surface reaction with ambient gases such as oxygen and water vapors. To confirm the reason in more detail, we also measured the contact angle (C.A.) variation of ZnO thin film surface with respect to the aging time. And we found that the initial ZnO surface changed from hydrophilic state to hydrophobic one. More and advanced details will be discussed in the meeting along with the final conclusions.

■ SESSION P1
10월 18일(목), 14:30 - 16:15
장 소: 5층 포이어

Fp-001 **Height-difference Correlation Function of the quenched Mullins-Herring Equation** 송 현석, 김 진민(*숭실대학교 물리학과.*) We consider a discrete surface growth model following the quenched Mullins-Herring (qMH) equation with an external driving force. At the critical force F_c, the surface width W shows a scaling behavior $W^2(t,L) \sim L^{2\alpha}\, f(t/L^z)$ with $\alpha = 1.35$, and $z = 1.60$ where L and t are the system size and time respectively. However, the height-difference correlation function G has an unusual scaling behavior $G(r,t) \sim r^{2\alpha'}\, g(r/t^{1/z'})$ with different anomalous exponents $\alpha' = 1.683$ and $z' = 1.994$. The correlation length ξ grows as $t^{1/z'}$ and becomes saturated with L^{ω} where ω is the window exponent satisfying $\omega = \alpha / \alpha' = z / z' = 0.802$.

Fp-002 **Critical behavior of XY model on the growing and the static scale free networks** KWAK Wooseop, YANG Jae-Suk[1], GOH Kwang-Il[1], SHIN Yongjin, KIM In-mook[1](*Dept. of physics, Chosun University. [1]Dept. of physics, Korea University.*) We study the critical behavior of XY model on the growing and the static scale free networks. For degree exponent of scale free network (γ) <3, there are no phase transitions for both networks. However, γ>5, we observe the order-disorder phase transition of XY model for both networks. The standard mean field behavior is observed not on the growing but on the static scale free network. We think that the critical behavior of XY on scale free networks is related to the assortatively of networks, where the growing scale free network is assortative, but the static one is neutral for γ>5.

Fp-003 **Conserved mass aggregation model with mass-dependent fragmentation on scale free networks** 김 엽, 이 동진, 권 성철(*경희대학교 물리학과.*) We investigate the condensation phase transitions of a conservedmass aggregation model with mass-dependent fragmentation on scale free networks. In the model, the whole mass m of a site isotropically diffuse with unit rate. With rate ω a mass m^{λ} is fragmented from the site and moves to a randomly selected nearest neighbor site. Since the fragmented mass is smaller than the mass m for λ <1, the on-site attractive interaction make the whole mass condensate into a node. For λ =0, the model is known to undergo the condensation phase transitions as the density of total masses (ρ) increases beyond acritical density ρ_C from the fluid phase into the condensedphase. For 0<λ<1, we numerical confirm for several values of ω that ρ_C logarithmically diverges for thesystem size (N) as ρ_C= C ln N on random networks and scale free networks (SFNs) with γ> 3. Hence in the thermodynamiclimit, the condensed phase disappears and no transitions take place. For SFNs with γ < 3, the system is always in the condensed phase with exponential background distribution. We also investigate random fragmentation and confirm that no condensations take palace for any γ> 2.

Fp-004 **Phase Transition of Directed Polymers in Random Media with a Defect in 2 Dimension** 이 재환, 김 진민(*숭실대학교 물리학과.*) We investigate a directed polymer problem in random media with a defect decreasing the random potential of the site at the center of two dimensional substrate. When the defect strength is weak the contribution of the defect to the polymer energyis negligible, while it affects whole system and changes the dynamics and scaling properties if the defect strength is strong enough. Various exponents near the criticalpoint between weak and strong defect strengths are also discussed.

Fp-005 **Detachment of game networks from survival networks and evolution of cooperation** PARK Sangmin, JEONG Hyeong-Chai(*Department of physics, Sejong university.*) We study evolutionary dynamics with separated networks between interaction and survival. The fitness of an individuals is given by the payoffs for the repeated prisoner's dilemma games with members in the other network while the competition for the survival takes place in the same group. We investigate the half-memory strategy space and show that always cooperation can be an evolutionary stable strategy for a wider parameter range comparing to the survival games on one network. Our result implies that the detachment of game networks from survival networks can be an important ingredient for the evolution of cooperation.

Fp-006 **Unusual Spiral Wave Dynamics in Two-dimensional Inhomogeneous Cardiac Tissues** WOO Sung Jae, HONG Jin Hee, KIM Tae Yun, BAE Byung Wook, LEE Kyoung Jin(*CRI Center for Neurodynamics and Department of Physics, Korea University.*) Understanding spiral reentry wave dynamics in cardiac system isimportant since it underlies various cardiac arrhythmia includingcardiac fibrillation. Primary cultures of dissociated cardiac cellshave been a convenient and useful system for studying cardiacwave dynamics, since one can carry out systematic and quantitativestudies with them under well-controlled environments. One key drawbackof the dissociated cell culture is that, inevitably, some spatialinhomogeneities in terms of cell types and density, and/or the degreeof gap junction connectivity, are to be introduced to the systemduring the preparation. These unintentional spatial inhomogeneitiescan result in some non-trivial wave dynamics, for example, theentrainment dynamics among different spiral waves and the generationof complex-oscillatory spiral waves. The aim of this paper is toquantify these general phenomena of in vitro cardiacsystem and provide explanations for them with a simple physiological model having some realistic spatial inhomogeneities incorporated.

Fp-007 **The propagation of spiking generated spontaneously on axon** LEE Dongmyeong, KIM Seunghwan(*The Asia Pacific Center for Theoretical Physics and Nonlinear &Complex Systems Lab, Dep. Physics POSTECH.*) We investigated the stochastic effect on the propagation of action potential spikes which are generated spontaneously in a stochastic version of the spatially dependent Hodgkin-Huxley equation (HH equation). If the number of ion

channels is small, an action potential can be generated spontaneously due to the fluctuation of the ion channel conductance. Using open or close transition rates of the ion channel, we can convert a deterministic HH equation to the stochastic HH equation which reflects the noise in ion channels. We found that the propagation life time of action potentials become maximal at some optimal value of the ion channels, which is understood through the competition between the fluctuation of ion channels and the recovery period of the sodium channel.

Fp-008 **시간 지연 변화에 따른 혼돈계의 제어 및 특성 분석** 이 대식, 김 칠민[1](*한국전기연구원. [1]배재대학교, 물리학과.*) 혼도계를 제어하기 위한 방법으로 현재 까지 많은 방법들이 제시되고 있다. 이중 가장 많이 사용하는 방법이 Pyragas가 제시한 시간 지연 되먹임에 의한 방법으로 암호통신, 레이저 시스템 등에 많이 응용되고 있다. 본 연구는 전자회로를 이용하여 혼돈계에 시간 지연시간을 특정 주파수로 변화시킨후 혼돈계에 되먹임 시켜 안정화 하였으며 연결 상수와 시간 지연 시간에 따른 현상을 time series analysis, phase diagram, bifcation diagram 등을 통해 분석하였다.

Fp-009 **Lipid rafts localization in macrophage driven by mechanical force** BYEONGHA JEONG, JU-YONG HYON[1], HWAN MYUNG KIM[2], JIN-HEE HONG, BONG RAE CHO[2], KYOUNG.J LEE, SEOK-CHEOL HONG[3](*Center for Neurodynamics, Physics Dept. [1]Biomicrosystems Progrma, Physics Dept. [2]Molecular Opto-Electronics Laboratory, Chemistry Dept. [3]Molecular Biophysics Laboratory, Physics Dept.*) Recent studies suggest that lipid rafts which are cholesterol- and sphingolipid-rich plasma membrane domains are regulated by integrin signaling during cell migration. However, in vivo dynamic redistribution of lipid rafts has not been clearly identified in real time yet. Here, we have utilized two-photon time-lapse confocal microscopy to characterize the dynamic redistribution of lipid rafts in macrophage after mechanical force was applied laterally by moving a micropipette engulfed by the macrophage. We found that lipid rafts were preferentially accumulated near the phagocytic sites during phagocytosis, while they were localized at some specific locations for several minutes after the mechanical stimulus. Our data suggest that lipid rafts were recruited as discrete microdomains to specific locations at which the cell may be anchored presumably via integrin-mediated binding in order to withstand the mechanical force.

Fp-010 **Localized Oscillators and Spiral Waves on the Development of HL-1 Mouse Atrium Cardiomyocytes** 이 경진, 홍 진희, 최 준호, 김 태윤(*고려대학교 물리학과 신경망동력학센터.*) Spiral wave have been observed in a lot of different biological as well as chemical systems. Cardiac spiral waves mediated many cardiac arrhythmias are the most well known examples in biological system. Here, in particular we have used HL-1 cell-line, which is able to divide, to investigate the properties of proliferating oscillators on the formation of cardiac spiral waves. We monitored the activities of HL-1 cardiomyocytes through a home-built microelectrode array recording system and a phase contrast optical mapping system. In the early stage after cell plating, a few HL-1 cells started to contract with the basic frequency of ~3 Hz. As time went, the active contraction was propagated to the adjoining cells and the mean IBI of HL-1 cells steadily increased. In a confluent layer of HL-1 cell-line, however, the mean IBI of HL-1 cells instantly decreased as dependent on the plated density and at this time, cardiac spiral waves could be observed with a phase contrast macroscope. In the investigation of the characterization of myocytes by immunostaining cells with myosin antibodies, we observed that the number and distribution of myocytes (oscillators) in HL-1 cell monolayers changed as cells divide. This study provides the first investigation into the wave dynamics in excitable media composed of the immortalized HL-1 cell-line. Proliferating HL-1 cell-line can form a functional cardiac tissue forming gap-junction connections and these connected oscillators gradually propagate and produce coordinated cardiac waves.

Fp-011 **Two Types of Cytosolic Calcium Oscillations with the Short and Long Time Scales in Rat Suprachiasmatic Nucleus** 이 경진, 홍 진희, 민 철홍, 정 병하(*고려대학교 물리학과 신경망동력학센터.*) Calcium dynamics is known to exist in many biological systems like as oocytes and cultured glia networks with various time scales from milliseconds to days. In a biological master clock, suprachiasmatic nucleus (SCN) neurons, cytosolic calcium oscillations in long time scale (circadian rhythm) are a well-known phenomenon. Also, calcium oscillations in short time scale (calcium spikes) have been shown in the dissociated SCN neurons and astrocytes. In particular, to investigate the relation between circadian rhythm and calcium spikes of the cytosolic calcium level in SCN slice preparation, we used a fluorescent calcium dye, fluo4-AM for a short time scale and a fluorescent calcium imaging protein (cameleon) for a long time scale. Although we observed calcium oscillations of high frequency (~10 second duration) with using fluo4-AM, the frequency and amplitude of calcium spikes showed no significant circadian variation and correlation. Whereas cameleon expressed SCN neurons showed circadian oscillations of the cytosolic calcium level but didn't show calcium spikes. Most of all, circadian calcium oscillations in SCN neurons exhibited the propagation of wave form. Therefore, we conclude that calcium spikes in short time scale have no relation to circadian rhythm of cytosolic calcium level and suggest possibilities that mechanism of calcium dynamics would differed between in shot and long time scale.

Fp-012 **Oscillatory Lasing Modes In a Coupled Circular Microcavity** CHO Jinhang, LEE Jinhyung[1], RIM Sunghwan[1], KIM Chil-Min[1](*Department of Physics, Sogang University. [1]Center for Quantum Chaos Application, Paichai University.*) We have numerically investigated oscillatory lasing modes in a coupled circular microcavity laser by solving the Schrödinger-Bloch equation with a nonlinear interaction between the light field and the lasing medium. Uniform pumping in the lasing process generates some special patterns as stationary ones, and the patterns are repeatedly shown dur-

ing the lasing process. In this case, the patterns may be interpreted as linear combinations of the nearly degenerate modes in which the classical trajectory inside the cavity encounter the boundary of the cavity with a nearly critical angle. The numerical results are posted with a brief physical analysis.

Fp-013 **Huygens" clocks: Synchronization of two pendula** 이 일구, 백 승기, 김 범준(*성균관대학교, 물리학과.*) The phase synchronization of two pendulum clocks attached to a common massive frame is numerically investigated. As was already observed by Huygens long time ago in 1656, we find that the two clocks exhibit the anti-phase synchronization in steady state, irrespective of initial conditions. As the difference Δ between the lengths of the two pendula, corresponding to the disorder strength in the general context of synchronization of phase oscillators, is varied, clearly observed is the onset of the loss of synchrony at a finite value of Δ. We also study how the escapement mechanism affects the emergence of synchronization.

Fp-014 **Magic Number Stabilities of para-H_2 Clusters Doped by a Single ortho-D_2** 추 정민, 권 용경(*건국대학교, 물리학과.*) Path-integral Monte Carlo calculations on small clusters of para-H_2 doped by a single ortho-D_2 molecule, $D_2(H_2)_N$, have shown that the clusters with 10 <N <20 have significant superfluid fractions at a low temperature of 1.6 K. However, it is found that the superfluid fractions are noticeably suppressed at the specific cluster sizes of N=12 and 18, at which the energy differences between the neighboring cluster sizes also show clear minima. This magic number behavior of the $D_2(H_2)_N$ clusters is found to be consistent with the one previously reported for pure H_2 clusters. In addition, we have found that the D_2 molecule is located at the cluster center and the H_2 density distributions show shell structures around D_2. The local superfluid density distributions computed with the local estimator recently proposed by one of us show that they have the same shell structures with the total density distributions, resulting in near uniform distributions of local superfluid fractions.

Fp-015 **Wave front model of excitable media including nonlinear dispersion** 이 경진, 권 오규(*고려대학교 물리학과 세포동력학연구센터.*) excitable media에서의 spiral wave의 구조와 운동에 대한 연구로 wave의 front만을 기술하는 방법이 있다. 이 방법은 excitable media를 구성하는 단위 요소의 구체적인 모델은 고려하지 않고 spiral wave pattern의 구조와 운동을 기술할 수 있다. 기존의 연구는 다음 두 효과를 주로 다루어왔다. 하나는 (1) wave의 굽은 정도와 수직방향의 front속력의 관계, 다른 하나는 (2) spiral core에서의 front의 수직 수평 속도의 효과에 초점을 맞추었다. 우리는 여기에 excitable media의 중요한 특징인 dispersion 효과 특히 nolinear dispersion 효과를 추가하여 complex period를 갖는 spiral wave를 구현하였다.

Fp-016 **Multifractal analysis of rainfalls in Korean peninsula** 김 경식, 임 규창[1], 김 수용[1], 장 기호[2], 강 지현(*부경대학교, 물리학과. [1]한국과학기술원, 물리학과. [2]KMA.*) Application of ideas from fractal and chaos theories to characterize rainfall is one of the most active and exciting areas of research in this field. Many studies performed thus far have yielded evidence of the existence of fractal and chaos properties in rainfall. In this work, we present a singularity spectrum of a rainfall time series to provide strong evidence of multifractality. A curdling cascade process in a well developed turbulence is presented as a candidate to describe the rainfall, and the analogy between the rainfall and turbulence is confirmed via the validity of the binomial multiplicative process to describe both systems

Fp-017 **Dynamical behaviors of inter-out-of-equilibrium state intervals of Korean futures exchange markets** 김 경식, 임 규창[1], 김 수용[1], 박 상범[2](*부경대학교, 물리학과. [1]한국과학기술원, 물리학과. [2]한국항공대학교, 경영학과.*) The recently discovered feature of financial markets, two phasephenomenon is utilized to categorize the financial time series intotwo phases, namely equilibrium and out-of-equilibrium states. Forout-of-equilibrium states, we analyze the time intervals at whichthe state is revisited. The power-law distribution ofinter-out-of-equilibrium state intervals is shown and we present theanalogy with the discrete-time heat bath dynamics, similar to randomIsing systems. In the mean field approximation, this model reducesto one-dimensional multiplicative process. By varying global andlocal model parameters, we discuss the relevance betweenvolatilities in financial markets and the interaction strengthsbetween agents in the Ising model.

Fp-018 **A study of α-relaxations in trehalose glasses** SEO Jeong-Ah, KWON Hyun-Joung, KIM Hyung Kook, HWANG Yoon-Hwae(*Department of Nanomaterials &BK21 Nano Fusion Technology Division, Pusan National University, Miryang.*) We measured the α-relaxations in trehalose glasses by photon correlation spectroscopy (PCS). Remarkably, the $|\varphi(t)|^2$ of VH components showed a crossover from stretched- to compressed-exponential relaxations as the temperature increased from 110 °C to 180 °C. We expect the unusual compressed exponential behaviors in trehalose glasses may originate from the bond structure change of trehalose molecules. To find the molecular structure change in trehalose molecules, we measured the Raman scattering spectra of trehalose glasses. The Raman scattering spectra of trehalose show the out-of-ring vibration modes around 1140 ~ 1150 cm^{-1} due to coupling of C-O stretching (ν(C-O)), C-H bending (δ(C-H)), and C-O-H stretching (ν(C-O-H)) modes. In the Raman spectra, the integrated area started to decrease and the position of Raman shift started to move to low frequencies at temperatures around 160 °C indicating that the out-of-ring vibrations in trehalose glasses change in this temperature range. From the Raman scattering measurements, we concluded that the unusual compressed-exponential relaxations in trehalose glasses were caused by the change of glycosidic links in trehalose molecules.

Fp-019 **A Study of Dielectric Loss Spectra of Galactose–Water Mixtures** KWON Hyun-Joung, SEO Jeong-Ah, KIM

Hyung Kook, HWANG Yoon-Hwae(*Department of Nanomaterials &BK21 Nano Fusion Technology Division.*) We studied the secondary relaxation in galactose-water mixtures by analyzing the dielectric loss spectra with two methods.The first method was free fitting without any constraint and the second method was the fitting with the coupling relation incoupling model (CM) [1, 2, 3]. The secondary relaxation time (τ_{sec}) obtained by the first method showed very similar trendas the RT coupling constant in mode coupling theoy (MCT) [4] changed. The characteristics of the secondary relaxation time(τ_{JG}) obtained by the second method were very similar to those of the τ_{sec} within the experimental errors but the fitting qualityof first case were better.

Fp-020 **비활성 미세아교세포의 활성 상태 전이 과정에서 나타나는 세포 구조 변화 및 운동성에 관한 연구** 양 태석, 박 진성, 권 오규, 민 철홍, 정 병하, 이 경진(*고려대학교 물리학과 세포동역학연구센터.*) 세포의 주화성(chemotaxis)이란 그 주위 환경 속에서 특정한 화학 물질의 인식을 통해 자신의 이동 방향을 결정하는 현상으로써, 가장 보편적으로 알려져 있는 세포 이동 메카니즘 중 하나이다. 뇌 세포 중에서 면역체계에 관여하는 것으로 알려져 있는 미세아교세포(microglia) 또한 손상된 신경세포로부터의 분비물의 인식을 통해 활성화되고, 목표 지점을 향해 이동해서 세포사멸을 유도하는 대표적인 주화성 세포이다. 본 연구에서는 미세아교세포가 비활성 상태에서 활성 상태로 전이되는 과정에서 나타나는 세포 형태와 운동성의 변화 양상에 관한 조사를 수행하였다. 비활성 상태에서 미세아교세포는 양방향(bipolar), 세방향(tripolar), 또는 부정형(amoeboidic)의 다양한 형태를 나타내 보이는데, 이 과정에서 세포체는 국부적인 진동 운동을 수행하며, 이러한 진동 패턴은 그 세포의 형성된 구조와 밀접한 연관성을 갖는다. 그리고, 외부로부터의 자극을 통해 활성화됨에 따라 미세아교세포는 목적지를 향해 이동하게 되는데, 이러한 유도 과정에 관여할 것으로 예상되는 아교세포에서 전파되는 칼슘파와의 상관관계를 규명하고자 한다.

Fp-022 **Blog spammer clustering through a bipartite network analysis** SHIN Jeongkyu, KIM Seunghwan(*The Asia Pacific Center for Theoretical Physics and Nonlinear &Complex Systems Lab./Brain Research Center, Dept. Physics, POSTECH, Pohang, Korea 790-784..*) We investigate the weblog (called 'blog') spam data, which is one of the most challenging problems in electric communication networks. We find that for a weblog spam the number of spam senders is usually bigger than number of victims similar to the E-mail spam, where spammers are known to counterfeit the sender information. We reconstruct the spammer-victim relationship as a bipartite network, which helps to cluster spammers into a few spammer groups via a N-body decomposition method. We speculate that each group either has the same victim list or uses the same spam hosting program.

Fp-023 **Group Properties in Financial Markets** OH Gabjin, EOM Cheoljun[1], JUNG Woo-Sung[2], KIM Seunghwan Kim(*Department of Physics, Pohang University of Science and Technology, Pohang, Gyeongbuk 790-784, Korea. [1]Division of Business Administration, Pusan National University, Busan 609-735, Korea. [2]center for Polymer Studies and Department of Physics, Boston university, Boston, MA 02215.*) We investigated the grouping property of the Korean stock market using the minimal spanning tree based on the cross-correlation between stocks. To quantify the degree of grouping in the stock market, we propose a new measurement using the shortest path length between stocks on the minimal spanning tree (MST). We find that while the average value of the cross-correlation matrix between stocks increases during the market crash, the grouping effect of industry sectors, however, decreases. We also find that the grouping behavior of the financial sector is significantly affected by the market crash.

Fp-024 **Dynamic Change in Global Networks of Multi-channel Human EEG in Different Mental States** HWANG Eunjin, KIM Seunghwan(*The Asia Pacific Center for Theoretical Physics and Nonlinear &Complex Systems Lab./Brain Research Center, Dept. Physics, POSTECH, Pohang, Korea 790-784.*) The interaction between multi-channels in the electroencephalogram(EEG) is considered to reflect the change in underlying brain dynamics. With the help of the evolution map approach proposed by M. Rosenblum et al., we measure the asymmetry of information flow between EEG signals recorded in anesthetic experiments. We introduce the concept of weighted directionality, a multiplication of phase synchrony and normalized directionality, and calculate averaged weighted directionality matrices for all channels for the periods before, during and after anesthesia. We define the dissimilarity between each matrix and apply clustering analysis. We have observed the clustering of the anesthetic state and the awakened state in different groups, respectively, which shows a functional difference in the human brain states reflected on interaction patterns of multi-channel EEG signals. We also have found the dynamic change in a clustering hierarchy during the post-anesthetic period.

Fp-025 **A microscopic model for financial market on regular lattices and complex networks** KIM Hong-Joo, YOOK Soon-Hyung, KIM Yup(*경희대학교 물리학과.*) We study a microscopic model for price formation in financial markets on regular lattices and complex networks. The model consists of many interacting traders with local and global interactions. The state of each trader i is represented by two states variable $s=\{+1. -1\}$. The local interaction makes each trader follow the same decision with their interacting partners like the ferromagnetic interaction in the spin models. The global coupling to the self-generating field represents the process which maximizes the profit of each agent. In order to incorporate more realistic situations, we also introduce an external field which changes in time and represents any internal or external interference in the dynamics of the market. For the proper choice of model parameters, the competition between the interactions causes an intermittency dynamics and we find that the distribution of logarithmic return of price follows a power-law. We also discuss the effects of the underlying topology on the return distribution.

Fp-026 **Bak-Sneppen model on the Sierpinski gasket** LEE KYOUNG EUN, HWANG JUN KYUNG, LEE JAE WOO(*Inha Univ., Physics.*) We study the avalanche dynamics of Bak-Sneppen model on the Sierpinski gasket (SG) fractal. Specially, avalanche dynamics is mapped numerically to branching process in critical stationary state on the SG lattice with the generator scaling base b=2 which corresponds to the fractal dimension $D_f = \ln 3/\ln 2 \sim 1.58$, the lattice size N=6564. We demonstrate that the Self-Organized Criticality (SOC) phenomenon exists on the SG fractal and displays interesting critical behavior. It is found that avalanche size distribution shows power-law behavior with the threshold of fitness barrier, $f_c \sim 0.4067$. The critical exponents τ, μ for avalanches and active sites are determined. Finally, the avalanche size is proportional to the number of active sites with fractal dimension $S \sim n_{cov}^{Dm/Df}$. Thus, we observe that a universal scaling relation between critical exponents is well satisfied underlying the fractal structure.

Fp-027 **Power-law wating time distribution from job categorization** 김 태영, 백 승기, 김 범준(*성균관대학교, 물리학과.*) The waiting time distribution of the time interval between two tasks for an individual is shown to follow the power-law form through the analysis of the "history" file generated from Linux commands. Different from the existing model based on the job priority, we suggest that one can also explain the power-law form of the wating time distribution by using the simple assumption that jobs are categorized and jobs within a category tend to be performed simultaneously. We also discuss another simple model based on the interacting agents in comparison with other models.

Fp-028 **Role of activity in human dynamics** HOANG ANH-TUAN Kiet, ZHOU Tao[1], WANG Bing Hong[1], 김 범준(*성균관대학교, 물리학과. [1]Univ. of Science and Technology of China.*) We analyze a huge database for an on-line movie-sharing system, and study the distribution of the interevent time between two consecutive watching actions of movies. Interestingly, we find that the level of activity, defined as the number of movies an individual watches per day, is closely related with the power-law exponent in the interevent time distribution. A complementary dataset from the short-message service (SMS) is also analyzed to yield the similar results. These findings demonstrate the significant role of activity in determining the pattern of human behaviors, highlight a common character in the interest-driven human dynamics, and are different from the observed universality classes in the task-driven systems.

Fp-029 **Single molecule biophysical investigation on DNA bubble dynamics** HONG Seok-Cheol, LEE Ja Yil, JOO Sihwa, KIM Sook Ho(*고려대학교 물리학과.*) Although the DNA bubble structure induced in negatively supercoiled DNA play crucial roles in DNA replication and transcription, its dynamical nature has not been fully understood yet mainly because traditional biochemical methods lack sufficient sensitivity and time resolution for such biological phenomena. Here we report our study on DNA bubble dynamics using single molecule biophysical techniques such as single molecule FRET and magnetic tweezers manipulation. Since magnetic tweezers are ideal for introducing negative supercoils to a DNA molecule and single molecule FRET technique is capable of following fast structural change of an individual molecule in real time, we developed a combined machine of the two techniques that would be suitable for the study because single molecule FRET would allow us to observe dynamics of the bubble on a single DNA molecule as it is induced by magnetic tweezers. In addition, using DNA strands with a palindromic sequence, whose bubble structure can convert to a cruciform (an analog to Holliday junction which is an important intermediate structure in DNA repair and recombination), we studied the formation of DNA cruciform and observed structural dynamics among various DNA structures generated under torsion.

Fp-030 **Ciplatin의 결합에 의한 DNA 물리적, 구조적 변화에 대한 연구: DNA 이차구조와 이온농도의 의존성에 관해서** 홍 석철, 현 주용[1], 박 진성, 이 경진, 이 남경[2], 홍 석만[3](*고려대학교 물리학과. [1]고려대학교 바이오마이크로시스템기술 협동과정. [2]세종대학교 물리학과. [3]세종대 생명공학과.*) 최근에 개발된 단분자 생물리 연구기법 중에서 Magnetic tweezers는 DNA를 포함한 다양한 생물분자들에 넓은 범위의 힘을 작용시키고, 토크를 가해 줄 수 있어서 이들과 관련된 다양한 생명현상의 물리적 양상을 이해할 수 있도록 돕는다. 본 연구진은 이러한 magnetic tweezers를 이용해서, 대표적 항암제 중 하나인 cisplatin이 DNA 염기사슬과 화학적으로 결합하는 과정에서 나타내는 DNA의 구조 변화를 실시간으로 관찰하였다. 순수한 DNA 사슬은 약 50nm 정도의 ξp(지속길이)를 갖는데 반해, cisplatin이 결합된 DNA의 ξp는 점점 짧아지며, cisplatin의 결합이 포화 상태에 이르렀다고 생각되는 농도에서 약 10nm까지 짧아진다는 사실이 확인되었다. 또한, 이러한 ciplatin의 반응성은 주변 양이온 농도가 높아짐에 따라 현저히 감소하는데, 이는 양이온이 음전하를 띠는 DNA 염기 사슬과 cisplatin이 결합하는 것을 방해하기 때문인 것으로 여겨진다. 더욱 흥미로운 사실은 수퍼코일 상태의 DNA에 대해서 cisplatin은 소량만으로도 DNA loop을 고정시킴으로서 강력한 DNA 구조 변형 물질로 작용할 수 있다는 사실이 확인되었다.

Fp-031 **Flocking and vortex formation through the viscous media** SUNGYUN Kim, HAN Seung Kee[1], KIM Seunghwan (*Asia-Pacific center for theoretical physics. [1]Chungbuk National University.*) We study the flocking behavior of self-propelling particles through the viscous media. The flocking behaviors of self-propelling particles are studied by imposing interactions between particles, such as body forces and alignment forces. In some cases like fish schooling, the interactions between particles are largely governed by fluid dynamics of the medium. A self-organized pattern with creation and merging of vortices can be seen through the interplay between the alignment along the direction of the flow and the attraction between particles. The diverse pattern formations are studied in the parameter space of the sensitivity of the alignment, the strength of body forces and the field of media for the alignment.

■ SESSION P1
10월 18일(목), 14:30 - 16:15
장 소: 5층 포이어

Kp-001 **Performance of InGaN/GaN Blue Light Emitting Diodes on Low Defect GaN Templates Prepared Using Wet Etch Sapphire Patterning** MUTHUSAMY Senthil kumar, CHEONG H.-S[1], LEE Y.S., CHUNG S.J., HONG C.-H., SUH E.-K. (*Semiconductor Physics Research Center and School of Semiconductor and Chemical Engineering, Chonbuk National University. [1]LG innotek, 978-1 Janduk-dong Gwangsan-gu, Gwangju 506-251, Korea.*) Group III nitrides have been proven to be a promising material system for fabricating efficient optoelectronic devices applicable in visible/ultraviolet (UV) region. InGaN active layers have been playing the key role behind the successful realization of high efficiency blue/green/near-UV light emitting diodes (LEDs). However, the quantum efficiency of InGaN/GaN LEDs has to be further improved to meet the requirement for display and general lighting applications. High threading dislocation (TD) density (order of 10^9~10^{10} cm^{-2}) in GaN template restricts the internal quantum efficiency of GaN based LEDs and should be reduced. Also, the loss of light extraction due to internal reflection within LED structure should be minimized. In this work, we present the reduction of TDs in GaN template using a simple wet etching process of sapphire substrate which can also enhance the light extraction efficiency. Pyramidal projections were formed on the sapphire surface via etching of SiO_2 mask patterned sapphire substrates in H_2SO_4:H_3PO_4 solution. Size of the pyramidal projection was controlled via adjusting the etching duration. GaN templates grown on wet etched sapphire yielded an order of reduction in TD density and the TD density was influenced by the size of the pyramidal projection. InGaN/GaN blue LEDs were fabricated on these GaN templates with different TD density and their emission efficiencies were evaluated by using photoluminescence and electroluminescence measurements. It was confirmed that the background TD density plays a dominant role in determining the quantum efficiency of InGaN/GaN LEDs. The external quantum efficiency of LEDs grown on wet etch patterned sapphire substrate was 2.3 times higher than that of conventional LEDs.
*This work was supported by the Korea Research Foundation Grant funded by the Korean Government (MOEHRD)"(KRF-2005-005-J07501).

Kp-002 **Spatially Resolved Electroluminescence of Periodic Deflector Embedded Light Emitting Diode** 정 현, 김 서군, 차 옥환, 서 은경, 변 지수[1], 김 종수[1], 정 문석[1](*전북대학교 반도체과학기술학과/반도체물성연구소. [1]광주과학기술원 고등광기술연구소.*) 본 연구에서는 deflector 역할을 하는 육각 역 피라미드형 구멍이 표면에 주기적으로 배열되어있어 LED의 광 추출 효율을 높여주는 PDE-LED(Periodic Deflector embedded-LED)의 특성을 광자의 경로에 따른 관점에서 분석하였다. 실험에 사용된 PDE-LED는 MOCVD (Metal-Organic Chemical Vapor Deposition)를 이용하여 SiO_2가 부분적으로 성장된 Sapphire 기판 위에 LED full structure를 성장하였으며, 활성층으로는 7주기의 InGaN과 GaN을 사용하였다. 표면에 나타나있는 육각 역 피라미드형 구멍의 크기는 3um 이며 그 사이의 거리는 6um이다. 공초점 광학현미경을 이용한 two-dimensional Electroluminescence mapping을 통해 광자가 주로 탈출하는 경로와 각 부분의 spectrum을 측정하였다. 광자의 탈출경로를 유도함으로써 시료 표면의 특정한 부분에서 밝은 발광이 나타났으며 각 부분의 spectrum을 통해 PDE-LED의 공간 의존 광학적 특성을 알 수 있었다.

Kp-003 **양자점 성장을 위한 SiO_2 박막의 나노패터닝 연구** 박 준모, 오 진경, 송 광민, 류 상완(*전남대학교 물리학과.*) 반도체 양자점의 장점을 이용한 새로운 특성의 반도체 소자를 개발되어지고 있다. 현재 일반적인 양자점 결정성장 방법으로 격자상수 불일치에 의한 양자점의 자발형성 방법이 사용되고 있으나, 이 경우 양자점의 간격과 크기를 조절하는 것은 매우 어려운 일로 알려져 있다. 본 논문에서는 양극산화알루미늄(Anodic Aluminum Oxide, AAO)의 나노패턴을 사용한 새로운 방식의 양자점 성장을 시도하기 위한 SiO_2 박막의 나노패터닝 방법을 연구하였다. 알루미늄 양극산화는 30nm~200nm 주기의나노패턴을 손쉽게 구현할 수 있는 장점이 있다. Al을 코팅한 기판위에 양극산화를 통해 35nm 주기의 AAO를 형성하고 AAO의 다공성 자발형성 패턴을 마스크로 사용하여 RIE(Reactive Ion etching)를 통해 SiO_2에 패터닝을 한 뒤 AAO를 제거하여 반도체 위에 다공성 SiO_2 주형을 제작하였다. .

Kp-004 **Electrical and Optoelectrical Properties of Single Crystalline InN Nanowires** 이 성훈, 이 원주[1], 한 성환[1], 김 진희[2], 김 봉수[3](*KAIST, 나노과학기술학제학과. [1]한양대, 화학과. [2]KRISS. [3]KAIST, 화학과.*) Nanodevices using individual indium nitride (InN) nanowire (NW) were fabricated by e-beam lithography. The NWs have diameters of 40 - 80 nm, lengths up to several tens of micrometers and single crystalline nature. I-V characteristics showed different patterns at high and low temperature regions. Ohmic I-V characteristics of InN NW is observed at high temperature regions and consistent with the pinning Fermi level of the metal electrode near the conduction band edge. At low temperature regions, the device shows a typical semiconductor behaviour with quantum tunnelingeffect through Schottky barrier rather than thermal activation transporting. The activation energy calculated at high temperature and low temperature regions are 28.2 meV and 5.08 meV, respectively. We have also fabricated a photocurrent generation device using InN NWs. The photocurrent of acceptor-sensitizer dyad on InN NWs was 8.3 nA/cm^2, which increased by62.7 % compared to that without InN NWs layers.

Kp-005 **Analysis on energy levels of multi-layered InGaN/GaN quantum wells** KIM Jin Soak, LEE Yun-Il, KIM Eun Kyu, KIM Hee Jin[1], YOON Euijoon[1](*Dept. of Physics and Quantum-Function Spinics Lab., Hanyang University. [1]School of Materials Science and Engineering, Seoul National University.*) The InGaN/GaN blue-green optical devices are typically using quantum well (QW) structures to enhance optical efficiency. The QW structures also can applicable to electrical devices. In these QW structures, the energy

level properties of the QW structures are very important. The energy level positions are mainly governed by the band discontinuity, ΔE_C, by the material combination and the quantum well width. However, the band edge discontinuity of the III-nitride heterostructures has not yet been firmly established. Thus, accurate theoretical calculations of the energy levels are very difficult. These factors and energy level properties can be investigated by the electrical measurements such as I-V, C-V, admittance spectroscopy, and deep-level transient spectroscopy (DLTS). Especially, the DLTS is very good method to study them. In this study, we analyze the ground energy levels and defect states of the InGaN/GaN multi quantum well (MQW) system with metal-semiconductor structure by performing C-V and DLTS measurements. The InGaN/GaN MQW structures used in this study were grown by metal-organic chemical vapor deposition methods. Each well thickness was measured as 1 nm. The MQW structure shows photoluminescence peaks near 410 nm. In the DLTS measurements, the structure shows several DLTS signals.

Kp-006 **전자빔 조사에 따른 GaN 에피층의 전기적 물성 변화 연구** 하 임경, 이 동욱, 김 진석, 김 은규, 배 성범[1], 오 대곤[1], 한 영환[2], 이 병철[2](*한양대학교 물리학과. [1]한국전자통신연구원. [2]원자력 연구소 양자광학 실험실.*) 최근의 GaN에 대한 청색 발광소자 영역에 대한 연구는 기존의 광소자에 양자우물(quantum well)이나 양자점(quantum dot) 등의 양자구조나 어긋나기(dislocation) 및 결함구조를 이용하여 출력효율이나 발광 특성을 조절하려는 노력으로 진행되고 있다. 반도체 결정에서 어긋나기나 결함은 성장조건에 의해 성장과정에서도 발생할 수 있지만, 전자빔이나 양성자 빔과 같은 고에너지로 가속된 자의 인위적인 조사(irradiation)에 의해서도 생성이 가능하다. GaN 반도체의 경우 전자 소자로 만들었을 때 높은 전압에서 동작할 수 있고, 낮은 누설전류(leakage current) 특성을 보여 고전압, 고전력 소자(hight power device)로의 응용역시 기대되는데, 스윗칭 (switching) 소자 등에서 전력의 손실을 방지하려면 소수 운반자(minority carrier)의 수명(life time)을 짧게 조절하여야 하는데, 이 경우에도 적절히 생성된 결함은 소수 운반자를 포획하여 운반자의 수명을 줄여준다. 본 연구에서는 유기금속화학기상증착법 (metal organic chemical vapor deposition-MOCVD) 기법으로 증착된 GaN 에피층(epi-layer)에 전자빔을 조사하여 조사 전 후의 결함상태 및 그 분포에 대해 연구하였다. 전자빔 조사에 따른 시료의 물성변화와 결함상태의 근원분석을 위해 1000 ℃의 온도에서 시간을 달리하며 열처리효과도 분석하였다. GaN 에피층의 두께는 1 μm 이고 운반자 농도가 $5 \times 10^{16} \sim 5 \times 10^{17}$ cm^{-3} 정도범위가 되도록 도핑(doping)되었다. 그 이후 1 MeV로 가속된 전자빔을 1×10^{15} cm^{-2} 농도로 조사하여 결함을 생성하였다. 전기용량 (C-V) 및 깊은준위 과도용량분광법 (Deep Level Transient Spectroscopy-DLTS)을 이용하여 운반자의 공간적인 농도분포와 결함상태에 대해 연구하였다.

Kp-007 **Optical Properties of HEMT Structures on Step-graded InAlAs Buffer Layers Grown by Molecular Beam Epitaxial Growth** JEON M.H., KIM J.K., HWANG S.H., PARK C.Y., JEON H.H.[1], LEEM J.Y.(*Department of Nano Systems Engineering, Center for Nano Manufacturing,Inje University, 621-749, South Korea. [1]Department of mechanical and materials engineering, Florida International University, USA.*) We have investigated the optical properties of the structures which have InGaAs/InAlAs 2DEG region on the $In_xAl_{1-x}As$ step-graded buffer layers grown by molecular beam epitaxy. Three models of $In_xAl_{1-x}As$ metamorphic buffer layers with the different indium gradient are shown as strain relaxed structures in lattice mismatched system. Also each buffer layer has different step thickness. Photoluminescence (PL) spectra of all the samples are recorded and analyzed. The PL spectra from the each model are obtained under several low temperature conditions. And PL results will be compared and discussed with other experimental results such as X-Ray Diffraction and Hall measurements.

Kp-008 **The Influence of Varied Thickness in InGaAs Underlying Layer on Self-assembled InAs Quantum Dots** JEON M.H, PARK C.Y, KIM J.K, JEON H.H[1], HWANG S.H, LEEM J.Y(*Department of Nano systems engineering, Center for Nano manufacturing, Inje university, Gimhae, Korea. [1]Department of Mechanical &Materials Engineering, Florida International University, USA.*) Self-assembled InAs quantum dots (QDs) underlying by $In_{0.23}Ga_{0.77}As$ layer with different thickness have been grown by molecular beam epitaxy (MBE). The samples are investigated the effect of underlying InGaAs layer on the optical and structural properties of self-assembled InAs quantum dots (QD) using transmission electron microscopy (TEM), photoluminescence (PL) spectra, and atomic force microscopy (AFM). TEM images show that the size of the InAs QD is influenced by changing the thickness of underlying InGaAs layer. It is found that the PL peak position is blue-shifted from 1.180 eV to 1.201 eV by depositing 4 monolayers (MLs) of underlying InGaAs layer. On the other hand, as increasing InGaAs layer, the smooth and relaxed area of InGaAs surface is also increased. Therefore, the emission peak position was red-shifted with an increase in the thickness of the InGaAs layer. We demonstrate that by changing the thickness of underlying InGaAs layer the emission wavelength of InAs QDs can be tuned.

Kp-009 **광학적 분석을 통한 InGaN/GaN 양자우물구조의 압전 전기장 결정에 관한 연구** 송 정훈, 송 재호, 김 민중, 홍 사용(*공주대학교 물리학과.*) InGaN/GaN 양자우물 구조는 조명용 발광다이오드 용으로 가장 각광을 받고 있는 후보 구조로서 최근들어 이에 대한 중요성은 학계, 산업계, 연구계 모든 분야에서 전세계적인 관심을 끌고 있다. 본 연구에서는 InGaN/GaN 를 이용한 발광다이오드의 광효율에 결정적인 영향을 끼치는 압전 전기장 (piezoelectric) field의 세기를 광학적으로 측정하고자 하는 시도를 하였다. 이를 위해서 먼저 입력 전류에 따른 파장의 변화를 측정하고, 주입된 운반자들에 의한 내부 전기장의 가리기 효과에 대해 연구하였다. 내부전기장 가리기 효과에 의해 주입전류에 따라 발광파장은 단파장 영역으로 이동하였고, 이에대한 분석을 통해 시료에 따른 압전 내부 전기장의 상대적인 차이를 분석하였다. 더 나아가서 InGaN/GaN 양자 우물구조에 역방향 바이어스를 인가하면서 photoluminescence (PL) 측정을 하였다. 여기광에 의해 운반자가 양자우물구조에만 선택적으로 흡수되도록 하기 위해서 여기광의 파장은 장벽층에서는 흡수되지 않고, 우물층에서만 흡

수되는 파장을 선택하였다. 역방향 전압에 인가에 따라 양자우물층의 총 전기장의 크기가 변하였고, 이에 따라 발광 파장이 변하였다. 역방향 전압 인가에 따라 PL 파장은 단파장 영역으로 이동하였다. 이는 양자우물내의 전체 내부 전기장의 세기가 감소함으로 나타나는 현상으로 이를 통해서 양자우물 구조의 내부 전기장에 대해서 분석하였다.

Kp-010 **Comparison of Electro- and Photo-luminescence Spectra from GaAs-based Spin-LED Structures.** LEE Tae Kyu, PARK Jung Hyun[1], CHOI Jung Ho[1], OH Eunsoon[1], PARK Y. J[2], SHIN K. H[2], KIM K. Y[2](*Deparment of Physics , Chungnam National University.* [1]*Department of Physics, Chungnam National University.* [2]*KIST.*) We have investigated electroluminescence (EL) and photoluminescence (PL) from GaAs-based spin-LED (light emitting diode) structures. In the PL experiments, circularly polarized excitation beam was used to create spin-polarized carriers, whereas in the EL, spin polarized electrons in magnetic layers are injected into semiconductors. In both spectra, an excitonic transition peak of a GaAs active layer was observed at 1.52 eV at 10 K. There were two additional peaks in the spectra at 1.495 eV and at 1.478 eV. The circular polarization of the three peaks in EL and PL spectra were compared. We also obtained spin lifetime and carrier lifetime from time-resolved photoluminescence and calculated the spin injection efficiency.

Kp-011 **저온 성장한 완충층 위에 성장된 GaSb 박막의 광학적 특성** 박 정현, 이 태규, 오 은순, 노 영균, 김 문덕(*충남대학교 물리학과.*) Sb계 III-V족 화합물 반도체는 높은 전자 이동도 때문에 고속 전자 소자 응용이 가능하고, 좁은 띠 간격 물질이므로 장파장 영역의 광소자 응용 또한 가능하여 최근 많이 연구되고 있다. 이러한 Sb계 III-V족 화합물 반도체의 광학적 특성을 연구하기 위하여, Molecular Beam Epitaxy (MBE) 법을 이용하여, GaAs 기판 위에 성장된 GaSb 박막의 Photoluminescence (PL)를 측정하였다. GaAs 기판과 GaSb 박막의 접합 계면에서의 결함을 줄이기 위해 저온의 얇은 InAs, AlSb, GaSb 완충층 (buffer)을 사용하였더니, InAs 완충층을 제외한 AlSb, GaSb 완충층에서 GaSb 박막의 결정성이 좋아져 PL Intensity가 증가함을 확인할 수 있었다. 또한, 이 두 시료의 온도 의존성을 측정한 결과, 두 시료 모두 15 K에서 90 K까지 PL Intensity가 증가하다가 90 K 이상에서 intensity가 떨어지는 것을 확인할 수 있었다. 대부분 온도가 올라가면 PL Intensity가 급격히 떨어지는 GaAs나 다른 물질과 비교해서 intensity가 떨어지지 않는 것으로 보아 좋은 quality를 갖고 있음을 알 수 있다. GaSb 박막을 이용한 시료에서 spectrum 상에서 관찰된 두 peak의 power-dependence를 측정하였다. power dependence로부터 이 두 peak이 excitonic transition에 의한 것과 Donor-Acceptor Pair (DAP) transition에 의한 peak으로 생각된다.

Kp-012 **Optical properties of InGaN/GaN Green MQW with intermediate layer and different Well, Barrier thickness** LEE Yong Seok, PARK Jae Young, KIM Hee Yun, HAN Nam, HONG Chang Hee, SUH Eun Kyung(*전북대학교 반도체화학공학부/반도체물성연구소.*) 현재 LCD Back Light Source 및 여러 광소자의 광원으로써 사용 중인 녹색 LED는 낮은 발광효율로 인하여 내부양자효율 (IQE), 외부양자효율 (EQE) 향상을 목적으로 많은 연구가 진행 중이다. 본 실험에서는 이러한 녹색 LED의 녹색양자효율을 향상시키기 위하여 양자우물 내 에서의 intermediate layer와 우물두께, 장벽두께의 변화에 관한 실험을 실시하였다. MOCVD 장비를 이용하여 5주기 InGaN/GaN MQW 을 성장하였으며, 성장온도는 우물 710 ℃, 장벽 880 ℃이며, 압력 200 mbar에서 성장하였다. 양자우물 내의 Intermediate layer성장 온도를 710℃에서 880℃로, 성장 시간을 40 sec, 100 sec, 150 sec 로 변화시키며 실험한 결과 880℃, 100sec 일때의 RT-PL의 세기가 가장 강하게 나왔다. 또한 InGaN 우물두께를 26 Å, 28 Å, 30 Å, 32 Å 로 변화 한 후 RT-PL, LT-PL, HR-XRD을 측정한 결과 30 Å일 때의 PL 세기와 결정성이 향상된 결과를 보였다. 또한 장벽두께를 120Å, 140Å, 160Å, 180Å로 변화시키며 실험한 결과 성장 두께가 증가할수록 높은 PL 세기를 보였다.

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Kp-013 **넓은 EL Spectrum 반치폭을 가진 HVPE White-LED의 특성** 황 선령, 이 충현, 전 헌수, 홍 상현, 허 인혜, 김 경화, 양 민, 안 형수, 김 석환[1], 진 용성[2], 조 인성[2], 임 원택[2], 이 재학[2], 시 상기[2](*한국해양대학교 나노반도체전공.* [1]*안동대학교 물리학과.* [2]*더리즈(주).*) GaN, InGaN, AlGaN 등의 III-V족 질화물 반도체는 넓은 에너지 간격을 갖는 직접 천이형 반도체이며, UV/blue 광소자, 전자소자 등에 대한 적용이 가능하기 때문에 많은 연구그룹에 의해 연구되어왔다. 본 실험에서는 Al_2O_3(0001) 기판 위에 MOCVD 방법으로 얇게 성장된 templated n-GaN 웨이퍼를 사용하였으며, 혼합소스 HVPE 방법을 이용하여 선택성장(SAG : selective area growth)으로 LED 구조를 성장시켰다. p-type, n-type 도핑물질로서 각각 Mg과 Te을 이용하였으며 클래드층으로 AlGaN 층을 이용하였다. 활성층은 넓은 EL spectrum 반치폭을 얻기 위하여 알루미늄(Al)과 인듐(In) 원소를 첨가하였으며, 특히 In 원소의 조성비에 따른 EL spectrum 반치폭의 변화를 조사하기 위하여 AlGaN 활성층에 In 원소를 0.1g, 0.2g, 0.3g, 0.4g, 0.5g으로 첨가하면서 SAG-LED의 EL 특성을 비교하였다. SEM 측정결과 선택성장이 잘 되었음을 알 수 있었고, photolithography 공정과 p-metal, n-metal 공정을 통하여 소자를 제작한 후 EL 측정을 하였으며 그 결과 In 원소가 0.1g일 때 400nm에서 main peak 파장이 관찰되었고 넓은 EL spectrum 반치폭을 가짐으로서 white emission을 보였다. 또한, main peak 파장이 In 원소가 증가할수록 장파장으로 이동하는 특성을 보였다. HVPE방법으로 Al_2O_3(0001) 기판 위에 SAG-LED 구조를 제작함으로서 넓은 영역의 EL spectrum 반치폭을 갖는 HVPE white-LED 제작과 visible spectrum을 통한 색 조절의 가능성을 확인할 수 있었고 full color display 구현과 LED 개발 분야에서 경쟁력 강화를 위한 핵심요소 기술의 도출이 가능할 것으로 기대된다.

Kp-014 **혼합소스 HVPE 방법에 의한 n-type GaN 와 p-type GaN 성장** 황 선령, 허 인혜, 전 헌수, 이 충현, 홍 상현, 김 경화, 양 민, 안 형수, 김 석환[1], 진 용성[2], 조 인성[2], 임 원택[2], 이 재학[2], 시 상기[2](*한국해양대학교 나노반도체전공.* [1]*안동대학교 물리학과.* [2]*더리즈(주).*) 혼합소스 HVPE 방법은 도펀트를 Ga 에 직접 넣어 포화상태로 만들어 사용하며 이는 장치가 간단해지며 비

용이 적게 드는 장점이 있다. 또한 다양한 도펀트를 사용할 수 있어 n형, p형, 3원 화합물 또는 4원 화합물의 에피성장이 가능하다. 본 연구에서는 사파이어 기판 위에 혼합소스 HVPE 방법으로 n-type GaN와 p-type GaN 를 성장하였다. n-type 도펀트로 Te 을 사용하였고, 혼합소스 HVPE 방법에 의한 Te-doping 농도의 재현성을 확인하기 위하여 일정한 Te 량을 Ga 소스에 첨가하여 반복적으로 성장한 후 그 시료에 대하여 XRD, Hall 측정을 하였다. Te-doped GaN 박막은 XRD 분석을 통하여 (002)와 (004)의 피크가 관찰되었으며 이는 육방정계 기판의 c-축 방향으로 에피성장이 되었음을 확인하였다. 그리고 실온에서 Hall 측정을 한 결과, n형 전도성을 가지며 sheet 캐리어 농도는 $1.60 \times 10^{14} \sim 3.98 \times 10^{14}$ / ㎠ 로 측정되었다. 그 결과 혼합소스 HVPE 방법으로 재현성을 확인 할 수 있었다. 또한, p-type GaN 의 경우는 MOCVD 방법에서 CP_2Mg 소스를 사용하여 성장할 수 있으나 본 연구에서는 혼합소스 HVPE 방법으로 metal Mg 을 Ga 소스에 직접 넣어 성장하였다. 그 시료에 대하여 Hall 측정 결과, p형 전도성을 가지며 sheet 캐리어 농도는 대략 8.54×10^{14} /㎠ 로 측정되었다. 따라서 혼합소스 HVPE 방법은 n-type 또는 p-type GaN 를 성장하기에 적당한 방법이라고 판단되며 HVPE 방법에 의한 광소자 제작에도 유용한 방법이라고 판단된다.

Kp-015 **Corrugated Layer를 이용한 자기정렬 In(Ga)As/GaAs 양자점의 구조적 특성 연구** 김 준오, 이 상준, 노 삼규, 김 창수, 최 정우[1](*한국표준과학연구원 첨단산업측정그룹. [1]경희대학교 전자정보학부.*) 최근 규칙적으로 정렬된 양자점 (Quantum Dot, QD)구조 제작의 접근 방법으로, 가공된 기판을 사용하지 않고 성장 변수와 층구조 (layer structure)의 조절을 통하여 수직 또는 수평으로 1차원적으로 스스로 정렬되는 QD 구조 형성기술에 관한 연구가 활발하게 진행되고 있다. 본 연구에서는 내부 변형을 활용한 다층 적층 자발형성법을 이용하여 1차원적 사슬모양 (chain-like)으로 정렬된 QD 구조를 형성하고, 형성된 양자점의 수평 자기정렬 현상과 광학적 특성을 Atomic Force Microscope (AFM) 과 Photoluminescence(PL) 측정을 통하여 관찰 하였다. 고분해능 X선 회절법 (HR-XRD)을 이용한 역격자분포 (RSM)의 분석을 통하여, 특정방향으로의 QD 배열은 GaAs 기판 방향의 미세한 오차 ([100]+/-0.1°)로부터 발생한 경사면 (vicinal step)에 의한 것은 아님을 증명하였다. 또 다른 성장 방법으로 GaAs buffer layer 위에 Migration-enhanced epitaxy (MEE) 법을 이용하여 InGaAs 2-D layer를 형성한 후, In(Ga)As 양자점을 형성하였다. 성장 변수가 되는 In 조성, 성장 온도, InGaAs 층의 두께 등, 여러 변수를 바꾸어 최적의 corrugated layer를 형성하고 그 위에 양자점을 형성하여 1차원적 자기정렬을 시도하였다.

Kp-016 **Growth and Characterization of $In_xAl_{1-x}N$ layer on GaN/Sapphire(0001) Template** 오 태수, 김 서군[1], 우 승희[1], 정 현[1], 김 희윤[1], 홍 창희[1], 서 은경[1](*전북대학교 나노반도체 디스플레이학과. [1]전북대학교 반도체 화학공학부.*) $In_xAl_{1-x}N$ alloys are a possible candidate for light emitters and detectors operating in extremely wide spectral regions covering from deep UV to IR, since their band-gap energy (Eg) ranges from 6.2 eV (AlN) to 0.7 eV (InN). Also, the use of appropriate $In_xAl_{1-x}N$ (x~17%) enables to fabricate lattice-matched GaN-based hetero-structures that can be used for high-performance laser diodes. However, the growth of $In_xAl_{1-x}N$ alloys is extremely difficult due to the large differences in chemical and physical parameters between AlN and InN. We performed growth of the $In_xAl_{1-x}N$ layers directly on GaN/Sappire (0001) templates by metalorganic chemical vapor deposition (MOCVD). Depending on growth temperature, crystalline quality and Indium molar fraction of the grown $In_xAl_{1-x}N$ layers were estimated by Scanning electron microscope (SEM), Atomic force microscope (AFM) and High resolution X-ray diffraction (HRXRD). The Indium Incorporation efficiency decreased with increasing growth temperature and drastic compositional decrement was observed at growth temperature of 710 °C. Also, optical properties of grown $In_xAl_{1-x}N$ layers were characterized by using photoluminescence (PL), cathodeluminescence (CL) and absorption measurements. Acknowledgements.
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Kp-017 **InAs/(In,Ga)Sb 제 2형 초격자(Type II superlattices)구조를 이용한 적외선 검출소자 (superlattices infrared photodetector, SLIP)의 특성 비교** 신 현욱, 김 준오[1], 이 상준[2], 노 삼규[2], 최 정우(*경희대학교 물리학과. [1]경희대학교 물리학과, 한국표준과학연구원. [2]한국표준과학연구원.*) InAs/(In,Ga)Sb 제 2형 초격자(Type II superlattices)를 이용하여 고효율, 고온 동작을 위한 적외선 검출소자 (superlattices infrared photodetector, SLIP)의 제작을 위해 에너지 밴드 모델, 암전류 모델 등을 통하여 활성층 최적화 구조를 설계하였다. 적외선 대기창인 3~5 μm의 MWIR 영역과 8~12 μm의 LWIR 영역에서 동작하는 적외선 검출소자는 산업적 응용뿐만 아니라 야시경 등 군수용으로도 그 유용성이 인정되고 있고, 특히 InSb 등은 대기창인 3~5μm에 민감하게 반응하는 물질이다. 그러므로 Tight Binding Method를 사용하여 에너지 밴드를 계산하고, 분자선 에피탁시(Molecular beam epitaxy, MBE) 성장법을 이용하여 InAs/(In,Ga)Sb 제 2형 초격자 구조의 적외선 검출소자를 성장하여 단색화 장치 등을 이용하여 소자의 전기적, 광학성 특성을 비교 분석하였다.

Kp-018 **Blue/Green PDE LED의 전기발광에 미치는 영향에 관한 연구** 우 승희, 김 형구, 차 옥환, 정 상조, 홍 창희, 서 은경(*Semiconductor Physics Research Center and Department of Semiconductor Science and Technology, Chonbuk National University.*) 질화물 반도체를 이용한 청색/녹색 LED 는 소자 활성층에 내재된 많은 결함에도 불구하고, 높은 발광효율을 갖는 소자 구현이 가능한 것으로 알려져 있다. 특히 이러한 결함들은 활성층 내부에서의 재결합 효율을 높일 수 있는 밴드구조를 형성시키기도 하여 국소적으로 캐리어를 밀집시킬 수 있고 따라서 다른 화합물반도체 소자와 비교해 볼 때 높은 추출효율을 나타내고 있다.본 연구에서는 청색과 녹색 LED 소자 내부의 결함이 발광특성에 미치는 영향을 알아보기 위하여 전류변화에 따른 발광현상을 저온에서부터 상온까지 측정·분석하였다. 그 결과 청색과 녹색 LED 는 전류변화와 온도변화에 따라 서로 다른 내부양자효율을 나타내는 특성을 보였다. 이는 주입된 전류에 대한 국소적 결함의 특성 발광 매커니즘에 의한 것이라 여겨진다. 따라서 온도와 전류변화에 따라 청색과 녹색 LED 의 국소적 결함이 전자거동에 어

떠한 역할을 하는지 조사하였다.

Kp-019 **Current Dependent Electroluminescence of Periodic Deflector Embedded Light Emitting Diode** 정 현, 김 서군, 차 옥환, 서 은경, 변 지수[1], 김 종수[1], 정 문석[1](*전북대학교 반도체과학기술학과/반도체물성연구소. [1]광주과학기술원 고등광기술연구소.*) 최근 LED의 광 추출효율을 증대시키기 위한 노력이 많이 진행되어 오고 있다. 그 중 표면에 deflector 역할을 하는 육각 역 피라미드형 구멍을 주기적으로 배열하여 활성층에서 생성된 광자가 외부로 탈출하는 경로를 유도하는 PDE-LED(Periodic Deflector Embedded Light Emitting Diode)는 광 추출 효율의 증대를 성공시킨 사례이다. 본 실험에서는 주입된 전류의 양에 따른 PDE-LED의 광 특성을 Confocal microscope을 이용한 two-dimensional Electroluminescence mapping을 통하여 분석하였다. 주입되는 전류의 양이 증가될수록 state filling에 의해 spectrum의 peak point는 전체적으로 blue-shift가 나타났다. 광자가 비교적 많이 탈출 될 수 있게 유도된 부분에서는 전류가 증가할수록 spectrum의 변화는 비교적 어두운 부분에서의 spectrum의 변화와 다르게 나타났음을 관찰하였다.

Kp-020 **Effect of AlGaN/GaN short superlattice inserted structure on thermal and electrical performance of green InGaN-based light emitting diodes under accelerating test** 유 재형, CUONG tran viet, 강 지혜, 김 형구, 홍 창희(*전북대학교 반도체 물성연구소.*) We report an amelioration of electrical and thermal performance of green-InGaN/GaN multiple quantum well light emitting diodes with AlGaN/GaN short superlattice inserted structure. It was found that the insertion of short superlattice alleviates the effect of threading dislocations on degradation of electrical performance. Moreover, the short superlattice was noticeably used to spread the current in lateral direction, which results in minimizing the heat generation suffering under large applied current and long-term accelerating test promoting K-factor stabilization and decrease of thermal resistance.

Kp-021 **변조도핑을 이용한 고효율 레이저의 제작 연구** 성 승현, 류 상완, 유 준상[1], 강 중구[1], 정 대철[1](*전남대학교 물리학과. [1](주)OE솔루션.*) 본 연구에서 제안한 양자우물 구조를 갖는 반도체 레이저는 활성층 내의 전자와 정공이 양자우물 내에서 재결합하여 발광을 하므로 양자우물이 활성층의 광학적 특성을 결정하게 된다. 기존의 양자우물 근처에서 압전 전계에 의해 양자우물의 에너지밴드 구조가 휘어 밴딩되는 현상이 나타난다. 이는 양자우물의 계면에 압전전하들이 유도되고 이들에 의한 압전전계가 발생하게 되면, 에너지 밴드가 휘게 되는 것이다. 이것은 전자와 정공의 파동함수를 공간적으로 분리하여 발광효율을 감소시키게 되는 것이다. 따라서 양자 우물의 에너지 밴드모양을 변화시켜 양자우물의 발광효율을 증가시킬 필요성이 있다고 생각된다. 또한 이 가설을 증명하기 위해, 변조도핑을 통해 양자우물 내부의 전기장을 조절하여 양자우물의 에너지 밴드 다이어그램을 변경하는 기술을 이용한 고온동작 레이저를 제작하였다. 본 연구에서는 EPI 상태의 InP wafer를 사용하여 양자 우물의 전기장 조절을 위한 변조도핑을 실시하고 에너지 밴드 다이어그램을 변화시켜 주었다. 변조도핑된 EPI 구조를 사용하여, 1.3um FP-LD를 제작하고, 광소자가 고온동작에서 높은 효율을 보이는 지 특성을 조사였다. 일반 EPI구조를 이용했을 경우, SE(Slope Efficiency)가 0.32 mW/mA 정도인데 비해, 변조 도핑된 EPI구조를 이용한 1.3um FP-LD는 0.41 mW/mA정도의 SE값이 평균적으로 측정되었다. 변조 도핑된 EPI구조를 LD제작에 이용할 경우, 보다 높은 효율을 보이는 것을 알 수 있었다.

Kp-022 **Random Mask를 이용한 Surface texturing을 형성하여 광 추출효율을 개선한 GaN LED 의 제작** 김 승환, 김 태기[1], 배 성준[2], 이 정수[1], 양 계모[1](*전북대학교, 반도체화학공학부. [1]전북대학교, 반도체화학공학부. [2](주) 옵토웰.*) LED 소자는 반도체 물질과 air 사이의 큰 굴절률 차이로 발생하는 내부 전반사에 의해 광이 외부로 빠져나가지 못하고 갇히게 되어 광 추출효율을 감소시킨다. 본 연구에서는 광 추출효율의 개선 방안으로 Random Mask를 이용하여 표면이 거친 LED 칩을 제작하였다. Surface texturing 조건을 다양하게 변화를 주어 surface texturing 조건이 LED의 특성에 미치는 영향을 연구하였다. 또한, 기존의 conventional LED를 제작하여, 표면이 거친 LED와의 광 특성을 비교 분석하였다.

Kp-023 **Atomic and electronic structure of single crystalline $InGaO_3(ZnO)_m$** 장 기주, 이 우진, 최 은애, 방 준혁, 류 병기 (*한국과학기술원, 물리학과.*) Transparent oxide semiconductors have attracted muchattention due to their possible applications for new optoelectronic devices. Recently, transparent thin film transistors have been demonstrated, based on high quality, single crystalline $InGaO_3(ZnO)_m$ (IGZO), which consists of an alternating stack of InO_2 layers and $GaO(ZnO)_m$ blocks. In this work we investigate the atomic and electronic structure of IGZOs with m = 1 - 6 through first-principles calculations within the density functional framework. We optimize the atomic positions for each value of m, and find that the Zn and Ga atoms are located at tetrahedral and trigonal-bipyramidal sites, respectively, whereas the In atom located at an octahedral site is surrounded by six O atoms. We calculate the equilibrium lattice constantsand the variation of the band gap with m. We also discuss the role of O-vacancies in n-type conductivity observed in oxide semiconductors.

Kp-024 **Optical Characterization of CdSe (ZnS) quantum dots : Study of Temporal evolution of Photobrightening and Photodarkening Effects** 김 려화, GOKARNA Anisha, 황 준석, 임 용택[1], 정 봉현[1], 조 용훈(*충북대, 물리학과. [1]생명공학연구원.*) We have investigated photobrightening effect in two different kinds of quantum dots : colloidal CdSe(ZnS) core-shell quantum dots with and without PEG. The optical characteristics of these two types of QDs were studied by time dependent photoluminescence technique with variation in the laser power (from 50uW to 20mW) at room temperature. Compared to QDs only, QDs in presence of PEG showed a better stability in the PL characteristics. These results were also confirmed by time resolved PL measurements, wherein we could see that the lifetime of QDs in presence of PEG increased to nearly twice the value of the lifetime of QDs only.

Kp-027 **Laege Area Nano Imprint Lithography for display devices Application** CHOI BumHo, KIM Won Jae, KIM Young Baek, PARK Jong Woon, LEE Jong Ho, YU Yun Seop[1](*National Center for Nanoprocess and Equipments, Gwangju Research Center, Korea Institute of Industrial Technology. [1]HanKyong National University.*) Nano Imprint lithography (NIL) has been studied for future generation semiconductor application which can replace conventional optical lithography system. Since NIL can define sub 10 nm patterns with high throughput and low cost, several application area was developed in the field of display and optic such as polarizer, wave guide, splitter etc. Especially, NIL can be adapted newly developed organic lighting emitting diodes lighting devices in order to pattern ITO layer or enhance out-coupling efficeincy. We have investigated the possibility of application to OLED lighting devices of NIL. To enhance out-coupling efficiency, 200 nm diameter dot with the space of 600 nm was defined to ITO coated glass substrate at relatively low temperature than conventional thermal NIL technology to prevent deformation of glass. Dot and line patterns were successfully transferred onto the substrate using RIE and meal-lift-off method. In the conference, OLED lighting devices fabricated using NIL technology will be presented in detail.

Kp-028 **Comparative Analysis of Electrochemical Properties of Carbon Nano-fibers Grown on Si Substrate with Different Conductivity** JEON M.H., LEE S.K., HWANG S.H., MOON J.H., LEE K.S., LEE D.Y.[1](*인제대학교 나노메뉴팩쳐링 연구소. [1]Korea Electrotechnology Research Institute, Korea.*) The electrochemical and structural properties of carbon nano-fibers (CNFs) for dye-sensitized solar cell (DSSC) were studied. The CNFs were synthesized on Si substrate with different conductivities. One substrate had the conductivity about 0.05 $(\Omega\cdot cm)^{-1}$ and the other substrate had the conductivity about 200 $(\Omega\cdot cm)^{-1}$. Thermal chemical vapor deposition (CVD) was utilized for the synthesis of CNFs using a Fe catalyst. Acetylene (C_2H_2) was used as carbon source and ammonia (NH_3) was used as reactive gas for the growth of CNFs. The hall measurement for doping level of the substrate was carried out by Four-probe station method. The structural properties of CNFs were investigated by field-emission scanning electron microscopy (FE-SEM), transmission electron microscopy (TEM), and Raman spectroscopy. The electrochemical properties of CNFs were measured by electrochemical impedance spectroscopy (EIS). In the result of SEM measurement, the diameter of the CNFs on high doped Si substrate was larger than that of the CNFs on the low doped Si. In EIS spectrum, the redox reaction frequency of the CNFs on high doped substrate was about 2 kHz and that of the CNFs on low doped substrate was about 0.8 kHz. In this study, we found that the electrochemical properties of the CNFs on high doped substrate were superior to that of the CNFs on low doped substrate.

Kp-029 **Electronic structure, structural and optical properties of TiO_2 films** BOJAN karunagaran, SUH E.-K(*Semiconductor Physics Research Center and School of Semiconductor and Chemical Engineering, Chonbuk National University.*) Thin films of TiO_2 were deposited on silicon and glass substrates by direct current magnetron sputtering. Structural and optical properties of the prepared films were studied by using X-ray diffraction (XRD), Raman scattering, UV-vis spectroscopy and spectroscopic ellipsometry (SE). XRD shows the amorphous nature of the as-deposited films and the films annealed at 473 K and above shows crystallinity. Electronic band structure, band parameters and optical spectra of TiO_2 are calculated using Vienna ab initio simulation package (VASP), which calculates the Kohn-Sham eigenvalues within the framework of density functional theory (DFT). The calculations have been performed with the use of the local-density approximation (LDA). The interaction between electrons and atomic cores is described by means of non-norm-conserving pseudo-potentials implemented in the VASP package. The pseudo-potentials are generated in accordance to the projector-augmented-wave (PAW) method. The use of the PAW pseudo-potentials allows us to construct ortho-normalized all-electron-like wave functions for the Ti-3d, -4s, O -2s and -2p as valence electrons. Detailed analysis of the density of states (DOS), charge density, electron localization function and optical constants of TiO_2 is made and their agreement with the experimental data is demonstrated.
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Kp-030 **푸리에 변환을 통한 전이점 연구** 윤 재진, 정 용우, 김 태중, 김 영동, ASPNES D. E.[1](*경희대학교 나노 광물성 연구실 및 물리학과. [1]Department of Physics, North Carolina State University.*) 많은 물질들의 광 특성들을 조사하기 위한 측정 방법에는 라만 분광법, 타원 편광 분석법, X-선 회절 실험 등 여러 가지가 있다. 위와 같은 방법으로 측정한 광 스펙트럼 데이터를 정확하게 분석하기 위해서는 측정된 데이터의 노이즈를 줄이는 것이 가장 큰 문제이다. 특히 전이점 연구에서는 측정 데이터를 미분을 하게 되는데 그럴 경우 high frequency 노이즈는 더욱 증폭이 되게 되고 따라서 효과적인 분석을 하기에는 많은 어려움이 따른다. 우리는 이런 노이즈를 제거하기 위하여 푸리에 변환을 통한 reciprocal space analysis를 이용하였다. Reciprocal space analysis는 측정된 광 스펙트럼을 푸리에 변환하여 low, medium, high-index 푸리에 계수로부터 baseline effects, 정보, 노이즈를 구별하여 우리가 필요로 하는 정보는 최대한 얻어내고 노이즈는 최대한으로 줄 일수 있게 하는 분석방법이다. 본 연구 에서는 라만 분광기로 측정한 InGaN 데이터와 타원 편광 분석기를 이용하여 측정한 GaAs 와 ZnCdSe alloy의 유전 함수를 reciprocal space analysis를 통하여 효과적으로 노이즈를 제거함으로써 보다 정확한 전이점 연구를 실시하였다.

Kp-031 **Dependence of Photocurrent spectrum for $CdGa_2Se_4$ Thin Film** HONG Kwangjoon(*Chosun University.*) Single crystal $CdGa_2Se_4$ layers were grown on a thoroughly etched semi-insulating GaAs(100) substrate at 420 ℃ with the hot wall epitaxy (HWE) system by evaporating the polycrystal source of $CdGa_2Se_4$ at 630 ℃. The temperature dependence of the energy band gap of the $CdGa_2Se_4$ obtained from the absorption spectra was

well described by the Varshni's relation, $E_g(T) = 2.6400$ eV - (7.721 $\times 10^{-4}$ eV/K)$T^2/(T + 399$ K). Using the photocurrent spectra and the Hopfield quasicubic model, the crystal field energy(Δcr) and the spin-orbit splitting energy(Δso) for the valence band of the $CdGa_2Se_4$ have been estimated to be 106.5 meV and 418.9 meV at 10 K, respectively. The three photocurrent peaks observed at 10 K are ascribed to the A_1-, B_1-, and C_{11}-exciton peaks.

Kp-032 **Point defect for $CdGa_2Se_4$ Single Crystal Thin Film grown by hot wall epitaxy** LEE Sangyoul, HONG Kwangjoon(*Chosun University.*) The stochiometric mix of evaporating materials for the $CdGa_2Se_4$ single crystal thin films was prepared from horizontal furnace. After the as-grown single crystal $CdGa_2Se_4$ thin films were annealed in Cd-, Se-, and Ga -atmospheres, the origin of point defects of single crystal $CdGa_2Se_4$ thin films has been investigated by PL at 10 K. The native defects of V_{Cd}, V_{Se}, Cd_{int}, and Se_{int} obtained by PL measurements were classified as donors or acceptors. And we concluded that the heat-treatment in the Cd-atmosphere converted single crystal $CdGa_2Se_4$ thin films to an optical p-type. Also, we confirmed that Ga in $CdGa_2Se_4$/GaAs did not form the native defects because Ga in single crystal $CdGa_2Se_4$ thin films existed in the form of stable bonds.

Kp-033 **Spin-Orbit Interaction and Surface States in Electronic Structure of Bi_2Te_3 Observed by Angle-Resolved Photoemission Spectroscopy** NOH Han-Jin, OH S.-J.[1], PARK J.-H.[2], KIM H.-D.[3], RAMEAU J.[4], VALLA T.[4], KIDD T.[4], JOHNSON P. D.[4], HU Y.[4], LI Q.[4](*Dep. of Phys. Chonnam National University. [1]Dep. of Phys. Seoul National University. [2]Dep. of Phys. POSTECH. [3]Pohang Accelerator Laboratory. [4]Brookhaven National Laboratory.*) The electronic structure of p-type doped Bi_2Te_3 is studied by angle resolved photoemission spectroscopy (ARPES) to experimentally confirm the mechanism responsible for the high thermoelectric figure of merit. Our ARPES study shows that the band edges are located off the Γ-Z line in the Brillouin zone, which provides direct observation that the spin-orbit interaction is a key factor to understand the electronic structure and the corresponding thermoelectric properties of Bi_2Te_3. Successive time dependent ARPES measurement also reveals that the electron-like bands crossing E_F near the Γ point are formed in an hour after cleaving the crystals. We interpret these as surface states induced by the surface band bending possibly due to the quintuple inter-layer distance change of Bi_2Te_3.

Kp-034 **Observation of abrupt Metal-Insulator Transition in GaSb thin film** 최 성열, 김 봉준, 이 용욱, 김 현탁, 최 정용[1], 조 성래[1](*한국전자통신연구원, 신소자/소재 그룹, 테라전자소자팀. [1]울산대학교 물리학과, 스핀소재연구실.*) We have successfully fabricated epitaxial GaSb thin film on GaAs(100) substrate by MBE(Molecular Beam Epitaxy) at substrate temperature of 500 ℃. The GaSb thin film with hole concentration of n_p» 3.0 x10^{18} cm^{-3} showed an abrupt first-order metal-insulator transition (MIT) at room temperature without a structural phase transition on the temperature dependent of resistivity measurement. It is possible MIT temperature control without change hole concentration.

Kp-035 **Investigation of Dielectric Function of Interfacial Layers between High-k HfO_2 and $Si_{1-x}Ge_x$ Substrate with Various Ge Concentrations Using Electron Energy Loss Spectroscopy and First Principle Calculation** JANG Jiyoung, PARK Tae Joo, HWANG Cheol-Seong, KIM Miyoung(*서울대학교 재료공학부.*) High-k HfO_2 gate dielectric films have been investigated due to the high dielectric constant and wide band gap. However, the degradation of the channel mobility in metal-oxide-semiconductor field effect transistors containing a high-k HfO_2 gate dielectric appears to be unavoidable. Thus strained $Si_{1-x}Ge_x$ substrate is considered as an alternative. In the present study, we have conducted Low-loss electron energy loss spectrum in TEM on the interfacial layer between HfO_2 and $Si_{1-x}Ge_x$ substrate obtaining the complex dielectric function by means of Kramers-Kronig relations. The low-loss region in EELS presents information about the excitations of outer shell electrons and the electronic structure of material, which determines the optical properties. According to the several studies, thermal oxidation of $Si_{1-x}Ge_x$, which shows nonstoichiometric GeO_x formation and metallic Ge segregation in the interfacial layer during post-deposition annealing(PDA) has an effect on the various electrical properties. So the electrical properties of oxide layers with various Ge concentrations have to be clarified by EELS. And we could apply first principles density functional theory to simulate low-loss EELS features using the full potential linearized augmented plane wave(FPLAPW) method. Comparison of experimental results and theory show good agreement.

Kp-036 **Undoped 및 Co-doped $CdGa_2O_4$ 형광체의 광학적 특성** 최 성휴, 방 태환[1], 김 형곤[2], 김 남오[2](*조선대학교, 물리학과. [1]성화대학, 전기제어계측과. [2]조선이공대학, 전기과.*) Undoped 및 Co-doped $CdGa_2O_4$ 형광체 결정을 성장하여 성장된 결정의 구조와 격자상수를 구하였다. 결정구조는 cubic 구조이었으며, 격자상수 a=8.5949Å과 a=8.5915Å으로 주어졌다. 이들 결정의 광흡수 스펙트럼은 측정시료의 온도를 297K에서 200-2600nm 파장영역을 측정하였으며, 기초흡수단 영역에서 측정된 광흡수 스펙트럼으로부터 광학적 에너지 간격을 계산하였다. $CdGa_2O_4$:Co 결정에서 첨가한 cobalt 불순물에 기인한 광흡수 스펙트럼이 500-700nm와 1200-1800nm 영역에서 관측되었다. 결정장이론에 의하면 불순물 광흡수 스펙트럼은 대치하여 들어간 cobalt 불순물이 모체격자의 T_d 대칭점에 Co^{2+} 이온으로 위치하고, Co^{2+} 이온의 분리된 에너지 준위간의 전자 전이에 의한 피크들로 해석된다.

Kp-037 **$CdGa_2O_4$ 및 $CdGa_2O_4$:Er 형광체의 광학적 특성** 최 성휴, 방 태환[1](*조선대학교, 물리학과. [1]성화대학, 전기제어계측과.*) $CdGa_2O_4$ 및 $CdGa_2O_4$:Er 형광체 결정을 성장하여 성장된 결정의 구조와 격자상수를 구하였다. 결정구조는 cubic 구조이었으며, 격자상수 a=8.5949Å과 a=8.5913Å으로 주어졌다. 이들 결정의 광흡수 스펙트럼은 측정시료의 온도를 297K에서 200-850nm 파장영역을 측정하였으며, 기초흡수단 영역에서 측정된 광흡수 스펙트럼으로부터 광학적 에너지 간격을 계산하였다.

$CdGa_2O_4$:Er 결정에서 첨가한 Er 불순물에 기인한 광발광 스펙트럼이 650-700nm와 1500-1600nm 영역에서 예리한 방출피크가 관측되었다. 결정장 이론에 의하면 erbium 불순물에 의한 광발광피크는 모체결정에 대치하여 들어간 drbium 불순물이 모체격자의 T_d 대칭점에 Er^{3+} 이온으로 위치하고, Er^{3+} 이온의 분리된 에너지 준위간의 복사전이에 의한 피크들로 해석된다.

Kp-038 **잉크젯 방식을 이용한 TIPS pentacene 유기박막 트랜지스터 제작 및 특성 연구** CHOI MinHee, HAN SeungHoon, LEE SunHee, KIM YongHee, CHOO DongJoon, KWON SoonKi[1], JANG Jin(*Advanced Display Research Center, Kyung Hee University. [1]School of Nano&Advanced Materials and Engineering Research Institute, Gyeong Sang University.*) 잉크젯 프린팅은 디스플레이 및 전자소자 제작에 적용할 경우 기존의 포토리소그래피 방법을 대체할 수 있게 되고 원하는 곳에만 패턴을 만들 수 있기 때문에 제작 공정이 간단하고 공정 비용에 있어서 절감이 가능하다. 특히, 몇몇 반도체를 잉크젯 프린팅방식에 의해 제작된 TFT의 경우 10^{-2} ~ 10^{-4} cm2/Vs의 전계 효과 이동도를 나타내는 것으로 보고되고 있다. 본 연구에서는 bottom contact구조의 P형 OTFT 를 잉크젯 프린팅 방식으로 제작하였다. P-type 저분자 반도체 물질인 TIPS pentacene을 용액으로 제조하여, OTFT의 반도체층으로 프린팅 하였다. 사용된 TIPS pentacene 용액의 농도는 1.0 wt.% 이고, 사용된 용매는 1,2-Dichlorobenzene으로 TIPS pentacene 프린팅 시 기판의 온도를 상온과 60 ℃로 각각 나누어 실시하여 기판온도에 따른 유기박막트랜지스터의 특성을 확인하였다. 이 때, 기판 온도 60 ℃에서 프린팅 하였을 경우 상온에서 프린팅 한 소자보다 우수한 전기적 특성을 나타내었고, 점멸비 ~10^7, 전계효과 이동도 0.24 cm^2/Vs 의 우수한 전기적 특성을 나타내었다. *Acknowledgement 이 연구(논문)는 산업자원부의 21세기 프론티어기술개발사업인 차세대정보디스플레이기술개발사업단의 기술개발비(F0004082-2007-23)지원으로 수행되었습니다.

Kp-039 **Quantum Dots을 결합한 GaN 표면 거칠기에 따른 광학적 특성** 백 설, 김 용환, 이 선균, GOKARNA Anisha, 조 용훈(*충북대, 물리학과.*) 백색 LED를 구현하는 보편적 방법은 UV-LED 광원과 형광체(phopohre)를 결합하는 것이다. 그러나 형광체를 이용하게 되면 발광효율이 떨어지기 때문에, 형광체를 대신하여 nanocrystal을 이용하는 방법이 모색되었다. 또한 기존의 LED는 소자 위쪽으로 빛을 내는 방식 (top emitting)을 취하고 있어, 빛이 발광 층에서 위쪽으로 나오는 동안 주변에 흡수되어 빛의 손실이 발생하는 문제점이 있었다. 그리하여 본 연구에서는 소자의 위층인active layer의 표면을 변화시켜, 내부 전반사 율을 낮추어 발광층에서 발생하는 빛의 양을 증가시켜 내부 양자효율의 증대를 기대해본다. 표면의 거칠기를 달리한 활성층위에 spin coater을 이용하여 colloidal quantum dots(QDs)을 도포하여 결합시켰다. 표면의 변화에 따른 활성층의 특성을 PL measurement를 통해 알아보았고, 활성층과 QDs와의 결합 특성을 confocal microscope를 이용하여 확인하였다.

Kp-040 **Spectroscopic ellipsometry를 이용한 $Ga_{1-x}Cr_xN(0 \le x \le 0.1)$ 화합물 박막 연구** 변 준석, 공 태호, 김 영동, KIM J.J.[1], MAKINO T.[1], YAO T.[1](*경희대학교 이과대학 물리학과 및 나노광물성연구실. [1]Institute for Materials Research, Tohoku Univ..*) $Ga_{1-x}Cr_xN(0 \le x \le 0.1)$는 실온에서의 DMS(diluted magnetic semiconductor) 물질로써 많은 관심을 받고 있다. 본 연구에서 측정한 시료는 Al_2O_3(0001) 기판 위에 500°C의 낮은 온도에서 300nm 두께의 GaN buffer layer를 증착시키고, 그 위에 800°C의 높은 온도에서 150nm GaN buffer layer를 증착한 후, 그 위에 약 500nm 정도의 $Ga_{1-x}Cr_xN(x = 0.004,\ 0.013,\ 0.063,\ 0.101)$ 박막을 NH3-MBE (molecular beam epitaxy)를 이용하여 증착하였다. VUVSE(vacuum UV spectroscopic ellipsometry)로 실온에서 $Ga_{1-x}Cr_xN$ 화합물 박막을 0.7~0.9 eV의 분광영역으로 입사각 70°에서 측정하여 pseudodielectric function spectra $\langle\varepsilon\rangle = \langle\varepsilon_1\rangle + i\langle\varepsilon_2\rangle$를 얻었다. VUV-SE는 6 eV 이상의 유전함수를 측정할 수 있는 장비로써, dielectric function data를 구하는데 매우 좋은 기기이다. 측정된 데이터를 통해 E_0, E_1, E_2 peak를 확인할 수 있었고, 특히 E_1, E_2 peak의 경우 7-8 eV 에 존재하기 때문에 기존의 저에너지 타원편광분석기로는 볼 수 없었던 것을 확인할 수 있었다. Cr 의 함량에 따른 CP (critical point) 에너지 값을 구하기 위해 standard analytic CP expression을 이용하였다. 측정된 E_0, E_1, E_2 CP 에너지 값을 위의 방법으로 분석한 결과, E_0, E_1, E_2 CP 에너지 값의 Cr 함량에 따른 선형 변화를 관찰하였는데 3가지 밴드갭 모두다 Cr 의 함량이 클수록 증가하는 모습을 보였다. 결과적으로 host semiconductor에서 Cr 금속 이온 전이의 3d level과 GaN 밴드 전자의 sp level사이의 상호작용을 설명하는 sp-d hybridization model을 이용하여 GaN의 band structure에서 Cr의 3d level을 추정할 수 있었다.

Kp-041 **Quasi-particle energy spectra of IV-VI semiconductors under pressure** KIM Jinwoong, LEE Geunsik, JHI Seung-Hoon(*Department of Physics, Pohang University of Science and Technology.*) The IV-VI semiconductors are widely used for thermoelectric materials or in optoelectronic devices. While many theoretical and experimental works have been carried out to understand their electronic structures, we are particularly interested in accurate computations of quasi-particle energies of the materials under external pressure, which is necessary for studying their transport and optical properties with a better accuracy. We have calculated the electronic structures of IV-VI compounds under pressure beyond the local density approximation using ab initio pseudopotential method and GW approach. We include semi-core d-electrons of tellurium in the valence to properly take into account the p-d coupling, which is found non-negligible.

Kp-042 **Piezo-reflectance in Amorphous SiN_x Films Grown on p-Si Substrate** JO Hyun Jun, KIM Jong Su, BYEON Clare C, PARK Jucheol[1], HEO Sung[1], CHUNG JaeGwan[1], LEE EunHa[1], PARK Gyeong-Su[1], KO Byoung Su[2], BAE In Ho[2] (*Advanced Photonics Research Institute (APRI), GIST. [1]AE Center, Samsung Advanced Institute of Technolgy. [2]Department of Physics, Yeungnam University.*) Optical properties of a-SiN_x films grown on p-Si (001) substrate were investigated by photoluminescence (PL) and piezo-reflectance (PzR). Three a-SiN_x films were deposited at different gas flow rates of SiH_4; 200, 300 and 400 sccm (N-rich, normal, Si-rich). The a-SiN_x films showed strong PL lines which were related to intrinsic levels in p-Si substrate and radiative electronic states in SiN_x. To investigate non-radiative transition levels, PzR

measurements were performed at room temperature. The PzR spectrum of normal SiN_x showed two non-radiative transition levels at 1.14 and 2.95 eV. In case of N-rich SiN_x, most of the transition related to non-radiative process.

Kp-043 **Monte-Carlo 전산모사 방법을 사용한 온도와 에너지 분포에 따른 유기물의 전하 이동도** 송 시호, 정 재훈, 김 태환(*한양대학교.*) 온도와 위치 변화에 따른 유기물의 전하 이동도를 Monte-Carlo 전산모사 방법으로 계산하고 전하의 이동도가 유기물로 제작된 소자에 미치는 영향을 조사하였다. 여러 가지 온도와 불순물의 에너지 분포에 따른 유기물의 전하의 이동도를 전계의 변화에 따라 계산하였으며 이 결과를 기존에 발표된 실험 결과와 비교 분석하였다. 유기물의 전하이동도를 Monte-Carlo 전사모사 방법을 사용하여 계산할 경우 표동-확산 모델을 사용하여 계산한 방법보다 전하의 이동도를 정확하게 계산할 수 있는 장점이 있다. 유기물에서의 전하의 이동도가 온도와 에너지 분포에 의하여 영향을 받기 때문에 유기물에서의 전하의 이동도의 계산은 유기물의 전기적 및 전자적 성질을 이해하는데 도움이 된다. Hopping 비율을 구하고 hopping site 분포를 계산하여 전하의 이동도를 계산한다. 전하의 이동도에 유기물의 온도와 에너지 분포가 어떻게 영향을 미치는지를 조사하였다. Monte-Carlo 전산모사 방법을 사용하여 계산된 온도와 에너지 분포에 따른 전하 이동도는 유기물내에서 전하의 전송특성을 이해하는 기초지식을 제공하여 유기물을 이용하여 제작된 소자의 전하수송메카니즘을 이해하는데 도움을 준다.
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Kp-044 **The electronic states and structural properties of oxygen doped $Ge_2Sb_2Te_5$** 장 문형, 박 승종, 이 연진[1], 조 만호, 황 정남, 조 용훈[2], 이 종흔[2](*연세대학교. [1]한국표준과학연구원. [2]고려대학교.*) Oxygen doped $Ge_2Sb_2Te_5$ films with oxygen content from 0 to about 48 at.% were deposited on SiO_2 layers using a reactive ion beam sputtering deposition method. The core level photoelectron spectra measured at the beam line 8A1 of Pohang Light Source allowed us to confirm that the oxygen is mostly bonded with Ge atoms. However, as oxygen content increased, the Ge-O bond was saturated and the Sb oxide was formed. Moreover, the Ge and Sb oxide stoichiometry were not preserved. From X-ray diffraction patterns and atomic force microscopy images, we found the segregation of oxide on film. Ac two-point impedance method was carried out with crystallized films to verify the formation of oxide at grain boundaries. Four-point probe measurements were conducted to observe how the oxide formed affects the crystallization temperature.

Kp-045 **$SrRuO_3$ 버퍼 레이어를 이용한 페로브스카이트계 물질 $Pr_{0.7}Ca_{0.3}MnO_3$ 박막의 저항 변화 특성 분석** 주 상현, 김 주연[1], 최 은집[1], 홍 완식, 박 경완, 석 중현(*서울시립대학교 나노과학기술학과. [1]서울시립대학교 물리학과.*) 최근 페로브스카이트계 물질 중 $Pr_{0.7}Ca_{0.3}MnO_3$를 이용하여 비휘발성 메모리 (ReRAM)로 응용하기 위한 연구가 활발히 진행되고 있다. rf-magnetron sputtering 방법을 이용하여 Pt 하부전극 위에 증착한 $Pr_{0.7}Ca_{0.3}MnO_3$(PCMO) 박막이 저항변화 특성을 보이고 있다. 저항 변화 특성이 금속 전극과 PCMO 박막의 계면에서 일어나기 때문에 버퍼레이어로 $SrRuO_3$(SRO)를 사용하여 저항 변화 특성의 개선과 수율을 확보하고자 하였다. rf-magnetron sputtering 방법을 이용하여 in situ한 환경에서 $Pr_{0.7}Ca_{0.3}MnO_3$ (PCMO)박막의 상,하부에 $SrRuO_3$ 버퍼레이어를 증착하여 PCMO 박막의 저항 변화율을 개선하였다. SRO 버퍼레이어를 사용했을 때, 높은 저항을 가질 때의 저항값과 낮은 저항을 가질 때의 저항값의 비율을 나타내는 Electroresistance(ER) Ratio ($\triangle R/R = (R_{high} - R_{low})/R_{low}$))가 2000%로 측정되었다. 버퍼레이어를 사용하지 않았을 때는 약 800%의 특성을 나타냈다. 더욱이 버퍼레이어를 사용했을 때 재현성이 향상되었다. 그리고 SRO 버퍼레이어를 PCMO 박막의 상,하부에 증착한 샘플에 후열처리(O_2) 했을 때 PCMO와 SRO의 결함이 줄어들면서 저항 변화 특성이 향상되었다. 그리고 상부전극으로 사용하던 Ag를 Au로 바꾸고 하부전극 역시 Au로 바꾸었을 때 저항 변화 특성이 대칭적으로 변화하였다. 본 연구를 통해 SRO buffer layer를 사용함으로써 PCMO 박막의 저항 변화 특성의 향상은 물론, 재현성도 크게 개선할 수 있었고, 후열처리공정을 통해 PCMO 박막의 저항 변화 특성을 더욱 향상시킬 수 있었다. 그리고 전극교체를 통해서 I-V 커브의 비대칭적인 문제를 해결하였고 Pt-Ag를 사용했을 때 보다 Au-Au 전극을 사용한 샘플에서 더 좋은 저항 변화 특성을 얻었다.

Kp-046 **Low voltage complementary thin-film transistor inverters with pentacene-ZnO hybrid channels** 임 성일, 오 민석, 이 기문, 황 도경(*연세대학교 물리 및 응용물리 사업단.*) We report on the fabrication of complementary thin-film transistor (CTFT) inverters with pentacene (p-type) and ZnO (n-type) hybrid channels on rf-deposited AlO_x dielectrics. All deposition processes were carried out on glass substrate at low temperatures (<100°C). Since our p-channel TFT showed somewhat equivalent field mobility of 0.11 cm^2/Vs compared to that of the n-channel device (0.75 cm^2/Vs), our hybrid CTFT inverters were designed with identical dimensions for both channels. The CTFT device demonstrated an exellent voltage gain of ~21 with a low static power dissipation of ~1.5 nW at a low supply voltage of 7 V. And by adopting organic-pentacene p-channel and inorganic-ZnO n-channel, we have fabricated a model device of hybrid complementary TFT inverters at a low channel deposition temperature below 100 °C. Although thoses p- and n-channels were deposited on high-temperature-processed thin gate oxide/p-Si here, our complementary device demonstrated good potentials toward air-stable logic applications, operating with an exellent voltage gain of ~26 at 2 V as well as with a dynamic response of ~10 msec.

Kp-047 **Dependency of Nonvolatile Memory Behavior on the concentration of PVK forAu nano-crystals embedded in PVK** LEE Jong Dae, SEUNG Hyeon in, HAN Byeong Il, PARK Jea-Gun(*Nano SOI Process Laboratory, Hanyang University.*) Memory effect in organic molecules is based on electrical bistability of the materials and the bistable phenomenon was observed in poly(N-vinylcarbazole) (PVK) layer, containing many small discrete Au

nanocrystals, sandwiched between Al electrodes. For devices fabricated with different concentration of PVK, the dependency of the resulting nonvolatile memory behavior on the concentration of PVK was investigated and the device was more stable at low concentration. It may be found that low concentration of PVK is a good uniformity of roughness. The nonvolatile memory behavior will require a good uniformity of roughness of PVK, which depends on the concentration.

Kp-048 **Mechanism for Organic Nonvolatile Memory with the Structure of Al/α-NPD/Al Nanocrystals Surrounded by Al_2O_3/α-NPD/Al** SEO Sung-ho, KIM Yool-guk, PARK Jea-gun, KIM Yoon-joong[1](*Department of Electrical &Computer Engineering, Hanyang University. [1]Electron Microscopy Team, Korea Basic Science Institute.*) Recently, low molecular organic non-volatile memories have been developed as a next generation of non-volatile memory because of nano-meter device-feature size and nano-second access and store-time. We developed organic nonvolatile memory fabricated with the device structure of α-NPD/Al nanocrystals surrounded by Al_2O_3/α-NPD/Al where α-NPD is N,N'-bis(1-naphthyl)-1,1'biphenyl4-4''diamine. One layer of Al nanocrystals was uniform produced between α-NPD layers, confirmed by 1.2MV high voltage transmission-electron-microscope. That achieved the conduction bistability(I_{write}/I_{erase}) of ~10^2, threshold voltage for a set state of 3V, and write/erase(W/E) cycles of >1x10^5. Al nano-crystals surrounded by amorphous Al_2O_3 were included in conductive organic material α-NPD. We obtained the best conduction bistability and threshold voltage at the α-NPD thickness of 30nm, the evaporation rate of 1.0Å/sec and the Al nanocrystal layer thickness of 20nm. They presented seven different reversible current paths approving electron charge or discharge on Al nanocrystals. Thus, our device demonstrated multi-level nonvolatile memory behavior

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Kp-049 **Development for Stack type Organic Nonvolatile Memory Fabricated with the Device Structure of Al/Alq_3/Ni Nanocrystals/Alq_3/Al** NAM Woo-sik, OH Young-hwan, PARK Jea-gun, KIM Young-min[1](*Hanyang University, Department of Electrical &Computer Engineering. [1]Korea Basic Science Institute, Electron Microscopy Team.*) We developed stack type organic nonvolatile memory (NVM) by using Ni nanocrystals. This memory is fabricated with the device structure of Al / Alq_3 / Ni nanocrystals / Alq_3 / Al where Alq_3 is aluminum tris (8 hydroxyquinoline). We obtained the best conduction bistability at the Alq_3 thickness of 30nm, the evaporation rate of 0.1 Å/sec and the middle Ni nanocrystals layer thickness of 10nm. Electrical behavior of bistable switching device is obtained by sweeping the voltage from 0 to 10V. Our device showed excellent bistable memory characteristic; i.e., V_{th} of 2.5V, V_{write} of 3.5V, V_{erase} of 6V, I_{on}/I_{off} ratio is as many as >1*10^4 for bottom NVM. Top NVM showed similar characteristic; i.e., V_{th} of 2.6V, V_{write} of 3.8V, V_{erase} of 5.8V, I_{on}/I_{off} ratio is >1*10^4. The voltage between V_{write} and V_{erase} is a region of negative differential resistance (NDR). We achieved four levels of conduction current state by using NDR, so we realized multi level cell. As a result, we achieved outstanding organic bistable device by using Ni nanocrystals for Middle layer.

Acknowledgement This research was supported by Korea ministry of commerce, industry and energy for the 0.1 Terabit Non-volatile Memory Development.

Kp-050 **반도체 MEMS 공정용 마이크로 블라스터에 대한 연구** 배 익순, 홍 영명[1], 유 현준[1], 장 종민[1], 강 태욱[1], 김 희성[1], 유 인식[2], 공 대영[1], 은 덕수[1], 이 종현[1](*경북대학교 산업대학원. [1]경북대학교. [2]경동정보대학.*) 마이크로 블라스터는 마이크로단위의 파우더(powder)를 고압으로 분사하여 마스킹(masking)된 부분을 제외한 나머지 부분을 식각하여 원하는 구조체를 만드는 장비이다. 현재 국내에서는 이 기술을 이용하여 구멍(hole)가공만 하는 단순 가공 형태로 사용되며, 구멍의 사이즈는 1mm정도가 한계이다. 본 연구에서는 마이크로 블라스터를 이용하여 100um이하의 미세가공 및 구조물 가공기술을 확보하여 반도체 MEMS 공정 기술에 적용 가능성을 보였다. 이는 기존의 습식 식각 방법과 건식 식각 방법과는 별개의 반도체 MEMS 공정 기술을 확립시키는 것이다. 반도체 MEMS 공정에 가장 많이 사용되는 재료는 유리기판과 실리콘 기판이다. 반도체 MEMS 공정 기술에 적용 가능 하도록 마이크로 블라스터 장비를 제작하고, 유리 기판과 실리콘 기판을 사용하여 각각의 변수에 따른 식각 특성을 분석하였다. 먼저 파우더의 직경이 50um, 25um, 10um의 사이즈를 가지는 파우더를 이용하여 유리기판과 실리콘 기판을 식각하여 표면 특성을 조사하였고, 파우더의 재료에 따른 표면 식각 특성을 분석하였다. 파우더의 직경과 재료는 유리 기판과 실리콘 기판에 따라 식각율과 식각 후의 표면 형상을 결정하는데 가장 중요하다. 그리고 한 구역을 식각하는 공정 시간과 전체 반복 횟수, 노즐의 이동 속도에 따른 표면 식각 특성을 분석하였다.

Kp-051 **Macro pore를 이용한 태양전지의 표면 texturing에 관한 연구** 조 재범, 공 대영, 장 종민, 김 희성, 은 덕수, 배 익순[1], 이 종현(*경북대학교, 전자전기컴퓨터공학부. [1]경북대학교, 산업대학원.*) 태양전지란 태양에너지를 전기에너지로 바꿔주는 소자를 말한다. 태양전지 개발에서 가장 핵심적인 사항은 효율 증가이다. 효율을 증가시키는 방법에는 표면 반사 방지막(Anti-Reflection Coating: ARC)과 표면 텍쳐링(texturing) 등이 있다. 본 논문에서는 다공질 실리콘을 이용한 표면 텍쳐링 방법에 대한 연구를 하였다. 기존의 나노(nano) 기공(pore)을 가지는 다공질 실리콘과는 다르게 매크로(macro) 기공을 가지는 다공질 실리콘을 형성하여 기공내의 n+형성이 용이하게 하고 표면적을 넓혔다. 결정방향이 (100) 실리콘 웨이퍼(wafer)에 앞면에는 질화막(Si3N4)을 약 5000Å의 두께로 증착(deposition)시킨 후, 사진석판(Photolithography) 공정을 하여 양극 반응(anodic reaction)을 할 패턴을 형성시켰다. 그리고 뒷면에는 알루미늄을 증착한 후 400℃에서 40분 동안 열처리를 하였다. 다공질 실리콘 시편 제작은 HF / DI / EtOH 혼합 용액을 사용했으며, HF의 농도가 10 wt%가 되도록 용액을 혼합했다. 반응 면적의 제어 요소는 전류 밀도로 하였다. 양극 반응은 단위 면적당 1mA에서 1시간 동안 반응시켰다. 양극 반응 후, NaOH 20 wt% 용액에 10초 정도 담궈 기공 내부에 불

필요한 부분을 제거하였다. 본 연구에서는 형성된 매크로 다공질 실리콘을 SEM, 반사율, 투과율을 측정하여 특성을 분석하였다.

Kp-052 **$In_xGa_{1-x}N/GaN$ 단일양자우물의 전하 활성화 에너지와 전자적 부띠에너지** 김 혁주, 김 봉준, 김 태환, 유 건호[1], 배 성범[2], 이 규석[2](*한양대학교, 전자컴퓨터통신공학부. [1]경희대학교, 물리학과. [2]전자통신연구원, 광소자연구부.*) 금속유기기상 증착법을 사용하여 성장한 $In_xGa_{1-x}N/GaN$ 단일 양자우물에 대하여 광학적 성질을 조사하고 전하활성화 에너지를 결정하기 위하여 온도에 의존하는 광류미네센스 측정을 하였다. 광류미네센스의 세기를 적분한 값을 온도의 역함수로 나타내어 $In_xGa_{1-x}N/GaN$ 단일 양자우물에 있는 전하의 활성화 에너지를 결정하였다. $In_xGa_{1-x}N/GaN$ 단일 양자우물에서 전자적 부띠를 결정하기 위하여 spontaneous 편광과 piezoelectric 편광 효과를 고려하여 자체일관적으로 계산하였다. $In_xGa_{1-x}N/GaN$ 단일 양자우물에 있는 전하 활성화 에너지와 자체 일관적 수리방법으로 계산한 부띠 에너지 준위의 상관관계를 관찰하였다. 이 결과는 $In_xGa_{1-x}N/GaN$ 단일 양자우물에 점유하고 있는 전하의 활성화 에너지와 부띠에너지준위의 상관관계를 이해하는데 도움을 준다.

*This work was supported by the Korea Science and Engineering Foundation (KOSEF) grant funded by the Korea government (MOST) (No. R0A-2007-000-20044-0).

Kp-053 **High Efficient Green Luminescent Phosphor for LED Applications** 노 도영, NAZAROV Mihail[1], 이 성표[1](*광주과학기술원, 신소재공학과. [1]광주과학기술원,신소재공학과.*) We report the synthesis and luminescence properties of multiphase green phosphor based on $SrGa_2S_4$ thiogallate. One of the important questions for practical application of thiogallates in LED, displays and other devices is radiant efficiency and stability. Usually these materials are very bright and have very high efficiency, but sometimes their stability toward hydrolysis and temperature is not sufficient. That's why we propose to use the multiphase ternary compounds with oxide phase because they are much more stable than ternary sulfides. The multiphase $\{SrGa_2S_4 + MgGa_2O_4\}:Eu^{2+}$ samples were synthesized by solid-state reaction at 1000 ^{0}C with a carbon reduction atmosphere for 4 h. The synthesized samples exhibit a deep green color and the total intensity is higher the intensity of the best commercial $SrGa_2S_4$ phosphor about 15%. The FWHM is narrower about 5 nm and general luminescence is shifted from 535 nm to 539 nm. Our study confirms that proposed multiphase green phosphor is well suitable in lighting and display devices with better color rendering index and chromaticity coordinates.

■ SESSION P3
10월 19일(금), 13:00 - 14:45
장 소: 5층 포이어

Dp-098 **Dielectric functions and critical points of $PbTiO_3$, $PbZrO_3$, and $PbZr_{0.57}Ti_{0.43}O_3$ grown on $SrTiO_3$ substrate** 이 호선, 박 준우, 이 호석, XING G.[1], IZUMSKAYA N.[1], AVRUTIN V.[1], XIAO B.[1], MORKOC H.[1], 강 태동(*경희대학교 물리학과. [1]Virginia Commonwealth University, USA.*) Single crystalline $PbTiO_3$, $PbZrO_3$, and $PbZr_{0.57}Ti_{0.43}O_3$ thin films on $SrTiO_3$ (001) substrates were grown by a combination of by molecular beam epitaxy and rf sputtering methods. We measured the dielectric functions of the thin films using spectroscopic ellipsometry and determined the interband critical point energies using standard critical point model. We compared the critical point energies to the band structure calculations in the literature. Our data suggest that anti-crossing behavior occurs between E_a and E_b near Zr=0.17. This phenomenon is attributed to a coupling between X_{1c} and X_{3c} bands caused by intrinsic alloy disorder.

Dp-099 **페라이트 도금법에 의한 CoNi-페라이트 자성 박막의 성장과 자기적 성질** 이 정식, 하 태욱, 김 현민(*경성대학교, 물리학과.*) 페라이트 도금 방법은 수용액 중에서 박막을 형성하는 방법으로 기판온도가 100 ℃ 이하로 낮기 때문에 내열성이 없는 물질을 기판으로 사용할 수 있는 장점이 있다. 유리 기판 위에 온도 80 ℃에서 CoNi 페라이트 박막을 제작하였다. 박막의 조성비를 조정하기 위해 반응용액에 $NiCl_24H_2O$ 와 $CoCl_26H_2O$의 양을 조절하여 박막을 성장하였다. 박막은 30분간 성장시켰으며, 거울 면과 같은 광택을 지녔다 박막의 x-선 회절 패턴은 다결정 스피넬 구조의 단일상을 보였다. 포화자화 M_s는 300 emu/cm^3~470 emu/cm^3의 값을 가지며, 보자력은 50 G 에서 600 G 의 값을 가진다.

Dp-100 **Magnetism and Electronic Structure of a Weak Ferromagnetic Compound Sc_3In** 정(JEONG) 태성(Taeseong), 권(KWON) 용경(Yongkyung)(*건국대학교, 물리학과.*) The electronic structure of Sc_3In was studied based on the density functional theory within the local-density approximation. The Stoner exchange interaction constant I, which determines the magnetic susceptibility of interacting electrons through $\chi = \chi_0 / [1-N(E_F) I]$, has been computed by using fixed spin moment calculations. This turns out $I N(E_F) = 1.1$, larger than unity, which corresponds to a ferromagnetic instability. Large enhancement of the static susceptibility compared to its non-interacting value is found due to a peak in the density of states at the Fermi level. Sc_3In is so-called a weak itinerant ferromagnet, which is also characterized by low values of the magnetic ordering temperature T_c. The weakness of the magnetism is due to the sizable overlap of the magnetic orbitals. This allows small perturbations, such as those caused by a change of composition and by application of pressure or magnetic field, to drive a weak itinerant ferromagnet into a non-magnetic state.

Dp-101 **$FeCr_2X_4$ (X=S, Se) 스피넬 화합물의 방사광 분광 연구** 김 그라시아, 이 현진, 김 대현, 강 정수, 김 삼진[1], 김 철성[1], 이 한길[2], 김 재영[2](*가톨릭대학교, 물리학과. [1]국민대학교, 물리학과. [2]포항가속기연구소.*) $FeCr_2S_4$ 형의 스피넬(spinel) 화합물들은 온도 변화에 따른 금속-절연체 전이와 외부 자기장에 따른 거대 자기저항 (giant magnetoresistance: GMR) 현상을 나타낸다 [1]. 한편 $FeCr_2S_4$ 와 $FeCr_2Se_4$는 같은 스피넬 구조를 가졌지만 매우 다른 자기적 성질을 보인다. $FeCr_2S_4$는 T_C ~ 172 K 근처에서 강자성 전이 현상을 보이는 반면 (T_C: 퀴리 온도), $FeCr_2Se_4$는 T_N ~ 218 K 근처에서 반강자성 전이 현상을 보인다 (T_N: Neel 온도) [2]. 그러나 $FeCr_2X_4$ (X=S, Se) 형의 스피넬 화합물에서 관찰된 GMR 현상, 금속-절연체 전이, 강자성, 반강자성 등의 원인에 대한 이해는 아직 충분하지 않은 실정이다. $FeCr_2X_4$ 스피넬 화합물이 나타내는 자기적 성질들의 원인을 이해하기 위해서는 $FeCr_2X_4$ 의 전자 구조의 연구가 매우 중요하다. 이 연구에서 우리는 $FeCr_2X_4$ (X=S, Se) 를 대상으로 방사광을 이용한 광전자 분광 (photoemission spectroscopy: PES), 연 x선 광흡수 분광 (x-ray absorption spectroscopy: XAS), 원형자기이색성 분광 (magnetic circular dichroism: MCD) 등의 실험을 수행함으로써 $FeCr_2X_4$ 의 전자 구조를 연구하였다. 이러한 연구를 통하여 Cr 이온의 원자가와 3d 전자들의 스핀배열 상태, 각 오비털들의 에너지 분포 등을 결정하였으며, 나아가 이 연구 결과를 토대로 하여 $FeCr_2X_4$의 전자구조가 $FeCr_2X_4$ 의 전자기적 물성에 미치는 영향을 이해하고자 하였다.
[1] A. P. Ramirez, et al., Nature 386, 156 (1997). [2] J. H. Kang, et al., J. Appl. Phys. 99, 08F714 (2006).

Dp-102 **방사광을 이용한 $Ca_3Co_{2-x}X_xO_6$ (X=Rh, Ir) 의 전자 구조 연구** 이 현진, 김 그라시아, 김 대현, 강 정수, 박 혜림[1], 정 윤희[1], 정 민철[2], 신 현준[2], 이 한길[2], 정 민철[2](*가톨릭대학교, 물리학과. [1]포항공과대학교, 물리학과. [2]포항가속기연구소.*) 최근 $Ca_3Co_2O_6$산화물에서 큰 열기전력(thermoelectric power) 현상이 발견된 후, Co 이온 대신 Rh과 Ir 들을 치환한 Ca_3CoXO_6 (X=Rh, Ir) 산화물에서 재미있는 자기적 물성이 관측된 바 있다. Ca_3CoXO_6의 물성을 이해하려면 이 물질의 전자 구조의 이해가 매우 중요하다. 마름모계 구조 (rhombohedral structure)의 Ca_3CoXO_6는 c축 방향으로 체인을 이루면서 CoO_6 삼각형 프리즘(trigonal prism)과 CoO_6 팔면체 (octahedron)가 서로 번갈아 자리한다 [1]. 체인들은 Ca 이온들에 의하여 떨어져 있는데, Co-Co (혹은 X-X) 간의 inter-chain 거리는 (약 5.2 A) Co-X 간의 intra-chain 거리 (약 2.6 A) 보다 훨씬 길어 일차원적인 자기적 특성을 가질 것으로 예상된다. 그러나 프리즘 위치와 팔면체 위치에 있는 Co 이온들의 원자가 상태와 스핀 배열 상태, Co 를 다른 원소로 치환시킬 때 치환된 원소들이 어떤 위치(site)로 치환되는지, 그리고 원소치환에 따른 Co 이온의 원자가 및 스핀 상태의 변화 등에 대해서는 아직 잘 이해가 되지 않은 현황이다. 이러한 의문점들을 이해하기 위하여 본 연구에서는 $Ca_3Co_{2-x}X_xO$ (X=Rh, Ir) 의 전자구조를 연구하였다. 방사광을 이용하여 주사 광전자 현미경(scanning photoelectron microscopy : SPEM), 연 x선 광흡수 분광법 (soft x-ray absorption spectroscopy: XAS) 과 연 x선 원형 자기 이색성 분광법 (soft x-ray magnetic circular dichroism : XMCD) 등의 실험을 수행함으로써 상분리 가능성 여부, Co이온의 원자가 상태와 스핀 상태, Co 이온 대신 Rh, Ir등의 4d 전이 금속 원소나 5d 전이 금속 원소가 치환되었을 때의 전자구조의 변화 등을 연구하였다.
[1] T. Burnus, et al., Phys. Rev. B. 74, 245111 (2006).

Dp-103 **Structural, transport, and magnetic propertiesof $Pr_{1-x}Ca_xCoO_3$ (0.45 x 0.6)** 우 영수, TONG Peng, 김 봉주, HASSEN Arafa, 김 성백[1], 이 성익[1], 정 상욱[2], 김 복기(*부산대학교 물리학과. [1]포항공대 물리학과. [2]Rutgers Uni. 물리학과.*) $Pr_{1-x}Ca_xCoO_3$ 시료에서의 전기적, 자기적, 구조적 특성에 관한 연구를 수행하였다. 시료는 고상반응법을 통해 합성되었고, High Pressure Oxygen Annealing 을 통한 후처리 과정으로 산소의 당량비를 3근처로 맞출 수 있었다. 이러한 시료에서의 전하정렬 상전이에 관한 실험을 수행하였는데, 전하정렬 상전이는 Ca의 양(x)이 0.5 이상일 때 관측이 되었다. 전하정렬 상전이는 약 80 K 에서 130 K 사이에서 관측이 되었다. 전하정렬 상전이부근에서의 온도에 따른 전기적, 자기적 특성을 측정하였으며, 구조적 특성에 관한 연구결과도 소개할 예정이다.

Dp-104 **Study of the anomalous magnetic field history dependent properties of $Sm_{1-x}Ca_xMnO_3$ ($0.8 \le x \le 0.92$)** 김 봉주, TIAN Qian, HASSEN Arafa, 우 영수, 이 성익[1], 정 상욱[2], 김 복기(*부산대학교 물리학과. [1]포항공대 물리학과. [2]Rutgers Uni. 물리학과.*) We have studied the structural, magnetic, and electrical properties of the electron-doped manganites $Sm_{1-x}Ca_xMnO_3$ ($0.80 \le x \le 0.92$). The samples have prepared by solid state reaction method. We carry out XRD rietveld refinement with various temperatures and have been applied to understand crystal structure, which correlate with the magnetic and electric properties. This series have two crystal phases at low temperature, which is monoclinic and orthorhombic. And the volume fractions of these two phases have temperature dependence. Magnetic susceptibility and electrical conductivity have been measured under various conditions. The samples showed the insulator-metal transition at low temperature, which is the result of percolative mixture between the long-range ordered antiferromagnetic phase and the short-range ordered ferromagnetic phase. Moreover, the competition between ferromagnetic and antiferromagnetic ordering occur the history dependent phenomena with cooling magnetic field.

Dp-105 **Vibration spectroscopy of proton-irradiated KH_2PO_4** LEE Cheol Eui, OH Byoung Hoo, LEE Jong Su(*고려대학교 물리학과.*) A proton-beam-irradiated ferroelectric KH_2PO_4 (KDP) crystal was studied by means of Raman spectroscopy. It is shown that proton irradiation gives rise to changes in the transverse-optic phono motions of the K-PO_4 translatory band and the stretching vibration of the PO_4 tetrahedra in the KDP crystal.

Dp-106 **Fringe Field Effect of Py Electrodes in Spin FET** SHIM Seong Hoon, LEE Yun-Hi, CHANG Joonyeon[1](*National Research Laboratory for Nano Device Physics, Department of Physics, Korea University, Seoul 136-713, Korea. [1]Center for Spintronics Research, Korea Institute of Science and Technology, Seoul 136-791, Korea.*) In the spin field effect transistor (FET) proposed by Datta and Das, spin transport along the channel and spin precession due to the spin-orbit coupling in an asymmetric potential play the major roles to modulate spin resistance. Polarized spins parallel to transport direction are assumed to be injected and detected by ferromagnetic source and drains. Unlike the spin-valve geometry where spin direction is normal to transport direction, the two ferromagnets (FMs) are parallel to the transport direction in the spin FET which may inevitably yield fringe field effect caused by the edges of FMs on top of channel. The fringe field at the edges causes local Hall effect on the carriers of the channel. Therefore, it is necessary to examine a possible role of the fringe field carefully in order to minimize side effects. In this work, we investigated the magnetization behavior of two FMs which will be used for spin source and drain in spin FET using magnetic force microscopy (MFM) upon sweeping external magnetic fields. The magnitude of stray field and saturation magnetization (M_S) of FM electrodes were evaluated by Hall measurement. Exchange coupling between two FMs was also studied with various gap sizes and compared with the result of simulation based on micromagnetic simulator.

Dp-107 **rf-스퍼터링 방법으로 성장된 Zn(Co, Ga)O 박막의 성장조건에 따른 결정성 및 물리적 특성 조사** 이 창민, 최 석철, 아스타나 사켓[1], 도 중희[1], 손 상호[1](*경북대학교 나노과학기술학과. [1]경북대학교 물리학과.*) ZnO는 대표적인 투명 전도성 산화물(Transparent Conducting Oxides:TCO)로서 기존의 투명 전극 재료를 대체하기 위한 많은 연구가 되어왔다. 또한 최근에는 3d 전이금속이 미량 첨가된 ZnO가 반도체성과 자기적 성질을 동시에 갖는 소위 자성반도체(Diluted Magnetic Semiconductor:DMS)로서의 기능성을 가짐으로 스핀전자공학(spintronics)에의 응용성 관련 연구도 많이 진행되고 있다. 본 연구에서는 rf-스퍼터링 방법으로 사파이어(Al_2O_3)와 유리 기판을 이용하여 성장 조건을 달리하여 Co와 Ga이 2-5%정도 미량으로 도핑된 Zn(Co, Ga)O 박막을 제작하였다. Al_2O_3기판 위에 성장된 Zn(Co, Ga)O 박막은 에피탁시 ZnO 박막이 성장되는 것과 같이 (00l)면에 대한 방향성 성장이 강하게 일어남을 알 수 있었다. 또한 유리 기판에 성장된 Zn(Co, Ga)O 박막은 다결정성 박막임에도 불구하고 (00l) 방향성 성장(oriented growth)이 강하게 일어남을 알 수 있었으며 실험 조건에 따른 전기적 전도성, 자기적 성질, 그리고 광학적 특성에 대하여 조사하였다.

Dp-108 **육각층상형 $LuFe_2O_4$의 A-site 및 B-site 도핑에 따른 결정구조 변화 분석 및 전하정렬과 자기전이의 상관성 연구** 정 진환, 정 진원, 노 한진, 김 성백[1](*전남대학교 물리학과. [1]포항공과대학교 물리학과.*) 육각 층상형 다강체 산화물인 $LuFe_2O_4$의 A-site인 Lu 대신에 일부를 Y, Er 등으로 치환하고, B-site Fe 자리의 일부를 Mn, Co 로 치환하여 이 물질의 결정구조가 어떻게 변화하는지 X-선 회절 실험과 중성자 회절 실험을 수행하여 분석하였다. 또한 도핑에 따라 이 물질의 전하정렬 온도와 자기전이 온도를 전기전도도 및 자화량을 측정하여 연구하였다. 이 두 온도는 결정구조의 뒤틀어짐에 상당히 밀접한 관련이 있고, 정렬되는 전하의 종류에도 민감함을 알 수 있었다. 이러한 결과들은 $LuFe_2O_4$의 강유전성의 원인이 전하정렬에 의한 것임을 확인시켜 주었고, 자기적 성질과 전기적 성질이 강하게 연관되어 있음을 의미한다.

Dp-109 **X-선 광전자 분광학 및 X-선 흡수 분광학을 이용한 $Lu(Fe,Mn,Co)_2O_4$의 전자구조 연구** 정 진원, 정 진환, 노 한진, 김 성백[1](*전남대학교 물리학과. [1]포항공과대학교 물리학과.*)

전하정렬을 통해 강유전성을 갖는 육각층상형 $LuFe_2O_4$의 B-site에 Fe 대신 Mn, Co 를 도핑하여 전하정렬 가능성을 의도적으로 깨뜨렸을때, 각 전이금속의 전자적 상태를 X-선 흡수 분광학 및 X-선 광전자 분광학을 사용하여 연구하였다. X-선 광전자 분광 스펙트럼은 뚜렷이 Fe의 두가지 상태를 보여주었고, 도핑에 따라 그 비율이 달라지는 경향을 보였다. 이것은 도핑이 전하정렬을 효과적으로 깨뜨린다고 해석되었고, 이 분광학적 결과와 전하정렬 및 자기전이 온도와의 상관성을 연구함으로써 이 물질의 강유전성의 근원을 종합적으로 이해하려고 시도하였다.

Dp-110 **Review of Density Functional Theory and Prospect for g-Factor Calculation in $Bi_xCa_{1-x}MnO_3$ and ZnO using DFT** 나(NA) 성호(Sung-Ho)(*부산대학교 물리학과/유전체물성연구소*) DFT(density functional theory), which has been successful in many diverse fields to find electron state in real complicated material, is reviewed. During the last decade DFT has been applied to calculation of ESR g-factor of condensed matters. And this approach could be similarly used for $Bi_xCa_{1-x}MnO_3$ - material having complicated magnetic character and/or for ZnO - important candidate for many technical uses.

Dp-111 **Single crystal investigation on Rb-Tl mixed crystal by neutron diffraction** OH In-Hwan, MATTAUCH Stefan[1], HEGER Gernot[2], LEE Cheol Eui[3](*Department of Physics, Korea Univeristy. [1]Forschungszentrum Juelich, Institut fuer Festkoerperforschung, Germany. [2]RWTH Aachen, Institut fuer Kristallographie, Germany. [3]Department of Physics, Korea University.*) The structure of Rb-Tl mixed crystal was investigated by neutron diffraction. The ionic radius of Rb and Tl are the same, however, they showed different crystal structures from each other. The mixed crystal showed a crystal structure similar to TDP. It may be very interesting to study this mixed system systematically. Accordidng to the NQR-study, this system shows no phase transition but for RDP and TDP both systems show phase transitions, for example, paraelectric - ferroelectric and paraelastic-ferroelastic, respectively. In this phase, the lone-pair electrons of Tl seem to play a very important role.

Dp-112 **$ErFe_2O_4$의 물리적 특성에 관한 연구** 김 재영, 이 보화, 김 철성[1](*한국외국어대학교, 물리학과. [1]국민대학교, 물리학과.*) 다결정 시료 $ErFe_2O_4$를 CO/CO_2 혼합가스 분위기 하에서 고체상태반응법으로 제작하여 자기적, 전기적 특성을 연구하였다. XRD 측정 결과, 상온에서 Hexagonal 구조를 갖는 단일상임을 확인하였다. VSM 을 이용한 온도에 따른 자화율 측정 결과, 238 K 와 249 K에서 2단계 상전이 현상을 관찰하였다. 238 K 에서는 구조적 변화에 의한 일차 상전이가 일어나며, 249 K 에서는 자기적 변화에 의한 2차 상전이가 일어났다. 4단자 전기 저항 측정에 의한 결과 상전이가 일어나는 온도 구간에서 급격한 저항의 변화를 확인하였다.

Dp-113 **Electron Spin Resonance of Dodecylamine-Iintercalated Vanadium Oxide Layered Structure Compounds** LEE Cheol Eui, KWEON Hyocheon, LEE Kyu Won[1](*Department of Physics , Korea University. [1]Department of Physics, Korea University.*) Dodecylamine-intercalated vanadium oxide layered structure compounds (C12VO), which are composed of organic and inorganic layers, were studied by means of electron spin resonance (ESR). According to the synthetic routes, there are two kinds of C12VO with same molar ratio of starting materials (V_2O_5 : dodecylamine = 2:1). One of them is made by V_2O_5 powder and dodecylamine (called "PC12VO"), which were added to distilled water and submitted to stirring for 24h in air. The other one is made by $V_2O_5 \cdot nH_2O$ and dodecylamine (called "SC12VO"), which were submitted to stirring for 24h. The amine molecules are hydrolyzed during the above process. The ESR spectra of both samples were composed of two Lorentzian lines. Judging from the results of ESR experiment, PC12VO seems to have more simple spin structure than that of SC12VO and undergo a ferromagnetic phase transition; the linewidth rapidly increases and the resonance field drastically decrease with decreasing temperature below 270 K, indicating a ferromagnetic transition around 270 K. On the other hands, SC12VO has more V^{4+} ions and seems to have more complicated spin structure than that of PC12VO. The linewidth increases with increasing temperature above 330K in PC12VO and those in SC12VO decreases in the whole temperature, which can be attributed to hopping of holes and motional narrowing.

Dp-114 **Monte Carlo Study of the Classical Heisenberg Model with Staggered Single Ion Anisotropy and Antisymmetric Exchange Interaction** LEE Cheol Eui, LEE Kyu Won(*Department of Physics, Korea University.*) We have studied the antiferromagnetic Heisenberg model with staggered single ion anisotropy and antisymmetric exchange interaction by using a Monte Carlo simulation. By varying the single ion anisotropy or the antisymmetric exchange interaction, magnetic hysteresis loops in their ground-states as well as temperature dependent magnetization were calculated. As a result, a variety of magnetic phases were observed including canted antiferromagnetism and spin reorientation.

Dp-115 **First-Principle Study of Atomic and Electronic Structures of MnAs** KIM Kyoung Yeon, CHOI Hyoung Joon(*Department of Physics and IPAP, Yonsei University.*) We studied atomic and electronic structures of MnAs by a first-principles pseudopotential method. We used the local spin density approximation to the density functional theory and used pseudo-atomic orbitals to expand the electronic wavefunctions. We considered both the NiAs structure and the zinc-blende structure. Our result shows that MnAs is ferromagnetic in both structures and that it is half-metallic in the zinc-blende structure. Computational resource for this work is provided by KISTI under the 10th Strategic Supercomputing Support Program.

Dp-116 **A Change of Ferromagnetism in Co Doped ZnO Dilutie Magnetic Semiconductor** KIM Sung-Jin, CHO Yong Chan, LEE Seunghun[1], CHO Chae-Ryong, JEONG Se-Young (*Department of Nano Fusion Technology, College of Nanoscience and Nanotechnology, Pusan National University, Miryang, 627-706, Korea.*

[1]*School of Nano-Science and Technology, Pusan National University, Miryang, 627-706, Korea.*) Ⅱ-Ⅵ semiconductor has drawn much attention to spintronic applications because recent theoretical studies have predicted room-temperature ferromagnetism in transition metal doped ZnO. Theoretical predictions have suggested the possibility of room-temperature ferromagnetism in Ⅱ-Ⅵ based DMS materials. V. Cr, Fe, Ni doped ZnO is half-metallic double-exchange ferromagnet, Mn doped ZnO is an antiferromagnetic insulator which can be changes to ferromagnet by additional doping of holes, whereas Ti or Cu doped ZnO remains paramagnetic. It was also shown that electron doping stabilizes the ferromagnetic ordering of Fe, Co, or Ni doped ZnO[2]. We investigated $Zn_{1-x}Co_xO$ (x=0, 0.05, 0.1, 0.2) dilutie magnetic semiconductor films on Al_2O_3 (0001) substrate by RF magnetron system. Magnetic circular dichroism (MCD) spectroscopy provides a sensitive tool for exploring the magnetic and electronic structural properties of DMSs[1]. With magnetic circular dichroism(MCD) experiment, the change of ferromagnetic properties was investigated by Co ions and hydrogen doping level. The XRD showed that the doping concentration does not change the c-axis wurtzite structure of ZnO, and we could not find any Co cluster phase. Optical transmission specta showed characteristic absorption edges around 568, 615, and 660nm wavelength. These localized absorption bands were attributed to d-d transitions of tetrahedrally coordinated Co^{2+}. These indicated that the Co ions substituted the Zn^{2+} ions. And we also investigated the hydrogen effect of ZnCoO films with changing hydrogen concentration[3-4].

[1] Hyeon-Jun Lee and Se-Young Jeong et al., Appl. Phys. Lett. 81, 4020 (2002). [2] Shinji Kuroda et al., Nature Mater. 6, 440-446 (2007). [3] C. H. Park and D. J. Chadi, Phys. Rev. Lett. 94 127204 (2005). [4] H. -J. Lee and S. –Y Jeong et. al., Appl. Phys. Lett . 88 062504 (2006).

Dp-117 **Theoretical study of the spin-charge coupling in the mixed-valence system $LuFe_2O_4$** KIM Mi Kyung, MOON Kyungsun(*연세대학교 물리학과.*) The mixed-valence system $LuFe_2O_4$ has both the ferroelectric and the magnetic property below a certain temperature. The magnetic transition occurs at around 250K from the 2D-antiferromagnetic to the disordered phase.[1)] For the ferroelectric property, this material has a sequential charge transition upon increasing the temperature: 3D-CDW→2D-CDW→ Disorder.[2)] The system exhibits a ferroelectricity up to near 330K, at which the phase transition occurs from the 3D-CDW to the 2D-CDW. At around 500K, the 2D-CDW order disappears and becomes disordered. Experiments have demonstrated that the spontaneous electric polarization shows two-step transitions. The additional transition occurs at around 250K between the two ferroelectric states with different permanent electric polarizations.[3)] We presume that this transition is due to the coupling between the charge and spin order. In this work, we will theoretically examine the spin-charge coupling and the multiferroicity.

1) J. Iida, M. Tanaka, Y. Nakagawa, S. Funahashi, N. Kimizuka, and S. Takekawa, J. Phys. Soc. Jpn. 62, 1723 (1993) 2) Y. Yamada, K. Kitsuda, S. Nohdo, and N. Ikeda, Phys. Rev. B, 62, 12167 (2000) 3) N. Ikeda, H. Osumi, K. Ohwada, K. Ishii, T. Inami, Y. Murakami, K. Kakurai, K. Yoshii, M. Mori, Y. Horibe, and H. Kito, Nature(London) 436, 1136 (2005)

Dp-118 **Effects of the spin-orbit interaction on the crystalline structures of p-bonded heavy elements** KIM Kyoo, SHIM JH[1], KWON SK, MIN BI(*POSTECH. [1]Department of Physics, Rutgers University.*) From a model calculation based upon the tight-binding results, it has been known that Peierls induced distorted structures are favoured in soft potential p-boned systems. However, first principle band calculation incorporating the spin-orbit (SO) interaction shows that polonium (Po, Z=84), a typical p-bonded system, crystallizes in simple cubic structure rather than a helix-type Te structure. To examine effects of the SO interaction on p-bonded crystal structures, we have extended the first principle full-potential augmented plane wave (FLAPW) band calculations to Bi (Z=83) and At (Z=85), where the SO interactions are as large as in Po. Fermi surfaces and susceptibility results suggest that the SO interaction tends to reduce Peierls transition strength in p-bonded heavy elements. However, we found that, even with the large SO interaction, Bi and At favor Peierls-like distorted structures in contrast to Po.

Dp-119 **^{11}B NMR study of antiferromagnetic anisotropy on GdB_4.** 남 승관, 강 기혁, 한 기성, 민 병진, 권 세근, 최 성훈, 최 헌화, 김 성훈, 권 달중, 성 시진, 이 무희, 조 병기[1](*건국대학교 물리학과. [1]광주과학기술원.*) The nuclear magnetic resonance of ^{11}B has been observed in the single crystal of GdB_4. The possibility of seeing from general tetraborides compounds, the single crystal of GdB_4 is space group p4/mbm of tetragonal structure. It has an anisotropy from below T_N against c-axis. The measurements were performed in the temperature range T = 5 ~ 300 K. Each it measured the ^{11}B NMR spectrum, spin-lattice relaxation time, spin-spin relaxation time from the condition which the magnetic field and c-axis are parallel or perpendicular. The ^{11}B NMR spectrum it leads, shift and linewidth are strongly temperature-dependent due to the 4f moments. In addition, both are proportional to the magnetic susceptibility, indicating that the hyperfine field at the boron site originate from the 4f spins of Gd. Below T_N, the single broad resonance peak of ^{11}B NMR splits into several peaks reflecting the local magnetic fields due to antiferromagnetic spin arrangements. The spin-lattice and spin-spin relaxation rate, independent of temperature above T_N, decrease significantly below T_N confirmig the suppression of spin fluctuation.

Dp-120 **자구벽 메모리 소자 진단을 위한 자구벽-추적 광학계의 개발** 김 갑진, 이 장원[1], 조 영진[1], 서 순애[1], 최 석봉(*서울대학교 물리천문학부. [1]삼성종합기술연구원.*) 기존 메모리 기술의 한계를 극복할 수 있는 대안으로 자구벽 나노선 소자가 각광받고 있다. 이러한 나노선 소자에서 발생하는 빠른 자성현상을 이해하기 위해서는 자기분해능과 높은 시간분해능을 갖춘 장비의 개발이 필요하다. 이에 본 연구에서는 광학 현미경, 3차원 자력계, 나노초 레이저 기술을 접목하여 자구벽-추적 광학계를 개발하였

다. 자구벽-추적 광학계는, 약 500 nm의 공간분해능, 수 ns의 시간분해능으로 3차원 자화 벡터를 측정할 수 있는 기능을 제공한다. 이러한 자구벽-추적 광학계를 이용하여, 100-800 nm 선폭의 자구벽 소자의 국소 자기이력곡선 특성을 측정하였다. 이때, 자구벽 소자는 수평자기이방성을 보이는 NiFe 소자와 수직자기이방성을 보이는 CoFe/Pt 다층박막 소자를 사용하였다. 또한 추가적인 레이저를 삽입하여 열자기 기록에 의한 자구를 생성시킴으로서 수직자기이방성을 가진 시료의 자구벽 형성이 가능함을 확인하였다.

Dp-121 **Thermoelectric power in the magnetic polaron system** 김 범현, 유 운종, 김 규, 민 병일(*포항공과대학교 물리학과.*) The magnetic polaron, which is formed as a ferromagnetic (FM) cluster in the paramagnetic (PM) or antiferromagnetic (AF) background, has attracted renewed attention in relation to the colossal magnetoresistance (CMR) and the spintronic materials research. The magnetic and electric phenomena of some magnetic systems which experience the ferromagnetic and insulator-metal transitions with CMR effect near the transition temperature TC are well described by the magnetic polaron concept.In this study, the thermoelectric power in the magnetic polaron system has been investigated. Using the Monte-Carlo method combined with the exact diagonalization and the linear response theory, we have studied the temperature and external magnetic field dependence of the thermoelectric power S for the magnetic polaron system. We have considered a two-dimensional system with local Ising spin and the itinerant carriers. In the high temperature limit, S follows the Heikes formula. In the finite temperature region, S shows different behavior because of the Hund coupling between itinerant carriers and local spins. Also, S exhibits the magnetothermoelectric effect near T_C.

Dp-122 **L자 모양 NiFe 나노선의 자기저항 측정** 문 경웅, 조 영진[1], 김 광석[1], 이 장원[1], 서 순애[1], 최 석봉(*서울대학교 물리·천문학부. [1]삼성종합기술원.*) 자구벽 메모리 소자의 자기적 특성을 측정하였다. 자구벽 메모리 소자의 기본 구조로서 두께 20nm, 폭 300~500nm의 NiFe 나노선을 L자 형태로 제작하였다. 이 나노선 소자에 외부 자기장을 여러 각도로 인가하면서 자화 상태를 비등방성-자기저항(AMR) 측정을 통하여 분석하였다. 외부 자기장을 서서히 증가시켜 자화역전의 임계값에 다다르면, 자화역전 현상에 의해 전기저항 값이 순간적으로 바뀐다. 이 자기장을 반전 자기장(switching field) H_c로 표기하였다. 반전 자기장보다 수 Oe 적은 자기장 하에서 전류를 주입하여, 전류 주입에 의한 자화역전 현상이 발생함을 확인하였다. 이 때, 필요한 임계전류 I_c를 외부자기장의 함수로 측정하였고, 또한 외부 자기장의 인가 각도에 따른 경향성을 측정하였다. 이를 통하여, L자 형태의 NiFe나노선의 자화역전이 외부 조건에 따라, 1) 자구벽 이동과 2) 결맞은 회전을 통해 이루어짐을 확인하였다.

Dp-123 **Numerical analysis of temperature of nano wire system with insulating layer for current induced domain wall motion** 하 승석, 유 천열(*인하대학교 물리학과.*) 현재, 도메인이 나뉘어져 있는 나노미터 크기의 도선에 전류를 흘려주어 도메인을 이동시킬 수 있는 current induced domain wall motion (CIDWM) 현상을 응용하여 물리적인 구동 장치가 없고 하드디스크의 단점을 보완할 수 있는 메모리 소자를 만들기 위해 많은 연구가 진행되고 있다. 이 새로운 메모리 소자를 race-track memory[1] 라고 하며, 현재까지 CIDWM 현상에 요구되는 전류밀도는 $10^{12}A/m^2$ 정도로 매우 크다는 단점이 있다. 이렇게 큰 전류 밀도는 소자에 높은 줄 열을 발생시킨다. 나노 와이어에 발생되는 줄 열은 나노 와이어의 기하학적 크기와 전류밀도의 양에 의존하며, 나노 와이어에서 발생된 열이 빠져나가는 경향은 기판과 절연체의 열적 특성과 두께와 매우 밀접한 관계가 있다. 이는 해석적, 수치해석적 선행연구를 통해 구체적으로 알아내었다. 이번 연구는 절연체가 있는 나노 와이어 시스템의 온도 분포를 구한 선행 연구 결과[2]를 유한요소법을 통해 수치해석적으로 구한 결과를 비교함으로써 선행된 해석적인 결과의 정확성을 보완하고, 이를 토대로 나노 와이어 시스템의 열 특성을 다양한 범위에서 분석해 보았고, 실제 실험에 있어 높은 발열 문제 해결에 도움을 주고자 하였다.
[1] S. S. P. Parkin, U. S. patent 6834005 (2003). [2] C.-Y. You and Seung-Seok Ha, Appl. Phys. Lett. **91**, 022507 (2007).

Dp-124 **^{175}Lu NMR investigation of $LuAl_2$** KANG Kihyeok, MEAN B. J., HAN K. S., KWON S. K., NAM S. K., CHOI S. H., CHOI H. H., KIM S. H., KWON D. J., SUNG S. J., LEE Moohee, CHO B. K.[1](*Konkuk university, Dept of Physics. [1]GIST, Department of Materials Science and Engineering.*) ^{175}Lu NMR measurements have been performed to investigate the local electronic structure of rare earth-aluminum intermetallic compound $LuAl_2$. The magnetic susceptibility is almost temperature-independent, which indicates a Pauli susceptibility for non-magnetic metals. Spectrum, Knight shift, spin-lattice relaxation time T_1, and the spin-spin relaxation time T_2 are measured as a function of temperature at 8.0, 7.0 and 4.7 T. ^{175}Lu NMR spectrum shows an extremely broad shape due to the quadrupolar broadening of the nuclear spin I=7/2 for the power sample of $LuAl_2$. The spin-lattice relaxation rate $1/T_1$ is proportional to temperature confirming the Korringa behavior as for nonmagnetic metals. The Korringa product is measured to be T_1T= 0.67 sec.K with the Korringa ratio of ξ =0.027. The spin-spin relaxation time T_2 becomes very short at high temperature due to the life-time broadening of spin-lattice relaxation time T_1. Second moment and EFG Tensor will be discussed in this poster.

Dp-125 **Terrace and Step Evolutions on Vicinal $SrTiO_3$(0 0 1) Surfaces.** 조 진형, 장 윤형, 민 성식, 김 철환, 문 학범(*부산대학교 유전체물성연구소.*) $SrTiO_3$ crystal, which has a simple cubic perovskite structure and consists of alternating stacks of TiO_2 and SrO atomic layers, has been widely used as a substrate for epitaxial growth of thin films, such as high-temperature superconductors, ferroelectric, ferromagnetic materials, and colossal magnetoresistive oxides. Furthermore, TiO_2 termination has been an important factor to have good interfaces between overcoated thin films. In this aspect, it is important to understand the evolution of terrace formation of $SrTiO_3$ prior to film growth.To study the evolution of terrace formation, $SrTiO_3$(0 0 1) substrate were etched for 2 min with BHF for chemical treatment, subsequently, the samples were neutralized with 30 % NH_4OH solution and rinsed with DI water.

Then, the samples were placed into the home-built rapid thermal annealer (RTA), and heated under O_2 condition. The samples were annealed at 1000 °C for 1 - 10 min in order to create a terrace-and-step structure on the surface, and the surface of the samples was investigated by atomic force microscopy (AFM). In consequence, the atomically flat TiO_2 substrate, with a step height of a unit cell and a terrace width of several hundred nanometers was successfully obtained. We will report the details of the evolution of terrace and step formation with respect to annealing time and annealing temperature.

Dp-126 **Ti-getter가 $Ti_{0.96}Co_{0.02}Fe_{0.02}O_2$ 의 자기적 특성에 미치는 영향** 김 성진, 이 상률, 백 종근, 김 응찬(*영남대학교, 물리학과.*) Solid State Reaction법으로 $Ti_{0.96}Co_{0.02}Fe_{0.02}O_2$ 시료를 제조하였다. 각각의 시료를 870℃, 900℃, 930℃로 24시간 열처리 하였다. 이 때 Ti-getter의 유무를 통해 각각의 온도에서 Ti-getter에 따라 시료의 특성이 어떻게 변화하는지 관찰하고자 한다. 제작된 시료의 구조분석을 위해 시료의 분말 회절실험을 실시하였다. VSM을 이용하여 시료의 자성을 측정하고, 금속이온의 형태와 시료 내에서 cluster로 존재하는지 여부를 조사하기 위해 TEM과 SEM, EDS실험을 하였다. XRD pattern 분석결과, 결정구조는 tetragonal구조로써, 순수한 Rutil-TiO_2상이 주를 이루며, 2차상으로는 getter가 없을 때는 Fe_2TiO_5, 있을 때는 Fe가 관측되었다. 시료의 자성을 측정한 결과, getter가 없을 때는 870℃일 때 자화값은 약 0.025μB/CoFe 정도로 강자성을 보이지만, 900℃와 930℃에서는 강자성을 보이지 않는다. Ti-getter가 있을 때의 자화값은 870℃에서는 약 1.1μB/CoFe, 900℃와 930℃일 때는 1.5μB/CoFe정도로 강자성을 보인다. 이러한 자성의 차이는 Ti-getter의 유무에 따른 2차상의 차이로 결정되어진 것으로 보인다. Titanium이 고온에서 산소와 질소, 공기 속의 수분과 쉽게 결합하는 성질을 가지고 있기 때문에 이것을 이용하면 좀 더 낮은 산소분압을 얻을 수 있다. 시료의 산소분압에 따라 자화값이나 원자 구조의 변화에 상당한 영향을 받게 되어 시료의 특성이 다르게 나타나는 것을 확인 할 수 있다. TEM과 SEM, EDS실험결과에서는 Co와 Fe가 골고루 분포하는 영역이 있는가 하면 Ti만 관측되는 부분도 존재했다. 시료의 Co와 Fe가 시료전체에 골고루 퍼져있는 것이 아니라 부분적으로 분포하고 있음을 확인 할 수 있다.

Dp-127 **Olivine-$LiFePO_4$의 결정학적 및 Fe이온의 초미세 상호 작용 연구** 김 철성, 문 승제[1], 심 인보[1](*국민대학교 물리학과. [1]국민대학교.*) Olivine 구조를 가지는 $LiFePO_4$ 는 리튬 2차전지의 양극 활물질로써 $LiCoO_2$보다 전기 화학적 특성이 우수하고, 친환경적이며 경제적이어서 실용화 가능성이 매우 높다. 본 연구에서는 Olivine-$LiFePO_4$를 직접합성법으로 제조하여 x-선 회절기(XRD), 진동 시료 자화율 측정기(VSM), Mössbasuer 분광기를 이용하여 시료의 결정학적 및 자기적 특성을 연구 하였다. X-선 회절도 분석 결과, olivine 구조이면서 p n m a 공간 그룹을 가지며, 이때의 격자 상수는 각각 a_0 = 10.329 Å, b_0 = 6.006 Å, c_0 = 4.698 Å 로 결정되었다. VSM, Mössbasuer 스펙트럼 분석결과 자기 상전이 온도를 확인 할 수 있었다. 상온에서의 이성질체 이동 값은 1.10 mm/s로 철의 이온 상태가 Fe^{+2}로 결정되었다. 또한 전기 사중극자 분열치는 2.96 mm/s로 큰 값을 가지는데, 그 이유는 x-선 회절 실험 분석결과 큰 이온 결합길이를 가짐으로써 철이온의 비대칭성이 증가하여 2중극자 상호작용이 사라지기 때문인 것으로 설명할 수 있다.

Dp-128 **열처리에 따른 $0.7FeTiO_3$-$0.3Fe_2O_3$ 고용체의 자화특성과 뫼스바우어 분광 연구** 김 우철, 배 성환, 김 철성(*국민대학교, 물리학과.*) 자성반도체 특성을 보이는 $0.7FeTiO_3$-$0.3Fe_2O_3$ 고용체를 직접합성법으로 열처리 방법을 달리하여 제조하였다. 시료의 결정학적 및 자기적 특성을 x-선회절, 뫼스바우어 분광, 진동시료 자력계를 이용하여 연구하였다. X-선 회절분석 결과 시료는 rhombohedral 구조를 가지며 격자상수는 서냉 열처리 시료의 경우 a = 5.081 Å와 c = 13.994 Å, 급냉 열처리 시료의 경우 a = 5.079 Å와 c = 13.997 Å인 값을 나타냈다. 4.5 K부터 400까지의 뫼스바우어 분광 실험결과 비정상적인 스펙트럼이 관측되었으며 스펙트럼은 corundum 구조의 A 와 B 부격자 내의 Fe^{3+}와 Fe^{2+}가 차지하는 세개의 자기적 성분으로 분석되었으며 4.5 K에서 초미세 자기장값은 서냉시료의 경우 H_{hf} = 512, 480 와 309 kOe 인 값을 가지며 급냉시료의 경우 H_{hf} = 511, 478와 304 kOe인 값을 나타냈다. 온도증가에 따라 완화현상에 의한 선폭의 증가가 관측되었으며 스펙트럼의 강도는 보통 분말에서 보이는 3:2:1:1:2:3 와는 다른 비대칭적인 강도를 나타냈다. 이로부터 철원자내 초미세 자기장은 입사 감마선에 대해 특정한 방향을 선호하고 있음을 알수 있었다. Néel 온도는 서냉시료의 경우 T_N = 380 K, 급냉시료의 경우는 T_N = 400 K를 나타내었다. 자기적 특성 실험결과, 외부자기장에 따른 자화(M-H)측정은 상온에서 강자성의 자기이력곡선을 보여주었으며 서냉시료의 경우 잔류자화값은 M_R = 1.1 emu/g, 보자력은 H_c = 31 Oe를 가지며 급냉시료의 경우 잔류자화, 보자력은 M_R = 5.8 emu/g, H_c = 219 Oe를 각각 나타냈다. Zero-field-cooling (ZFC)과 field-cooling (FC) 조건에서 취해진 온도에 따른 자화측정에서 두 상태 자화 사이에 큰 불가역성을 보여주었으며 서냉시료의 경우 reentrant spin-glass와 유사한 자기적 특성을 보여주었다.

Dp-129 **$FeGa_2S_4$의 Mössbauer 분광학 연구** 김 철성, 김 삼진, 명 보라(*국민대학교, 물리학과.*) 직접합성법으로 제조된 $FeGa_2S_4$ 시료를 X-회절기(XRD), Mössbauer 분광실험을 통하여 시료의 결정학적 및 자기적 성질을 연구하였다. 각각의 시약은 Fe, Ga, S 분말을 정확한 당량비로 석영관 바닥에 놓고 10^{-6} torr 진공으로 봉입하였고, 1000 ℃로 10일 동안 열처리 하였다. Rietveld 법을 이용하여 X-선 회절도로 분석한 결과 결정구조는 trigonal 구조로써, 격자 상수는 a =3.669 Å, c =12.096 Å이며, octahedral site에는 FeS_6, tetrahedral site에는 GaS_4가 차례로 C 축 방향으로 정렬되어 있다. 온도에 따른 Mössbauer 분광실험을 통하여 Néel 온도(T_N)는 33 K 로 결정되었다. 극저온에서는 전기사중극자 상호작용과 자기이중극자 상호작용에 의하여 비대칭적인 8-형태가 나타났으며, 상온에서의 이성질체 이동값(δ)이 0.74 mm/s으로 Fe의 이온상태가 +2가임을 알 수 있었다.

Dp-130 **Mössbauer 분광법을 이용한 다강체 물질인 $TbMn_{1.99}Fe_{0.01}O_5$ 의 미세자기 구조 연구** 김 철성, 김 동현(*국민대학교, 물리학과.*) 자기적 정렬에 의한 다강체 물질중 하나인 $TbMn_2O_5$물질에서 Mn의 거동을 알아보기 위하여 철을 미량 치환한 $TbMn_{1.99}Fe_{0.01}O_5$를 sol-gel 법으로 합성 후 x-ray diffraction (XRD), vibrating sample diffraction(VSM), Mössbauer 분광법을 이용하여 결정학적 특성 및 자기적 특성을 연구하였다. Rietvelt법을

이용하여 x-선 회절도를 분석한 결과 결정구조는 사면체 자리(A-site)와 팔면체 자리(B-site)에 Mn 이온이 치환된 orthorhombic 구조로 분석되었고 격자상수가 a_0=7.335 Å, b_0=8.524 Å, c_0=5.681 Å 임을 확인하였다. VSM을 이용한 $TbMn_{1.99}Fe_{0.01}O_5$의 M-T curve의 형태는 4f 궤도 모멘트의 기여에 따른 변화를 보임을 알 수 있었다. 극저온인 4.2 K에서 Mössbauer 스펙트럼은 6개의 공명흡수선이 2 set로 존재하였고 각각의 전기 사중극자 분열치 값은 0.35, -0.09 mm/s로 분석되었다. 특히 사면체 자리와 팔면체 자리에 의한 전기 사중극자 분열치 값이 큰 차이를 보이는 것으로 보아 $TbMn_{1.99}Fe_{0.01}O_5$ 에서의 비 대칭적인 격자 구조와 자기 구조에 의한 다강체 성질의 발현임을 확인 할 수 있었다.

Dp-131 **Magnetoresistance and Planar Hall Effect of GaMnAs** SUH Jooyoung, KIM Eun Kyu, CHUN Seung-Hyun[1], CHANG Joonyeon[2](*Quantum-Function Spinics Lab. &Department of Physics, Hanyang University. [1]Department of Physics, Sejong University. [2]Center for Spintronics Research, Korea Institute of Science and Technology.*) GaMnAs films have attracted much attention since they have magnetic and semiconducting properties simultaneously, which makes it possible to combine complementary properties of semiconductor quantum structures and ferromagnetic systems in single devices. Much effort has focused on understanding magnetic properties of GaMnAs especially anisotropic magnetization by investigating magnetotransport measurement as well as magnetic domain observations. In general magnetic anisotropy of GaMnAs is affected by Mn concentration, hole density, applied strain and temperature. Giant planar Hall effect manifested in GaMnAs is known to helpful to understand the magnetization switching of GaMnAs largely depending on the anisotropic magnetization. In the work, magnetoresistance (MR) and planar Hall effects under various orientation of applied magnetic field were investigated intensively for the understanding of anisotropic magnetization of fabricated GaMnAs film. We have fabricated Hall bar in which current flows along [-110].

Dp-132 **The Spin Structure of Haematite at Low Temperature** LEE Seong-Joo, JUNG Hyunok, LEE Soonchil (*Department of Physics, Korea Advanced Institute of Science and Technology.*) We investigate the magnetic properties of natural Haematite(α-Fe_2O_3) crystal at 4.2 K using SQUID and ^{57}Fe nuclear magnetic resonance (NMR). Haematite is an antiferromagnet of the corundum structure. Above Morin temperature (~260 K), the spins of Haematite are aligned in the (111) plane with a small canting angle, and aligned in the [111] direction below Morin temperature. The M-T curve shows that the net magnetization in the (111) plane is increased again as temperature decreases below 30 K. The M-H curve shows that the hysteresis exists in the (111) plane at low temperature. We obtain the NMR spectra in external magnetic field of up to 7.02 T at 4.2 K. The result showed that the spins rotate in the direction perpendicular to that of the external field. Comparison of the M-H curve and the field dependence of NMR resonance frequency suggests that the antiferromagnetic state and the weak-ferromagnetic state coexist at low temperature.

Dp-133 **The investigation on YbB_4 single crystal with ^{11}B NMR spectroscopy** 민 병진, 조 용래, 강 기혁, 한 기성, 김 성훈, 권 세근, 남 승관, 최 성훈, 최 헌화, 권 달중, 성 시진, 이 무희, 조 병기[1], 김 주영[1](*건국대학교,물리학과. [1]GIST,신소재공학과.*) ^{11}B nuclear magnetic resonance (NMR) measurements on the YbB_4 single crystal have been performed to investigate the local electronic spin structure and dynamics. The ^{11}B spectrum and shift spin-lattice and spin-lattice relaxation rate were measured down to 20 K at 8 T. The satellite transition ($I = \pm 3/2 \longleftrightarrow \pm 1/2$) were separated from the central transition ($I = +1/2 \longleftrightarrow -1/2$) with the result of the two relaxation rates and simple numerical calculations. The temperature dependence of the line width nicely corresponds to the susceptibility result. The reason of the slightly unusual figure shown in the spin-spin relaxation rate could be found with more studies.

Dp-134 **Electronic structures and magnetic properties of spinel $FeCr_2S_4$ and $FeCr_2Se_4$** BAIK Seung Su, CHOI Hong Chul, KWON Se Kyun, MIN Byung Il(*Postech.*) $FeCr_2S_4$ is a ferrimagnet with T_C=172K, whereas $FeCr_2Se_4$ is an antiferromagnet with T_N=218K. At low temperature, $FeCr_2Se_4$ becomes ferrimagnetic. To explore the similarities and differences between $FeCr_2S_4$ and $FeCr_2Se_4$, electronic structures and magnetic properties of spinel $FeCr_2S_4$ and $FeCr_2Se_4$ are studied by using the FLAPW (full-potential linearized augmented plane wave) band method. Temperature dependent half metallic and insulating properties of $FeCr_2S_4$ are discussed as compared to the insulating $FeCr_2Se_4$. The orbital ordering of Fe and Cr 3d-orbitals and the Jahn-Teller distortion in these compounds are also discussed.

Dp-135 **Soft x-ray spectroscopy investigation of rare-earth orthoferrite $TbFeO_3$** PARK Jae-Hoon, PARK Byeong-Gyu, KIM S. -B., LEE J. -S, JANG H., KO K. -T., KIM J. -Y[1](*POSTECH, Department of Physics. [1]Pohang Accelerator Laboratory.*) The rare-earth orthoferrite has been known as the canted-antiferromagnetic system with high Neel temperature(>600K). The small net ferromagnetic monents is due to the canting of spins. The direction of net ferromagnetic moments is the c-direction of crystal. The $TbFeO_3$ single crystal was grown by using the flux method. The soft x-ray spectroscopy experiments for Terbium orthoferrite are performed at 2A B/L at PLS(Pohang Light Source). The x-ray magntic circular dichroism signal was measured with applied H-field along each crystal-axis direction, such as a-, b-, c-axis at Tb $M_{4,5}$-edge and Fe $L_{2,3}$-edge. The XMCD signal can be measured along only c-axis. It is consistence with the previously reported results about magnetic anisotropy. Although the intensity of XMCD signal is very weak, that of Tb $M_{4,5}$-edge can be measured at room temperature. It implies that the magnetic moment of Tb ion is alive at room temperature. And, the XMCD spectra at Fe L-edge and Tb M-edge show that they have the same sign. Thus, we decide that the directions of net ferromagnetic moments of Fe ion and Tb ion are same direction.

Dp-136 **제일원리계산에 의한 Mn이 델타 도핑된 GaSb**

계의 Mn의 위치에 따른 전자구조와 자성에 관한 연구 권 오룡, 윤 원석, 홍 순철(*울산대학교, 물리학과.*) 묽은 자성반도체(DMS)는 일반적으로 Ⅲ-Ⅴ과 Ⅱ-Ⅵ 반도체에 자성 원소의 도핑에 의해 만들어 진다. 그러나 현재까지 만들어진 DMS는 스핀분극 전류 문제가 있고, 큐리온도가 비교적 낮기 때문에 이 문제를 해결한 DMS를 실현하기까지는 아직도 많은 연구가 요구되고 있다. 이러한 문제를 해결하기 위한 방안의 하나로 자성물질을 반도체에 델타 도핑하는 방법이 제안되었다. 본 연구에서는 반도체인 GaSb에 자성 원소인 Mn을 델타 도핑한 계에 대해 제일원리계산을 수행하였다. 여기에 Ga:Mn의 비가 (7:1)인 원자구조에서 Mn이 Ga 자리를 치환한다고 가정하였고, Mn이 도핑된 위치가 전자구조와 자성에 미치는 영향을 알아보기 위하여 GaSb에 도핑된 Mn의 위치를 첫 번째 층에 모두 치환된 것과 Ga 두 번째 층에 Mn원자 하나를 치환한 것에 대한 연구결과를 비교하였다. Vienna Ab-initio Simulation Package (VASP)를 사용하여 원자 구조를 결정하였고 최종적인 자성에 대한 연구는 교환상관전위에 대해 Generized Gradient Approximation (GGA)를 도입한 full-potential linearized augmented plane wave (FLAPW) 방법을 이용하였다. 이 구조에서 가장 안정된 자성구조를 찾기 위하여 상자성(PM), 강자성(FM), 반강자성(AFM)에 대해 계산을 수행하였으며, Mn이 치환된 층과 관계없이 FM 상태가 가장 안정한 것으로 조사 되었다.

Dp-137 **Ni-Cu ferrite 의 초미세 상호작용 연구** 김 철성, 현 성욱, 최 한나(*국민대학교, 물리학과.*) 최근 전자기파 흡수체로서 많은 주목을 받고 있는 Nickel-Copper ferrite를 Sol-gel법으로 제조하여 그 물리적 특성을 알아보고자 하였다. X-선 회절기(XRD)와 진동시료형 자화율 측정기(VSM)를 이용하여 결정학적 및 거시적인 자기적 특성을 분석하였고, 뫼스바우어 분광 실험을 통하여 $Ni_{0.5}Cu_{0.5}Fe_2O_4$ 물질의 초미세 상호작용에 대한 연구를 수행하였다. X-선 회절실험의 정량적인 정련 분석(Rietveld refinement)을 수행한 결과, a_0=8.35 Å의 격자상수를 가지는 cubic spinel 구조로써 그 공간군이 Fd3m 임을 확인하였다. VSM 측정을 통하여 거시적 자기 특성을 측정한 결과, M_s = 36.67 emu/g, Hc= 54.75 Oe 임을 알 수 있었다. 4.2 ~ 700 K 에서 온도에 따른 뫼스바우어 분광 실험을 수행하였고, Copper가 0.5 치환된 시료의 경우 상온에서 이성질체 이동 값(δ)이 0.26 mm/s 으로 Fe의 이온상태는 +3가 임을 확인 할 수 있었다. 또한, 상온에서 6개의 공명흡수선이 2 set로 존재하고 초미세 자기장 값(H_{hf})이 A-site 의 경우 519 kOe, B-site의 경우 486 kOe로 분석되었다. 이러한 차이는 부격자 사이의 Fe-O-Fe 상호 교환 작용이 두 개의 공간 격자군에서 다르게 작용함을 알 수가 있었다.

Dp-138 **Fist-Principles Calculations on Electronic Structure and Magnetism of fcc Fe (001) Surface** YUN Won Seok, LEE Dongkook, CHA Gi-Beom, HONG Soon Cheol(*University of Ulsan, Department of Physics.*) Magnetic thin films exhibit significantly different magnetic properties from their bulks, such as magnetic crystalline anisotropy, enhanced magnetic moment, and critical behavior. These differences are caused by the increasing influence of the reduced dimensionality with decreasing film thickness and by the strain induced by the epitaxial constraint at the interface. In the bulk, bcc Fe is a ferromagnetic (FM) ground state and metastable fcc-like Fe can exist in various magnetic states of paramagnetic (PM), antiferromangetic (AFM), FM, and spin-spiral states, depending on the lattice constant and the lattice distortion. It is well known that bulk fcc Fe exists only at temperature above 1186 K. But it was observed that fcc Fe can be stabilized by below room temperature epitaxial growth of Fe on a Cu (001) substrate whose lattice constant is close to that of an fcc Fe. This system has attracted a large number of studies as a model for studying the correlation between atomic structure and magnetism. Theoretically, a first-principles study has demonstrated that the most stable state of fcc Fe is AFM with tetragonal distortion in the bulk state. The similar behavior was confirmed by full-potential linearized augmented plane-wave (FLAPW) method [1]. In this work, we have carried out extensive studies the correlation between magnetism and atomic structure of fcc Fe (001) surfaces, using the highly precise all-electron FLAPW method based on generalized gradient approximation (GGA) for exchange-correlation potential. We used equilibrium lattice constant (3.49 Å) of bulk fcc Fe for AFM state which agrees with a previous FLAPW calculation [1]. In order to take into account both bulk and surface properties, the fcc Fe systems were simulated by single slabs with varying thickness (3, 5, 7, 9, and 11 layers) so that we checked if the center layer has bulk properties. As a result, the most stable state was calculated to be FM coupling of two adjacent Fe layers at the surface and interface and the inner layers are stabilized in an AFM state like in bulk. The calculated total magnetic moment per Fe was ~2.72 μ_B at surface for each most stable system, because of spin d states are almost completely occupied and band narrowing from density of states results.
[1] D. Lee and S.C. Hong, J. of Magn. 12, 68 (2007).

Dp-139 **Magnetism and Magnetostriction of bcc and fcc Iron: Density Functional Study** LEE Dongkook, YUN Won Seok, HONG Soon Cheol(*University of Ulsan, Department of Physics.*) Thanks to recently developed state-of-the-art synthesizing technology, we may have an artificial material produced in a designed way. Even though it is well known that the ground state of Fe is bcc ferromagnetic (FM), fcc Fe grown on fcc substrates such as Cu, Rh, Ag, and Au is stabilized in an antiferromagnetic (AFM) state. If the grown film is thick enough, then the film turns to be FM. Up to now the transition from an AFM state to a FM one is suspected to come from a structural transition from fcc to bcc. Even a pure bulk Fe has a complicated magnetic phase and its magnetism is still needed to be clarified. In this study we investigated the magnetism of bcc and fcc bulk Fe using the full-potential linearized augmented plane wave method within a generalized gradient approximation. We calculated the total energies in nonmagnetic (NM), FM and AFM states. The ground state of bulk Fe is confirmed to be of bcc FM. For fcc-like Fe an AFM state is most stable compared to NM and FM states which exist as low spin (LS) and high spin (HS) states. The fcc-like AFM and HS FM states were found to be stabilized in a tetragonal distortion, while the LS FM state remained in a cubic symmetry. Magnetic moments are found to be quite sensitive to tetragonal distortion, i.e. the ratio of c/a.. We will present the magnetic crystalline anisotropies of the bcc and fcc Fe.

Dp-140 **How to Make a Non Magnetic Element a Ferromagnetic: an Ab Initio Study*** GUL Rahman, CHO Sunglae, HONG Soon Cheol(*University of Ulsan, Department of Physics.*) Much attention has been paid to understand the origin of ferromagnetism in diluted magnetic semiconductors (DMS) and to use it for future electronic devices. The well studied DMSs i.e. (Ga,Mn)As [1] and (In,Mn)As [2] have low solubility and Curie temperatures below room temperature which limit their application to future spintronic devices. One of the possible approaches to modify the electronic and magnetic behavior of these DMS is to produce magnetic semiconductor superlattice which is conventionally know as digital ferromagnetic heterostructures (DFH). These DFH are obtained by delta-doping and such digital compounds are of particular interest because of their unique magnetic and electronic properties [3]. There are some reports on the magnetism of digitally-doped Mn into GaAs [3], Ge [4], GaSb [5], and Si [6]. In all these compounds the doping element (Mn) is magnetic in bulk. Is it possible to make non-magnetic element (Ti) a ferromagnetic when digitally doped into III-V semiconductor? Here we investigate the electronic and magnetic properties of digitally doped Ti into InP using the full potential linearized augmented plane wave method in generalized gradient approximation. We found that Ti shows half metallic ferromagnetism when digitally doped into InP. The electronic and magnetic properties were investigated as a function of spacer layer thickness and we found that ferromagnetic state is more stable than antiferromagnetic state. We also found that the magnetic and electronic properties of $(TiP)_1/(InP)_n$ is independent of spacer layer thickness and the magnetic properties are strongly confined in TiP plane. Such confinement is supported by total energy, density of sates and spin density contours.

*This work was supported by by KOSEF through NRL program (Grant 2006-02202). [1] T. Jungwirth et al., Phys. Rev. B 72, 165204 (2005).[2] H.Ohno et al., Phys. Rev. Lett. 68, 2664 (1992).[3] S. Sanvito and H. A. Hill, Phys. Rev. Lett. 87, 267202 (2001).[4] Contineza A, Antoniella F, and Picozzi S, Phys. Rev. B 70, 035310 (2004).[5] G. I. Boishin, J. M. Sullivan, and L. J. Whitman Phys. Rev. B 71, 193307 (2005).[6] M. C. Qian et.al., Phys. Rev. Lett. 96, 027211(2006).

Dp-141 **Cooling rate dependence of magnetic properties in Ca3CoRhO6 polycrystalline sample** 박 혜림, MEERA K, 장 태환, 이 효진, 구 태영, 김 성백, 정 윤희(*포항공과대학교 물리학과.*) Ca3CoRhO6는 Magnetically frustrated triangular ising-like one demensional chain 한 구조를 가지고 있다. chain내부는 CoO6 prism과 RhO6 octahedral이 번갈아가며 규칙적으로 정렬된다. Sample을 sintering하는 과정에서 Cooling rate를 조절하여 [quenching or slow cooling (0.5K/min)] 임의로 chain 내부의 ordering을 깨어 Neutron diffraction과 PPMS(magnetic property)를 측정하여 보았다. ordering의 깨어짐효과를 Magnetic phase diagram에서 transition이 일어나는 온도와 Magnetic field의 변화로 관찰 할 수 있었다

Dp-142 **Ultrafast Demagnetization of TbFe at Elevated Temperatures** KIM J. -W., LEE K. -D., JEONG J. -W., SHIN S. -C.(*Department of Physics and Center for Nanospinics of Spintronic Materials,Korea Advanced Institute of Science and Technology, Daejeon 305-701, Korea.*) Recently, much attention has been focused on large perpendicular magnetic anisotropy (PMA) materials to increase writing speed as well as recording density. In this experiment, we have investigated laser-induced magneto-optical dynamics of $Tb_{40}Fe_{60}$ alloy thin film with high PMA by using the femtosecond time-resolved magneto-optical Kerr effect (TRMOKE). In order to explore magneto-optical dynamics in detail, the time-resolved Kerr rotation (KR), Kerr ellipticity (KE), and reflectivity were measured by 400-nm probe beam at various sample temperatures (295, 310, 319, 325, 345 K). The magneto-optical responses within 1 ps are found to be very interesting. In this regime, KR and KE signals show instantaneous peaks right after laser pumping. Their peaks are nearly same height and become blurred with elevated temperatures. Strikingly, the normalized KR curve well matches the normalized KE curve ($\Delta\theta/\theta \sim \Delta\varepsilon/\varepsilon$) below 325 K. These results suggest a possibility that the peaks are ascribed to the genuine magnetism. This is the contrasting result in comparison with the observations in other materials such as Ni and Fe, where the peak in a few ps regime comes mainly from non-magnetism [1,2]. Our conjecture is further supported by an additional experiment performed near the Curie temperature ($T_C \sim 345$ K). At this temperature, instantaneous peak did not appear in KR and KE measurements, but in reflectivity. Therefore we conclude that instantaneous peaks in magneto-optical signals are originated from the genuine magnetism and demagnetization in TbFe could occur within 1 ps. This characteristic of TbFe is expected to be very useful to ultrafast spin devices.

*This research work was supported by Korea Science and Engineering Foundation through the Basic Research Program and Ministry of Science and Technology of Korea through Leading Basic S&T Research Project. [1] B. Koopmans, M. Van Kampen, J. T. Kohlhepp, and W. J. M. de Jonge, Phys. Rev. Lett. 85, 844 (2000) [2] T. Kampfrath, and R. G. Ulbrich, Phys. Rev. B 65, 104429 (2002)

Dp-143 **Electronic structure and superconducting property of metastable bcc Ni** KIM Bongjae, CHOI Hong Chul, KWON Se Kyun, MIN Byung Il(*POSTECH.*) Superconductivity and magnetism are known to be mutually competing properties: one nature usually suppresses the other. In stable fcc phase, Ni has a dominant magnetic character which is greatly reduced in its metastable bcc phase indicating the possibility of superconductivity. Recent progress in thin film growth techniques allows us to investigate metastable phases, which was hard to be synthesized before. In this presentation, we report magnetic and superconducting properties of fcc- and bcc-Ni from the total energy band structures approach. We estimated λ and Tc of bcc-Ni as 0.39 and 0.09K, respectively (λ: electron-phonon coupling constant; Tc: superconducting transition temperature). Because the Stoner exchange enhanced parameter, I_{XC}, of bcc-Ni is nearly close to one, the superconductivity in bcc Ni, if it exists, will not be originated from the conventional super-

conducting mechanism. The possible mechanism will be discussed.

Dp-144 **Electric and magnetic behaviors of Li and Co co-doped ZnO diluted magnetic semiconductor grown by Laser MBE** 이 효진, 박 상연, 양 일규, 정 윤희(*포항공과대학교, 물리학과.*) Transition metal doped oxide semiconductors have become an important topic of scientific interest due to the application of spin-based information processing technologies at room temperature. In this study, a set of Li and Co codoped ZnO epitaxial thin films were grown on sapphire (0001) substrates by using Laser MBE deposition technique. X-ray diffraction results revealed that the Li and Co codoped ZnO thin films possess single ZnO wurtzite structure and Li and Co ions substitute for the Zn sites without changing the wurtzite structure. Magnetic properties were investigated using PPMS vibrating sample magnetometry (VSM). The longitudinal resistivity and hall measurement were performed by using the van der pauw method. The magnetic and transport properties of Li and Co codoped ZnO thin films in detail will be presented.

Dp-145 **Magnetic ordering effects on Raman spectra of hexagonal phase of $HoMnO_3$ film** HIEN N.T.M., HOANG L.H.[1], LEE D.[2], JANG S. Y.[2], LEE J.-H.[2], NOH T. W.[2], YANG In Sang(*Division of Nano-Sciences and Department of Physics, Ewha Womans University, Seoul, 120-750, Korea. [1]Division of Nano-Sciences and Department of Physics, Ewha Womans University, Seoul, 120-750, Korea Faculty of Physics, Hanoi National University of Education, 136 Xuanthuy, Hanoi, Vietnam. [2]ReCOE &FPRD, Department of Physics and Astronomy, Seoul National University, Seoul 151-747, Korea.*) Hexagonal $HoMnO_3$ films was growth on $Pt(111)//Al_2O_3$ (0001) substrate by laser ablating deposition method. Temperature dependence (15-300K) of Raman spectra of hexagonal $HoMnO_3$ film has been studied. The hardening of the E_2 phonon mode with decreasing temperature below the magnetic ordering temperature (T_N~75K) manifests the spin-phonon coupling in hexagonal $HoMnO_3$ film. We have observed some broad Raman scattering bands at 400- 600 cm^{-1}, and broad peaks at 761, 934 and 1405 cm^{-1}. The frequency shift, FWHM, and normalized intensities of these bands show anomalous behavior with temperature at the magnetic ordering temperature T_N. This shows that the bands are closely related with the magnetic ordering in this material.

Dp-146 **Temperature-dependent Raman scattering study of multiferroic $MnWO_4$** HOANG L.H., HIEN N.T.M.[1], CHOI Woo Seok[2], LEE Yoon Sang[3], TANIGUCHI Kouji[4], ARIMA Takahisa[4], YOON S.[1], YANG In Sang[1](*Division of Nano-Sciences and Department of Physics, Ewha Womans University, Seoul, 120-750, Korea; Faculty of Physics, Hanoi National University of Education, 136 Xuanthuy, Hanoi, Vietnam. [1]Division of Nano-Sciences and Department of Physics, Ewha Womans University, Seoul, 120-750, Korea. [2]ReCOE &FPRD, Department of Physics and Astronomy, Seoul National University, Seoul 151-747, Korea. [3]Department of Physics, Soongsil University, Seoul 156-743, Korea. [4]Institute of Multidisciplinary Research for Advanced Materials, Tohoku University, Sendai 980-8577, Japan.*) We have studied Raman spectra of multiferroic monoclinic $MnWO_4$ single crystals as a function of temperature. A polarization analysis of the spectra collected from oriented single crystals allows us to completely assign the symmetries of the 18 observed peaks, as expected from theoretical analysis. The six internal modes have been identified by their weak temperature dependence. The anomalous temperature dependence of some internal modes confirms the additional decay channel opens at ~ 30 K and ~180 K. The B_g phonons (Mn-O bond vibrations) show deviation from the normal frequency-temperature dependence expected for anharmonic decay below ~30K. Characteristic second-order Raman peaks have been assigned to overtones and combination of phonons with different symmetries. These overtones also show changes in frequency and intensity at ~180 K. These facts seem to show that there exit some phase transitions at ~ 30K and ~ 180K in this material. Clarifying whether the transition is in the local structure of the oxygen octahedra or whether it is in the magnetic/electronic ordering requires further study.

Dp-147 **Electronic structures and magnetic properties of RB_4 (R= Gd, Tb, Dy, Yb, Pr)** 최 홍철, 심 지훈[1], 권 세균, 민 병일 (*포항공과대학교 물리학교. [1]Department of Physics and Astronomy, Rutgers University, Piscataway, NJ, 08854, USA.*) Rare-earth tetraboride RB_4 consists of the rare-earth R ion planes stacked along the c-axisand two kinds of boron atoms between R ion planes. The first type of the boron atoms forms B_6 octahedraoriented along the c-axis,which are connected by the second type of boron atoms. A strong structural anisotropy in these compounds gives rise to the electrical and magnetic anisotropic properties.RB_4 has a complex magnetic ground state except for YbB_4. It was recently proposed that the magnetic state has a strong correlation with the orbital degree of freedom.In this study, we have investigated the electronic and magnetic properties of RB_4 using the ab initio total energyelectronic band structure method.The generalized gradient approximation wasadopted for the exchange-correlation potential and the spin-orbit coupling interaction was also considered. We assumed the collinear spin configuration in these calculations.We have found stable magnetic ground states for RB_4 (R = Gd,Tb,Dy,Pr), but a non-magnetic ground state for YbB_4. And, f electrons of Pr ions with mm2 symmetry are found toshow orbital ordering in FM PrB_4 .Since band hybridization among the B ions is strong, R ions are hardly expected to affect the covalent states among the B ions.

Dp-148 **Realization of GaMnAs/GaAs freestanding structures for investigation of strain induced spin-orbit interaction** HYUNG KOOK Choi, TAESOON Hwang, JOON SOO Lee, YUN DANIEL Park(*CSCMR and FPRD Department of Physics &Astronomy, Seoul National University, NS 50, Seoul 151-747, Korea.*) We present the preparation of free standing bridge structure by employing N/MEMS technique for investigating strain effect on GaMnAs diluted magnetic semiconductor. It is well known that magnetic ordering temperature(Tc), anomalous Hall conductivity and magnetic anisotropy is sensitive to strain because it changes the

valence band spin splitting and mixing of the spin-orbit split-off bands via tuning the spin-orbit interaction[1,2]. We can achieve strain relaxation by forming freestanding structure. Perfect etch selectivity between GaMnAs/GaAs and InGaP(or AlAs) is utilized to realize suspended GaMnAs/GaAs micromechanical freestanding structures. We prepared GaMnAs(200nm)/AlAs or InGaP (500nm)/SI-GaAs(001) substrate by low temperature molecular beam epitaxy(LT-MBE). After growth, we conducted typical measurements such as Hall effect, SQUID magnetometry, and θ-2θ HRXRD measurements to characterize the feature of GaMnAs epilayer regrown by LT-MBE. The resulting structural, magnetic, and transport properties are similar to typical GaMnAs grown on GaAs. This structure can be utilized for studying of strain control of Tc and magnetic anisotropy in GaMnAs.
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Dp-149 **Determination Of Magnetic Structures In $La_{2/3}Ba_{1/3}MnO_3/LaNiO_3$ Multilayer By Soft X-ray Resonant Magnetic Scattering** 박 지회, 이 동렬[1], 최 용성[2], FREELAND John W.[2], 김 재영[1], SINHA Sunil K.[3], GOLDMAN Allen M.[4](*포항공과대학교, 물리학과. [1]포항가속기연구소. [2]Advanced Photon Source. [3]University of California. [4]University of Minnesota.*) We present a soft x-ray resonant magnetic scattering (SXRMS) study of magnetic structures in a $[La_{2/3}Ba_{1/3}MnO_3$ (47.3 Å)/$LaNiO_3$ (11.5 Å)$]_{10}$ multilayer, which shows an antiferromagnetic interlayer coupling between ferromagnetic LBMO layers with paramagnetic LNO spacer layer. To investigate the evolution of the magnetic structures under the applied field, we have measured the specularly reflected intensities with circular polarized soft x-rays at various incidence angles and photon energies near the Mn L_3 edge (639 eV) while field cycling. We have observed markedly different features in SXRMS hysteresis loops with incidence angles and photon energies, implying nonuniform magnetic depth profiles. To determine the field-dependent magnetic depth profiles quantitatively, the experimental results have been compared with the theoretical calculations using self-consistent distorted-wave Born approximation (DWBA) method. To quantifying magnetic domain configurations related to the antiferromagnetic interlayer coupling, we have assumed the model suggested by Idzerda et al., where the measured intensities as the incoherent sum of the scattered intensities from the fraction of the multilayer in the particular moment configuration

Dp-150 **Physical Properties by Strain Effect in Multiferroic Material $LuFe_2O_4$ Thin Film** 정 민화, 장 태환, 김 성백, 정 윤희(*포항공대 물리학과.*) In the past several years, there has been a revival of interest in understanding magnetic ferroelectrics because of their potential in advanced multifunctional devices. Many experiments and theories have been done to known about the mechanism of magnetic-electric coupling. Among the many model, Ikeda"s studies reported experimental evidence for ferroelectricity arising from electron correlations in the triangular mixed valence oxide, $LuFe_2O_4$. We grown it thin film by PLD technique because of thin film advantage : strain effect, easy controlled thickness etc. The magnetic and electric properties was measured by Phyisical Property Mesurement System.

Dp-151 **Stress evolution of Co film on InP in the monolayer regime** PARK Yong-Sung, JEONG Jong-Ryul[1], SHIN Sung-Chul(*Department of Physics and Center for Nanospinics of Spintronic Materials, Korea Advanced Institute of Science and Technology. [1]Department of Physics, Cavendish Laboratory, University of Cambridge.*) The ferromagnetic metal/semiconductor (FM/SC) hybrid system has attracted great interest because their novel structural and magnetic properties provide fundamental studies in magnetism and offer possibilities for spintronic applications[1-3]. III-V semiconductor InP has a direct bandgap energy and a high carrier mobility, and is used in optoelectronic devices for realizing low rectifying contacts. In addition, InP has better properties in thermal conductivity, breakdown voltage, electron mobility and so on, compared with GaAs. Therefore, study on FM/InP system might provide possibility to new device applications. In FM/SC systems it is significant to understand physical and chemical properties of interface regions between ferromagnetic metal and semiconductor, because these properties play critical roles in characteristics of spintronic devices. It is very important to study stress among such physical properties, because a stress is generated inevitably during film growth, and it has an influence on magnetic properties as well as mechanical properties. In this study, we report experimental investigations of the in situ stress evolution of Co on InP (001) in UHV chamber equipped with a highly sensitive optical deflection-detecting system. InP substrates of size of 25 μm (t) x 1.5 mm (l) x 3 mm (w) were used in stress measurement. Co films were deposited on InP at ambient temperature from a water-cooled e-beam evaporator at a rate of 0.76 Å/min. In situ stress of Co/InP system was performed by a highly sensitive laser deflection system using a one dimensional position sensitive detector (PSD) during Co deposition. STM measurements of Co/InP were also carried out at several specific Co film thickness to understand growth mode of Co on InP. From our in situ stress data (i.e. the integral forces in films of unit width as a function of film thickness), stress behaviors are characterized by the following features: (i) large compressive stress up to -9.4 GPa at the initial stage of Co growth; (ii) large tensile stress from Co deposition of 1 ML to 3 ML, following compressive stress (iii) relaxed tensile stress after about deposition of 3 ML. Abrupt compressive stress at the very beginning of growth might be attributed to diffusion of In atoms to Co matrix because Co-In alloys are larger than pure Co units. It might be understood that tensile stress, which appears after 1 ML growth of Co, is due to lattice mismatch of 1.93 % between Co and InP. STM images in monolayer regime show growth mode of Co on InP, which well coincides with in situ stress evolution.

Dp-152 **Geometrically frustrated magnetic system $Ce_{5-x}La_xNi_2Si_3$** KWON Y.S., LEE K.E., IM H.J., JUNG M.H.[1](*Department of Physics, Sungkyunkwan University. [1]Quantum Materials Research Team, Korea Basic Science Institute.*) The mag-

netic susceptibility and isothermal magnetization have been studied on $Ce_{5-x}La_xNi_2Si_3$ (x=0, 0.5, 1, 2, 3 and 4.5). The temperature of antiferromagnetic ordering due to the twelve magnetic Ce ions in two hexagons decreases with increasing x and is suppressed above x = 2. The paramagnetism which arises from 2/20 of the spins lying inside the hexagonal is observed below T_N in x≤1. The signature of spin fluctuation is also observed in magnetization curves. The spin fluctuation is suppressed as the magnetic field exceeds the metamagnetic transition field.

Dp-153 **기하학적으로 혼돈된 자기계 $Pr_5Ni_2Si_3$** 권 용성, 이 찬익, 이 경은, 임 호준, 정 명화[1](*성균관 대학교 물리학과. [1] 한국기초과학지원연구원 양자물성팀.*) 여러 자기적 배열을 갖는 $Pr_5Ni_2Si_3$ 전도와 자기적 성질에 대한 연구를 하였다. 강자기적인 배열이 70K과 55K에서 관측이 되었고, 또한 반강자성적인 배열이 43K에서 발생하였다. 12K 이하의 온도 영역에서 반강자성 배열에서 강자기적 배열로의 메타 마그네틱 전이가 H_m=3T에서 관측되었고, 이 자기장에서 자기저항이 급속히 감소하였다. 그리고 H>H_m에서 스핀 fluctuation이 사라지는 것이 관측되었다.

Dp-154 **Dramatic Change of Optical Properties at a Quantum Critical Point in the Heavy Fermion System $CeNi_{1-x}Co_xGe_2$** KWON Y.S., SONG Y.Y., LEE K.E., HONG J.B, IM H.J., KIMURA S.[1](*성균관대학교 물리학과. [1]UVSOR Facility,Institute for Molecular Science.*) Optical properties of $CeNi_{1-x}Co_xGe_2$ (0£x£1) have been studied via infrared spectroscopy. Tuning the Co-doping concentration reveals clear demarcation in the optical properties at x=0.3, where non-Fermi liquid behavior appears. For x>0.3, a hump in the optical conductivity s1 is observed at about 0.2 eV, resulting from strong hybridization between conduction electrons and Ce 4-f electronic states. For x£0.3, in contrast, no such hump is observed. The low frequency plasmon observed below coherence temperature T^* for x>0.3 is also consistent with the existence of heavy quasiparticles. These dramatic changes in the optical response at x=0.3 indicate that the heavy electron Fermi surface of $CeNi_{1-x}Co_xGe_2$ (x>0.3) ceases to exist at this magnetic quantum critical point.

Dp-155 **Direct Observation of Oxygen Stabilization Fatigue Free Layered Ferroelectric $Bi_{3.25}La_{0.75}Ti_3O_{12}$** KIM Su Jae, MORIYOSHI Chikako[1], KIMURA Sayaka[1], KUROIWA Yoshihiro[2], KATO Kenichi[3], TAKATA Masaki[3], NOGUCHI Yuji[4], MIYAYAMA Masaru[4](*BK21 Team of Nano Fusion Technology, Pusan National University. [1]Department of Physical Science, Hiroshima University. [2]Department of Physical Science, Hiroshima University and CREST/JST. [3]RIKEN Harima Institute and CREST/JST. [4]Research Center for Advanced Science and Technology, The University of Tokyo.*) Electron charge density distributions in layered ferroelectrics $Bi_4Ti_3O_{12}$ (BiT) and $Bi_{3.25}La_{0.75}Ti_3O_{12}$ (BLT) are investigated by analyzing high-energy synchrotron-radiation powder-diffraction data of SPring-8 using the maximum entropy method (MEM)/Rietveld method. BiT shows that chemical bonding resulting from orbital hybridization is established between Bi-O in the perovskite layer only along the aaxis, whereas BLT exhibits isotropic chemical bonding of Bi/La-O with a high electron density both along the a and b axes. High endurance to polarization fatigue reported for BLT films is suggested to originate from the stabilization of oxygen in the perovskite layer due to the isotropic chemical bonding of Bi/La-O.

Dp-156 **Anomalous thermal property in $Ce_{1-x}Gd_xCoSi_3$** KWON Y.S., HONG J.B., IM H.J., JUNG M.H.[1](*Department of Physics, Sungkyunkwan University. [1]Quantum Materials Research Team, Korea Basic Science Institute.*) The thermal property has been studied on $Ce_{1-x}Gd_xCoSi_3$, where an antiferromagnetic ordering is observed. T_N linearly decreases with increasing x and is suppressed at x=0.2. The non-Fermi-liquid behavior in C/T is found at x=0.2. Another anomaly is found at 3K when x>0.2. C/T is very large below 3K and diverges at x=0.4. The -lnT behavior in C/T is also observed at x=0.4. This indicates that new quantum critical point exists in x=0.4.

Dp-157 **Structure of Boron Environment of BaO-B2O3-V2O5 Glass System** 김 영훈, 강 재필, 차 유정, 홍 성덕, 서 용문, 송 승기, 김 선하[1], 한 옥희[1](*명지대학교 물리학과. [1]한국기초과학지원연구원, 대구센터.*) In the previous work[1], We observed two types of lineshape(narrow and broad line) using 11B NMR and analyzed using a computer simulation technique to obtain their N4 value (the fraction of four-coordinated boron atoms) for the region 0.25≦K≦1.0 and 0.5≦R≦2.5 (K = BaOmol% / B2O3mol% , R = V2O5mol% / B2O3mol%) in BaO-B2O3-V2O5 glasses. In this region the N4 values of BaO-B2O3-V2O5 glasses increase with increasing K showing the similar behavior for those of binary BaO-B2O3 samples, and the ternary glass structure can be viewed as binary glass structure diluted by vanadium oxide.Following the previous analysis, we focus on the structure of boron environment for the region 1.0≦K≦2.0 and 0.5≦R≦2.5. In this region the values of N4 decrease as the values of K increase and it indicates that the structure of the sample can not be explained by the Krogh-Moe model[2] which predicted that the values of N4 increase as increasing the boron content in the glasses. The value of N4 measurement for those samples in the region 1.0≦K≦2.0 using 11B NMR can be formulated as a function of K and R according to the structural model proposed in this work.
Reference[1] Y. H. Kim et al, Bulletin of the KPS, April (2007).[2] J. Krogh-Moe, Phys. Chem. Glasses, 6, 46 (1965).

Dp-158 **Defect characteristics of the iso/nonisomorphic crystals on their lattice dynamics** 서 용문, 김 영훈, 차 유정, 홍 성덕, 송 승기(*명지대학교 물리학과.*) Disorders in the isomorphic and nonisomorphic crystals observed by the nuclear resonance are static and dynamic respectively[1]. In the case of the non-isomorphic crystals, the dynamic feature of disorder is mainly attributed to the formation of the ligand deficient octahedra (LDO) with their double well local site lattice potential. It leads to the critical non-linear domain wall motion that can be interpreted as the two time scale feature of the local field fluctuation between the normal

lattice vibration and infrequent jumping of the octahedral site atoms. This has manifested itself in the nuclear quadrupole resonance (NQR) spectra of the high temperature cubic phase[1, 2].In this work we present the nuclear quadrupole resonance spectra of the isomorphic crystals where compositional disorder prevails among the mesh of two competing matrixes. This was shown clearly by the NQR line spectra, the results of which can be interpreted as the static distribution of the two sorts of the same valency atoms. The mutual influence of each matrix on their lattice dynamics was observed by the relaxation spectra showing their temperature shifts. References 1. J. Hypf. Intr. DOI 10.1007 (2005)2. KPS Meeting / April (2007)

Dp-159 **양자임계점에 관한 $Ce_{1-x}Gd_xCoGe_3$ 전자 구조의 체계적 연구: 공명 광전자분광 연구** 임 호준, MIYAZAKI Hidetoshi[1], ITO Takahiro[2], KIMURA Shin-ichi[2], 홍 종범, 권 용성 (*성균관대학교 물리학과. [1]Dept. of Quantum Engineering, Nagoya University, Japan. [2]UVSOR, Institute for Molecular Science, Japan.*) 최근 $Ce_{1-x}Gd_xCoGe_3$ 계는 새로운 양자임계점 (x = 0.4) 을 보이면서 많은 주목을 받아 연구되고 있다. 그 원인중의 하나로 Gd과 Ce의 f 상태의 속박에서지의 변화가 제안되었다. 이번 학회에서는 공명 광전자분광 측정을 통해 그 전자구조를 직접적으로 연구하였다. 측정결과 양자임계점 근처에서 Ce과 Gd 4f 상태의 속박에너지는 거의 변하지 않으며, Ce 4f 와 전도 전자의 혼성 세기도 연속적으로 변하였다. 이것은 전자상태의 변화가 직접적으로 양자임계점의 관여하지 않는 것은 나타내며, f 전자들의 자기적 요동이 주요 원인인 것을 암시해준다.

Dp-160 **First-Principles Calculation Of Atomic Force And Stress Tensor In The LDA+U Formalism** PARK Seyoung, CHOI Hyoung Joon(*Department of Physics and IPAP, Yonsei University..*) In strongly correlated systems, the electronic structure of magnetically ordered insulating phases can be described with the LDA+U formalism, effectively. To study atomic structures of such systems, we derived formulas for the atomic force and the stress tensor from the total energy functional of the LDA+U formalism, considering both a pseudo-atomic orbital (PAO) basis method and a plane-wave basis method. In the PAO basis method, Pulay correction terms are also derived and included. In the plane-wave basis method, the density matrix is obtained by projecting the electronic wavefunctions onto d orbitals which satisfy the sum rule of the total number of electrons. Computational resource for this work is provided by KISTI under the 10th Strategic Supercomputing Support Program.

Dp-161 **Orientational Ordering in the Solid ortho-H_2 : Path-Integral Monte Carlo Study** 신 현덕, 권 용경(*건국대학교 물리학과.*) Molecular solid of ortho-H_2 was observed to be orientationally ordered to form a Pa3 structure at low temperatures below 2.7K, which is understood to be due to the anisotropic interaction between hydrogen molecules. In order to study this orientational ordering, we have performed Monte Carlo simulations on rigid rotors localized at FCC lattice sites with electric quadrupole moments, since most of the anisotropy in the H_2-H_2 interaction can be explained by electric quadrupole-quadrupole interaction. Classical Monte Carlo calculations have shown that as the temperature lowers the rotors are indeed ordered to a Pa3 structure but the transition temperature is much higher than the experimental value for quantum solid of ortho-H_2. This discrepancy is due to quantum nature of the rotational dynamics of the hydrogen molecules. Path-integral Monte Carlo technique has been employed to make a full quantum treatment of the rotational motions of the interacting rigid rotors, whose results are compared with the experimental results for solid ortho-H_2.

Dp-162 **Stress Dependence of Growth Mode Change of Epitaxial Layered Cobaltite γ-$Na_{0.7}CoO_2$** 종역 손, 영한 신, 형준 김, 진형 조[1](*포항공과대학교 신소재공학과. [1]부산대학교 물리학과.*) We report stress dependence of growth characteristics of epitaxial γ-$Na_{0.7}CoO_2$ films on various substrates deposited by pulsed laser deposition method. On the sapphire substrate, the γ-$Na_{0.7}CoO_2$ thin film exhibits spiral surface growth with multi-terraces and highly crystallized texture. For the γ-$Na_{0.7}CoO_2$ thin film grown on the (111) $SrTiO_3$ substrate, the nano-islands of ~ 30 nm diameter on the hexagonal grains are observed. These islands indicate that the growth mode changes from step-flow growth mode to Stranski-Krastanow (SK) growth mode. On the (111) MgO substrate, the large grains formed by excess adatoms covering an aperture between hexagonal grains are observed. These experimental demonstrations and controllability could provide opportunities of strain effects of Na_xCoO_2, physical properties of thin films, and growth dynamics of heterogeneous epitaxial thin films.

Dp-163 **혼합알칼리 유리에서 나타나는 dc 전도도 및 dc 활성화 에너지의 비선형 특성** 김 맥, 송 철호, 최 현우, 진 근영, 임 영훈[1], 양 용석(*부산대학교, 나노과학기술대학, 나노융합기술학과, RCDAMP, 밀양 627-706. [1]세명대학교, 교양과정부, 충북 제천 390-711.*) 고체로써 높은 이온 전도도를 가지는 물질은 배터리, 화학 센서, 스마트 창 등의 응용이 가능하다. 이처럼 높은 이온 전도도를 갖는 고체 전해질에 다른 원소를 치환하면 전도도를 쉽게 제어할 수 있다. 특히, 알칼리 이온을 포함하는 물질에서는 물성의 변화가 치환된 알칼리 조성비에 따라 비선형적인 모습을 보이기 때문에 이를 혼합알칼리 효과라 한다. 혼합 알칼리 효과는 이온 거동과 관련된 전기 전도도, 이온 확산, 유전 완화, 내부 마찰 등에서 관찰된다. 본 연구의 목적은 유전체 비정질 $(Li_{1-x}Na_x)_2B_4O_7$, $(Li_{1-x}K_x)_2B_4O_7$, $(Li_{1-x}Rb_x)_2B_4O_7$, $(Li_{1-x}Cs_x)_2B_4O_7$에 대한 온도와 주파수에 따른 유전 변화를 측정함으로써, 혼합알칼리 효과의 크기 강화 및 다양한 소자로의 응용성을 찾는 것이다. Jonscher의 보편법칙을 이용하여 dc 전도도 값을 구했으며, 온도가 감소할수록 단일 알칼리 유리와 혼합 알칼리 유리 간의 dc 전도도 값의 차이가 크게 나타나는 것을 발견했다. Li 이온과 크기 차이가 큰 이온이 섞일수록 dc 전도도의 최소값이 감소했으며, 이를 통해 두 알칼리 이온간의 크기 차이가 클수록 혼합 알칼리 효과가 강해지는 것을 확인할 수 있었다. Arrhenius 방정식으로 dc 전도에 대한 활성화 에너지를 구했으며, 활성화 에너지에서도 혼합 알칼리 효과가 나타났다.

Dp-164 **강유전체 릴랙서의 탄성 특성 연구** 고 재현(*한*

림대학교, 물리학과.) 강유전체 릴랙서는 최근 그 우수한 압전특성으로 인해 큰 주목을 받고 있는 물질군을 일컫는다. 본 연구에서는 페로브스카이트 계열 강유전체 릴랙서와 텅스텐-브론즈 구조를 갖는 릴랙서의 완화상전이와 관련하여 이 완화상전이가 탄성계수의 변화에 어떠한 영향을 주는지를 조사하였다. 그 결과 페로브스카이트 구조의 릴랙서가 보이는 탄성특성의 변화는 소위 극성나노영역의 형성 및 동적 특성과 밀접한 관련이 있음이 밝혀졌다. 반면에 텅스텐-브론즈 계열 릴랙서의 경우는 극성나노영역 이외에 다른 자유도가 탄성파와 결합하여 특성 변화를 일으키는 것으로 추정된다.

* 이 연구는 2006년도 정부재원(교육인적자원부 학술연구조성사업비)으로 한국학술진흥재단의 지원을 받아 연구되었음(KRF-2006-331-C00088).

Dp-165 **Fermi Surface Topology Effects on the Electron-Phonon Coupling in Electron-doped Cuprates** 김 창영, 송 동준, 박 승룡, 임 춘식, EISAKI H[1], 김 철, 진 형욱(*연세대학교 물리학과. [1]AIST.*) We have performed high resolution angle resolved photoemission (ARPES) studies on electron doped cuprate superconductors $Sm_{2-x}Ce_xCuO_4$ (x=0.10, 0.15, 0.18). Imaginary parts of the electron removal self energy by a newly developed method shows kink-like features due to electron-bosonic mode coupling. The kink-like feature is seen along both nodal and anti-nodal directions but at different energies of 50 and 70 meV. Such energy scales can be reconciled by taking the Fermi surface topology and phonon dispersions into account, revealing the kink structures are due to the electron-phonon coupling. Estimated electron-phonon coupling constant λ from the self energy is about 0.6 independent of doping and is isotropic. We discuss the difference between the electron and hole doped cases and other energy scales.

Dp-166 **$Na_xK_{3-x}Li_2Nb_5O_{15}$ 세라믹스의 강유전성** 최 병춘, 박 희진, 김 은지[1], 정 수태[2], 전 병억[3], 박 종호[4], 김 진수(*부경대학교 물리학과. [1]부경대학교 물리교육학과. [2]부경대학교 전자공학과. [3]부경대학교 기초과학연구소. [4]진주교육대학교 과학교육과.*) Na을 일부 치환한 $K_3Li_2Nb_5O_{15}$ 세라믹스 ($Na_xK_{3-x}Li_2Nb_5O_{15}$, NKLN)를 고상반응법으로 제조하였다. 알칼리 니오브 산화물 ($ANbO_3$, A=K,Na, Li)은 perovskite, $LiNbO_3$ 및 정방형 tungsten-bronze 구조가 섞인 복합구조 세라믹스 특성을 보인다. 이러한 어려움을 극복하기 위하여 2단계의 하소 또는 소결 과정을 적용하였다. Na이 A 자리의 K을 치환한 량에 따른 이온전기전도도 및 유전완화현상을 비교하였다. 또한 유전상수의 온도에 따른 변화와 D-E 이력현상을 조사하여 NKLN 세라믹스의 강유전성을 비교하였다. 단일상의 정방형 tungsten-bronze 구조가 형성되는 Li 또는 K 과잉의 비화학량론적 조성 또는 하소 및 소결 조건을 조사한다.

Dp-167 **강유전체 $KNbO_3$의 구조상전이 특성 연구** 양 용석, 송 철호, 김 정환, 김 맥, 진 근영, 최 현우[1](*부산대학교 나노과학기술대학, 나노융합기술학과, 밀양 627-706. [1]부산대학교 물리학과, 부산 609-735.*) $KNbO_3$는 높은 강유전 상전이 온도 (T_c = 435 ℃)를 가지는 물질로서 비선형 광학 및 광도파로 소자로 응용될 수 있다. $KNbO_3$는 T_c 이하에서는 온도가 내려 가면서 정방정계 (225 ℃), 사방정계 (-10 ℃), 능면정계 순으로 연속적인 구조상전이가 일어나며, T_c 이상에서는 입방정계 구조를 가진다. 지금까지 상전이에 대한 전기적, 구조적 특성에 대하여 많은 연구가 이루어져 왔으나, 구조상전이에 따른 열적 특성에 대한 연구는 부족하며, 기계적 특성에 대한 연구는 없는 상황이다. 따라서, 본 연구에서는 실시간 XRD, 시차 주사 열량계 (DSC) 및 열기계분석기 (TMA)를 이용하여 구조 상전이 온도 근처에서의 구조적, 열적, 기계적 특성을 서로 비교 분석하였다. 입방정계에서 정방정계 및 정방정계에서 사방정계로 상전이 하는 온도 근처에서의 각 결정상의 실시간 XRD Bragg 봉우리 크기의 변화는 DSC 측정에서 나타나는 열 변화율과 잘 일치하였다. TMA 측정 결과, 상전이 온도 근처에서 외력에 대해 민감하게 반응하는 역학적 특성변화가 나타났으며, TMA 곡선의 변화율 또한 각 결정상의 부피비에 비례하는 것을 알았다. 본 연구를 통해 구조적, 열적 및 기계적 측정에 대한 비교 분석이 상전이 동역학 연구에 매우 유용한 정보를 제공하는 것을 보였다.

Dp-168 **Properties of W- and Ti-doped VO_2 thin films prepared by sol-gel process** CHAE Byung Gyu, KIM Hyun Tak, YUN Sun Jin(*ETRI.*) Doping the VO_2 thin films with the transition metals is known to largely affect the properties of the metal-insulator transition. W- and Ti-doped VO_2 thin films were grown on sapphire by the sol-gel method. The films were characterized by observing the orientation, the surface morphology, and the stoichiometry. Both films were grown with (020)-preferred direction, but it was not highly oriented. The W and Ti concentrations in the films are found to be approximately 1.2 at.% and 20 at.% from the computer simulation for RBS spectra, respectively. In general, the transition temperature is lowered and increased by doping with metal ions. W-doped VO_2 film undergoes metal-insulator transition at lower temperature, 305K than that of undoped films. However, Ti-doped VO_2 film has higher transition temperature, 350K. The further study is required for understanding the effects of doping VO_2 film with metal ions.

Dp-169 **Ferroelectric properties of sol-gel derived $Bi_{4-x}La_xTi_3O_{12}$ films prepared on Pt/Ti/SiO_2/Si substrates** PARK Sungmin, BAEK Jongho, SHIN Jeho, PARK Doyoung, PAK Jaemoon, KIM Hyunjun, CHEONG Hyeonsik, PARK Gwangseo (*Dept. of Physics, Sogang University.*) The ferroelectric properties of $Bi_{4-x}La_xTi_3O_{12}$ (BLT) thin films were studied. The films were coated on Pt/Ti/SiO_2/Si substrates by spin coating method.The crystal structure, chemical composition and internal vibration modes were measured using x-ray q-2q scan method, Electron probe micro-analyzer, Raman spectroscopy, respectively. The orientation of the films was (117) and (200). Various type of grains and lattice expansion or reduction was observed in terms of the content of La and the annealing temperature of the films. Raman spectra on the films showed the modes of 271cm^{-1}(TiO_6 tortional bending) and 849cm^{-1}(TiO_6 symmetric stretching). The BLT film with x = 0.25 films showed that the peak in the vicinity of 560cm^{-1} was splitted into 543cm^{-1} and 566cm^{-1}, which was understood as orthorhombic distortion. In addition, a 476cm^{-1} peak appeared remarkably due to

Ti-O torsion in TiO_6 octahedra unit cell. The BLT films with x = 0.25 had larger values of polarization and coercive field than other films, and they showed poor fatigue properties. However, the BLT films with x = 0.75 showed a good fatigue property.The ferroelectric properties will be discussed in terms of the microstructure and the distortion of the unit cell in the films.

Dp-170 **Properties of interfacial dead layers for $Pb_{1.10}(Zr_{0.52}Ti_{0.48})O_3$ thin films on Pt electrodes** KIM Hyunjun, LEE yongwoo, PARK Sungmin, PAK Jaemoon, SHIN jeho, PARK Gwangseo(*Dept. of Physics, Sogang University.*) $Pb_{1.10}(Zr_{0.52}Ti_{0.48})O_3$ thin films were deposited on $Pt/Ti/SiO_2/Si(100)$ substrates using pulsed laser deposition and sol-gel methods, respectively. In order to investigate properties of dead layers between PZT films and Pt electrodes, the crystal structure of the PZT films was investigated by the x-ray diffraction which showed (111) orientation dominantly, and the tetragonality which is supposed to be a crucial indication informing the characteristic of dead layers was investigated by Raman spectra. We will introduce a proper current density model of dead layers which can be revealed by x-ray reflectivity and I-V characteristics as a function of temperature. We will also discuss on correlation between electrical properties of dead layers and ferroelectric properties of the films.

Dp-171 **Pyrolysis modification of Ferroelectric $Bi_{4-x}La_xTi_3O_{12}$ films coated on Pt/Ti/SiO2/Si substrates** SHIN jeho, PARK sungmin, PARK Doyoung, KIM Hyunjun, PAK Jaemoon, JUNG Hyeonsik, PARK Gwangseo(*Dept. of Physics, Sogang University.*) Ferroelectric $Bi_{4-x}La_xTi_3O_{12}$ films consist of Bismuth layered-perovskite structure were fabricated on $Pt/Ti/SiO_2/Si$ substrate to study the effect of modification on pyrolysis processes. The crystal structure of the films and internal vibrational modes were analyzed by x-ray diffraction and Raman spectroscopy, respectively. The grain size of each film was almost same and had only (200) oriented grains without any phases. In addition, orthorhombic distortions were shown very slightly. The value of remanent polarization and coercive field of the film with La(x) = 0.25 was 6.09μC/cm^2, 53kV/cm, respectively. The structural and electrical properties which can strongly depend on pyrolysis will be discussed.

Dp-172 **The Degradation Mechanism of $(Na,K)NbO_3$ Thin Films** 이 해준, 이 재영, 강 선희, 김 일원, 정 귀상[1], 배 세환[2], 진 병문[3](*울산대학교, 물리학과. [1]울산대학교, 전기전자시스템공학부. [2]동아대학교, 신소재물리학과. [3]동의대학교, 물리학과.*) The $(Na,K)NbO_3$ ceramics have been studied extensively, because of their good piezoelectric and ferroelectric properties. Recently, $(Na,K)NbO_3$ ferroelectric thin films have been studied for applications in memory devices, due to their high remanent polarization and good fatigue endurance. So, we have deposited the ferroelectric $Na_{0.5}K_{0.5}NbO_3$ (NKN) thin films on $Pt(111)/Ti/SiO_2/Si$ substrates by using a RF-magnetron sputtering. The NKN films annealed at 700°C in the O_2 ambient exhibits good ferroelectric properties. We have investigated the degradation mechanism of the NKN films with measuring the low frequency dielectric and impedance spectroscopy as a function of temperature. The leakage current density – applied electric field (J-E) and time (J-t) characteristics also has been studied. To investigation of polarization switching kinetics, the polarization fatigue test and switching current transients study were performed with various temperature and applied voltages.

Dp-173 **Conduction mechanism of Lead-free $(Na_{0.5}K_{0.5})NbO_3$-$LiNbO_3$ Ceramics** HUSSAIN Ali, 이 재신, 원 성식[1], 김 일원[1], 안 창원[2], 이 정식[3](*울산대학교, 첨단소재공학부. [1]울산대학교, 물리학과. [2]한국기초과학연구원, 부산센터. [3]경성대학교, 물리학과.*) $0.95(Na_{0.5}K_{0.5})NbO_3$–$0.05LiNbO_3$ (NKN–LN) ceramics were fabricated by the conventional solid-state sintering technique. We have investigated their ferroelectric and piezoelectric properties as a function of temperature. The 0.95NKN–0.05LN ceramics sintered at 1075 °C exhibit good ferroelectric properties with high remnant polarization (2Pr) of 21.5 μC/cm^2 and the coercive field (2Ec) of 21 kV/cm. Promising piezoelectric properties of d_{33} = 172 pC/N and kp = 34.5 %. We also discussed the conduction behavior of NKN–LN ceramics by measuring low frequency dielectric spectroscopy and the I-V characteristics as a function of voltage and temperature.

Dp-174 **NMR Study on spin configuration of single crystal MnV_2O_4** LEE Jooseop, SHIM Jeong Hyun, LEE Soonchil, KATSUFUJI Takuro[1](*Department of Physics, Korea Advanced Institute of Science and Technology. [1]Department of Physics, Waseda University.*) Transition metal spinels of AB_2O_4 type have attracted great intersts for their intrinsic geometrically frustrated structure and corresponding peculiar properties. Among them, MnV_2O_4 is of specil concern for the Vanadium ion has trply degenerate orbital state in its t_2g level. This kind of degeneracy leads to spin-lattice coupling, which result in magnetic and structural phase transition at the same temperature in case of single crystal. The magnetic phase transition is know to be from paramagnetism cubic to ferrimagnetism, however, the exact spin configuration is still in question. In this article, the detailed structure of both Mn and V ions is investigated mainly by NMR technique. The NMR peak frequency depedence on the strength of applied magnetic field tell us about the cantings of respective spins with high precision.

Dp-175 **Anomalous magnetic field effects on the neutron powder diffraction patterns of the Kagome mixed compounds, $(Co_xNi_{3-x})_3V_2O_8$** CHOI Yong Nam, PARK Sungil, LI Wen-Hsien[1] (*Korea Atomic Energy Research Institute. [1]Dept. of Phys., Taiwan Nat'l Central Univ..*) $(Co_xNi_{1-x})_3V_2O_8$ (CNVO) is a mixed compound of $Ni_3V_2O_8$ (NVO) and $Co_3V_2O_8$ (CVO), both of which have the Kagome staircase spin lattice and complex magnetic phase transitions at low temperature region(PM-IC-IC'-C-C'). The commensurate magnetic phases of NVO and CVO are known as antiferromagnetic (T_N=3.7K) and ferromagnetic (T_C~6K), respectively. Neutron powder diffraction and magnetization results revealed that the commensurate magnetic phases of the CNVO(x=0.033, 0.067 and 0.167) were antiferromagnetic. Extraordinarily both magnetic

and nuclear Bragg peaks (not limited to the low angle region) were affected by the magnetic field at low temperature ($T=8.3K<T_C$). The peak intensities decreased as the magnetic field increased with varying degree. These anomalous phenomena were observed even in the paramagnetic phase albeit in a smaller scale. Experimental detail and discussion will be presented.

Dp-176 **Leakage Current and Dielectric Properties of $BiFeO_3$-$Bi(Zn_{1/2}Ti_{1/2})O_3$ Ceramics** 송 태권, 김 명호, 조 정호, 성 연수, 여 홍구, 왕 림(*창원대학교, 나노신소재공학부.*) $BiFeO_3$-$Bi(Zn_{1/2}Ti_{1/2})O_3$ (BF-BZT) ceramics were made by a solid-state reaction method. BF shows multiferroic properties at room temperature, but it is difficult to measure its ferroelectric and piezoelectric properties due to the large leakage current in ceramics. In order to reduce the leakage current and to form a possible morphotropic phase boundaries, the effects of BZT addition in BF were studied. Crystal structures and microstructures were investigated with XRD and SEM. Leakage currents were much reduced with BZT doping. Dielectric spectroscopy especially at low frequency region was studied.

Dp-177 **The variation of the flux pinning effect of SiC (or Ag)-MgB_2 and the effect of solvent treatments on the MgB_2 superconducting properties** SONG K.J., KO R.K., KIM H.S., KIM T.H., LEE N.J., HA H.S., HA D.W., OH S.S., MOON S.H.[1], PARK C.[1], YOO S.I.[1](*KERI. [1]SNU.*) The variation of the flux pinning effect of Ag_8-MgB_2, $(SiC)_4$-MgB_2, and sintered pure-MgB_2 due to aging in air for two and half years, was investigated. No major impurity phase was identified. They, however, contain a small amount of MgO, MgAg, MgB_6, Mg_2C_3, or Mg_2Si impurity phases, which were also observed in the samples before aging. After aging, the J_c values of $(SiC)_4$-MgB_2 composite superconductor are larger than those of the Ag_8-MgB_2, sintered pure-MgB_2, and commercial MgB_2 powder. The aging in air led to degradation of pinning effect of the Ag_8-MgB_2 composite superconductor, while no change in in-field superconducting properties was observed in $(SiC)_4$-MgB_2 composite superconductor. In addition, to examine the effect of solvent treatments on the superconducting properties of MgB_2, solvent-treated MgB_2 powders were prepared by mixing with water, acetone, or ethanol. No degradation of the superconductivity of MgB_2 by the acetone or ethanol treatments, was observed. The effect of water was different from those of acetone or ethanol. These and other results will be discussed.
*[This research was supported by the Korea Electrotechnology Research Institute R&D Program.]

Dp-178 **펠티에 교류 열량계를 이용한 MgB_2와 $YBaCuO_7$의 비열 측정** LEE Nammi, JANG Yong-sik, YOON wonsik, PARK sangkook, RI H.-C(*Department of Physics, Kyungpook National University.*) 펠티에 교류 열량계를 이용하여 비열을 측정하였다. 300μg 이하의 작은 질량을 가지는 MgB_2 와 $YBaCuO_7$ 초전도 시료들의 비열을 30K 에서 상온까지의 넓은 온도 구간에서 정밀하게 측정하였다. 이러한 결과를 이용하여 MgB_2 와 $YBaCuO_7$ 벌크형 시료들의 열전도율(thermal diffusitivity)를 구하였다. $YBaCuO_7$ 에서는 관찰되지 않지만 MgB_2 에서 현저하게 나타나는 flux jump 현상을 해석하는데 활용하였다.

Dp-179 **Superconducting proximity effect in lateral F/S-F-S/F mesoscopic heterostructure** 기 동근, 이 후종(*포항공과대학교 물리학과.*) Since superconductor (S) and ferromagnet (F) have ground states with incompatible spin configurations, the superconducting properties in F would be suppressed and vice versa. Very recently, however, a large supercurrent flowing through substantial length of a half-metallic CrO_2 thin film and a coherent Aharonov-Bohm interference effect in Ho, a spiral magnetic system, were reported [1,2]. These results in contradiction to simple prediction seem to point to the existence of an unusual spin-triplet superconducting ground state existing at S/F interfaces. Although the ground state of this kind has already been theoretically proposed, the experimental results in Ref. [1] are different from the theoretical prediction. In this study, we thus intended to examine the existence of the spin-triplet supercurrent across a conventional metallic F using mesoscopic F/S-F-S/F heterostructure. We have used both a soft F material (permalloy) with easy spin-flip tendency and a hard F material (cobalt) with low spin-flip tendency as an F channel to examine the spin-triplet supercurrent. Extension of the superconducting order in an F was also examined by taking the differential resistance as a function of bias current, magnetic field, and temperature. The difference in the supercurrent and the differential conductance across a soft and a hard F will be focused.
[1] R. S. Keizer et al., Nature 439, 825 (2006). [2] I. Sosnin et al., Phys. Rev. Lett. 96, 157002 (2006).

Dp-180 **Numerical simulation of self-heating on interlayer tunneling spectroscopy of $Bi_2Sr_2CaCu_2O_{8+x}$** PARK Jae-Hyun (*POSTECH.*) For interlayer-tunneling-spectroscopic measurements, large self-heating arises on a small $Bi_2Sr_2CaCu_2O_{8+x}$ (Bi-2212) stack structure with lateral dimension of ~3x3 mm^2, due to poor thermal conductivity of Bi-2212. This increases the sample temperature by ~150 K for a bias about 50-70 mV per junction. In this study, we numerically estimated the self-heating around a Bi-2212 sample stack during I-V or dI/dV-V measurements. We estimated the temperature discrepancy between the sample stack and the thermometer stack, which were assumed to be about 0.5 mm apart from each other (this mimicked the actual measurement configuration employed in our earlier studies). Our results show that the temperature nonuniformity due to self-heating is negligible (<2 K) along the c-axis direction of Bi-2212 including the top Au electrode. On the other hand, the temperature discrepancy between the sample and the thermometer can be as large as ~20 K for the highest bias assumed. Our results indicate that the thermometry using the lateral arrangement of a Bi-2212 thermometer stack does not provide accurate-enough temperature reading of the sample stack. We will present the corbino-disk structure sample, which may allow uniform current flow and heat flow. A new in-situ thermometry using a small surface junction isolated from the round shaped cur-

rent-bias electrode, which are located on top of the Bi-2212 sample stack, may allow genuine temperature measurements of the Bi-2212 sample. Once the thermometry is accomplished accurately the self-heating can be eliminated by using the "heating compensation" technique [1] introduced by us previously, which may enable the genuine tunneling spectroscopic measurements.
[1] Myung-Ho Bae, Jae-Hyun Choi, and Hu-Jong Lee, Appl. Phys. Lett. 86, 232502 (2005).

Dp-182 **Superconducting SFS junction qubit** NOH TAE WAN, KIM MUN DAE[1], SIM HEUNG SUN(*KAIST (Korea Advanced Institute of Science and Technology). [1]KIAS (Korea Institute of Advanced Study).*) We propose a qubit system consisting of ballistic SIFIS junction (S: superconductor, I : insulating interface, F : metallicferromagnet). In the system, 0 and pi states are degenerate at the vicinity of the crossover between the two states and quantum tunneling leads to coherent superposition which can be used as aquantum bit (qubit). The coherent oscillation frequency of qubit is calculated for various values of insulating barrier height Z and the ratio $kappa$ of fermi wave vectors of superconductor and ferromagnet. We suggest the manipulation of the qubit by using gate voltage pulse which effectively changes $kappa$. Since our qubit system involves two states with no current, and no external magnetic flux is required to manipulate the qubit system, we can efficiently reduce unnecessary couplings from environment to decrease decoherence.

Dp-183 **Magnetic pinning properties and flux jumps in superconducting MgB_2** YOON. W.S., KIM. C.J.[1], KIM. B.G.[1], RI. H.-C.(*경북대학교 물리학과. [1]KAERI.*) Magnetization studies have been carried out on MgB_2 polycrystalline samples in the temperature range of 5-44 K and in the magnetic field up to 7 Tesla. The critical current density was calculated from hysteresis loops using the Bean's critical state model, and the highest value of J_c at 20 K was 2.7×10^5 A/cm^2 at 2 Tesla. The hysteresis loops were carefully examined to determine the temperature and magnetic field range where flux jumps appeared. The first jump occurred typically at 1 Tesla. Due to the strong pinning, we observed the presence of flux jump below H=1 Tesla at temperature below 30K. Unusually we showed the magnetic moment sign inversion phenomena.

Dp-184 **Study of magnetic field profiles in striated YBCO thin film using scanning Hall probe microscopy** YOON. W.S., KIM. B.G.[1], KIM. C.J.[1], RI. H.-C.(*경북대학교 물리학과. [1]KAERI.*) We studied the transport current distribution in patterned multi strip thin YBCO film. By using scanning Hall probe microscope has been used to map the distribution of magnetic flux in striated YBCO thin film carrying transport of magnetization currents at 77 K. Both shielded and trapped field were studied as a function of applied field and transport current. The results of Hall probe magnetic measurements were used in the inverse calculation to obtain the current distribution across the strips.

Dp-185 **Low temperature scanning laser microscopy of $YBaCuO_7$ thin film** PARK sangkook, KIM maengjoon, JANG yongsik, YOON wonsik, LEE nammi, RI H.-C(*Department of Physics, Kyungpook National University.*) Low temperature scanning laser microscopy (LTSLM) can be used for a two-dimensional display of various sample responses arising from the localized excitation. As shown in many experiments, LTSLM becomes particularly interesting when applied to superconductors. By using the $YBaCuO_7$ thin film which is etched physically with ND-YG pulsed laser, we have measured the distribution of the critical temperature. We suspected the shorter once exposed laser beam time constant, the better signal to noise ratio we can get with eliminating whole substrate heating effect. We modified laser beam configuration by adopting maximum 3kHz modulated laser beam which is produced by mechanical opto chopper as needed. In this paper, it is written that our investigation to improve data acquisition method to measure spontaneous sub 100micro level signal which can be hidden by whole substrate heating effect.

Dp-186 **High critical current density and strong flux pinning properties in mixed rare earth (Nd,Eu,Gd)$Ba_2Cu_3O_{7-d}$ superconducting coated conductors** KO Rock-Kil, SONG Kyu-Jeong, SOHN Myung-Hwan, PARK Chan[1], HA Hong-Soo, KIM Ho-Sup, HA Dong-Woo, OH Sang-Soo, AHMAD Dawood[2], JOON-HO Lee[2], SEUNG-SU An[2], YOUNG-CHEOL Kim[2](*Korea Electrotechnology Research Institute. [1]Seoul National University. [2]Pusan National University.*) Due to the electromagnetic properties of (LRE)$Ba_2Cu_3O_{7-d}$ (LRE: light rare earth such as Nd, Sm, Eu, Gd) are much higher than those of $YBa_2Cu_3O_{7-d}$, (LRE)$Ba_2Cu_3O_{7-d}$ materials have important potential for high field power applications. Recent studies reported that the mixed rare earth (Nd,Eu,Gd) $Ba_2Cu_3O_{7-d}$ bulk and thin film on single crystal $SrTiO_3$ exhibit very high critical current density (J_c) and irreversibility fields (H_{irr}). We report highly enhanced J_c and its strong flux pinning properties in mixed rare earth (Nd,Eu,Gd)$Ba_2Cu_3O_{7-d}$ (NEG-123) superconducting coated conductors. In order to investigate the possibility of using NEG-123 as the superconducting layer of the HTS coated conductor, the NEG-123 thin film was deposited on biaxially textured metal templates using pulsed laser deposition system. Systematic studies on the influences of pulsed laser deposition parameters (deposition temperature, deposition pressure, processing gas, laser energy density, etc.) on microstructure, texture and superconducting properties of NEG-123 coated conductor, were carried out. These results will be presented together with the discussion on the possible use of this material in HTS coated conductor.
*This research was supported by a grant from Center for Applied Superconductivity Technology of the 21st Century Frontier R&D Program funded by the Ministry of Science and Technology, Republic of Korea.

Dp-187 **^{11}B NMR study of DyNi2B2C** 권 세근, 강 기혁, 민 병진, 한 기성, 최 성훈, 최 헌화, 김 성훈, 권 달중, 남 승관, 성 시진, 이 무희, 조 병기[1](*건국대 물리학과. [1]광주과학기술원.*) B

pulsed NMR measurements have been performed at 8 T to investigate local electronic structure and 4f spin dynamics for DyNi2B2C single crystal. B NMR shift and linewidth are huge and strongly temperature dependent. In addition, both are proportional to magnetic susceptibility, indicating that the hyperfine field at the boron site originates from the 4f spins of Dy. The shift and the spin-lattice relaxation rate show high anisotropy for field parallel and perpendicular to the c-axis. Anisotropy of the shift and the relaxation rates suggests that the hyperfine field perpendicular to the c-axis is larger. In DyNi2B2C, the anisotropy of the NMR shift and the relaxation times as well as its temperature dependence can be analyzed to understand microscopic details of the 4f spin dynamics.

Dp-188 **Calculation of the tunneling density of states in ferromagnet-superconductor-ferromagnet trilayers using the Eilenberger equation.** LEE Nayoung, CHOI HAN-YONG, ESCHRIG Matthias[1](*SungKyunKwan University. [1]Universität Karlsruhe.*) We calculate the tunneling density of states of ferromagnet/superconductor/ferromagnet (F/S/F) trilayers using the Eilenberger equation in the low temperature limit. The S/F interfaces are modeled as spin inactive potential barriers. When the relative orientations of the two F layers are parallel or anti-parallel, the induced triplet component has the short coherence length ξ_{ex} like the singlet one. On the other hand, when their orientations are perpendicular, the long range triplet components are also induced in addition to the short range singlet and triplet components. We calculate the tunneling density of states of the F/S/F trilayers at the outer boundary of the one F layer for the parallel, anti-parallel, and perpendicular orientations in the real. The results will guide the experimental search for the odd frequency triplet pairing state.

Dp-189 **The Flux Method for Growing Superconducting $YBa_2Cu_4O_8$ Single Crystals** 김 창영, 최 성균, 박 승룡, 송 동준, 임 춘식, 진 형욱, 김 철, 김 용관(*연세대학교 물리학과.*) $YBa_2Cu_4O_8$ (Y-124) is the high temperature superconductivity, which shows Tc=80K. Unlike the well-known $YBa_2Cu_3O_7$ (Y-123), usually so called YBCO, Y-124 is attractive to appraise the role of the double CuO chain in high temperature superconductivity. Also, it may give the clue for the Metal Insulator Transition (MIT) phenomenon when Y substrates Pr because $PrBa_2Cu_4O_8$ becomes an insulator. However, the active study on this novel material cannot be rigorously accomplished. It is mainly because Y-124 single crystal is difficult to be made due to the complicated growth method: typically, high oxygen pressure up to 3000 bar at approximately 1100℃. Here we present the new method for the single crystal by using the flux method with KOH. Under 1 atm, black and shiny Y-124 single crystal is synthesized from $YBa_2Cu_3O_7$ (Y-123) polycrystalline powder with both CuO and KOH. With this sample, we did the experiments such as single crystal X-ray diffraction, XRD, polarized optical microscope. These measurements turned out that it had good quality in order to perform the further experiments: angle-resolved photoemission spectroscopy (ARPES), infrared spectroscopy (IR) and so on.

Dp-190 **A superconducting phase diagram with the bizarre shape in the under-doped regime of sodium cobalt oxyhydrates $Na_xCoO_2yH_2O$** 유 봉우, 김 정구, 윤 석원[1](*서울대학교 자연과학대학 물리천문학부. [1]카톨릭대학교 자연과학대학 물리학부.*) A characteristic feature of the cuprate superconductors is the existence of an optimal electronic doping regimes. That is thought to be a universal characteristic of cuprate superconductors. Recently, this feature of the cuprates has been challenged for the new superconductor, sodium cobalt oxyhydrates $NaxCoO_2$ yH_2O.To determine the properties of this novel superconductor $NaxCoO_2yH_2O$ as a function of electronic doping, we have synthesized a series of powder samples with varying Na content x. Deintercalation of Na and oxidation was performed using oxidizing agent $KMnO_4$. The superconducting properties were characterized using a quantum design SQUID magnetometer. The Na/Co ratio of the products was measured using ICP-AES. Co oxidation state was measured by redox titration.By controlling the amount of Na chemically and measuring directly the Co valence, we have tried to draw a superconducting phase diagram using a series of samples over the broad range of cobalt valence. We have made the under-doped samples using the spontaneous oxidation process and checked the physical properties.Our findings are sharp inconsistent with recent reported phase diagram of Milne et al. to vicinity of the under-doped regime.

Dp-191 **Electrical Transport Behavior of Superconductor-Graphene Junction** 노 현호, 김 정구, 김 진희[1](*서울대학교 물리천문학부. [1]한국표준과학연구원 전자소자그룹.*) Graphene, the monolayer of graphite, is a good candidate for validating 2-D quantum transport phenomenon. We investigate electrical transport through the exfoliated graphene for observing such phenomena. In our works, graphene sheets are contacted with superconductor to check the proximity effect in superconducting region. We also discussed transport properties of junctions depending on the distance between electrodes, the numbers of layer and transparencies of the graphene.

Dp-192 **Extraction of density of states from experimental tunneling current of intrinsic Josephson junction layers.** 복 진모, 최 한용, 이 후종[1](*성균관대학교 물리학과. [1]포항공대 물리학과.*) Intrinsic Josephson junction (IJJ) 에서 전위차에 따른 전류의 측정값 I(V) 로부터 상태밀도함수 A(ε)를 추출하는 방법을 계발하였다. I(V) 는 A(ε) 의 자기 convolution 으로 주어진다 [1]. 이로부터 초전도체-부도체-도체 (SIN) 접합체에서는 전류를 전위차로 미분한 값이 상태밀도함수와 같음을 알 수 있다. 그러나, SIS 나 IJJ 에서는 이 같은 간단한 관계가 성립하지 않아 실험값으로부터 물리적으로 의미 있는 상태밀도함수에 대한 정보를 얻는 것이 어렵다. 이 일에서는 위의 I(V) 와 A(ε) 사이의 식을 뒤집어, SIS 나 IJJ 에서도 적용될 수 있는 상태밀도함수를 추출하는 방법을 계발하였다. 이는 저온극한에서 잘 알려진 folding-unfolding 관계와 같은 결과를 주는 반복계산법 [2]을 유한 온도로 확장한 방법이다. 이 방법을 Mesa 구조를 갖는 $Bi_2Sr_2CaCuO_8$의 IJJ에서 측정한 I(V)에 적용하여 상태밀도함수를 추출하였다. 이 결과를 바탕으로 기존의 해석이 어떻게 수정되는 지를 논의한다.

[1] Gerald D. Mahan, Many-Particle Physics, 3rd ed. (Plenum, New York, 2000). [2] Homer D. Hagstrum, Phys. Rev. 150, 2 (1966).

Dp-193 **$TmBa_2Cu_3O_{7-x}$ 초전도 박막의 자기장 방향에 따른 자기적 특성** 안 승수, 고 락길[1], 김 영철, 김 건철, 이 준호, AHMAD Dawood, 박 인석(*부산대학교 물리학과. [1]한국전기연구소.*) (RE)BCO계열 중 하나인 $TmBa_2Cu_3O_{7-x}$(TmBCO) 박막을 PLD 장비를 이용하여 STO(100) 단결정 위에 증착시켜 제작하였다. 제작된 박막의 임계온도는 86K 였고, SQUID 자력계를 이용하여 온도에 따른 자기적 특성과 자기장의 변화에 따른 자기적 특성을 자기장의 방향을 변화 시키면서 측정하였다. 77K에서 TmBCO 박막의 임계전류밀도는 4.5MA/cm^2로 높게 나타났으며, c축에 평행한 자기장에서 보다 ab면에 평행한 자기장에서 임계전류밀도가 약간 크게 나타났다. 그리고 침투깊이 λ_{ab}와 λ_c는 각각 0.1μm와 0.6 μm였다. 또한, 시료에 대한 자기장의 각도가 변함에 따라 자화값은 "$\cos^2\theta+\sin\theta\cos\theta$"로 변하였다.

Dp-194 **Transition-edge sensors for x-ray and gamma-ray detection** 권 용대, 이 영화, 이 상준[1], 김 선기[1], 이 화용, 이 경범, 이 민규, 김 용함(*한국표준과학연구원. [1]서울대학교 물리 천문학부.*) 이중 초전도 박막인 Transition Edge Sensor(TES) 기술을 바탕으로 폭넓은 파장대의 복사선들의 검출이 가능해졌다. 본 연구에서는 TES의 초전도 상전이 시 급격한 저항변화 특성을 이용 X-선 또는 감마선의 흡수에 의한 온도변화를 측정하였다. Ti 와 Au로 구성된 이중박막을 TES 물질로 사용하였다. 근접장 효과(proximity effect)를 Ti와 Au의 두께 비로 조정하여 상전이 온도를 100 mK 근처에 맞출 수 있었다. X-선 실험에서는 1 μm 두께의 Au를 흡수체로 사용하였다. 감마선 측정을 위한 흡수체는 0.3 mm 두께의 Sn을 사용하였다. TES의 작동 온도인 100 mK에서 Sn는 초전도체 상태로 전자의 열용량 최소화로 에너지 흡수에 따르는 온도 변화를 크게 한다. Stycast 등의 epoxy를 사용하여 기존의 X-선 검출용 소자에 Sn 흡수체를 부착하여 감마선 측정이 용이하게 제작 하였다

Dp-195 **Josephson Vortex dynamics in Tilted Magnetic Fields** JIN Yong-Duk, KI Dong-Keun, HU Jong-Lee(*Pohang University of Science and Technology, Department of Physics.*) Pancake and Josephson vortex phases formed in a cuprate high-T_c superconductor have been studied extensively. Josephson vortices are known to form a regular lattice structure under a moderate magnetic field. The resonance between moving Josephson vortex lattice and the plasma mode is theoretically predicted with a characteristic vortex flow velocity for each mode. The resonance is confirmed experimentally by the observation of the Josephson vortex flow sub-branches in samples containing a finite number of intrinsic junctions. In addition, the pinning interaction between pancake and Josephson vortices has attracted much attention, where rich features are expected. We investigated c-axis tunneling current-voltage characteristics for stacks of $Bi_2Sr_2CaCu_2O_{8+x}$ intrinsic Josephson junctions in various magnetic fields for tilt angles, where Josephson and pancake vortices coexist. The tilt angle was tuned within 0.05 degree in both positive and negative angles. In a few-tesla field range we observed the usual Josephson-vortex-flow multiple branches, arising from the resonance between collective motion of Josephson vortex lattice and the plasma modes. As the tilt angle increases, i.e., as more pancake vortices is introduced, the number of Josephson vortex flow branches increases while the splitting becomes clearer. The angular dependence is attributed to pinning of the Josephson vortex motion to pancake vortices, which gives information on how pancake vortices affect the collective Josephson vortex motion. Although the complete picture (of influence of pancake vortices on JVFB) is yet to be emerged, our data are expected to provide valuable information on the interaction between Josephson and pancake vortices.

Dp-196 **Observation of macroscopic quantum tunneling in intrinsic Josephson junctions of $Bi_2Sr_2CaCu_2O_{8+x}$** LEE Gil-Ho, PARK Jung-Hwan[1], KHIM Zheong Gu[1], LEE Hu-Jong(*Department of physics, Pohang University of Science and Technology, Korea. [1]Department of Physics and Astronomy, Seoul National University, Korea.*) Macroscopic quantum phenomena are expected in a superconductor as superconducting electrons form a single quantum state. According to the resistively and capacitively shunted junction (RCSJ) model, the dynamics of Josephson junctions can be described by the motion of a phase particle in a tilted washboard potential. The escape of a phase particle from the washboard potential determines the critical current of a Josephson junction. In this study, we measured the critical current distribution of $Bi_2Sr_2CaCu_2O_{8+x}$ intrinsic Josephson junctions (IJJs) down to 15 mK to examine the macroscopic quantum tunneling through the washboard potential barrier. The escape rate of the phase particle decreases with lowering temperature but is saturated at temperatures below about 100 mK as the phase particle transfers from the thermally activated escape regime to the quantum-tunneling escape regime.

Dp-197 **superfluid transition of SUBMONOLAYER HELIUM FILMs** KIM Eunseong, KIM Duk Young(*KAIST.*) The superfluid transition temperature of two dimensional helium films adsorbed on porous media decreases linearly as the film thickness is decreased. This result shows good agreement with Kosterlitz-Thouless transition. However the first few atomic layers of a helium film do not participate in superflow and effectively localized due to the disorder and the van der Waals interaction of porous media. This strongly adsorbed helium film is called the inert layer. Sarfatt suggested in 1969 [1] that adsorbed solid helium films, at coverages below the value for onset of conventional superfluid film behavior, constitute possible candidate for a supersolid system. In order to examine superfluidity in the inert layer helium films we employ a torsional oscillator technique. Here we will present preliminary results on two dimensional solid helium films.
[1] J. Sarfatt, Phys. Lett. A 30, 300(1969)

Dp-198 **Analysis of effect of Gd and Yb ions on magnetic properties of $RuSr_2RECu_2O_8$ sintered sample** AHMAD Dawood,

김 영철, 안 승수, 박 인석, 김 건철(*부산대학교 물리학과.*) The magnetic susceptibility, M-H plot of $RuSr_2RECu_2O_8$ (Gd, Yb) superconductor are measured. Magnetic transition temperature $T_{mag,,}$ superconducting transition temperature T_c and upper critical field Hc_2 of both samples are obtained from these measurements. We have found that T_{mag} = 140K, T_c of both sample for Gd is 23K and for Yb is 25K respectively. Hc_2 (0) >30 T in both samples. These values have been compared with other ruthenate superconductors and results have been discussed on the basis of physical properties of our samples.

Dp-199 **AB INITO STUDIES ON INTERACTION BETWEEN CARBON NANOTUBES AND VARIOUS ORGANIC MOLECULES** PARK SoHee, KONG Ki-jeong, SO Hye-Mi, LEE Jeong-O, CHANG Hyunju(*Korea Research Institute of Chemical Technology.*) Single-walled carbon nanotubes (SWNTs) have been studied widely with experimental and theoretical interests in their various applications. Particularly, chemical treatment of carbon nanotubes with various molecules has been intensively investigated, because it is regarded to afford a significant breakthrough in many applications, such as sorting of NTs with their chiralities, chemical and biological sensors and nanodevices. Recently, it was reported that some electrophilic molecules could attack the SWNTs selectively depending on their chiralities[1]. However, the interactions between the SWNTs and these electrophilc organic molecules have not been clearly understood yet. In this work, we will present theoretical results of systematic studies on the interactions between the SWNTs and the electrophilic molecules, such as 4-bromobenzene diazonium tetrafluoroborate (4-BBDT), 2,4,6-triphenylpyrylium tetrafluoroborate (2,4,6-TPPT), 1,3-benzodithiolylium tetrafluoroborate (1,3-BDYT), and benzendiazonium tetrafluoroborate (C6H5N2+Cl-)[2]. Firstly, we have investigated the binding energy of organic molecules to the outer wall of SWNTs with different chiralities. We have also investigated the size dependence of binding strength by carrying out a series of total energy calculations on the organic molecules interacting with the various sizes of SWNTs. We will also discuss the change of electronic properties, such as the amount of charge transfer and the change of density of states around the Fermi energy.

Dp-200 **Structural Analysis of Phospholipid Membaranes; Neutron and X-ray Scattering Study** JING H.Y., 문 준혁[1], 김 만원[1], 홍 대현, 최 동진, 서 영수[2], 김 기연[3], 이 정수[3], 신 관우(*서강대, 화학과및 바이오융합. [1]KAIST, 물리학과. [2]세종대, 나노공학과. [3]KAERI.*) Vertically oriented phospholipids bi- and multi-layers composed of the two differently charged lipids, PC and PS, with different mixed composition, were prepared by self-assembly method on a hydrophilic Si substrate. X-ray reflectivity data show the effect of composition, as well as the average charge density, on the structure of the repeatedly stacked multilayers. Then in-suit neutron reflectivity measured in liquid cell, where the peptide solution was served as the buffer solution, was used to probe the penetration process of CPP peptides into the mixed bi- and multi-layers. Using X-ray reflectivity, neutron reflectivity and atomic force microscopy we could monitor structural changes of lipid layers upon peptide adsorption. Some analysis will be given in details, which will help us to understand the interaction mechanism between peptides and biomembranes in biological system.

■ SESSION P3
10월 19일(금), 13:00 - 14:45
장 소: 5층 포이어

Ep-071 **임피던스 매칭에 의한 RFID 안테나 설계 및 제작** 이 동엽, 김 준호(*인천대 물리학과.*) UHF 대역의 RFID 안테나 설계와 제작을 하였다. 안테나 제작시의 에러와 안테나 부착시의 다양한 유전상수를 가진 물체를 가정하여서 밴드폭이 큰 안테나를 HFSS를 이용하여 설계를 하였고 Gen2 칩을 사용하여서 안테나 태그를 제작하였다. 제작된 안테나 태그는 리더기와 연동하여서 거리에 따른 인식율 테스트를 수행하였는데 1 m 이상의 거리에서 인식율이 우수하게 나타났다.

Ep-072 **무수은 평면형광램프(Flat Fluorescent Lamp)의 상판 형광막에 따른 방전특성** 문 희송, 이 상목, 정 규용, 손 인호[1], 정 진구[1], 서 정헌[2], 손 상호(*경북대학교 물리학과. [1]유엔아이. [2]경북대학교 물리교육.*) 수광형 디스플레이인 LCD는 Back Light와 같은 광원을 필요로 한다. 그 중 무수은 평면형광램프(Flat Fluorescent Lamp)를 제작, 상판에 CL(CathodeLuminescence)용 형광체 Paste를 이용한 형광막을 형성하여 방전 특성을 살펴보았고 상판에 형광막을 형성하지 않은 패널과 PL(PhotoLuminescence)용 형광막을 형성한 패널을 제작하여 방전 특성을 비교 분석하였다. 상판 형광막 형성은 Screen Print법으로 하였고 형광체는 CL용으로 ZnS:Ag, PL용으로 $BaMgAl_{10}O_{17}$:Eu를 사용하였다.

Ep-073 **필름격자를 이용한 광섬유 가속도 센서** 이 윤재, 서 대철[1], 이 남권[1], 김 치엽[1], 이 대수[1], 권 일범[1], 조 재흥[2](*한남대학교 물리학과, 한국표준과학연구원. [1]한국표준과학연구원. [2]한남대학교.*) 구조물의 진동을 측정하기 위하여 저가의 광섬유 센서를 개발하였다. 이 센서는 LED, PD, POF(Plastic Optical Fiber) 그리고 출력 광을 변조시키는 역할을 하는 필름 격자가 부착된 외팔보로 구성된다. 동작원리는 다음과 같다. LED에서 나온 광이 입력 광섬유에서 필름 격자를 통과하여 출력 광섬유를 통해 PD로 도달한다. 외팔보가 외부 힘에 의해 진동하게 되면 입출력 광섬유 사이의 필름 격자에 의해 출력 광의 세기는 정현파 형태로 변조된다. 이 때 출력 광의 변조 특성은 필름 격자의 격자 간격, 외팔보의 진동속도 등에 좌우된다. 두 개의 광원을 사용하고 각각의 광 경로상의 필름 격자를 서로 엇갈리게 하면 일정한 위상차를 갖는 2개의 광 출력을 얻을 수 있다. 신호 처리를 과정에서 아크탄젠트 함수로부터 구한 위상을 위상 연속화를 통해 외팔보의 변위를 계산하고, 이렇게 구한 변위를 외팔보의 변위와 가속도 사이의 관계식을 통해 가속도를 측정할 수 있었다.

Ep-074 **PSM 표면에 알부민을 흡착시킬 때의 반사율 및 PL 측정** 김 한중, CHENG Horchhong, 이 기원, 김 영유(*공주대학교 물리학과.*) 다공질규소를 이용하여 알부민 센서를 제작하기 위해 PSM(porous silicon microcavity)을 제작하고, 알부민 흡착에 따른 PL 및 반사율 특성을 조사하였다. PSM 표면에 알부민을 흡착시키면 PL의 세기는 감소하고 발광중심파장은 red shift 되었다. 그리고 특정파장에서 반사율의 세기는 감소하였으며 red shift 되었다. 이 때 알부민의 농도를 증가시키면 red shift 정도가 증가하였다.

Ep-075 **단층 다공질규소의 표면에 알부민을 흡착시킬 때의 반사율 및 PL 측정** 김 한중, CHENG Horchhong, 최 선혜, 이 기원, 김 영유(*공주대학교 물리학과.*) 다공질규소(porous silicon)를 이용하여 사람 혈청 알부민(human serum albumin)을 감지할 수 있는 단백질 센서를 개발하기 위해 단층 다공질규소의 알부민 흡착 특성을 조사하였다. 다공질규소 제작시 양극산화시간과 전류밀도를 변화시켜 다공질규소층의 두께와 크기가 다른 기공(pore)을 가진 다공질규소를 제작하여 알부민 흡착에 따른 가시광선 영역의 반사율과 PL을 측정하였다. 그 결과 알부민 흡착시 반사율의 세기가 감소하고 red shift 되었으며, 특정파장에서의 봉우리가 2중으로 나누어졌다.

Ep-076 **Optimizing Study of Thermal Analysis Parameters to High-Current Radioisotope Targets** KIM J. H., KIM Sang-Rok[1], PARK Hyun(*한국원자력의학원. [1]한일원자력.*) Since extremely large quantities are involved in the commercial production of medical and industrial radioisotopes, the proton beam intensities are pushed as high as possible to maximize production yields. Past production has been limited by the cyclotron capacity (energy and beam intensity) in most cases. However, with the introduction of a new generation of high-intensity proton linear accelerator (LINAC) capable of delivering several 10 mA of 100-MeV protons, the maximum rate at which radioisotopes can be produced is now limited by the thermal performance of the targets. Like several other solid target designs, the one employed at KIRAMS for the production of radioisotopes such as Ga-67 and Tl-201 is based on a system in which an enriched solid target material is plated onto a water-cooled backing plate. Therefore, target failure results in the loss of a substantial amount of expensive target materials. Hence, in practice, the beam current limit chosen for a particular target design tends to be rather conservative in order to prevent such failures. In this work, a parameter study of the target under proton bombardments was conducted with the aim of finding ways to increase the beam current limit associated with the present target design and to optimize future designs. Finite-element-analyses (FEA) were made of the heat flux and the temperature distributions in the target under different operational conditions by means of a computer program. The target configuration employed at Los Alamos National Laboratory (LANL) was taken as an initial condition (proton energy: 100 MeV, average beam current: 250 uA, and average beam power: 25 kW). The results of the parameter study are presented and are discussed in terms of maximizing the beam current limit on the target.

Ep-077 **광음향 효과를 이용한 탄소나노튜브/에폭시 복합소재의 열확산도 측정** 이 재란, 김 석원(*울산대학교, 물리학과.*) 오늘날 에폭시를 이용한 복합재료(epoxy-based composite)는 접착성, 경량성, 화학 및 부식에 대한 우수한 저항성으로 항공산업과 자동차 산업에 많이 사용되고 있으며 이러한 소재의 다양한 활용을 위해 기계적, 물리적, 화학적 특성 연구가 활발하게 진행되고 있다. 본 연구에서는 소재의 특성 연구의 한 부분으로 탄소나노튜브/에폭시 복합소재의 열적 특성을 조사하였다. 본 연구에서는 에폭시에 0 ~ 2 mass% 범위 내의 CNT(carbon nano tube)를

함유한 탄소나노튜브/에폭시 복합소재에 전자빔의 조사선량을 차등화 하여 조사한 후 광음향 분광법을 이용하여 시편의 면에 수직한 방향의 열확산도를 측정하였다. 직경이 11.5 mm인 원반형으로 제작된 시료에 입사되는 광은 파장 532 nm인 Nd:YVO_4 레이저이고 이를 Beam Expender로 직경 12 mm로 확대해 chopper를 이용하여 주파수 5 Hz ~ 200 Hz로 변조하였다. 입사되는 변조 광에 의해 시료에서 발생되는 광음향 신호의 진폭과 위상차를 마이크로폰(B&K 4192)과 Lock in Amp(SR5110)로 측정하여 전자빔 조사선량에 따른 열확산도를 결정하고 분석하였다.

Ep-078 **Biosensors using porous aluminum oxide** 강 봉근, 여 운진, 유 경화(*연세대학교 물리학과.*) We have fabricated biosensors using porous aluminum oxide (PAO) and electrical property measurements. PAO was fabricated by anodixing aluminum films and gold was deposited on the surface of PAO to immobilize antibodies and thiolated DNA molecules. Biomolecules such as hepatitis B antigen and thrombin were detected by measuring the change of capacitance and conductance. The change of electrical properties is probably resulted from the blocking of PAO pores due to antibody-antigen or aptamer-thrombin bindings. The sensitivity of this biosensor could be improved by reducing the pore size of PAO.

Ep-079 **Electrical transport properties of carbon nanotube networks and electrodeposited polypyrrole/single-walled carbon nanotube networks** 김 지헌, 오 제승[1], 장 영욱, 유 승환, 최 향희[1], 유 경화(*연세대학교 물리학과. [1]연세대학교 나노메디컬센터.*) We have investigated electrical transport properties of carbon nanotube networks (CNT-NETs) with different densities. The dense CNT-NETs were prepared by a contact printing method and the spare CNT-NETs were fabricated by direct growth using CVD on ferritin spin-coated substrates. The temperature dependence data of electrical conductance indicated that electrical transport of dense CNT-NETS is dominated by metallic channels, where that of spare CNT-NETs by semiconducting paths. In addition, We have also studied the influence of electrodeposited polypyrrole (PPy) on the electrical transport properties of CNT-NETs since PPy modification has been used to improve the sensitivity of CNT based chemical sensors. Depending on the thickness of PPy, different temperature dependences of the conductance were found. The measured data have been interpreted using a fluctuation-induced tunneling model.

Ep-080 **Bioelectric impedance spectroscopy to monitor cell proliferation and apoptosis** 이 리미, 최 향태[1], 연 수인[2], 신 전수[2], 김 건홍[1], 유 경화(*연세대학교 나노메디컬 협동과정. [1]연세대학교 의과대학 생화학-분자생물학 교실. [2]연세대학교 의과대학 미생물학 교실.*) We have investigated the time dependence of impedance spectroscopy during cell proliferation and apoptosis. Three different kinds of cells such as NIH3T3, Hela, TE2 cells were loaded between two Au electrodes with a gap spacing of 50 mm and incubated at 37°C in CO_2 atmosphere. In order to induce apoptosis, H_2O_2 was added in the case of NIH3T3 cells, whereas TRAIL was used for Hela and TE2 cells. The impedance between two electrodes exhibited different behaviors depending on the frequency; as the cells grew, the impedance at 0.1 kHz decreased, but it increased at 1 kHz. Possible origins of frequency dependence of impedance are discussed. During the apoptosis, the time dependence of impedance was found to be dependent on the concentration of H_2O_2 or TRAIL. This result implies that impedance spectroscopy can be applied for drug screening.

Ep-081 **DNA Sensor using Pt-Decorated Carbon Nanotubes** 김 창호, 양 정도, 황 성식, 유 승환, 최 향희, 유 경화(*연세대학교 나노메디컬국가핵심연구센터.*) We have fabricated biosensors based on Pt-decorated carbon nanotube field-effect transistors (CNT-FETs) for the detection of DNA hybridization. Since thiolated DNA molecules are easily bonded with Pt, Pt was decorated on CNTs by a spontaneous electroless deposition to improve the sensitivity. DNA hybridization was monitored by measuring the electrical properties of the CNT-FETs in real time. When complementary DNA molecules to the target ones were added, the conductance decreased and then saturated gradually. For comparison, we have performed similar measurements with CNT-FETs without Pt decoration. Pt-decorated CNT-FETs have exhibited higher sensitivity than bare CNT-FETs. Possible origins of improved sensitivity are discussed.

Ep-082 **Thermoelectric power of individual single-crystalline Bi nanowires** LEE Seunghyun, ROH Jongwook, HAM Jinhee, LEE Yeniseul, KIM Haeyoung, JEON Kyejin, LEE Wooyoung(*Department of Materials Science and Engineering, and National Core Research Center for Nanomedical Technology, Yonsei University, Seoul, Korea.*) High-efficient thermoelectricity requires materials with a large figure of merit, ZT, defined by $ZT = \sigma S^2 T/\kappa$, where σ is the electrical conductivity, S the thermoelectric power, and κ the thermal conductivity. However, due to interdependence of σ, S, and κ, the optimization of thermoelectric properties remains still challenging. The thermopower S can be improved by the reduction of dimensionality from 3D to 1D, giving rise to a dramatic increase in the electronic density of states (DOS) at near energy band edges. In the present work, we report the thermoelectric power (TEP) and electrical conductivity of individual single-crystalline Bi nanowires made by a novel spontaneous growth method. Single-crystalline Bi nanowires were grown onto an as-sputtered Bi thin film by heat treatment at 270 ℃ for 10 hours. The growth of Bi nanowires is attributed to thermal expansion mismatch between the Bi film and a thermally oxidized Si substrate. The Bi nanowires were dispersed onto a SiO_2/Si substrate whose underlying high-doped Si layer was used as a back gate. Electrical contacts to a nanowire among them were defined using a combination of photolithography, electron-beam lithography and a lift-off process. A micro-heater was fabricated to be adjacent to one of the nanowire-electrode contacts. The heat generated by the local heater initially propagates through the silicon oxide layer (1 ㎛ thick), creating a temperature gradient across the Bi nanowire and the surface of the substrate to which it is thermally anchored. The temperature of

the Bi nanowire-electrode junctions was monitored by the resistance changes of the thin electrodes by the four-probe method. These resistance changes were mapped to the temperature changes of junction electrodes later by measuring resistance changes of electrodes at different temperatures at equilibrium. The resultant temperature gradient across the Bi nanowire was found to be 0.1 - 0.5 K/mm, while typical power consumption in the micro-heater was less than 100 mW. The thermoelectric voltage across the Bi nanowire can be readily measured using the electrode contacts with a lock-in amplifier. The modulation of thermoelectric power of individual single-crystalline Bi nanowires by electric-field effect will be also presented.

Reference [1] Arun Majumdar, Science 303, 777 (2004) [2] Joshua P. Small, Li Shi, Philip Kim, Solid State Communications. 127, 181 (2003)

Ep-083 **pH sensors using carbon nanotube networks** 황성식, 장영욱[1], 오제승, 강봉근[1], 최향희, 유경화[1](*연세대학교 나노메디컬센터. [1]연세대학교 물리학과.*) We have fabricated pH sensors using carbon nanotube networks (CNT-NETs). CNT-NETs were prepared using a spray method on slide glasses. Since the spray method produces relatively uniform CNT-NETs, most devices made from CNT-NETs have shown similar resistance values at room temperature. Particularly, 200 devices had the resistance values of the same order among 300 ones. To detect pH, CNT-NET devices were covered with microfluidic channels with the metal contacts passivated and the electrical conductance change was measured. As the pH value increased, the conductance increased. Moreover, most devices exhibited similar sensitivity, although CNT-NETs are random networks consisting of semiconducting and metallic carbon nanotubes.

Ep-084 **Ultra-high sensitive pH sensors based on Pd patterned structures** LEE Youngtaek, LEE Eunsong-yi[1], CHOI Wonjin[1], JEON Kyejin[1], LEE Wooyoung(*Department of Materials Science and Engineering, and National Core Research Center for Nanomedical Technology, Yonsei University, 134 Shinchon, Seoul 120-749, Korea. [1]Department of Materials Science and Engineering, Yonsei University, 134 Shinchon, Seoul 120-749, Korea.*) In the past decade, significant effort has been put towards development of the pH changes measurement techniques for environmental, biological, and biomedical applications. The pH sensors using Pd materials have some merits such as simple structure, enzyme free, fast response time, good selectivity and highly sensitivity. In the present work, we applied the sensing mechanism of Pd hydrogen gas sensor and the micro-sized patterned pH sensors based on the Pd hydrogen gas sensors successfully detect the hydrogen ions in the solution. A combination of E-beam lithography and a lift-off process was used in order to pattern Pd pH sensor (width = 5 μm, length = 5 μm). The Pd layer and SiO_2 were deposited using DC sputtering system. SiO_2 was used for the electrical passivation layer. A circlet window with 1μm diameter was fabricated on the passivation layer in order to absorb the hydrogen ions in the buffer solution. And we dropped buffer solution of pH4 on the circlet window and measured the real-time detection of electrical resistance by 4-probe measurement system. The 10 μA of sensing current was applied for the real-time detection. The initial resistance of the fabricated Pd pH sensor was 72Ω for DI-water. After dropping buffer solution of pH4, the maximum resistance was measured 88Ω of the resistance and 76s of the response time. That is the Pd patterned structure sensors were used to create highly sensitive (18%), fast response time (76s), and real-time electrically based sensors for pH. The sensitivity is defined $S=(R-R_0)/ R_0\times100\%$, where R and R_0 are real time resistance and initial resistance, respectively. The small size and capability of Pd patterned structure for sensitive, enzyme free, real-time detection of pH could be exploited in biochemical detection. The variation of the resistance in the patterned structure was observed to be reproducible for cycles of absorption and desorption of hydrogen ions to the Pd patterned structure in a few tens of second. When the pH buffer solution was dropped on the sensors, (1) hydrogen ions are absorbed on the Pd surface (hydrogen atoms of α phase) (2) absorbed hydrogen ions diffuse into the Pd interstitial sites, and (3) react with Pd atoms to form Pd-hydride (PdHx, β phase). The resistivity of PdH_x is higher then pure Pd, since absorbed hydrogen ions play a role as additional scattering sources. Our results demonstrate the possibility of implementing pH sensors for detection of hydrogen ions in the solution using micro-patterned Pd devices. Further studies will be extended to the fabrication of pH sensors using Pd nanowires for a variety of buffer solutions in order to improve the pH sensitivity and response time.

Reference [1] R. M. Penner, et al., Anal. Chem. 74, 1546 (2002). [2] M. H. Yun, et al., Nano Lett. 4, 419 (2004).

Ep-085 **Digital Quantizer With High Temperature Immunity** JUNG Sung-Woo, NOH Byung-Hoon, JEONG Yoon-Ha[1](*National Center for Nanomaterials Technology (NCNT). [1]National Center for Nanomaterials Technology (NCNT), Pohang University of Science and Technology (POSTECH).*) A new and simple digital quantizer scheme, based on the e-periodic transfer characteristics of a single electron box (SEB), is proposed in this letter. Digital quantizer performance is demonstrated using a Monte-Carlo simulator. This scheme can be used in digital logic to eliminate the effect of unstable input and to simplify the entire circuit. Additionally, the operation temperature of this scheme can be extended to 50K. The 4-bit analogue-to-digital converter (ADC) is implemented successfully to investigate the application of the proposed digital quantizer.

Ep-086 **Design and Manufacture of KIRAMS-30 RF System** JUNG In Su, AN Dong Hyun, KANG Joon Sun, JANG Hong Suk, YANG Tae Keun, LEE Min Young, HONG Sung Seok, CHAI Jong Seo, KWON Key Ho[1](*KIRAMS. [1]SKKU.*) Particle Accelerator Development Team in KIRAMS developed KIRAMS-13, a 13MeV medical cyclotron, for Positron Emission Tomography(PET) in 2001. Now, KIRAMS-13 has spread to the provinces through the national project, "Development of Cyclotron and FDG Synthesis modules." But, there is just one cyclotron for

Single Photon Emission Computed Tomography(SPECT) in Korea, which is made by IBA, Belgium. So, KIRAMS set up a research project of 30MeV Cyclotron development. named KIRAMS-30. It has high-performance compared with commercial cyclotrons and was installed in Advanced Radiation Technology Institute(ARTI) to product radioactive isotopes. In this paper, we show a RF system design and manufacture of KIRAMS-30.

Ep-087 **비휘발성 메모리용 이중 컨트롤 층 구조의 금속 산화물 나노 부유 게이트 캐패시터 제작 및 전기적 특성 연구** 김 선필, 이 동욱, 이 태희, 김 은규, 김 영호[1](*한양대학교 물리학과. [1]한양대학교 신소재공학과.*) 금속박막과 폴리아믹산 (polyamic acid)의 금속 산화반응을 이용하여 자발형성된 금속산화물 나노입자를 나노 부유게이트 메모리 (nano-floating gate memory) 구조에 응용하는 연구가 그동안 진행되어 다. 이 방법은 7 nm 크기의 금속 산화물 나노입자를 단일층으로 균일하게 제작이 가능하고 동시에 50 nm 두께의 폴리이미드 층을 컨트롤 층으로 사용할 수 있다. 하지만 폴리이미드는 저유전체 물질이어서 비휘발성 메모리 소자의 제작에 있어 소자 크기조절에 제한이 있음이 확인되었다.본 연구에서는 이러한 단점을 보완하기 위하여 폴리이미드층을 30 nm 이하로 줄이고 그 위에 실리콘 산화층(SiO_2)을 20 ~ 30 nm 증착하여 이중 컨트롤 층을 형성하여 그 전기적 특성을 연구하였다. 실험에 사용한 폴리이미드 물질은 Dupont사에서 제조된 BPDA-PDA (biphenly dianhydride - paraphenylene diamine) 계열의 PI-2610D 이다. 제작된 소자는 전기적 특성분석을 위하여 제작된 시편에 알루미늄 게이트를 150 nm 증착시켜 전기용량-전압 특성을 HP4280A 와 Boonton 7200을 사용하여 분석하였다.

Ep-088 **Fabrication and characterization of nonvolatile nano-floating gated memory device with self-assembled metal-oxide nano-particles** LEE Dong Uk, KIM Seon Pil, LEE Tae Hee, KIM Eun Kyu, KOO Hyun-Mo[1], CHO Won-Ju[1], KIM Young-Ho[2] (*Quantum-Function Spinics Lab. and Department of Physics, Hanyang University. [1]Department of Electronic Materials Engineering, Kwangwoon University. [2]Division of Advanced Materials Science and Engineering, Hanyang University.*) As the demands of high density integration and high performance nonvolatile memory for the applications of portable electronic devices are continuously increasing, the nano-crystal memory is proposed as one of the next generation non-volatile memory devices due to the lower operation voltage and the better scalability. In this study, the nano-floating gated memory devices consisting of metal-oxide nano-particles and polyimide gate insulator were fabricated on the p-type (100) UNIBOND silicon-on-insulator wafers with a 100 nm top silicon layer and a 200 nm buried oxide layer. The phosphorus in-situ doped poly-Si layer of 100-nm-thick was deposited on the top Si by low pressure chemical vapor deposition method at 650 ^{o}C for source and drain regions. The metal-oxide nano-particles were created by chemical reaction between BPDA-PDA polymer precursor and metal film. The curing process was carried out at 400 ^{o}C for 1 h after a soft baking of 135 ^{o}C for 30 m in the rapid thermal process (RTP) system in N_2 ambient. The electrical property was characterized by using capacitance-voltage, current-voltage and retention time measurement. The transmission electron microscopy and the selected area diffraction patterns were measured also to investigate the morphology of the metal-oxide nano-particles embedded in polyimide layer.

Ep-089 **Highly Sensitive Hydrogen Sensors Using Pd Nanowires Array Fabricated By Electron-Beam Lithography** CHO Chunghwan, LEE Eunsong-yi, LEE Junmin, JEON Kyejin, LEE Wooyoung(*Department of Materials Science and Engineering, Yonsei University, 134 Shinchon, Seoul 120-749, Korea.*) The Pd nanostructures such as nanowires, nanochains, and nanotubes, have recently attracted considerable interests due to the possibility of hydrogen sensor applications. Although there have been a few recent efforts to describe the hydrogen sensing performance in Pd nanostructures, to date, hydrogen sensing performance in Pd nanowire array for hydrogen sensing have not been studied. In this work, we have investigated hydrogen sensing properties of Pd nanowires array fabricated by electron-beam lithography from sputtered Pd thin films. Pd thin films were deposited on a thermally oxidized Si(100) substrate in a dc magnetron sputtering system with a base pressure of 4×10^{-8} Torr. A combination of electron beam lithography and a lift-off process has been utilized to fabricate arrays of Pd nanowires (w = 300 nm, l = 10 μm) from continuous Pd films with t = 60 – 400 nm. In our previous study, lithographically patterned Pd nanowires with w = 300 nm and t = 60 – 400 nm were found to detect hydrogen gas in the H_2 gas concentration range 20 – 20,000 ppm at room temperature by measuring the change of electrical resistance in the nanowires. Although the lithographically patterned Pd single nanowires were found to show low detection limit (20 ppm) and fast response time (~ 10 seconds), they were observed to be damaged by repeated cycling of hydrogen absorption and desorption. From a technological viewpoint, Pd nanowires array is more advantageous than individual nanowires. The origin of the nanowires thickness dependence for H_2 sensing performance will be addressed in detail. The effects of thermal annealing of the Pd nanowires array will be also discussed.

Reference [1] F. A. Lewis, The palladium hydrogen system, Academic press, New York (1966) [2] J. RaviPrakash, et al., Sens. and Actu. 120, 439 (2007)

Ep-090 **음향방출(AE) 신호를 이용한 프레스 공정에서의 불량품 검출을 위한 다양한 신호 분석** 김 석원, 이 원규[1], 김 동훈[1], 박 상진[1], 김 인구, 이 제홍(*울산대학교, 물리학과. [1]울산대학교, 기계자동차공학과.*) 자동 프레스공정에서 연속 생산 시 crack이나 scrap 상승으로 인하여 불량품이 발생하게 된다. 그 결과 불량 제품이 연속적으로 생산되고 프레스의 금형에도 큰 손상을 주게 된다. 이러한 문제점을 해결하기 위해 실시간으로 불량품 검출을 하면서 이와 더불어 프레스 금형의 파손을 사전에 예방하고자하여 AE 센싱 시스템을 도입하였다. 본 연구에서는 프레스 공정 시 발생하는 음향방출(AE, Acoustic Emission) 신호를 프레스의 중량과 가공방법에 따라 음향센서, 프리앰프, AE 보드를 사용하여 수집하고, 시간에 따른 다양한 신호를 AE WIN software를 사용하여 정상파와 불량 파를 비교 · 분석하였다. 그 결과, 프레스 중량과 프레스 가공 방법에 따라 기준이 되는 음향방출 신호의 크

기와 모양이 차이가 나는 것을 확인할 수 있었다. 이러한 특성을 이용하여 프레스에서 발생되는 음향신호를 실시간으로 분석한 후 프레스 공정에 feedback하여 불량 발생 시 전체 공정을 제어할 수 있는 자동화 시스템 기술을 개발하고자 한다. 향후 본 연구의 결과를 바탕으로 프레스 공정 외에 산업체 전반에서 사용되는 다양한 기계장치에 적용될 수 있도록 Labview와 같은 상용화된 프로그래밍 언어를 사용하여 간편하면서도 효과적인 자동화 시스템을 구성하고자 한다.

Ep-091 **The Influence of Dopant on the Dielectric and Electrical Properties of Layer Structured Bismuth Lanthanum Titanate Ceramic with Tungsten Doping** KIM Yu Sung, KIM Jin Soo, FU Zuo Ling, CHOI Byung Chun, JEONG Jung Hyun(*부경대학교 물리학과.*) To investigate the effects of ion doping, W-doped bismuth lanthanum titanate (BLTW) ceramics were prepared by using a solid state reaction method. Dielectric dispersion and electrical properties on temperature and frequency dependence were studied by using a complex dielectric constant and electrical conductivity, respectively. A strong low-frequency dielectric dispersion of BLTW ceramics remarkably decreased by W doping, and the electrical conductivity decreased. The ac complex impedance Cole-Cole plot exhibited on semicircle, which indicated the bulk properties of grain. A schematic model of the BLTW ceramics was described by the equivalent circuit. Compared to that of BLT, the electrical conductivity of BLTW ceramics decreased. The W doping on BLT must give a lower conductivity to improve the ferroelectric properties, which explained by ion doping and defects.

Ep-092 **유전율이 높은 세라믹안테나의 이득증가 방법에 관한 연구** 강 준희, 정 용섭, 정 대민, 양 형우, 손 지명[1], 김 진영[1], 김 동근[2](*인천대학교, 물리학과. [1]키스컴. [2]문화화인세라믹.*) RFID(Radio Frequency IDentification)는 유비쿼터스의 가장 기본이 되는 기술로서 바코드 기술을 대체할 수 있으며 다양한 응용분야에 접목이 가능하다. 현재 RFID 이동형 제품의 경우 안테나와 리더가 일체형으로 구성되기 때문에 작고, 가벼운 세라믹안테나를 많이 사용하고 있으나, 세라믹안테나는 유전율이 높아 안테나의 이득이 감소하는 문제점이 발생한다. 이러한 안테나의 이득 감소는 인식 거리의 감소에 직접적으로 영향을 주게 된다. 본 연구에서는 이동형 제품의 세라믹안테나 이득을 증가시키는 방법으로, 안테나 후면 케이스에 금속재질을 추가하였다. 이득증가 비교를 위하여 안테나 후면 케이스에 금속재질의 추가 유무에 맞추어 세라믹안테나를 각각 제작하였다. 금속 재질 미추가 시 중심주파수인 912MHz에서 -25dB 이하의 S11 특성을 보였으며, 축비는 1.8dB, 이득은 -0.7dBi 으로 관측되었다. 금속 재질 추가 시 중심주파수인 912MHz에서 -20dB 이하의 S11 특성을 보였으며, 축비는 1.6dB, 이득은 1.8dBi 였다. 본 연구의 결과로 안테나 후면 케이스에 금속 재질 추가 시 안테나의 이득이 2.5dBi 증가하는 것을 발견할 수 있었다.

Ep-093 **Photoconductivity enhanced by single-walled carbon nanotube network in solar cells based on poly[3-hexylthiophene]** LEE Cheol Eui, KIM Nam Kyoon, YOON Sungmin, LEE Kyuwon, LEE Eunmo(*Department of physics, Korea University.*) We have studied photoconductivity enhanced by single walled carbon nanotube (SWCNT) network in solar cells based on poly[3-hexylthiophene] (P3HT) and (6,6)-phenyl-C_{61} butyric acid methyl ester (PCBM) by means of electrical and photoluminescence measurements. The SWCNTs act as hopping centers for hole transport as well as exciton dissociation sites. Hydrophilic solvent was employed in order to avoid difficulties in forming homogeneous thin films due to strong intertube van der Waals attraction.

Ep-094 **Simultaneous Detection of Tumor Markers Using Ultra-long Carbon Nanotube Devices** PARK Dong-Won, SO Hye-Mi[1], HWANG Jea-Ho[1], JEON Eun-kyoung[1], KIM Byoung-Kye[2], BUH Gyoung-Ho[1], KONG Ki-jeong[1], CHANG Hyunju[1], KIM Beom Soo, KONG Jing[3], LEE Jeong-O[1](*충북대학교, 화학공학과. [1]한국화학연구원, 융합바이오기술연구센터. [2]전북대학교, 물리학과. [3]Massachusetts Institute of Technology, Dept of Electrical Engineering &Computer Science.*) For the simultaneous detection of multiple tumor markers, we have fabricated ultra-long carbon nanotube sensors that can detect carcinoembryonic antigen (CEA) and prostate specific antigen (PSA), simultaneously. Ultra-long carbon nanotubes, several millimeters long, were grown by ethanol CVD, and fabricated as FET sensors by using conventional photolithography. To functionalize each segment of a single ultra-long nanotube device with multiple-tumor markers, we first functionalize the entire device with CDI-Tween 20 linking molecules, and then immobilized CEA and PSA antibodies using the microfluidic channel. The electrical conductance from CEA-antibody functionalized and PSA-antibody functionalized segment of a ultra-long carbon nanotube device was monitored simultaneously with Ag/AgCl reference electrode as a liquid gate. Clear decrease of conductance observed from PSA-functionalized segment when we applied diluted PSA solution in 10 mM PBS. We will discuss the advantages of long-nanotube device in detail

Ep-095 **3-D package 공정에서 Cu의 확산을 방지하는 W-C-N 확산방지막에 대한 연구** 김 수인, 이 창우[1](*국민대학교 물리학과. [1]국민대학교 나노전자물리학과.*) 반도체 소자 집적도 향상을 위하여 반도체 Package 공정에서는 기존의 평면 공정에서 입체 공정인 3-D package 공정으로 변경되어 반도체 집적도를 향상시키고 있다. 또한 3-D package 공정에서는 RC 지연을 방지하기 위하여 금속 배선을 비저항이 낮은 Cu 금속 배선 공정을 사용하고 있다. 하지만 Cu는 저온에서 쉽게 Si과 반응하여 반도체 소자에 여러 가지 문제점을 발생 시킨다. 이러한 문제점을 개선하기 위하여 Cu와 Si기판 사이에 Cu의 확산을 방지하는 확산방지막에 대하여 연구가 진행되고 있다. 따라서 본 연구에서는 3-D package에 적용되는 Cu의 확산을 방지하기 위하여 질소와 탄소를 첨가한 3개의 화합물로 구성된 Tungsten-Carbon-Nitrogen (W-C-N) 확산방지막을 사용하였다. 실험은 물리적 기상 증착법(PVD)으로 질소비율을 변화하며 확산방지막을 증착하였고, 이를 여러 가지 온도에서 열처리하여 열적인 안정성에 대한 실험을 실시하였다. 결정구조를 확인하기 위하여 X-ray Diffraction 분석을 하였으며, Si/W-C-N 확산방지막 위에 Cu를 증착하여 Cu와 Si 기판 사이에서의 확산방지막의 특성을 연구하였다.

Ep-097 **플라즈마 충격에 의한 PR stripper 활성화에의한 효율적인 Photoresist 제거 연구** 김 수인, 이 창우[1](*국민대학교 물리학과. [1]국민대학교 나노전자물리학과.*) 반도체 소자 생산성 향상을 위하여 Si 웨이퍼의 크기는 비약적으로 발달하여 현재 300mm 웨이퍼 공정에 이르게 되었다. 이러한 웨이퍼 크기 발달과 더불어 소자 선폭도 급속하게 감소하였다. 이러한 선폭의 감소로 인하여 기존 식각 공정에서 식각 후 남은 잔여 PR residue는 소자 생산에 큰 영향이 없었으나 현재는 이러한 residue는 소자에 치명적인 문제를 발생 시킨다. 또한 이러한 residue를 제거하기 위한 공정 증가로 소자의 생산성이 줄어들게 되었다. 따라서 반도체 공정에서는 이러한 residue를 효과적으로 제거하는 기술의 개발이 필요하게 되었다. 본 논문에서는 세정액 분자에 플라즈마 충격을 가하여 세정액을 활성화함으로써 세정 능력을 극대화 할 수 있도록, 그리고 세정공정 시간을 단축시키기 위한 연구를 진행하였다. 또한 각 세정공정마다 증가한 세정 공정으로 인하여 세정액의 사용이 많아져 세정액 폐수로 인한 환경문제가 심각해지고 있다. 세정액 충격을 이용한 세정액 활성화 방법을 사용함으로써 세정액의 절감효과가 높은 것이 확인되었다.

Ep-098 **Quasi-persistent photocurrent in the composite of conjugated polymers and fullerenes** LEE Cheol Eui, YOON Sungmin, KIM Nam Kyoon, LEE Kyuwon, LEE Eunmo (*Department of physics, Korea University.*) In the last decade, a large amount of attention was given to the so-called bulk heterojunction solar cells based on a blend of P3HT (poly[3-hexyl thiophene]) and PCBM ([6,6]phenyl C_{61} butyric acid methyl ester). The quasi-persistent photocurrent of P3HT/PCBM thin films as a function of temperature under continuous wave illumination were characterized in this study. Also, the open-circuit voltage (V_{OC}) was investigated for different temperatures. Measurements of the light absorption, photoluminescence, and I-V characteristics are used to study the photocurrent and its decay.

Ep-099 **트윈 타겟 스퍼터 시스템을 이용하여 PEN 기판 상에 성막한 플렉시블 전면 발광 유기발광소자용 IZO/Al 애노드의 특성** 김 한기, 문 종민(*금오공과대학교 정보나노소재공학.*) 스퍼터링 공법은 손쉬운 컨트롤에 의한 공정상의 용이함, 높은 수율, 증착물질과 기판과의 탁월한 접합특성 그리고 대면적화의 용이함 등의 장점으로 인해 가장 널리 사용되고 있는 박막 증착법 중 하나이다. 그러나 플라즈마 형성 시 발생하는 강한 에너지를 가진 입자들의 충돌로 인해 기판부의 온도가 증가하게 되며 입자들의 물리적인 충돌로 인한 유기물질의 구조를 파괴하는 특성으로 인해 유기물 전자소자나 플렉시블 전자소자 제작으로의 응용이 어렵다고 알려져 있다. 본 연구에서는 플라즈마 노출에 의한 기판의 온도 상승을 최소화 시킬 수 있는 새로운 개념의 선형 트윈 타겟 스퍼터 시스템을 이용하여 전면발광 유기발광소자의 IZO/Al 다층 애노드를 제작하고 그 특성을 연구하였다. 선형 트윈 타겟 스퍼터 시스템은 서로 마주보고 있는 타겟사이에 일방향의 자장을 형성시킴으로써 플라즈마를 구속시킬 수 있는 스퍼터 공법으로 플렉시블 디스플레이 응용에 대한 관심이 높아지고 있다. 이를 이용하여 플렉시블 전면발광 유기발광소자용 Al 반사층과 IZO 애노드층을 PEN 기판 상에 성막하고 Al 반사층의 두께 변화에 따른 기계적, 광학적, 전기적 특성을 분석하였다. 선형 트윈 타겟 스퍼터 시스템을 이용하여 성막한 Al 반사층을 가진 Al/IZO 다층 애노드는 60 %에 가까운 반사율을 나타내었으며 저온 공정에도 불구하고 치밀한 비정질 구조의 박막의 성막할 수 있었다. 또한 IZO/Al/PEN 기판은 Bending test시 1000회 이상의 bending후에도 초기 저항을 유지하였으며 crack의 형성이 없는 안정한 구조를 나타내었다. 이를 이용하여 플렉시블 전면발광 유기발광소자를 제작하였으며 기존의 ITO/Ag를 이용한 전면발광 유기발광소자의 전류-전압-휘도 특성과 비교 분석 하였다.

Ep-100 **Characterization of Ni doped IZO anode fabricated by DC magnetron co-sputtering method for organic light emitting devices** 김 한기, 최 광혁, 정 진아, 배 정혁(*금오공과대학교 정보나노소재공학.*) Co-sputtering법을 이용하여 유리 기판 위에 Ni이 도핑된 유기발광소자용 Ni-IZO 애노드를 성막하고 유기발광소자의 적용가능성을 연구하였다. Co-sputtering 공정시 IZO의 성막 조건은 최적화된 일정한 조건을 (5mTorr, 100W, Ar=20 sccm) 유지하고 Ni 타겟의 파워만 변수로 조절하여 각각 1, 3, 5, 7W의 DC 파워를 이용해 투명 IZO 박막에 Ni을 도핑시켰다. 이렇게 제작된 IZO:Ni 투명전극의 Ni 파워 증가에 따른 전기적, 광학적, 구조적, 표면 특성을 분석하고 상온에서 성막된 a-ITO와 그특성을 비교하였다. 특히 3W의 파워로 Ni이 도핑된 IZO:Ni 전극의 경우 상온에서 제작하였음에도 불구하고 $4.0x10^{-4}$의 낮은 비저항 값을 나타내었다. 유기발광소자의 적용 가능성을 타진하기 위해 Ni이 도핑된 IZO, a-IZO 그리고 a-ITO 애노드를 이용하여 유기발광소자를 제작하고 그 특성을 비교 분석하였다. Ni이 도핑된 IZO 전극상에 제작된 유기발광소자가 가장 우수한 J-V-L 특성을 나타내었으며 이는 Ni이 도핑된 IZO 애노드 박막이 상용화된 ITO를 대치할 수 있는 가능성을 나타낸다.

Ep-101 **Characteristics of flexible ITO electrode on PET substrate grown by Roll-to-Roll (R2R) sputtering system for flexible optoelectronics.** 김 한기, 배 정혁, 조 성우, 최 광혁, 문 종민, 정 진아(*금오공과대학교.*) 플렉시블 광전소자의 기술진보와 더불어 가벼워 휴대하기 용이하고 휘어지면서도 디스플레이의 기능을 그대로 유지할 수 있는 플렉시블 디스플레이에 대한 관심이 날로 증대되고 있다. 플렉시블 디스플레이의 실현을 위해선 고분자 및 금속 박판 형태의 기판위에 투명 전극을 형성해야 하기 때문에 저온 성막 공정 기술이 필수적이며 이를 위해 Roll-to-Roll 스퍼터에 대한 관심이 높아지고 있다. 이에 본 연구에서는 직접 디자인한 Roll-to-Roll 스퍼터를 이용하여 플렉시블 디스플레이 전극에 적용할 수 있는 플렉시블 ITO 전극을 성막 하고 전기적, 광학적, 기계적, 구조적, 표면 특성을 분석하였다. 본 실험에 사용된 Roll-to-Roll 스퍼터는 선형 이온처리 장치와 선형 스퍼터건을 내장하고 있으며 Tension 조절 장치를 이용하여 PET 기판의 Rolling에 따른 Tension을 조절할 수 있다. 뿐만 아니라 Cooling 드럼을 이용하여 PET 기판의 온도를 저온으로 유지함으로써 저온 성막이 가능한 스퍼터 장치이다. 이를 이용하여 DC 파워, Ar/O2 비율, 작업압력 및 Rolling 속도를 변수로 상온에서 ITO 박막을 PET 기판위에 성막하고 그 특성을 일반적인 DC 스퍼터를 사용하여 제작한 ITO/PET 샘플과 비교 분석 하였다. 성막된 ITO 박막의 전기적, 광학적 특성을 알아보기 위해 Hall measurement 분석 및 UV/Vis spectrometer 분석을 각 각 진행 하였으며, 구조적 특성을 알아보기 위해 X-ray diffraction (XRD) 분석을 진행하였다. SEM분석을

통해 상온에서 성장된 ITO의 표면 특성을 관찰하였고, Bending 테스트를 통해 제작된 ITO 박막의 기계적 안정성을 평가하였다. 최적화된 ITO 박막으로부터 5.5×10-4Ω-㎝ 의 비저항 값과 가시광선 영역에서 약 80 % 이상의 투과율을 얻을 수 있었으며 Bending test 결과 1000회 이상 bending 시험에서 초기 저항을 유지하였다.

Ep-102 **Characteristics of Transparent Indium Gallium Zinc Oxide (IGZO) films prepared by co-sputtering method for flexible transparent thin film transistors** 김 한기, 정 진아(*금오공과대학교 정보나노소재공학.*) 플렉시블 광전소자의 기술진보와 더불어 가벼워 휴대하기 용이하고 휘어지면서도 기능을 유지할 수 있는 플렉시블 투명 트랜지스터에 대한 관심이 날로 증대되고 있다. 이에 본 연구에서는 차세대 비정질 투명 산화물 반도체로 알려진 비정질 인듐 갈륨 아연 산화물 반도체 박막을 Co-sputtering 방식을 이용하여 유리, PET, PEN 기판 상에 성막하고 그 특성을 분석하였다. Co-sputtering 타겟으로는 IGO (Ga2O3 5wt %doped In2O3)와 IZO (ZnO 5 wt % doped In2O3) 타겟을 이용하였으며 각각 DC 파워 변화에 따른 전기적, 광학적, 구조적, 표면 특성을 분석하였다. 특히 Hall measurement 분석을 통해 비정질 IGZO의 전기적 특성에 영향을 주는 스퍼터 공정 변수를 분석하였으며, X-ray photoelectron spectroscopy 분석을 통해 DC 파워 변화에 따른 IGZO 박막의 조성 변화를 분석하였다. 뿐만 아니라 고분자 기판 (PEN, PET)에 성막된 비정질 IGZO 박막의 bending에 따른 기계적 안정성을 분석하여 차세대 플렉시블 투명 트랜지스터용 active layer로의 가능성을 분석하였다.

Ep-103 **Spin Injection into a Semimetal** LEE Kyoung-il, LEE Wooyoung, CHANG Joonyeon[1], HAN Suk-hee[1], SHIN Kyung-ho[1], JEUNG Won Yong[1], JOHNSON Mark[2](*연세대학교 금속공학과. [1]한국과학기술연구원. [2]Naval Research Laboratory.*) Spin injection in spintronics has been a basic research topic of continuing interest, since the electrical spin injection from a ferromagnetic metal into a nonmagnetic metal was first demonstrated in bulk Al [1]. The observation of spin injection from a ferromagnetic semiconductor to a nonmagnetic semiconductor a nonmagnetic semiconductor has instigated major research efforts in these fields [2-4]. Recent spin injection experiments on Al films patterned into mesoscopic structures have shown a dramatic increase in the magnitude of the injected nonequilibrium spin population [5,6]. In the present work, the spin injection technique is extended to a new materials system, semimetals. The Spin transport in a spin-valve device incorporating Bi thin film and two ferromagnetic (FM) contacts, a spin injector ($Ni_{81}Fe_{19}$) and a spin detector ($Co_{84}Fe_{16}$), has been investigated by using a non-local geometry [1]. The non-local output voltage is found to depend upon the relative magnetization states of the two FM electrodes, indicating that the spin-polarized electrons are injected from the first FM (injector) into Bi, create a spin accumulation, and are detected by the second FM (detector) due to spin accumulation. From Using Johnson and Silsbee theory, the spin diffusion length in our thin semimetallic film is estimated to be δ_S ~ 230 mm at 2 K. We believe this is the first demonstration of spin injection and detection in a semimetal, and the observation of a longest value of the spin diffusion length justifies this to be an interesting materials system.

Ep-104 **얇은 반사막 층을 추가한 새로운 구조에서 초해상 ROM 광디스크의 재생 신호 연구** 김 덕호, 김 준서, 최 혁철, 유 천열, 곽 금철[1](*인하대학교, 물리학과. [1]LG Electronics Institute of Technology(LG-Elite).*) 초해상 광디스크에서는 기록 마크의 크기가 사용하는 광학계의 회절한계 보다 작기 때문에 재생신호의 세기가 충분치 않아 실용화에 어려움이 있다. 이에 온도에 따라 굴절률이 바뀌는 GeSbTe 층 등을 이용한 초해상 현상으로 재생신호를 증가시키고 있다. 본 연구에서는 일반적으로 사용되는 층 구조에 얇은 두께의 반사막층을 도입하여 Fabry-Perot 과 유사한 구조를 사용하여 재생신호를 크게 향상시킬 수 있음을 자체 제작한 FDTD(Finite-Difference Time-Domain) 전산 모사 방법으로 발견하였다. 레이저 빔의 가열에 의해 GeSbTe 층의 굴절률이 변하는 범위의 크기(aperture size)를 변화시켜 가며 레이저 빔의 위치에 따른 재생신호의 변화를 계산하여 재생 신호의 변화를 계산하였다. 추가된 반사막으로는 5 nm의 Al 층이 사용되었으며, 재생신호의 변화는 최대값을 기준으로 Al이 없었을 때와 비교했을 때 약 2.5배 증가됨을 발견하였다.

Ep-105 **NiO Nnanowire Based Nonvolatile Memory Devices** 김 성인, 이 재학, 장 영욱, 유 경화(*연세대학교 물리학과.*) We have fabricated resistive switching memory devices (ReRAM) using NiO nanowires. Ni nanowires were prepared using Anodic Aluminum Oxide (AAO) templates and conventional electrochemical deposition method. Then, Ni nanowires were thermally oxidized in air. The fabricated NiO nanowires exhibited significant hysteric I-V curves. Furthermore, clear memory effects were observed with high on/off ratio. Since the resistive memory effects are observed even in NiO nanowire with a length of about 20 um, possible origins of resistive memory effects are discussed.

Ep-106 **Nanobiosensor Based On Carbon Nanotube Field-Effect Transistors** 유 승환, 오 제승[1], 이 형섭, 장 영욱, 최 향희[2], 임 국진[3], 연 수진[4], 신 전수[4], 유 경화(*연세대학교,물리학과. [1]연세대학교,나노메디컬협동과정. [2]연세대학교,나노메디컬연구센터. [3]LG생명과학연구소. [4]연세대학교,의과대학.*) We have fabricated carbon nanotube field-effect transistors for sensing biomolecules and detected S100 and hepatitis B by measuring the change of electrical conductance. To improve the reliability of nanobiosensors, the metal contacts were passivated using SiO_2 or SiN_x and the CNT-FETs were covered with microfluidic channels. All chemical modifications and binding events between antibodies and antigens occurred inside microfluidic channels. When hepatitis B antigens were bound to hepatitis B antibodies, the conductance was found to increase. On the other hand, the conductance was observed to decrease when S100 antigens were added. For re-usability of CNT biosensors, refreshing properties have been also investigated.

Ep-107 **Polymer Electrolyte-Gated Organic Thin Film Transistors** 임 종선, 김 수지, 이 학성, 윤 성철, 강 영구, 이 창진(*한국화학연구원, 화학소재연구단.*) We report the fabrication and extensive characterization of solid polymer electrolyte-gated or-

ganic thim film transistors (PEG-OTFTs) in which a Si wafer containing a dissolved Li salt is used to modulate the hole conductivity of a polymer semiconductor. The large capacitance of the solution-processed polymer electrolyte gate dielectric facilitates polymer semiconductorconductivities on the order of 10^3 S/cm at low gate voltages (<3 V). The use of a larger anion in the polymer electrolyte,bisphenol A ethoxylate(4EO/phenol) diacrylate) [BEDA], yielded transistors that showed clear current saturation andsquare law behavior in the output characteristics, which also points to electrostatic (field-effect) charging. Collectively, the results indicate that PEG-FETsmay serve as useful devices for high-current/low-voltage applications and as testbeds for probing electricaltransport in polymer semiconductors at high charge density.

Ep-108 **OLED용 Thin Film Passivation 공정 및 System 개발과 OLED 특성** 류 성원, 홍 재석, PATIL Sunil Ramdas, 김 종연, 배 강, 조 도현, 이 병로, 김 종재, 홍 우표, 박 승환, 김 화민(*대구가톨릭대학교, 전자공학과.*) OLEDs는 대기 중에 노출될 경우, cathode 쪽에 형성되는 핀홀과 기공(pores)과 같은 결함 site를 통해서 투과되는 수분과 산소에 의해 수 시간 내에 특성이 저하(degradation)되어 결국에는 수명이 다하는 단점 때문에 상용화에 걸림돌이 되고 있다. 현재 OLEDs는 metal can 또는 glass can에 의한 Encapsulation 기술이 상용화되어 우수한 투습 또는 투산소 방지 특성을 보여 주지만, 공정의 어려움과 이에 따른 공정 단가 증가와 sealent를 통한 투습과 투 산소를 방지하기 어려운 단점을 갖고 있다. 따라서 OLEDs 소자를 구현하기 위해서는 OLEDs는 대기 중에 산소와 수분으로부터 보호되어야 한다. 최근 이러한 문제를 해결하기 위하여 Thin Film Passivation 타입의 OLEDs(TFP-OLEDs)에 대한 연구들이 많이 진행되고 있다 TFP-OLEDs란 metal 또는 glass can 대신 투습율과 투산소율이 매우 낮은 투명한 유기 또는 무기 박막으로 봉지된 OLEDs를 의미한다. 아직 OLEDs에 적용 가능한 Passivation 박막과 공정기술이 정례화 되지 않은 상태에서 TFT-OLEDs 제작이 어렵기 때문에 현재 우수한 passivation 물질로 보고되고 있는 유기 또는 무기 박막을 실제 OLEDs에 적용하기가 쉽지 않다. 본 연구에서는 장수명의 OLEDs를 제작하기 위하여 본 연구 팀이 개발한 투습율과 투산소율이 매우 낮은 무기 혼합 박막과 유기 박막을 OLEDs의 passivation 층으로 실제 적용하기 위하여 OLED용 Thin Film Passivation System을 본 연구팀의 공정기술에 맞추어 직접 제작하고 본 시스템을 사용하여 제작된 OLEDs의 발광 특성과 수명연장에 대한 결과를 보고 한다.

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Ep-109 **RF, DC 스퍼터링에 의해 성막된 Al_2O_3가 첨가된 AZO 투명 전도 박막의 전기적, 광학적 특성** 장 덕우, 홍 재석, 류 성원, 김 용기, 방 태복, 하 재영, 이 병로, 김 종재, 홍 우표, 박 승환, 김 화민(*대구가톨릭대학교, 전자공학과.*) 디스플레이 산업 발달에 따른 투명전극 수요의 증가로 기존의 ITO를 대체할 수 있는 투명전극의 물질 및 공정 개발에 많은 관심이 집중 되고 있다. 일반적으로 사용되고 있는 ITO는 낮은 비저항과 우수한 광투과도를 나타내지만, 높은 단가와 플라즈마 분위기에서 안정성이 떨어지는 문제점을 갖고 있다. 그 대체물질로 최근 ZnO계 투명전도 박막에 대한 연구가 활발히 진행 중에 있으며 indium에 비해 자원이 풍부하여 단가가 낮으며, 3.37eV의 적은 밴드갭과 80% 이상의 광 투과도를 나타낸다. 또한 ITO 박막이 수소 plasma에 노출된 후 투과율이 20~40% 가량 감소하는 반면, Al을 도핑하여 성막된 AZO 박막 투과율의 감소가 없는 것으로 보고되었다. 순수한 ZnO 박막의 경우, 전하 운반자의 낮은 농도로 인하여 높은 비저항을 나타내지만 Ga, Sb, F, Al, Al_2O_3 등의 불순물을 도핑하여 전하 운반자 농도를 증가시킴으로써 낮은 비저항을 나타낼 수 있다. 특히 Al - doped ZnO (AZO) 박막은 밴드갭 3.5~3.7eV, 비저항은 10^{-3} ~ 10^{-4} Ω · cm의 값을 나타낸다. 이에 본 연구에서는 AZO 박막의 전기적 · 광학적 특성을 개선하기 위하여 DC · RF Magnetron Sputtering 법으로 성막하여 특성을 비교 · 분석 하였다. 전기적 특성은 4-Point Probe방식으로 면저항(Sheet Resistance)을 측정하였으며, 박막의 Thickness와 면저항과의 관계식으로 비저항을 조사하였고, 광학적 특성은 가시광 영역에서의 광 투과도를 측정하여 밴드갭과 굴절률을 조사하였다.

*본 연구는 2007년 산업 자원부의 부품 · 소재 기술개발사업에 의해 지원된 것임.

Ep-110 **무기물을 이용한 Flexible OLED용 투습방지박막의 특성 연구** 고 현규, 홍 재석, 류 성원, 김 덕수, 권 오정, 이 병로, 김 종재, 홍 우표, 박 승환, 김 화민(*대구가톨릭대학교, 전자공학과.*) OLED 소자의 발광효율과 수명은 수분과 산소에 노출될 경우 급격한 성능저하(degradation)를 초래한다. 더욱이 Flexible OLED 에 이용될 polymer 기판은 높은 투습률로 인하여 Flexible Display제작에 큰 장애가 되므로 투습방지를 위한 새로운 barrier 층의 재료와 공정 기술이 필요하다.본 연구에서는 유리형성자로서 굴절률이 작으면서 band gap이 큰 SiO_2와 유리변형자로 굴절률과 극성(polarizability)이 큰 ZnO를 혼합하여 $(SiO2)_x$:$(ZnO)_y$ Target을 제작하여 RF-magnetron sputtering 방법으로 polymer (PEN) 기판 위에 단층의 투습 방지용 무기 혼합 박막을 성막 하였다. 증착된 무기 혼합 박막의 투습과 투산소 특성은 Mocon test를 이용하여 가시광 영역에서의 투과율 변화를 대기 중 노출시간의 함수를 조사함으로써 성분비, 박막 두께 그리고 굴절율 방법에 따른 투습 특성을 체계적으로 비교함으로써 무기 혼합 박막은 혼합할 무기물 선택, 혼합 비, 박막 두께, 그리고 공정 방법에 따라 투습률과 투산소율이 획기적으로 개선될 수 있음을 보여주며, 무기 혼합 박막의 투습과 투산소 특성에 영향을 주는 가장 주요한 인자로서는 박막의 극성 (Polarizability)과 박막 밀도 (packing density)임을 보고하고 이 결과를 산화물 박막의 투과 기구 (passivation mechanism)에 기초하여 설명한다.

*본 연구는 2007년 한국 산업기술재단의 지역혁신인력양성사업에 의해 지원된 것임.

Ep-111 **Imaging ellipsometry for detecting protein patterns on solid surface** 배 영민, 이 대식, 김 세르게이(*한국전기연구원.*) Imaging ellipsometry (IE) make it possible to image patterns of bio-molecules adsorbed on a solid surface. IE is based on off-null ellipsometry, in which the intensity of the light beam reflected from a film on a solid surface is proportional to the square of the reflectance. Configuration of our IE system has a component sequence of polarizer-compensator-sample-analzyer(PCSA), a objective lens and a CCD camera as a photonic detector. IE was ap-

plied to detect protein patterns on solid surface. In this presentation, Protein G pattern, which was formed by spotting protein G solution onto the gold surface, was detected. In addition, binding of antibody onto the protein G pattern, and antibody-antigen reaction was detected. From the experiments, it was concluded that IE can be applied as the array-based detection technique in immunosensor with the advantages of allowing label-free detection, high sensitivity and operational simplicity.

Ep-112 **Physical Properties of Plasma Nitrided SiON Films Using a Various Base Oxide** YIM Chanjung, LEE Dongwon[1], CHO Mann-Ho[2], KO Dae-Hong(*Yonsei University, Department of Ceramics Engineering. [1]New power plasma Co. [2]Yonsei University, Institute of Physics and Applied Physics.*) N incorporation into SiO_2 films is significantly used for the gate dielectric film to suppress leakage current and dopant diffusion as SiO_2 gate dielectric oxide is scaling down. The increase of the incorporated nitrogen into the oxide film is resulting in the increase of dielectric constant and high density of the film. The plasma nitridation is very attractive to perform the reliable leakage current and control of dopant diffusion. In particular, the amount of incorporated N into the film is very important because the high concentration of N at the film surface can control the dopant diffusion. Moreover, the formation of Si_3N_4 states at the interfacial layer can cause stress to the Si substrate, resulting in the generation of the interfacial trap sites. The formation of Si_3N_4 layer in the gate dielectric film increases the dielectric constant, increasing the physical thickness in the same equivalent oxide thickness (EOT). We report the result on the investigation of the physical properties of plasma nitrided SiO_2 films using the difference base oxide including sparsely and densely oxide. The quantity and the chemical state of the incorporated N are critically dependant on whether the base oxide is dense or not. In particular, the quantity of incorporated N into the sparse oxide is significantly increased, while the molecular state of N_2 in the film is decreased.

Ep-113 **Cell Sensors Using Single-Walled Carbon Nanotubes** 최 향희, 권 오준[1], 유 승환[2], 강 봉근[2], 윤 채옥[1], 유 경화[3](*연세대학교 나노메디컬 국가핵심연구센터. [1]연세대학교 의과대학 암센터 암연구소 BK21 의과학사업단. [2]연세대학교 이과대학 물리학과. [3]연세대학교 이과대학 물리학과, 나노메디컬 국가핵심연구센터.*) We have developed cell sensors using single-walled carbon nanotubes (SWNTs) to monitor the cell growth. SWNTs were synthesized by CVD and the metal contacts were passivated using PMMA to minimize the effects of contact resistance change. Several Hep 1 cancer cells were loaded on SWNTs and incubated for more than 36 hours. With Hep 1 cancer cells on SWNTs the hysteric I-V curves were found and this hysteresis was reduced as the cell growth progressed. Possible origins of the hysteresis are discussed.

Ep-115 **Improvement of 10 V Josephson voltage standard** 김 규태(*한국표준과학연구원.*) 한국 표준준과학연구원에서 국가 전압표준기로 유지하고 있는 조셉슨 전압표준기가 세계수준을 목표로 향상되었다. 10의 -10승 수준에서 정확도 개선 결과와 불확도 분석 결과, 그리고 일본 표준기관과의 비교측정 결과를 소개한다.

Ep-116 **나노 바이오 물질 관측을 위한 고기능 홀센서 제작** 주 성중, 홍 진기[1], 이 긍원[1], 이 원현, 정 구열, 김 영철(*고려대학교 응용물리학과. [1]고려대학교 디스플레이 반도체물리학과.*) 자성입자를 반도체 2차원 전자 위에 위치시킨 홀소자에서는 자성입자의 자화에 의한 stray field에 의하여 자기장을 형성할 수 있다. 이러한 자기장은 위치에 따라 그 크기와 방향이 변하는 국소화된 형태로 형성할 수 있으며, 전도에 기여하는 2차원 전자는 이 자기장에 의한 로렌츠 힘을 받아 소자의 자기저항을 유발한다. 2차원 전자의 특성에 의해 소자 면에 수평인 자기장성분은 자기저항에 기여하지 않음을 고려할 때, 오직 수직 자기장 성분만이 소자에 영향을 줄 수 있으며, 자성입자의 자화는 소자 면에 수평이고, 전류에 평행한 외부자기장(Bext)에 의해 조절되었다. 저항은 4단자 방법에 의해 상온과 저온에서 측정하였다. 상온과 2K에서 측정된 자기장에 따른 저항의 변화는 비교적 크며, Hall저항이 아닌 보통의 저항을 측정하였음에도 불구하고, 측정된 데이터는 Hall저항과 같이 자기장의 방향이 바뀌어도 단조 감소하는 경향을 보인다. 즉, 외부자기장이 작은 부근에서 자기저항이 급격히 선형적으로 변한다. 특히, 2K에서는 외부 자기장이 양의 방향일 때, 음의 저항이 측정되었다. 보통의 자기저항이 외부 자기장에 대하여 짝함수(even function)임을 고려할 때, 본 소자의 특성은 매우 독특하다. 뿐만 아니라 직접도, 민감도 면에서 응용이 매우 뛰어난 소자이므로 이 소자를 이용하여 나노바이오물질의 특성을 관측할 수 있는 나노바이오 센서를 제작할 수 있을 것으로 기대된다.

Ep-118 **3ω 방법을 이용한 SiO_2 박막의 열전전도 측정** 조 승일, 최 헌오, 이 종오, 이 종규[1](*재료연구소, 원자력공인검사단. [1]부경대학교, 물리학과.*) SiO_2 박막 시편의 열전전도를 측정하기 위해 3ω 방법을 이용하였다. 3ω 방법은 수십 마니크로의 비결정질 박막과 같은 비결정질의 고체와 결정의 열적 특성을 측정하기 위한 유용한 방법이다. 본 연구에서는 제작한 3ω 측정 시스템을 사용하여 SiO_2 박막의 열전도도를 측정하였으며, 문헌값과 비교한 결과 잘 일치함을 확인하였다.

Ep-119 **Optical characteristics of the phosphor coated with SiO2 and ZnO** 서 정헌, 이 상목[1], 정 일용[1], 문 희송[1], 손 상호[1](*경북대학교 물리교육. [1]경북대학교 물리학과.*) A great deal of interest has been focused on phosphors in order to obtain efficient luminescent materials for the plasma display panel. In this study, to improve the properties of red, green and blue phosphors, we coated the surface of the phosphors with SiO2 and ZnO. A sol-gel process was used to coat phosphors with SiO2 and ZnO. We investigated the surface of the phosphors coated with SiO2 and ZnO by suing SEM(Field Emission Scanning Electron Microscopy) and compared the luminance spectrums of coating phosphors with the luminance spectrums of un-coating phosphors.

Ep-120 **Raman images of single cells and tissues using confocal micro-Raman spectroscopy** 박 도영, 윤 두희, 정 현식, 이 정

윤[1], 김 정호[1](*서강대학교 물리학과. [1]서강대학교 생명과학과.*)
생체 세포나 조직은 구성에 따라 생화화적 화합물(예를 들어, lipid and protein, Amide I, III, C-H bonding)의 분포가 다르다. 이 분포에 따라 각각 화합물에 해당하는 진동모드가 결정된다. 라만 분광법은 이런 생체 세포나 조직의 생화학 화합물과 관련한 진동모드 정보를 다른 과정을 거치지 않고 쉽게 측정 할 수 있다. 본 연구에서는 공초점 라만 분광법을 이용하여 생체조직과 세포의 lipid and protein, Amide I, C-H bonding의 진동 모드를 관찰하였고 이 진동모드를 기준으로 라만 이미지를 얻었다. 공초점 라만 분광은 514.5 nm의 파장을 가진 아르곤 이온 레이저를 여기광으로 이용하였으며, 대물렌즈를 통과한 레이저 빛은 약 1 ㎛의 크기로 초점을 형성한다. Edge-filter와 전하 결합소자 (CCD)를 이용하여 라만 신호를 검출하였다. 일반 생체조직과 세포의 lipid and protein, Amide I, C-H bonding의 진동 모드는 각각 ~1450 cm^{-1}, ~1650 cm^{-1}, 2800~3000 cm^{-1} 에서 관찰 할 수 있다. 또한, 이를 기준으로 생체 세포와 조직의 구성에 따른 진동 모드 변화를 측정하여 라만 이미지를 얻었다

Ep-121 **자동차 브레이크 패드의 열확산도 측정 연구**
김 석원, 최 병민(*울산대, 물리학과.*) 자동차에서 중요한 요소 중의 하나인 제동시스템은 자동차의 정지, 속도 감속의 역할뿐만 아니라, 운전자의 안전에서도 없어서는 안 될 부분이다. 현재 자동차에서 쓰이는 제동 형태는 마찰식 제동 시스템이 주로 사용되고 있으며, 그 기본원리는 마찰을 이용해 운동에너지를 열에너지로 변환하는 것이다. 특히 마찰식 제동 시스템 중에서 브레이크 디스크를 이용한 제동 시스템이 많이 이용되고 있고 시스템 설계에 있어서 열적 특성을 고려하는 것은 제동 시스템의 성능, 안정성에 있어서 없어서는 안 될 중요한 요소이다. 현재 브레이크 디스크에 대한 열적 특성 연구는 많이 진행되고 있지만, 디스크를 잡아주는 패드에 대한 열적 특성 연구는 아직 미미한 수준이다. 본 연구에서는 브레이크 패드에 대한 열물성 중의 하나인 열확산도를 고체재료의 열확산도 측정에 많이 사용되는 섬광법(laser flash method)을 이용하여 상온 ~ 500 ℃ 영역에서 측정하였다. 측정에 사용된 브레이크 패드는 재료와 제작 조건에 따라 16 종류로 분류하였으며, 크기는 측정에 용이하도록 지름 10 mm, 두께 1 mm인 원반형 모양으로 제작하였다. 측정된 결과는 브레이크 디스크 시스템의 열변형 및 온도 해석에 활용될 예정이다.

Ep-122 **진공속에서의 시료 가열장치와 시료 사이의 열전달에 관한 연구** 박 현재, 오 수기(*아주대학교, 에너지시스템학부.*) 진공에서 이루어지는 재료의 표면 개질 과정에서 시표 표면의 온도는 공정에 미치는 중요한 요소이다. 식각의 경우 시료의 표면 온도에 따라 식각률이 달라지고 화학 기상증착에 의한 박막형성 공정 또한 시료의 표면 온도가 박막 성장속도를 결정짓는 중요한 요소가 된다. 하지만 각 공정에서 시료의 온도를 희망하는 온도로 정확히 다루는 것은 공정 환경의 요소들로 인해 어려움이 있다. 본 연구에서는 진공 챔버의 내부 압력에 따라 시료 가열장치와 시료 사이의 열전달에 있어 전도, 대류, 복사 차지하는 비를 기존의 문헌을 인용하여 가정하였고, 푸리에의 식과 슈테판-볼츠만 식을 이용하여 열전달을 이론적으로 계산과 동시에 실험적인 결과와 비교하여 보았다. 특히, 열전도에서 사용되는 푸리에의 식의 경우 여러 상수들이 사용되는데 이중 몇몇의 값들이 공정의 압력에 따라, 그리고 시료와 가열장치의 표면 거칠기에 따라 달라지게 되어 각 조건에 따른 누센수(Knousend number)값을 계산하여 열전도의 방식이 물체의 접촉에 의한 것인지 물체 사이의 간격에 존재하는 기체 분자에 의한 것인지를 결정하였으며 이를 바탕으로 이론적 열전도값을 구하였고, 시료에 가해지는 압력에 따라 시료의 온도 변화를 관찰하고 이론적인 값과 비교하여 보았다.

Ep-123 **PML(Perfectly Matched Layer) 경계조건 및 FDTD를 이용한 Open Space에서의 음향 분석** 박 석현, 이 형원[1](*인제대학교 컴퓨터응용과학과. [1]인제대학교 컴퓨터응용과학과, 수리 과학 연구소*) 기존의 실내 공간에서의 음향 분석은 Raytracing, Image Method, Diffuse Method등 많이 나와있다. 하지만, 이런 알고리즘은 열린 공간에 대한 음향 분석을 하기엔 다소 부정확하고, 무리가 있다. 위의 열거된 알고리즘들은 다 실내 공간이라는 제약속에서 가정된 알고리즘이기 때문이다. 하지만, 본 연구에서는 그러한 단점을 고려하여 전자기파에서 주로 사용하는 PML 경계 조건과 FDTD 방법을 음향 분석에 맞게 적용하였다. 이 방법의 장점은 열린 공간에서 뿐만 아니라 실내 공간에서도 별다른 제약없이 가능하다는 것이다.

Ep-124 **높은 스펙트럼 분해능을 가진 초광대역 다중 CARS 현미경을 이용한 박막두께 측정** 최 대식, 정 세채[1](*한국표준과학연구원 전략기술부, 고려대 물리학과. [1]한국 표준과학연구원 전략기술부.*) 결맞는 반 스톡스 라만 산란 (CARS)은 기본적으로 두 개 이상의 파장이 다른 광을 필요로 한다. 우리는 한 대의 펨토초 레이저만을 이용하며 또 다른 광원을 얻기 위해서 포토닉 크리스탈 파이버(Photonic Crystal Fiber)를 사용하여 CARS 현미경 시스템을 완성하였다. 펨토초 레이저 빔을 분리하여 하나는 펌프 빔으로 다른 하나는 PCF를 여기 시키는데 사용되며 PCF에서 발생된 백색광에서 근 적외선 광만을 사용하기 위해서 롱 패스 필터를 사용하며 이 광을 스톡스 광으로 사용한다. 여기서 우리는 펌프 빔의 선폭을 증가시키기 위해서 격자 쌍과 슬릿을 이용하였다. 기존의 좁은 밴드 패스 필터 보다 분해능이 2배 정도 증가 되었다. 고 분해능 광대역 다중 CARS 현미경으로 두개의 다른 고분자 얇은 박막 두 층의 두께를 한 번에 측정하고자 한다. 얇은 박막은 본 실험실에서 직접 제작하였으며 실험실에 사용하는 AFM으로 매우 정확한 두께를 측정 할 수 있다.

Ep-125 **가스채색 박막의 촉매 변화에 의한 내구성 연구** 김 나라, 정 현식(*서강대학교 물리학과.*) Pd/WO_3 박막이 수소에 노출될 때 박막의 색깔이 변하는 가스채색 현상을 이용해 수소 검지 광센서로 응용하려는 연구가 진행되고 있다. 팔라듐(Pd)은 수소분자를 양성자와 전자로 분해할 뿐만 아니라, 분해된 양성자와 전자가 채색박막까지 확산하도록 하는 역할을 한다. 그러나 Pd는 표면에 hydrocarbon 등의 대기 오염물이 흡착되면 촉매로서의 특성이 현저히 저하된다. 이러한 Pd 표면의 오염이 수소센서 박막의 내구성 저하의 원인 중 하나로 알려져 있다. 본 연구에서는 Pd 이외에 Pt와 같은 다른 촉매금속을 함께 사용하는 것이 내구성에 미치는 영향을 연구하고자 한다. 2×10^{-6} torr의 base pressure와 2.0×10^{-2} torr의 working pressure에서 tungsten target을 사용하여 reactive RF sputtering으로 WO_3 박막을 제작하였다. Pd와 Pt 박막은 DC magnetron sputtering으로 WO_3 박막 위에 입혔다. In-situ Raman spectroscopy를 이용하여 제작된 박막의 특성과 채색 메커니즘을 확인하였다. 서로 다른 방법으로 만든 가스채색박막의 반

응성과 내구성을 알아보기 위해 밀폐된 chamber 안에 박막을 고정시킨 후 MFC로 1% 수소가스와 공기를 번갈아 주입하면서 632.8-nm He-Ne laser의 광투과도 변화율을 측정하였다.

Ep-126 **(1-x)($Na_{0.5}K_{0.5}$)NbO_3-x$LiNbO_3$(NKN-LN) 세라믹스의 히스테리시스 곡선과 압전성 연구** 박 희진, 김 유성, 김 샛별, 김 은지, 최 병춘, 전 병억[1], 정 수태[2], 박 종호[3](*부경대학교 물리학과. [1]부경대학교 기초과학연구소. [2]부경대학교 전자컴퓨터정보통신공학부. [3]진주교육대학교 과학교육.*) 압전체 세라믹 중에서 현재 PZT세라믹스의 대체물질로 비납계 압전물질인 $KNaNbO_3$계 세라믹이 활발히 연구되고 있다. $Na_{1-x}K_xNbO_3$ (NKN) 은 페롭스카이트 구조를 가지면서 높은 압전특성을 가진 세라믹중의 하나이다. 본 연구에서는 (1-x)($Na_{0.5}K_{0.5}$)NbO_3-x$LiNbO_3$(NKN-LN) (X= 0.1,0.2,0.3,0.4 mol)의 세라믹을 제작했고 이 세라믹의 히스테리시스 곡선과 압전성을 조사했다. 히스테리시스 곡선을 통해 시료의 x가 증가함에 따라 강유전성이 약해지는 것을 알 수 있었다. 시료의 압전특성을 얻기 위해 100℃의 실리콘 오일 속에서 DC 25 Kv/cm 의 전계를 25분동안 가하여 분극처리를 한 후,시료의 공진주파수 및 반공진 주파수를 LCZ meter(HP 4192A) 로 측정하여 압전정수 k_p 를 계산하였다.

Ep-127 **Feasibility of the Josephson fast-reversed DC source for evaluation of thermoelectric effects in the thermal AC-DC converters.** KIM Mun-Seog, CHONG Yonuk, KIM Kyu-Tae, KIM Wan-Seop, KWON Sung-Won, PARK Po Gyu(*KRISS.*) We developed the fast-reversed DC (FRDC) voltage source based on a programmable Josephson voltage standard (PJVS) which can produce an arbitrary voltage with the quantum accuracy. The source is used for evaluation of the thermoelectric effects which develop along the heater of the thermal AC-DC converters. The effects are reflected by the FRDC-DC difference of the thermal converter, when the DC voltage and the FRDC waveform are applied to the heater in turns. In this study, we measured the FRDC-DC difference for Fluke 792A and a multi-junction thermal converter in the frequency range below 1 kHz, and investigated the accuracy limitations of our Josephson waveform synthesizer as a FRDC source, especially due to the imperfect switching between the output voltage levels.

Ep-128 **Photoluminescence properties of $GdP_{1-x}V_xO_4:Eu^{3+}$ powder phosphors.** SHIM Kyoo Sung, JUNG Ye Ran, FU Zuo Ling, MOON Byung Kee, CHOI Byung Chun, JEONG Jung Hyun, YI Soung Soo[1], KIM Jung Hwan[2](*부경대학교 물리학과. [1]신라대학교 전자재료공학과. [2]동의대학교 물리학과.*) Red emitting $GdP_{1-x}V_xO_4:Eu^{3+}$ (x= 0.00, 0.25, 0.50, and 0.75) powder phosphors were prepared by solid state reaction method. And the doping concentration of Eu^{3+} ions was 3 mol.%. The microstructure and surface morphology of $GdP_{1-x}V_xO_4:Eu^{3+}$ powder phosphors under different compositions have been analyzed by X-ray diffraction (XRD) and field emission scanning electron microscope (FE-SEM), respectively. The results of both XRD and FE-SEM indicated that the particles present good crystalline state, whose crystalline grain sizes were in the range of ~100 nm. The optical properties of the powders presented that the characteristic emissions of Eu^{3+} due to $^5D_0 \rightarrow {}^7F_1$ (orange) and $^5D_0 \rightarrow {}^7F_2$ (red) transitions were detected. Furthermore, in the system of $GdP_{1-x}V_xO_4:Eu^{3+}$, the orange-to-red intensity ratio (O/R) depended on the ratio of P/V greatly. As the ratio of P/V decreased, the intensity ratio O/R was reduced. The crystallinity and the surface morphology of the powders are also highly dependent on the molar ratio of P/V. The highest emission intensity was observed with $GdP_{0.5}V_{0.5}O_4:Eu^{3+}$ powder whose brightness was increased by a factor of 40 times in comparison with that of $GdPO_4:Eu^{3+}$ powders.

Ep-129 **Evauation of singing by voice analysis 음성 분석을 통한가창(歌唱) 평가** 권 영헌, 이 건상, 박 동욱, 윤 여민, 차 영진, 노 우석, 조 경현, 염 기호, 원 종성(*한양대학교 응용물리학과.*) 최근 몇십년간 음성을 분석 할 수 있는 기술이 비약적으로 발전 한 데 비하여 우리주변에서 흔히 접할 수 있는 노래 반주기들은 박자만을 이용해 평가하는 방식을 가지고 있다. 본 연구는 이런 단점을 극복하기 위해 포만트 분석및 LPC, FFT 등의 알고리즘을 사용하여 더욱 다각적인 면에서 가창에 대한 평가방식을 얻어보고자 하였다.그 결과, 음성 분석으로부터 얻어지는 특징들을 이용한 더욱 객관적인 평가방식을 얻을 수 있었으며 이를 MFC를 통해 구현해 보았다.

Ep-130 **$Ba_{1-x}Eu_xTiO_3$ 세라믹의 강유전성 연구** 김 은지, 박 희진, 김 유성, 김 샛별, 최 병춘, 문 병기, 전 병억[1](*부경대학교 물리학과. [1]부경대학교 기초과학연구실.*) $BaTiO_3$의 강유전성이 발견된 이래로 다양한 물리적 특성에 대해 오랫동안 연구되어 왔다. 본 연구에서는 $Ba_{1-x}Eu_xTiO_3$를 Slovothermal방법으로 제작하였다. 각 세라믹스의 강유전성을 확인하기 위해 DE-hysterisis를 관찰하였고, RT~500°C 범위내에서 유전상수의 온도변화를 측정하였다.

Ep-131 **Synthesis and luminescent Properties of Eu^{3+}-doped $SrZnO_2$ phosphors** JUNG Ye Ran, SHIM Kyoo Sung, FU Zuo Ling, MOON Byung Kee, CHOI Byung Chun, JEONG Jung Hyun, YI Soung Soo[1], KIM Jung Hwan[2](*부경대학교 물리학과. [1]신라대학교 전자재료공학과. [2]동의대학교 물리학과.*) A novel red-emitting Eu^{3+}-doped $SrZnO_2$ phosphors was discussed. The crystallinity, surface morphology and photoluminescence spectra of the powders were highly dependent on the sintering temperatures. The surface morphology and photoluminescence intensity of the powders showed similar behavior as a function of sintering temperature. The crystalllinity and surface morphology of the powders were investigated using X-ray diffraction (XRD) and scanning Electron Microscope (SEM), respectively. Luminescence properties were analyzed by measuring the excitation and photoluminescence spectra. The phosphor shows the red emission radiated by the transitions from $^5D_0$ excited states to ^7F_J(J=0-4) ground states of Eu^{3+} ions found that under the ultraviolet excitation with a wavelength of 301 nm. Europium-activated phosphors are excellent emitters of red light. The Eu^{3+} ions luminescence under UV excitation usually consists of a number of prominent peaks centered at 580, 592, 612, 623, 655 and 708 nm. In this work, Luminescence properties of the

$SrZnO_2:Eu^{3+}$ powders have been studied.

Ep-132 **비대칭 RGB 컬러필터를 이용한 TFT-LCD의 최적투과율 구현 방법** 김 영훈, 윤 중민, 안 응진, 송 화동, 이 경하, 신 종근(*LG.Philips LCD.*) 공간사용의 효율성 및 소비전력에 있어 우수성을 갖고 있는 TFT-LCD 소자는 CRT를 대신하는 디스플레이 소자로서 자리를 잡았다. 자기발광성이 없어 후광이 필요한 TFT-LCD의 경우, 보다 높은 휘도를 얻기 위해 투과율을 향상시키는 연구를 계속해서 진행해 가고 있다. Pixel의 구조 및 광학 Sheet 등의 개발을 통해 휘도를 향상시키는 방법 등이 있으나, 비용과 생산성 검증 등에 있어 비효율적인 측면이 있다. 따라서 본 연구에서는 광학적인 계산을 통해 RGB 컬러필터의 비율을 조정하여 휘도를 높여줄 수 있는 시뮬레이션을 진행해 보았다. 백라이트를 비롯한 TFT-LCD 구성 재료의 스펙트럼을 측정하였고, RGB의 효율을 가장 높혀줄 수 있는 컬러필터의 면적을 계산해 보았다.

Ep-133 **Eu^{2+} ion concentration dependency on the luminescent characteristics of $BaSi_2O_5:Eu^{2+}$ ceramic phosphors** YANG Hyun Kyoung, CHUNG Jong Won, FU Zuoling, MOON Byung Kee, CHOI Byung Chun, JEONG Jung Hyun, YI Soung Soo[1], KIM Jung Hwan[2](*부경대학교, 물리학과. [1]신라대학교, 전자재료공학과. [2]동의대학교, 물리학과.*) Ceramic with compositions of $BaSi_2O_5:Eu^{2+}$ is prepared by solid state reaction method. The Eu^{2+} ions concentration was varied from 0.005 to 0.1 mol. The crystallinity and surface morphology of the films were investigated using X-ray diffraction (XRD) and scanning electronic microscope (SEM), respectively. Crystalline phase and surface morphology of ceramics have been very important factors to determine luminescent characteristics of ceramics. Photoluminescence (PL) spectra have been measured at room temperature using a luminescence spectrometer and excitation by a broadband incoherent ultraviolet light source with a dominant excitation wavelength of 332 nm. The emitted radiation was dominated by the red emission peak at 488 nm radiated from the transition of 4f5d of Eu^{2+} ions. The luminescence properties results not only from the improved crystallinity but also from the reduced internal reflections caused by rougher surfaces. The luminescent intensity and surface roughness exhibited similar behavior as a function of Eu^{2+} ion concentration.

Ep-134 **Synthesis and luminescent properties of $Zn_2SiO_4:Mn^{2+}$ ceramic phosphors by Mn^{2+} ion concentration** YANG Hyun Kyoung, CHUNG Jong Won, FU Zuoling, MOON Byung Kee, CHOI Byung Chun, JEONG Jung Hyun, YI Soung Soo[1], KIM Jung Hwan[2](*부경대학교, 물리학과. [1]신라대학교, 전자재료공학과. [2]동의대학교, 물리학과.*) Mn-doped Zn_2SiO_4 is a well-known green phosphor for its high luminescent efficiency and chemical stability. $Zn_2SiO_4:Mn^{2+}$ phosphor is widely used in cathode ray tubes, plasma display panels, and lamps as a green phosphor. Ceramic with compositions of $Zn_2SiO_4:Mn^{2+}$ is prepared by solid state reaction. The Mn^{2+} ions concentration was varied from 0.005 to 0.05 mol. Influence of Mn^{2+} doping on the crystallization, surface morphology and luminescent properties of $Zn_2SiO_4:Mn^{2+}$ ceramics has been investigated. X-ray diffraction (XRD), scanning electron microscopy (SEM) and luminescence spectrometer were measured as function of Mn^{2+} concentration to characterize the ceramic phosphors. The emitted radiation was dominated by the red emission peak at 523 nm radiated from the transition of $^4T_1$-$^4A_1$ of Mn^{2+} ions. As Mn^{2+} content increases from 0.005 mol to 0.03 mol, the crystallinity and PL intensity improved, but as Mn^{2+} content increases to 0.05 mol, the crystallinity and PL intensity of films was decreased. The luminescent intensity and surface roughness exhibited similar behavior as a function of Mn^{2+} ions concentration.

Ep-135 **Properties of small amount Li-doped ZnO thin films by PLD method** 김 유성, 박 희진, 김 샛별, 김 은지, 최 병춘, 정 증현, 전 병억[1](*부경대학교 물리학과. [1]부경대학교 기초과학연구소.*) We prepared ZnO thin films by pulse laser deposition(PLD) and physical properties analyzed optical and structural property. The Li-doped $ZnO_{1-x}Li_xO$(x=0.0005~0.005) thin films were grown by PLD method on Pt(111)/Ti/SiO2/Si(100) substrate and Al_2O_3 with temperature of 500℃. We tried to study the effects of a very small amount Li doped ZnO film. We observed that the characteristics of films might be depended on the structural and superficial composition of films. The thicknees and surface morphology of thin films were studied by using field emission scanning electron microscopy(FE-SEM), X-ray diffractometer(XRD). The electrical properties of ZnO thin films were measured by impedance analyzer. In order to investigate the potential application of transparent conductive ZnO films, the measurement of photoluminescence(PL) and hole concertration were carried out. Li doping typically increases the resistivity of n-type ZnO at previous literatures. Consequently, It is expected that Li doped ZnO films were potentials for transparent conductive oxide applications.

Ep-136 **Thermoluminescene of Lanthanum Fluoride** KIM Taekyu(*Jeonju National University of Education, Department of Science Education.*) The dielectric crystal Lanthanum Fluoride (LaF3) is a laser host material and different rare-earth ions doped LaF3 produce the variety of lasing emission. In this study, three dimensional thermoluminescence(TL) from the pure LaF3 and Ho, Pr, Tb, Sm and Nd ion doped LaF3 were measured with heating rate of 0.1 K/s in the temperature range of 50 ~ 380 ℃ and the wavelength range of 200 ~ 800nm. TL glow curve was obtained by accumulating TL intensity over the entire wavelength from 3D TL Main peak temperature of pure LaF3 exposed to x-ray with 25 keV is 250 ℃. The activation energy and kinetic order and frequency factor of 250 ℃ peak were analyzed with the peak shape method and the initial rise method and the curve fitting.

Ep-137 **Enhancement of the luminescent in $CaTiO_3:Pr^{3+}$ ceramic phosphors by Li^+ ion concentration** YANG Hyun Kyoung, CHUNG Jong Won, MOON Byung Kee, JEONG Jung Hyun, YI Soung Soo[1](*부경대학교, 물리학과. [1]신라대학교, 전자재료공학과.*) Crystalline phase and surface morphology of phosphors have been very important factors to determine luminescent characteristics of phosphors. $CaTiO_3:Pr^{3+}$ and Li added ceramic

samples were prepared by solid state reaction method. The Li^+ concentration was varied from 0.5 to 15 wt.%. X-ray diffraction (XRD), scanning electron microscopy (SEM) and luminescence spectrometer were measured as function of Li^+ concentration to characterize the ceramic phosphors. Influence of Li doping on the crystallization, surface morphology and luminescent properties of $CaTiO_3:Pr^{3+}$ ceramics has been investigated. The emitted radiation was dominated by a red emission peak at 613 nm radiated from the $^1D_2$-$^3H_4$ transition of Pr^{3+} ions. The luminescent intensity has a maximum at 1.0 wt.% Li-doped $CaTiO_3:Pr^{3+}$ ceramics, and its peak intensity was improved by a factor of 3.5 in comparison with that of $CaTiO_3:Pr^{3+}$ ceramic. The increased luminescence results not only from the improved crystallinity but also from the enhanced surface roughness. The luminescent intensity and surface roughness exhibited similar behavior as a function of Li^+ ions concentration.

Ep-138 **Realization of radiance temperature scale from 273 K to 1250 K by a thermal detector based thermometer** 박 철웅, 박 승남, 김 봉학, 이 동훈(*한국표준과학연구원.*) Radiance temperature scale has been realized by fixed point calibrations of a thermal-detector based radiation thermometer, which has two temperature ranges, LT from 273 K to 753 K and MT from 500 K to 1250 K. The LT has been calibrated by using the ice, gallium, indium, and tin point blackbodies and the MT by using the tin, zinc, aluminum, and silver point blackbodies. The temperature scales were obtained by fitting with the Planckian version of Sakuma-Hattori formula, which yields the best fits. The ambiguity of the temperature scale from the differences between both scales at the overlapped range is resolved by considering the difference of the size of source effects for the both ranges. The uncertainty of the realized scale is evaluated by mainly considering components from the fixed point realizations, the interpolation of the scale, the mid-term stability, and the size of source effects.

Ep-139 **Uncertainty evaluation of color correction factor (CCF) in luminous intensity measurement of a blue LED by Monte Carlo simulation** 박 성종, 이 동훈, 박 승남(*한국표준과학연구원.*) CCF is determined by combining all spectral data of which uncertainties are correlated. A Monte Carlo simulation was performed to evaluate the uncertainty of the CCF in a blue LED measurement, where the luminous intensity was measured by an illuminance meter with f_1' of 3 % and the spectral distribution of the LED measured by an array detector type-spectroradiometer. The spectral data with the target correlation uncertainty were generated by diagonalizing the matrix which represents the cross-coupling between uncorrelated random numbers. The calculated uncertainty of the CCF coincides with the value obtained by the analytical method within 0.03 %. The calculation demonstrates an advantage that the Monte Carlo method gives us the coverage factor as well as the probability distribution.

Ep-140 **열 증발원을 이용한 산화 인듐과 산화 주석 박막의 제작** 김 창오, 정 인승, 정 성호, 정 광호(*연세대학교, 물리학과.*) 산화인듐(InO_x)과 산화주석(SnO_x)을 기반으로 하는 투명 전도성 산화막은 디스플레이산업의 발달로 필요성이 증가되고 있다. 전자빔증착, 스퍼터링 증착 방법으로 제작된 인듐 주석 산화물(ITO) 박막에 대한 연구는 많이 보고되고 있다. 본 연구에서는 산화인듐(InO_x)과 산화주석(SnO_x)을 열 증발원을 이용하여 유리기판 위에 박막을 제작하고 특성을 관찰하였다. 초고진공상태에서 증발원을 가열하고, 산소분압을 조절하여 고진공상태를 유지시켜고, 기판온도와 증착 비율을 변화시키며 산화인듐과 산화주석 박막을 성장시켰다. x-선회절을 이용하여 박막의 결정성을 확인하였고, 박막의 표면 관찰을 위해 AFM을 사용하였다. 전도성 확인을 위해 4-point 방법을 적용하였다. 광전자분광스펙트럼(XPS)으로 박막내의 산소양을 비교하였다. 산화인듐의 경우 산소분압이 증가하면서 전도성은 다소 떨어졌으나 투명도는 향상되는 것을 관찰하였고, 산화주석은 산소분압 변화에 큰 차이를 나타내지 않았다.

Ep-141 **Electrical Sorting of Carbon Nanotube Transistors and its Application for Mass-producible Ultrasensitive Bio-Sensor** BUH Gyoung Ho, HWANG Jea-Ho, JEON Eun-kyoung, PARK Dong-Won, KIM Byoung-Kye[1], SO Hye-Mi, CHANG Hyunju, KONG Ki-jeong, LEE Jeong-O(*한국화학연구원, 융합바이오기술연구센터. [1]전북대학교, 물리학과.*) Carbon nanotubes (CNT) are attractive for their variety in electronic structure, which depends on their chiralities and diameters. However, uniformity control of CNTs in growth level or at least device integration is necessary for real applications. Although the network of CNTs has been investigated to achieve uniformity of device, the sensors made of cross-linked CNTs inevitably result in poor sensitivity. Here, we will present our investigation of electrical sorting to achieve the electrical uniformity without losing its sensitivity. By applying millisecond electrical pulse to CNTFET, we successfully sort out metallic nanotubes. The remaining semiconductor nanotubes show good uniformity in terms of threshold voltage, turn-on current, and turn-off current as well as high yield (approaching 100 %). Optimization of the electrical pulse will be discussed considering both device yield and uniformity. The electrical reliability of CNTFET in aqueous condition will be also discussed. Practical aspects of electrical sorting for bio-sensor will be presented in terms of cost and mass-producibility.

■ SESSION P3
10월 19일(금), 13:00 - 14:45
장 소: 5층 포이어

Kp-054 **Photocurrent properties of $CuInSe_2$ thin films grown by usinghot wall epitaxy** YOU Sangha, HONG Kwangjoon(*Chosun University.*) In this study, the photocurrent (PC) spectroscopy of undoped p-type CIS layers has been investigated at temperatures ranging from 10 to 293 K. Three peaks, A, B, and C, corresponded to the intrinsic transition from the valence band states of Γ_7(A), Γ_6(B), and Γ_7(C) to the conduction band state of Γ_6, respectively. The crystal field splitting and the spin orbit splitting were found at 0.0059 and 0.2301 eV, respectively. The behavior of the PC was different from that generally observed in other semiconductors: the PC intensities decreased with decreasing temperature. From the relation of log J_{ph} vs 1/T, where J_{ph} is the PC density, the dominant level was observed at the higher temperatures. We suggest that in undoped p-type CIS layers, the trapping center limits the PC signal due to native defects and impurities with decreasing temperature.

Kp-055 **Study on valance band splitting energy of photocurrent for $AgInS_2$ epilayer** HONG Kwangjoon, JEONG Junwoo, BANG Jinju, KIM Hyeojeong(*Chosun University.*) A silver indium sulfide ($AgInS_2$) epilayer was grown by the hot wall epitaxy method, which has not been reported in the literature. The grown AgInS2epilayer has found to be a chalcopyrite structure and evaluated to be high quality crystal. From the photocurrent measurement in the temperature range from 30 K to 300 K, the two peaks of A and B were only observed, whereas the three peaks of A, B, and C were seen in the PC spectrum of 10 K. These peaks are ascribed to the band-to-band transition. The valence band splitting of $AgInS_2$ was investigated by means of the photocurrent measurement. The crystal field splitting, Δcr, and the spin orbit splitting, Δso,have been obtained to be 0.150 eV and 0.009 eV at 10 K, respectively. And, the energy band gap at room temperature has been determined to be 1.868 eV.

Kp-056 **Ge이 이온주입된 ZnO 박막의 광학적 및 구조적 특성에 관한 연구** 이 도규, 김 성, 김 창오, 황 성원, 최 석호, R. G. Elliman[1](*경희대학교 전자정보대학 물리 및 응용물리 전공. [1]호주국립대학교 전자재료공학과.*) RF 스퍼터링 성장기법을 이용하여 400℃의 성장 온도에서 Si(100) 기판위에 ~100 nm의 ZnO 박막을 성장하였다. 성장된 ZnO박막에$1.5x10^{18}$, $3x10^{18}$, $4x10^{18}$㎝$^{-2}$의 Ge^- 이온을 주입하였으며, 700부터 1000 ℃까지 후속 열처리에 의한 광루미네센스 (photoluminescence; PL) 및 구조적 특성을 연구하였다. 15 K에서 PL을 측정한 모든 시료는 3.63 eV (369.7 nm)에서 ZnO 띠 근처의 bound exciton (BE)과 관련된PL 띠가 관찰되며, BE와 72 meV의 에너지 차이를 두고 phonon replica들의 PL 띠가 순차적으로 나타난다. 700부터 1000℃까지 열처리 온도가 상승함에 따라 BE와 관련된PL 세기는 증가하며, 포논들과 관련된 PL 세기는 감소한다. 모든 열처리 온도에서 Ge 이온주입량이 $1.5x10^{18}$ ㎝$^{-2}$ 일 때는 BE의 PL 세기가 도핑하지 않은 시료에 비해 커지나 도핑농도가 그 이상일 경우에는 $4x10^{18}$㎝$^{-2}$까지 증가함에 따라 PL의 세기가 감소하게 된다. 이런 PL 의 변화는 열처리 후 ZnO 속에 형성된Ge양자점과 깊은 관련이 있다. PL은 적외선 영역에서도 관찰되는데 열처리온도가 800℃에서 그 세기가 가장 크며 Ge 이온 주입량이 증가함에 따라서 PL 띠는 적색천이를 한다. 이 적외선 PL도 Ge 양자점과 관련이 있는 것으로 판단된다.

Kp-057 **Optical and structural properties of Ge nanocrystals formed in HfO_2 by ion implantation and annealing** 정 필성, 김 성, 김 혜룡, 남 지선, 최 석호, R. G. Elliman[1](*경희대학교 전자정보대학 물리 및 응용물리 전공. [1]호주국립대학교 전자재료공학과.*) Optical and structural properties of Ge nanocrystals (NCs) formed in HfO_2 by ion implantation and annealing have been studied by photoluminescence (PL), high resolution transmission electron microscopy (HRTEM), x-ray photoemission spectroscopy (XPS). The HfO_2 layer of 30 nm thickness was implanted with 15 keV Ge^- to nominal doses of $8.5x10^{15}$, $1.7x10^{16}$, and $2.5x10^{16}$ cm^{-2} at room temperature and subsequently annealed in a rapid thermal annealing apparatus at temperatures from 600 to 1100 °C for 5 min. The height and the width (base) of Ge NCs ranges from 12 to 20 nm and from 15 to 25 nm, respectively as dose increases from $8.5x10^{15}$ to $2.5x10^{16}$ cm^{-2}. The peak wavelength of the PL increases from 1300 to 1400 nm as annealing temperature (T_A) increases from 600 to 1100 °C and its intensity shows a maximum at T_A = 800 °C. These and related experiments including the implant dose dependence of the PL, the HRTEM images, and the XPS spectra suggest that the infrared PL band is originated from Ge NCs.

Kp-058 **Effect of IFVD Using PECVD Dielectric Films on The Optical Property of Compressively Strained InGaAsP/InGaAsP SCH MQWs** 이 희관, 유 재수, 정 관수(*경희대학교, 전자전파공학.*) 1.3-1.55 μm의 광통신 파장대역에서 폭넓은 응용을 갖는 compressively strained InGaAsP/InGaAsP 양자우물 구조는 레이저, DFB 레이저 및 광전변조기 등의 광전자 소자 제작을 위해 널리 사용되어 왔다. Impurity-free vacancy diffusion (IFVD)은 postgrowth 공정으로 밴드갭을 변화시킬 수 있어 광전자 소자들의 집적을 위해 그 가능성이 크다. IFVD에 있어서 dielectric capping층은 중요한 역할을 하며, 밴드갭 천이는 그 층의 특성에 크게 의존한다. 본 연구에서는 capping층을 위한 plasma enhanced chemical vapor deposition (PECVD)을 통한 SiO_x 및 SiN_x의 증착 시 SiH_4 flow rate를 변화시켜 IFVD에 의한 $In_{0.86}Ga_{0.14}As_{0.64}P_{0.36}$/$In_{0.88}Ga_{0.12}As_{0.25}P_{0.75}$ SCH 다중양자 우물 구조에서의 광 특성에 대한 영향을 조사하였다. 그러한 dielectric capping층의 특성은 spectroscopic ellipsometry를 이용하여 분석되었다. SiO_x 및 SiN_x films 내의 porosity는 SiH_4 flow rate의 감소와 함께 증가하였고, 이는 양자우물 혼합을 통한 vacancy의 out-diffusion을 강화하여 다중양자우물의 밴드갭 blueshift를 증가시키는 매우 중요한 역할을 하였다. 20 sccm SiH_4를 사용해 증착된 상대적으로 porous한 SiN_x capping층을 통해 850 ℃에서 30초 동안 rapid thermal annealing을 한 후 약 173 nm (106 meV)의 blueshift를 얻었다. Wells/barriers의 III족 조성이 거의 일정하게 유지되기 때문에 SiN_x층을 통한 V족의 interdiffusion의 영향이 우세한 것으로 사료되며, 그러한 mechanism이 transmission electron microscopy과 energy dispersive x-ray spec-

troscopy를 이용하여 분석되었다.

Kp-059 **MBE 증착방법으로 제작한 Ge/GeN_x 박막의 발광 특성** 한 문섭, 정 기영, 고 창훈, 주 지호, 배 명욱, 장 승훈, 박 경완[1](*서울시립대학교, 물리학과. [1]서울시립대학교, 나노과학기술학과.*) 본 연구는 MBE 증착방법으로 제작한 Ge 복합 화합물의 발광 특성에 관한 것이다. p-type Si(100) 기판 위에 Ge를 증착하고 N^+플라즈마를 이용하여 표면을 일부 질화(Nitridation)하여 GeN_x를 형성한다. 그 후 Ion gun을 이용하여 표면에 요철(roughness)을 형성하였다. Ge층과 GeN_x 층의 두께를 달리하여 반복 증착함으로써 Si기판위에 Ge/GeN_x multilayer를 형성하였다. 증착 시 압력은 $2.0*10^{-8}$ torr ~ $0.5*10^{-9}$ torr, 기판온도는 상온을 유지하고 실험을 실시하였다. 증착된 시료 중 일부를 대기압의 질소 환경에서 furnace를 사용하여 열처리하고, 일부 시료는 Ultra High Vacuum (UHV) 환경에서 e-beam heater를 이용하여 열처리 하였다. 500°C, 600°C, 700°C의 온도에서 각각 10분, 30분 동안 열처리한 시료들을 Photoluminescence(PL) 측정하였다. 박막두께에 따라 다른 종류의 multilayer를 제작하여 열처리 시간과 온도에 따라 발광파장의 PL 특성의 변화를 살펴봄으로써, 증착과 열처리 조건이 PL 특성에 어떠한 영향을 미치는지에 대하여 알아보았다. 또한 형성된 화합물들의 화학적 결합상태가 PL특성과 어떠한 관계가 있는지 확인하기 위하여 X-ray photoelectron spectroscopy (XPS) 분석을 이용하였으며, 표면 요철(roughness)변화를 분석하기 위하여 AFM을 이용하였다.

Kp-060 **Effect of chemical state change on luminescence properties for nitrogen-controlled silicon nitride films** 한 문섭, 장 승훈, 고 창훈, 주 지호, 배 명욱, 정 기영, 박 경완[1](*서울시립대학교 물리학과. [1]서울시립대학교 나노과학기술학과.*) 실리콘 기반의 Nano Structure는 차세대 전광소자 개발 및 응용에 큰 가능성을 보여주고 있다. 본 연구는 PECVD를 이용하여 제작한 Silicon-rich silicon nitride (SRSN) 박막의 발광 원인을 찾는 데에 목적을 두고 있다. PECVD 증착 방법을 이용하여 p-type Si(100) 기판 위에 SiH4 기체와 N2 기체의 조성비를 달리하면서 a-SiNx를 제작하였다. 시료 제작 시 Plasma RF Power는 50 W, 증착 압력은 0.9 torr, 기판 온도는 350°C의 조건을 유지하였다. 시료들의 열처리 조건에 따른 광학적 특성의 변화를 살펴보기 위해서, 증착된 a-SiNx를 Ultra High Vacuum (UHV) 상태에서 electron-beam을 이용하여 1000°C에서 5분, 30분, 2시간동안 열처리하였으며, 열처리된 각각의 시료들의 Photoluminescence(PL)를 측정하였다. 또한 열처리된 각각의 시료들의 화학적 결합 상태 분석을 위해 X-ray Photoelectron Spectroscopy (XPS) 측정을 실시하였으며, XPS 측정결과와 PL 측정결과간의 상호 연계성 연구를 통하여, 실리콘 기반 나노구조물들의 발광 원인에 관하여 논의하고자 한다.

Kp-061 **Flexible Metal Foil 기판 위에 제작된 비정질 실리콘 박막 트랜지스터의photo leakage current에 대한 연구** 김 응범, 김 세환, 오 동해, 김 가현, 허 지호, 장 진(*경희대학교 차세대 디스플레이 연구센터.*) Metal foil 기판은 flexible한 특성으로 인하여 Display분야에 응용도가 높으며 비정질 실리콘은 광 센서에 적용을 하기에 암전류가 매우 작고, 광감도는 우수한 장점을 가지고 있으며 스위칭 박막 트랜지스터와 비정질 실리콘 박막트랜지스터 센서의 제작 공정이 동시에 이루어져 공정이 간단하다는 장점이 있다. 본 연구에서는 electrolytic polishing으로 평탄화가 된 metal foil 기판을 이용한 image sensor를 제작하기 위한 비정질 실리콘 박막 트랜지스터의 photo leakage current의 변화를 연구하였다. 비정질 실리콘 박막 트랜지스터의 암전류는 드레인 전압 15 V, 게이트 전압 -5 V에서 약 10^{-12} A로 매우 작은 전류가 흐르며 2000 Lux 빛의 세기에서는 약 10^{-11} A의 전류가 흘러 dynamic range는 20 이상이 나옴을 확인하였다.

Kp-062 **Evaluation of construction ratio of metallic/semiconducting single-walled carbon nanotubes** 김 서군, 정 현, 차 옥환, 민 경인[1], 서 은경, 김 종수[2], 변 지수[2], 정 문석[2], 안 계혁[3], 이 영희[3](*전북대학교 반도체과학기술학과/반도체물성연구소. [1]전북대학교 물리학과. [2]광주과학기술원 고등광기술연구소. [3]성균관대학교 물리학과.*) Hipco 방법으로 성장된 Pristine SWCNT(single-wall carbon nanotubes) powder 내의 metallic SWCNT 를 nitronium ions을 이용하여 선택적으로 제거한 시료와 pristine SWCNT 시료를 metallic band와 semiconducting band를 모두 관찰할 수 있는 영역인 580 nm - 900 nm 사이에서 파장변화가 가능한 Dye laser와 CW-Ti:sapphire laser를 이용하여 tunable resonant Raman scattering을 측정하고 이를 이용하여 metallic CNT와 semiconducting CNT의 구성비율을 계산하였다. 이 결과를 UV-VIS-NIR absorption spectroscopy 결과로부터 얻은 구성비율값과 비교하여 상호검증하였다.
*Acknowledgements This work was supported by the Korea Research Foundation Grant funded by the Korean Government (MOEHRD) (KRF- 2005-005-J07501).

Kp-063 **주기적인 2차원 금속 나노 구조의 광학적 특성 분석** 송 광민, 김 일원, 노 세영[1], 이 인언[1], 정 민호[1], 허 주영[1], 주 창민[1], 김 숙영[1], 정 환재[2](*전남대학교 물리학과. [1]광주과학고등학교. [2]전남대학교 과학교육학부.*) 고순도의 알루미늄 (99.999%)을 황산, 인산, 크롬산 혼합 수용액을 새로운 전해액으로 사용하여 양극산화 함으로서 규칙적이고 매우 작은 주기를 가지며 자기 조립된 Anodic Aluminum Oxide (AAO)를 얻을 수 있었다. 측정에 사용된 AAO 나노 패턴은 35 nm 정도의 기공간의 간격과 10 nm 이하의 기공 크기를 보였으며, 얻어진 AAO 패턴 위에 Pt coating을 하여 주기적인 금속 나노구조를 제작하였다. 입사광의 각도를 변화시켜가며 파장 또는 포톤 에너지에 따른 금속 나노 구조의 반사 spectrum 을 측정한 결과, 반사 spectrum이 주기적으로 oscillation 하는 특성을 보였다. 특정 포톤 에너지대에서 높은 반사율을 보였으며, 입사각의 변화에 따라 반사 spectrum 의 peak point가 장파장 혹은 단파장 쪽으로 옮겨감을 확인하였다. 제작된 금속 나노 구조는 입사광의 각도에 따라 특정 파장의 빛만을 반사하는 2차원 광구조 (photonic structure) 와 같은 광학적 특성을 보였다.

Kp-064 **Tunneling measurement of Si nanocluster using AFM** HAN Moonsup, BAE Myeongwook, KIM Kyongmin[1], KIM Eunkyeom[1], SON Daeho[1], KIM Jeongho[1](*Department of Physics, University of Seoul. [1]Department of Nano Science &Technology, University of Seoul.*) AFM(Atomic Force Microscopy) have been developed to observe nanostructure on surface like Si nanocluster. It has a number of advantages over other techniques that make it a favorite among leading researchers. In this work, we measure tunnel-

ing current of Si nanocluster using AFM. For measuring tunneling current, we set AFM and prepare sample. SiO2 layer with thickness of 5nm was grown on p-type Si(001) at 990℃ in O2 atmospheric pressure by furnace. Si nanocluster was grown on SiO2 layer at 500℃ by LPCVD(Low Pressure Chemical Vapor Deposition) using pulse gas feeding. Si nanocluster on surface were measured by AFM. Sample was prepared with pluse gas feeding by LPCVD and then Al electrodes were grown by thermal evaporation in back side of sample. And we measured tunneling current of this sample.

Kp-065 **Growth Kinetics of Silicon Nanowires by Platinum Catalyst** JEONG Hannah, KIM Myoungha, SEONG Han-Kyu, HA Ryong, KIM Ungkil, CHOI Heon-Jin(*Department of Ceramic Engineering, Yonsei University.*) Silicon nanowires are one of the most promising nano building blocks for many applications in nano-electronics, nano-photonics and nano-bio informatics. Prior to this study, many researches have focused on the silicon nanowire growth using Au catalysts. However, Au acts as deep level impurities in silicon band gap structure which prevents the direct integration of Si nanowires in CMOS process. In this study, we have exploered new liquid forming Pt as catalyst through the study on the growth of Si nanowires using Au and Pt catalysts. The Si nanowires were grown in conventional CVD process by using $SiCl_4$ as a precursor, H_2 as carrier gas and Ar as diluted gas. The growth temperatures were between 950℃ and 1100℃ and the ranges of $SiCl_4/H_2$ were varied from 5 sccm to 20 sccm. We have successfully grew Si nanowires in both cases using Au and Pt. The growth rate of silicon nanowires was constant through the holding time in both cases, while growth rate using Pt is 2.3 times faster than Au. The activation energy for nanowire growth were estimated by the growth rate versus temperature data assuming that they are satisfied with Arrhenius equation. The calculated values were 130 kJ/mol in case of Au and 80 kJ/mol in case of Pt. These activation energies are believed to be associated with thermal decomposition of $SiCl_4$ at the interface of vapour-catalyst droplet, which is assumed to be the rate-determining step of overall growth via VLS mechanism. It indicates that Pt enhances the decomposition of $SiCl_4$ at the vapour-eutectic liquid interface by "chemical" catalytic effect. These results show the great potential of Pt as catalyst for silicon nanowire growth by its physical and chemical catalytic effects.

Kp-066 **Continuous Synthesis of CNTs on Nanoparticle Catalyzed Substrate** CHOI BumHo, KIM Won Jae, KIM Young Baek, PARK Jong Woon, LEE Jong Ho, KIM Woo Sam[1](*National Center for Nanoprocess and Equipments, Gwangju Research Center, Korea Institute of Industrial Technology. [1]DMS.*) CNTs has been extensively studied since first discovery from Dr. Ijima at 1991 due to its unique properties. CNTs has wide variety of application to future nano electronic devices, display, nano composite and so on. Among these applications, nano composites ares was considered to launch CNTs application to practical products. In this study, CNTs forest was grown by atmospheric pressure PECVD system on nanoparticle catalyzed Si/SiO_2 substrate. FePt nanoparticle was synthesized using centrifugal methods and spin-coated on the substrate at the speed of 400 rpm. Transmission electron microscope was used th measure the diameter and crystalinity. The synthesized nanoparticle has 2~5 nm diameter and showed crystaliinity. The maximum heights of CNTs forest was 470 ㎛. The growth time, temperature and RF power was 10 min, 680 ℃ and 30 W, respectively. More detail experimental results will be presented at the symposium.

Kp-067 **나노결정질 실리콘 박막의 물성에 대한 연구** 김 가현, 김 세환, 김 응범, 오 동해, 허 지호, 장 진(*경희대학교 차세대 디스플레이 연구센터.*) 나노결정질 실리콘 박막은 비정질 실리콘에 비해 준안정성과 이동도를 포함한 전기적 특성이 뛰어나며, 추가적인 결정화 공정이 필요 없어 다결정 실리콘에 비해 공정비용을 크게 절감할 수 있다. 본 연구에서는 수소 희석비를 조절하여 유리기판상에 증착된 나노결정질 실리콘 박막의 특성을 연구하였다. 라만 산란실험을 통해 계산한 결정질 실리콘의 박막 내 체적 부분율은 60.3 %였으며, X선 회절분석을 통해 계산한 평균 결정립 직경은 14.8 nm가 되는 것을 확인하였다.

Kp-068 **Characteristics of Platinum Silicided P-type Schottky Barrier Metal-Oxide-Semiconductor Field-Effect Transistors Scaled Down to Sub-micron Regime** 정 원진, 최 철종, 김 약연, 전 명심, 오 순영, 김 태엽, 장 문규(*한국전자통신연구원, IT 융합기술연구본부.*) We investigate the electrical and structural properties of platinum (Pt) silicided p-type Schottky barrier metal-oxide-semiconductor field-effect transistors (SB-MOSFETs), which were fabricated using the conventional self-aligned top-gate process with physical gate lengths ranging from 20 mm to 20 nm. The Pt-silicide (PtSi) film formed by two-step annealing exhibits good surface morphology and interface uniformity with minimum lateral diffusion of PtSi into channel region. The threshold voltage of long channel SB-MOSFETs increases with decreasing gate length down to 2 um whilst sub-micron SB-MOSFETs show the negative shift of threshold voltage with the gate length scaling down. Such a gate length dependency of threshold voltage in SB-MOSFETs could be attributed to constant built-in potential clipped at source/drain contacts for shorter channel length.

Kp-069 **MOCVD법으로 증착된 Sb 박막의 특성연구** 이 규현, 이 주영, 김 현창, 장 혁규, 송 용원[1](*(주)메카로닉스. [1]한국산업기술대학교.*) 안티몬(Sb)은 광디스크인 DVD-RW의 주원료로 사용되며, 최근에는 Ge-Sb-Te 삼원계를 기본으로 물질의 상변화를 이용하여 동작하는 메모리 소자인 PRAM(Phase change Random Access Memory)의 핵심 물질로 연구되고 있다. 기존에는 주로 sputtering을 이용한 물리적 증착법으로 박막을 증착하여 왔으나, 이 방법은 우수한 원할한 양산성과 종횡비에 한계가 있어 최근에는 화학기상증착법을 이용하여 양산성과 우수한 박막 특성을 얻고자 시도하고 있다. 본 연구에서는 $SbCl_3$ 와 3(i-PrMgCl) 의 화학반응을 이용하여 열적, 화학적 안정성이 우수한 $Sb(i\text{-}Pr)_3$ 전구체를 합성하였으며, 화학기상증착법으로 Sb 박막을 얻을 수 있었다. 증착용 기판으로는 20 nm 두께의 TiN 웨이퍼를 사용하였으며, 증착된 Sb박막은 XRD, SEM, AES 등을

통하여 물리적 특성을 조사하였다.

Kp-070 **A Study on Characteristics of Tellurium Thin Films Deposited by MOCVD** 이 규현, 이 주영, 김 현창, 장 혁규, 송 용원[1](*(주)메카로닉스. [1]한국산업기술대학교.*) PRAM's (phase change random access memories) are one of the most promising candidates for next generation non-volatile memories. Recently Ge-Sb-Te composites have been researched widely as the phase changing materials used in the field of PRAM devices. In this work, we have investigated the characteristics of Te thin films deposited by CVD. For the CVD process, $Te(i\text{-}Pr)_2$ and NH_3 were used as the Te precursor and the reactant gas, respectively. The $Te(i\text{-}Pr)_2$ was synthesized from $TeCl_4$ and 4 (i-PrMgCl) through one step chemical reaction and the Te precursor could obtain the purity level of 6N by the fractional distillation. The Te thin films were grown on 20 nm-thick TiN wafer deposited by a conventional CVD and their physical properties were studied by using XRD , SEM and AES.

Kp-071 **Dependence of Electrical Characteristics Behavior on Thermal Temperature in Ultra-thin Body (UTB) Silicon-on-insulator (SOI) n-MOSFETs** BAEK Ji-Young, KIM Seong-Je, SHIM Tae-Hun, PARK Jea-Gun(*Nano-SOI Process Laboratory, Hanyang University.*) The ultra-thin body fully depleted silicon-on-insulator metal–oxide–semiconductor field-effect transistors (UTB FD SOI MOSFETs) are very promising device for a high speed and low power consumption. In addition, since the enlargement of depletion layer in the source and drain region can be suppressed by buried oxide, drain-induced barrier lowering (DIBL) as well as short channel effect can be alleviated. On the contrary, as the design rule of MOSFETs is getting smaller, the self-heating problem in the UTB SOI MOSFETs is becoming a shortfall to be resolved because the thermal conductivity of SiO_2 layer is very low, i.e., 1.4 W/mK, two orders of magnitude less than that of silicon. In particular, the thinner top silicon thickness of less than 10 nm and the more complicated device of less than 45 nm design rule lead to significant self-heating. Thus, in our experiment, electrical characteristics behavior such as saturation drain current, electron mobility, and off-leakage current in UTB SOI n-MOSFETs of the top silicon thickness less than 10 nm were investigated as a function of thermal temperature. It was observed that as the temperature increase from 25 °C to 80 °C, the saturation drain current and electron mobility were degraded about 16, 17%, respectively, and off-leakage current was increased by 2.7 times of 4.5 nm UTB SOI n-MOSFET. Furthermore, it was confirmed for the first time that the behavior of thickness size-effect was negligible in the UTB FD SOI n-MOSFETs. Finally, we suggested the improvement technologies of device performance with high temperature.

Kp-072 **Double Junction Tunneling Floating Gate Memories using Silicon Nanoclusters** KIM Eunkyeom, KIM Kyoungmin, SON Daeho, KIM Jeongho, WON Sunghwan, HONG Wanshick, SOK Junghyun, PARK Kyoungwan, KO Changhoon[1], HAN Moonsup[1], KOO Hyun-Mo[2], CHO Won-Ju[2](*Department of Nano Science &Technology, University of Seoul, Seoul, KOREA. [1]Department of Physics, University of Seoul, Seoul, KOREA. [2]Department of Electronic Materials Engineering, Kwangwoon University, KOREA.*) Si nanocluster double layers memory in a MOSFET structure was investigated. The MOSFET Si nanocluster memory device was fabricated on the p-type (100) Unibond SOI wafers with a 100 nm top Si layer and a 200 nm buried oxide layer. The structures were created with up to two layers of size-controlled Si nanoclusters having a size of around 7 nm. The Si nanoclusters were deposited by using the pulse-type gas-feeding technique in low pressure chemical vapor deposition (LPCVD) system. The details of pulse-type gas-feeding technique were described in the previous work [1]. Two layers of silicon nanocluster were separated by a 10 nm thick SiO_2 using LPCVD with mixed gases of SiH_4 and O_2. In this work, we investigated the electrical characteristics of memory device. In the nonvoltile memory operations, it was found that two flat stairs are observed. The endurance characteristics of Si nanocluster floating gate MOSFET devices were observed at the program/erasing gate voltage was ±18 V for 100 ms at V_D= 50 mV. The drift of 0.5 V in the writing/erasing threshold voltage was observed after 10^4 writing/erasing cycles. The drift-up in the threshold voltage is attributed to the electron trapping in the oxide and interface of oxide.

Kp-073 **Memory Properties of Si Nanoclusters Formed by a Pulses-Type Gas Feeding Technique in The Nonvolatile Memory Device** KIM Kyongmin, KIM Eunkyeom, KIM Jeongho, SON Daeho, BAE Myeongwook[1], KOO Hyun-Mo[2], CHO Won-Ju[2], HAN Moonsup[1], WON Sung hwan, HONG Wan-Shick, SOK Junghyun, PARK Kyoungwan(*Department of Nano Science & Technology, University of Seoul. [1]Department of Physics, University of Seoul. [2]Department of Electronic Materials Engineering, Kwangwoon University.*) Recently, many researchers have reported on the fabrication of the silicon nanocluster based on floating gate memory. The Si nanocluster nonvolatile memory is expected to operate at low voltage compared to conventional flash memory due to thinner tunneling oxide, and to provide high performance features fast high program/erasing speed, long retention time, superior endurance and the further miniaturization of the conventional flash memory. In this paper, we deposited Si nanocluster floating gate using a digital gas-feeding method in the low pressure chemical vapor deposition to obtain Si nanoclusters with a uniform size and high density. The maximum density and average size of Si nanoclusters were obtained to be $7 \times 10^{11}/cm^2$ and 7 ㎚, respectively. To verify that this method is available to Si nanocluster nonvolatile memory application, we fabricated the floating gate memory device containing Si nanoclusters, which is formed through the pulse-type gas feeding method. It was found that the threshold voltage shift was 4.5 V upon applying the gate voltage at +18/-18 V. In the nonvolatile memory operations, the program and erasing times of Si nanocluster floating gate memory were 1 ㎲ and 50 ㎳, respectively, and the retention time was estimated to be about 10 years. The endurance characteristics keep above 10^5 cycles, which has 3 V memory

window during program/erasing process at room temperatures.

Kp-074 **Si-nanocrystalline nonvolatile floating gate memory device based on Schottky Barrier Tunneling Transistor** SON Daeho, KIM Eunkyeom, KIM Kyongmin, KIM Jeongho, WON Sungwhan, SOK Junghyun, HONG Wan-Shick, PARK Kyoungwan, KIM Taeyoub[1], JANG Moongyu[1](*Department of Nano Science &Technology, University of Seoul. [1]Nano- Bio Electronic Devices Team, ETRI.*) Si-nanocrystal as discrete floating gate in nonvolatile MOSFET memory devices has been extensively investigated. Recently, Schottky Barrier Tunneling Transistor (SBTT) have been proposed as an alternative to conventional MOSFETs for sub-100 nm integration because of excellent scaling properties and ease of fabrication. In SBTT, the source and drain are composed of silicide instead of impurity doped silicon. So SBTT is attractive for silicon-on-insulator (SOI) MOSFET because the parasitic resistance of source and drain is reduced. We had fabricated the nonvolatile floating gate memory device with Si-nanocrystal based on Schottky Barrier Tunneling Transistor. The fabrication processes began with the <100> p-type silicon substrate (14~24 Ωcm). A thin tunnel oxide (~5 nm) was grown by dry oxidation and then a layer of uniform Si-nanocrystal dots with a FWHM of 6±1nm and a density of $7x10^{11}$ cm^{-2} was deposited by a digital gas-feeding method in the LPCVD process.[1] Then the control oxide was deposited 30 nm thick SiO_2 using LPCVD at 400 ℃, and the gate electrode was deposited highly phosphorus doped n-type polycrystalline silicon. Erbium silicide in the source/drain was grown by RTA process after Erbium was sputtered and non-reacted erbium removed by wet etch in Sulphuric-acid hydrogen Peroxide Mixed (SPM) solution.In our work, we investigated the electrical characteristics of memory device. A significant threshold voltage shift of fabricated floating gate memory devices based on SBTT was obtained due to the charging effects of Si-nanocrystal. But, the charge retention characteristic retained no good memory window width after 100 sec.
[1] Chan Park, Kyoungmin Kim, Eunkyeom Kim, Junghyun Sok, Kyoungwan Park, Moonsup Han, Materials science and engineering B, Volume 140, Issues 1-2, 25 May 2007, Pages 103-108

Kp-075 **Ge movement inside SiGe layer of Strained SiGe-On-Insulator** HAN Yong-Soo, HONG Seok-Hoon, LEE Hun-Joo, LEE Gon-Sub, PARK Jea-Gun(*Hanyang University, Nano SOI Process Lab.*) The ε-SGOI (Strained SiGe-On-Insulator) wafer is essentially requested to maintain the device performance as the channel length of C-MOSFET becomes less than 60 nm. The condensation method is the most reliance and cost effective method to fabricate the ε-SGOI wafer. The mechanism of Ge movement inside SiGe layer via condensation is not clarified in spite of a lot of study. In SiGe/top-Si/Buried-Oxide/Si_sub structure, condensation method shows several Ge diffusion movements during the oxidation processing. It was found that the structure has initial Ge concentration 15at% and 40 nm SiGe layer thickness in oxidation processing condition of 950℃ is not changed both Ge concentration and SiGe thickness during the oxidation processing. It stayed a kind of equilibrium state on SiGe layer in spite of the oxidation processing is proceeded. It means that oxidation speed and diffusion speed of Ge in SiGe layer can be same in specific process condition. So we can control oxidation speed in condensation process precisely. The ε-SGOI wafer which has been fabricated under these conditions has the surface roughness from 0.171 nm to 0.189 nm at 36~40% Ge concentration. It shows high quality similar to a bare wafer.
*This work was supported by the Korea Science and Engineering Foundation (KOSEF) through the National Research Lab. Program funded by the Ministry of Science and Technology (No. M10400000436-06J0000-43610).

Kp-076 **The Influence of the Silicon Body Thickness on Low-field Mobility Behavior involving Surface Roughness Scattering in Ultra-thin Body (UTB) Silicon-on-insulator (SOI) n-MOSFETs** LEE Yong-Seon, MOON Hui-Chang, SHIM Tae-Hun, PARK Jea-Gun(*Nano-SOI Process Laboratory, Hanyang University.*) Since the size of MOSFETs has been continuously miniaturized and the short channel effect has become one of the critical issues for achieving future scaling, the ultra-thin body (UTB) MOSFETs are promising device structure as a deca-nano-scaled MOSFET structure. As the body thickness in a UTB MOSFET of less tan 5 nm, the mobility dependancy on effective fields is quite different from that of thick SOI or bulk MOSFETs. In other words, in a UTB MOSFET of less tan 5 nm, the mobility degradation can be observed not only at the high inversion charge density but also at the low inversion charge density because of the strong effect of both surface roughness scattering and Si-thickness fluctuation scattering. In this work, thus, we investigated the mobility behaviors involving surface roughness scattering, phonon scattering, and body thickness fluctuation in UTB MOSFETs by utilizing the self-consistent 2-dimensional Schrödinger solver and Monte Carlo simulation. It was found that the concept of average distance at each electron energy subband was feasible for analyzing the effective field dependancy of mobility in such a UTB channel, resulting from considering the structural distance from both front and back interfaces. In addition, it was suggested for the first time that surface roughness intra-band and inter-band scattering can be described by different angle dependancy which are specular reflection and diffuse scattering, respectively. Finally, it was confirmed that our method closely matches and well explains the behavior seen in published experimental data for 3 nm UTB SOI n-MOSFET.
*This work was supported by the Brain Korea 21 Project in 2007.

Kp-077 **Optical Property of ZnO:Ga and ZnO Thin Films at Room Temperature on Glass Substrate : Thickness Dependence** JEON M.H., HWANGBOE S.J., JEON H.H., SONG H.J., KIM D.H., LEE K.S.(*인제대학교 나노메뉴팩처링 연구소.*) Zinc Oxide (ZnO) is an alternative material for optoelectronic devices and gas sensor such as UV laser, LED, and TFT. Recently, Gallium doped ZnO (GZO) has been widely studied due to improve their conductivity. We investigate structural and optical property of ZnO and GZO films. ZnO and GZO with different thickness are pre-

pared on glass substrate by RF magnetron sputtering. The structural property of ZnO and GZO films are investigated by Transmission Electron Microscopy (TEM) measurement and Scanning Electron microscopy (SEM). It is found that grains of GZO film are more severely elongated than that of ZnO film based on TEM measurement. Also, grain size of GZO film is smaller than that of ZnO film. It shows that SEM result exactly corresponds with TEM result. The Optical property is also carried out by spectrophotometer (250~1600nm). The transmittance of GZO films is higher than that of ZnO films through all of the ranges. Sub 100nm, the optical property of ZnO films is better than that of GZO films.

Kp-078 **Influence of the annealing temperature on properties of ZnO film grown on glass substrate by rf magnetron sputtering.** JEON M.H, KIM G.C, JEON H.H, LEE J.S, HWANGBOE S.J, KIM D.H, CHOI W.B[1](*Department of Nano Systems Engineering, Center for Nano Manufacturing, Inje University. [1]Department of mechanical and materials engineering, Florida International University.*) Zinc oxide (ZnO) transparent conducting films possess very interesting properties in the electrical and optical application fields due to high conductivity and transmittance in the visible radiation region. Independent of the deposition technique used the properties of the films, especially the structural, electrical and optical ones, could be improved by post-annealing treatment under suitable condition.In this study, ZnO films are prepared on glass substrates by rf magnetron sputtering at room temperature and the thickness is approximately 300nm. The effects of annealing treatment on structural, electrical and optical properties of ZnO films with different temperature were investigated. By using x-ray diffraction (XRD), field-emission scanning electron microscopy (FE-SEM), we analyzed structural properties of ZnO thin films before and after anneal treatment. After annealing treatment, grain size is larger than before that and crystalline is more stable. Transmittance also enhanced about 9% in visible region by uv-vis-nir spectrometer. The resistivity are 3.76 Ω·㎝ and 0.771m Ω·㎝ in before and after anneal treatment repectively.From the results, we confirmed that the annealing treatment leads to improve high crystalline, electrical and optical characteristics of ZnO thin films.

Kp-079 **엑시머 레이저 어닐링에 의한 Al-ZnO의 특성 향상에 관한 연구** 정 의석, 김 지훈, 봉 하종, 이 영민, 성 준재, 이 아령, 심 다혜, 김 득영(*동국대학교*) ZnO는 반도체로써 뿐만이 아니라 투명전도성 물질로써도 큰 관심을 갖고 많은 연구가 진행 중에 있다. 본 연구에서는 RF Magnetron sputtering법을 사용하여 glass 기판에 Al-ZnO 박막을 성장하였다. 통상적으로 유리 기판 위에 성장된 ZnO 박막은 고온 장시간 열처리시 유리 기판의 변형에 의해 전체적인 박막의 특성이 저하되는 현상을 보인다. 본 연구에서는 이러한 단점을 보완하기 위해 통상적인 열처리 방법이 아닌 KrF 엑시머 레이저 어닐링에 의한 특성 향상을 도모 하였다. 성장된 박막에 대해 먼저 furnace 열처리를 통해 특성을 살펴 본 결과 400^0C에서 1시간 처리 하였을 때 비저항이 3 x 10^{-2}Ωcm 의 값을 나타내었다. 그러나 엑시머 레이저 어닐링을 한 시료의 비저항은 furnace 어닐링 한 시료 보다 낮은 비저항을 나타내었다. 또한 전자농도 및 이동도에 있어서는 furnace 어닐링 시료 보다 월등히 높은 값을 나타내었다. 본 논문에서는 레이저 어닐링된 Al-ZnO 박막의 전기적 광학적 특성에 대해서 보고할 예정이다.

Kp-080 **Hot Wall Epitaxy에 의한 $Cd_{1-x}Mn_xS$ 단결정 박막의 성장과 구조적.광학적 특성** 박 재환, 오 병성, 최 용대[1], 김 대중[2], 김 창수[3], 윤 만영[4](*충남대학교 물리학과. [1]목원대학교 광.전자물리학과. [2]목원대학교 테크노 과학연구소. [3]한국 표준과학 연구원. [4]중부대학교 정보통신학과.*) 화합물 반도체는 조성비에 따라 에너지 띠 구조나 격자상수 등을 조절할 수 있기 때문에 반도체 소자 응용에 많이 이용되고 있다. 그 중에서도 Ⅱ-Ⅵ족 화합물 반도체인 CdS는 에너지 갭이 약 2.50 eV인 직접천이형 반도체로서 여러 광전자 장치에 쓰인다. 여기에 용해도가 높고, 스핀 운동량이 큰 전이금속 Mn을 첨가하면 희박자성반도체(diluted magnetic semiconductor, DMS)인 $Cd_{1-x}Mn_xS$ 박막이 제작된다. 이러한 DMS는 띠 전자와 자기 이온간의 교환상호작용으로 다양한 자기광학적 효과를 나타내며, 스핀트로닉스를 구현할 수 있는 매우 흥미로운 물질이다. 본 연구에서는 열벽적층성장법(hot-wall epitaxy, HWE)을 이용하여 $Cd_{1-x}Mn_xS$ 희박자성반도체 에피막을 각각 GaAs(100±2° off)와 GaAs(111±0.5° off) 기판 위에 성장시켜 결정구조 및 광학적 특성을 비교하였다. 성장된 $Cd_{1-x}Mn_xS$ 단결정 박막의 표면특성은 Nomarski 간섭현미경과 AFM을 이용하여 살펴보았고, XRD와 DCRC 측정을 통하여 박막의 결정구조와 결정성을 확인, Cubic 구조와 Hexagonal 구조를 비교.분석 하고, Mn의 함유율에 따라 일어나는 각분리, 격자상수의 차이를 조사하였다. Mn의 조성비는 EDX의 측정으로 정하였고, 광발광 측정으로 Mn의 intra 천이를 관측,광학적 특성을 알아보았다.

Kp-081 **기판 온도 변화에 따른 $Cd_{1-x}Mn_xS$ 박막의 특성 연구** 김 대중, 박 재환[1], 최 용대[2], 이 종원[3](*목원대, 테크노과학연구소. [1]충남대, 물리학과. [2]목원대, 광전자 물리학과. [3]한밭대, 신소재공학부.*) 기판 온도 변화에 따른 고품질 육방정 $Cd_{1-x}Mn_xS$/GaAs (111) 박막들이 열벽 적층 성장법 (hot-wall epitaxy;HWE)을 이용하여 성장되었다. 성장된 박막들의 광학적 특성을 알아보기 위하여 분광학적 엘립소미트리 (spectroscdopic ellipsometry; SE)를 사용하여 실온에서 1.5-8.7 eV 사이 포톤에너지 범위에서 측정되었다. 측정된 데이터들은 유사유전함수 스펙트럼 $\langle\varepsilon(E)\rangle=\langle\varepsilon_1(E)\rangle+i\langle\varepsilon_2(E)\rangle$에 나타난 E_0, E_1, E_1,+Δ_1, E_0`, $E_1$` 와 같은 임계점 구조에 대하여 연구되었다. 또한 박막의 복소 유전함수와 밀접한 관계를 가지고 있는 굴절지수 n(E), 소광계수 k(E), 반사계수 R(E) 그리고 흡수계수 α(E)와 같은 광학적 특성 등을 연구하였다. 특히, 기판의 온도 변화에 따른 임계점 피크들의 이동과 넓어짐을 관측할 수 있었다. 또한, 광학적 에너지 밴드 갭이라고 일컬어지는 E_0 구조와 II-VI 족 화합물 반도체에서 보다 더 강하게 나타나는 엑시톤들의 상호 작용에 의한 E_1 구조는 기판온도 변화에 따라 저에너지 쪽으로 이동하는 것을 알 수 있었다. 특히 육방정 구조에서만 나타나는 E_1,+Δ_1 구조가 기판온도 변화에 따라 어떻게 변화하는지 조사하였다.

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Kp-082 **산소와 수소 Plasma로 표면처리한 Al_2O_3기판에 PAMBE로 성장된 얇은 ZnO 박막의 광학적 특성 변화** 이 선균,

곽 호상, 권 봉준, 김 지영, 고 항주[1], YAO Takafumi[2], 조 용훈(*충북대, 물리학과. [1]광기술원. [2]Institute for Materials Research, Tohoku University.*) Al_2O_3기판을 산소 plasma 또는 수소 plasma로 표면처리한 후 그 위에 plasma-assisted molecular beam epitaxy (PAMBE)성장된 ZnO얇은 막에 대한 구조적, 광학적 특성 변화를 알아보았다. 제작된 ZnO 박막은 High Resolution X-ray Diffraction (HRXRD)와 Atomic Force Microscop (AFM)를 사용하여 구조적 특성과 표면 특성을 관찰하였다. 또한 Photoluminescence(PL)와 Time-resolved Photoluminescence (TR-PL)를 측정하여 광학적 형광 특성과 시간분해 형광특성을 조사하였고 시료의 앞면과 뒷면에 대한 광특성도 함께 조사하였다. 전체적인 실험결과로 부터 시료A가 시료B보다 우수한 구조적 특성과 형광특성을 보였다. 이것은 산소공공(oxygen vacancy)이 산소plasma 표면 처리함으로 보다 적게 생겨나고 결국 좋은 격자일치(lattice matching)를 보여주므로 향상된 구조적 특징과 발광 결합특징을 나타났다. 형광측정실험에서는 free exciton(FX), bound exciton(DX) 그리고 이것의 phonon replica들을 저온(10K)에서 나타났고 시료 앞면에서의 형광 세기가 뒷면보다 상당히 커짐을 보였다. excitonic 재결합 형광 수명시간은 앞면에서보다 뒷면에서 훨씬 짧게 나타났고 그것은 non-radiative 재결합 효과로 짧아짐을 설명하였다.

Kp-083 **Evaluating the carrier types of ZnO using contactless electroreflectance** 김 성수, 정 현식, 이 종현[1], 홍 진표[1](*서강대학교 물리학과. [1]한양대학교 물리학과.*) Wurtzite 구조의 ZnO는 O vacancies와 Zn interstitials와 같은 intrinsic defect에 의해서 자연적으로 n-type으로 성장된다. Homojunction에 의한 ZnO 소자를 만들기 위해서는 p-type의 ZnO가 필요하지만 GaN, ZnSe와 같은 밴드갭이 큰 반도체에서는 p-type doping이 매우 어렵다. 주로 Hall measurement에 의해서 도핑된 시료의 carrier-type을 측정하지만 이러한 방법을 이용할 경우 시료에 손상을 가져오게 된다. Contactless electroreflectance (CER) 같은 광학적인 방법은 비파괴적이며 간단하게 carrier의 type을 결정할 수 있다. Electroreflectance의 경우 도핑에 의한 band bending에 의해서 n-type, p-type의 경우에 반대의 phase 변화가 생긴다. 실험에 이용된 ZnO는 sputtering에 의해서 성장되었다. CER 측정방법을 이용하여 ZnO 박막의 carrier type을 조사하였으며 photoluminescence를 측정하여 n-type과 p-type ZnO 광학적 특성을 분석하였다.

Kp-084 **Measurement of Whispering Gallery Modes of ZnO microplate using micro-photoluminescence imaging** 김 성수, 윤 두희, 정 현식, 김 용진[1], 이 규철[1](*서강대학교 물리학과. [1]POSTECH 신소재공학과.*) ZnO는 엑시톤 결합에너지가 60 meV로 크기 때문에 상온에서 이용 가능한 단파장 광소자 응용을 위한 연구가 활발히 진행되고 있다. 또한 상온에서 낮은 threshold pumping power에서도 레이징이 가능하기 때문에 레이저 다이오드에 응용될 것으로 기대되고 있으며, ZnO 나노구조를 이용하여 FET, Schottky 다이오드와 같은 다양한 전기소자가 만들어지고 있다. 6각형 모양의 ZnO microplate는 whispering-gallery-modes (WGMs)에 의해 resonator 역할을 하여 luminescence가 증대되기 때문에 작은 크기의 structure에서도 상대적으로 큰 발광효율을 얻을 수 있게 된다. 실험에 이용된 ZnO microplate는 soft solution process에 의해서 Si 기판 위에 성장되었다. 광학적인 방법으로 ZnO microplate에서의 WGMs를 측정하기 위해서 micro-PL imaging 장치를 이용하였다. 실험에 사용된 해상도는 약 1 μm이며 He-Cd레이저의 325 nm line이 여기광으로 이용되었다. 레이저를 시료에 조사하였을 때 중앙이 비어있는 Hexagonal 형태의 발광이 microplate의 주변에 나타나는 것을 CCD카메라로 관측하였으며 WGM에 의한 발광 스펙트럼을 시료의 위치를 변화시켜가면서 측정하였다.

Kp-085 **Electrical and Optical Properties of Annealed ZnO Thin Films Deposited by Pulsed Laser Deposition** SONG HOOYOUNG, KIM JAE-HOON, KIM EUN KYU(*Quantum-Function Spinics Lab. and Department of physics, Hanyang University.*) ZnO is very attractive material to use optical devices such as UV-light emitting sources or UV-sensing diodes. Also ZnO has the potentials that can be applied to fields of transparent conducting oxides, solar cell, surface wave devices. To realize these devices, the ZnO thin films should have qualified structural, electrical and optical properties. In this study, we demonstrate that the annealing process improves quality of ZnO single crystal. We also investigate role of the ZnO buffer layer to know the relation between electrical and optical properties by using various measurement systems, which are X-ray diffraction patterns with theta/2theta mode, energy dispersive X-ray spectroscopy, photoluminescence spectroscopy, scanning electron microscope to investigated the structural, optical and electrical properties.

Kp-086 **The effect of annealing on the properties of ZnO : Ga film prepared by RF magnetron sputtering** JEON M.H., LEE J.S., JEON H.H., KIM G.C., SONG H.J., KIM D.H.(*Department of Nano Systems Engineering, Center for Nano Manufacturing, Inje University.*) Ga doped zinc oxide (GZO) transparent conducting films possess very interesting properties in the electrical and optical application fields. ZnO based transparent conducting oxide films are widely used as solar cell, LCD, gas sensors and energy efficient windows due to high conductivity and high transmittance in the visible part of the radiation spectra. In this study, Ga doped ZnO films are prepared by RF magnetron sputtering on glass substrates at room temperature. After then, as grown films are annealed by furnace at 500 ℃ for 60 min in N_2 ambient. The effect of annealing on the structural and morphology properties of GZO films was investigated by X-ray diffraction (XRD) and field emission scanning electron microscopy (FE-SEM). The Optical properties of GZO thin films are analyzed by UV-VIS-NIR spectrophotometers. It is found that structural and optical properties of GZO films are improved by annealing and can be used for transparent electrode application.

Kp-087 **Study of Defects on $Zn_{0.95}Mn_{0.05}O$ by Using Deep Level Transient Spectroscopy** KIM Jae-Hoon, SONG Hooyoung, KIM Eun Kyu(*Quantum-Function Spinics Lab. and Department of Physics, Hanyang University.*) Wide-bandgap semiconductors such as GaN, ZnO and 6H-SiC have been widelyinvestigated for their applications to ultraviolet (UV) light emitters andhigh-power and high-temperature electronics due to their wide-bandgapnature and

high breakdown electric fields. Recently, an attention to ZnO is-growing rapidly because of its advantages over GaN including availabilityin bulk and much higher exciton binding energy (60 meV) compared with GaN(24 meV) which guarantees a stability of exictonic emission mechanismsabove room temperature. Especially, the ZnO has much interesting for abased material for the diluted magnetic semiconductor, because of itstheoretical high Curie temperature.In this study, $Zn_{0.95}Mn_{0.05}O$ films were grown by pulsed laser deposition(PLD) on sapphire substrates with ZnO buffer layer at some variedtemperature between from 200 K to 700 K. The defects in the $Zn_{0.95}Mn_{0.05}O$films were investigated by using deep level transient spectroscopy (DLTS)and photoluminescence measurements. For the DLTS measurement, Ti/Au wasdeposited over the large area of the sample to form an Ohmic contact. Onthe prepared sample the DLTS measurements were performed at temperaturerange from 20 K to 370 K. Some signals were found near at 200 K and that isconsidered to Mn related defect.

Kp-088 **유도결합 플라즈마장치를 이용한 ZnO 박막증착** 노 승정, 이 두형, 권 새롬, 박 영환, 이 석관, 정 보현, 김 희수, 김 용민, 현 준원, 고 승국[1](*단국대학교 응용물리학과. [1]울산대학교 물리학과.*) p형 ZnO 박막성장을 위해서 분자선 증착(MBE), 유기금속 화학기상증착(MOCVD), 펄스레이저 증착(PLD), 원자층 박막증착(ALD)과 같은 다양한 기술들이 이용되고 있다. 특히, 신뢰성 있는 p형 ZnO 박막성장은 광전자 및 디스플레이 소자 응용에는 여전히 제한적이다. 본 연구에서는, 유도결합 플라즈마(inductively coupled plasma)소스를 채용한 원자층 박막증착 장치(plasma enhanced atomic layer deposition: PEALD)를 이용하여 ZnO 박막을 성장하였다. ZnO 원자층 박막 증착과정에서 플라즈마 처리된 반응가스를 주입하여 전구체와의 반응을 유도하였다. Zn 전구체로서 (C2H5)2Zn, 반응체로서 H2O, 도너(donor)로서 질화물계, 그리고 캐리어 및 퍼지 가스로 아르곤을 이용하였다. ZnO 박막의 물성 및 특성을 비교하기 위하여 기판온도, 플라즈마 파워 및 유입소스의 변화량에 따른 박막을 증착하였다. 성장된 박막의 전기적 광학적 특성 및 결정성(crystal quality)은 four-point probe, Hall measurement, XRD, FE-SEM, AES, 그리고 PL을 이용하여 분석하였다.

* 본 연구는 핵융합센터 한빛 이용자 프로그램으로 지원됨.

Kp-089 **증착변수 및 후 열처리에 의한 ZnO 박막의 특성변화** 유 지현, 김 정현, 박 대성, 정 태수[1], 윤 창주[1](*전북대학교 반도체화학공학부. [1]전북대학교 반도체물성연구소.*) 최근 GaN 청색 발광 소자의 발전에 따라 높은 광투과도와 전기전도성을 함께 가지는 TCO (transparent conducting oxide)에 관한 요구가 높아지고 있다. 현재 범용적으로 사용되는 TCO 물질은 ITO(Indium Tin Oxide)박막이다. 하지만 GaN LED의 p-GaN층과 n-GaN층 접촉에서 non-linear 특성을 보이며, Indium의 희귀성과 높은 가격은 ITO 박막 이외의 차세대 TCO 물질의 개발을 요구하고 있다. ZnO 박막이 ITO 박막의 대체 물질로 연구되는 이유로는 낮은 전기 저항, 높은 가시광선 투과도, 낮은 가격과 풍부함을 들 수 있다. 그러나 rf 마그네트론 스퍼터링법을 이용하여 증착한 ZnO 박막은 높은 광투과도와 높은 비저항값을 보여 많은 연구가 필요하다. 본 연구에서는 rf 마그네트론 스퍼터링법을 이용하여 ZnO 박막을 증착한 후 여러 온도와 분위기에 열처리해줌으로써 ZnO 박막의 광투과도와 비저항에 미치는 영향을 조사하여 투명전도막 응용시에 따른 최적 열처리조건을 찾고자 하였다.

Kp-090 **RF-Magnetron Sputtering법에 의해 성장된 BeZnO 박막의 구조적·광학적 특성** 김 정현, 박 대성, 유 지현, 정 태수[1], 윤 창주[1](*전북대학교 반도체화학공학부. [1]전북대학교 반도체물성연구소.*) GaN와 밴드에너지가 같은 ZnO의 p 도핑 방법이 알려지면서 차세대 발광소자 재료 및 투명박막을 전기소자(TFT), 태양전지 등에 이용하려는 연구가 주목을 받고 있다. 고효율 ZnO계 발광소자 구현을 위해서는 3.37 eV의 밴드갭 크기를 조절할 수 있어야 한다. ZnO 계열 구조에서는 자외선 파장영역을 조절하기 위해서 Mg, Be, Se 그리고 Cd 등을 합금하여 밴드갭을 조절한다. 본 연구에서는 먼저 ZnO를 Rf sputter법에 의해 성장하여 구조적·광학적 특성을 조사함으로써 최적화된 조건을 얻은 후 Be를 co-sputtering하여 BeZnO 박막을 성장하였다. 이때 온도, 분위기 개스, 압력에 따른 박막의 특성을 조사하였다.

Kp-091 **Characterization of the intrinsic p-type ZnO by sputtering with controlling the oxygen partial pressure** 박 대성, 김 정현, 유 지현, 정 태수[1], 윤 창주[1](*전북대학교 반도체 화학공학부. [1]전북대학교 반도체물성연구소.*) ZnO has emerged as a great potential material for device performance in photonics, electronics, nanostructures and spintronics. However, the crystallite quality of p-type ZnO is often limited by fundamental problem of native defect such as Zn interstitials and oxygen vacancies. In order to improve the quality of intrinsic p-type ZnO grown by using sputtering system, the role of oxygen partial pressure during growth process on reducing the oxygen vacancies need to be considered. In this study, ZnO film was fabricated on sapphire (0001) substrate by using radio- frequency magnetron sputtering with various oxygen partial pressures. After grown, the film quality was characterized by using photoluminescence, HRXRD, and Hall measurement system. Furthermore, to understand the behavior of ZnO films, p-type/n-type structures were deposited on sapphire (0001) substrate and the I-V characteristic was carried out at room temperature.

Kp-092 **Controllable synthesis of ZnO nanocrystals at a low temperature by solvo-thermal method** CHAE Jong-Ah, BAE Jong-Seong, PARK Sungkyun, YOON Jang-Hee, KIM Jong-Pil (*Korea Basic Science Institute Busan Branch.*) Zinc oxide (ZnO) is a II–VI compound semiconductor with a wide direct bandgap (3.37 eV) and a large exciton binding energy (60 meV) at room temperature. Since the novel properties of nanomaterials depend on their size, shape and dimensionality, various approaches, including chemical vapor deposition, thermal evaporation, template involved process and solution-phase synthesis, have been employed successfully for the preparation of ZnO nanostructures with a wide variety of morphologies. We described the phase formation and controllable nanostructures of Zinc oxide were prepared by solvo-thermal method. The nanostructures were analyzed by x-ray diffraction (XRD) and transmission electron microscope (TEM). The chemical bonding states

is measured by x-ray photoelectron spectroscopy (XPS).

Kp-093 **The magnetic properties of Mn doped GaN grown using single GaN precursor via molecular beam epitaxy** 조 영훈, 박 승영, 정 명화, GAO Cunxu[1], 김 도진[1](*한국기초과학지원연구원, 양자물성팀.* [1]*충남대학교, 신소재공학부.*) Ferromagnetic semiconductor has attracted great attention for future spintronics because both charge and spin can be manipulated by external stimuli. GaMnN may be on of the possible room temperature ferromagnetic semiconductor candidates as a promising material for spin injection devices. However, the possibility of homogeneous and segregated precipitate coexisting could not be neglected in most cases. In these days, the effect of extrinsic magnetic signal resulting from the segregated precipitates to the intrinsic magnetic properties is a very interesting field to study. The solid solution Mn $Mn_{4-x}Ga_xN$ derives from the intermetallic Mn_4N. The atoms at the corners of the N centered fcc unit cell, Mn(I), may be randomly replaced by Ga. The manganese at the center of the faces, Mn(II), are strongly bounded to the N and are irreplaceable. Mn_4N can be derived from ordinary fcc Mn by inserting a nitrogen atom in the center of the fcc unit cell and leads to the occurrence of the two different manganese sites with and increase in volume. The compound is ferromagnetic below 752 K for x = 0. The [111] direction is the easy magnetization direction of Mn(I), whereas Mn(II) points in opposite direction and transforms triangularly in the (111) plane from the Γ_{5g}. For x = 1 there are only Mn(II) atoms ordering in a triangular antiferromagnetic arrangement (Γ_{5g} symmetry) below 278.5 K. So the magnetic properties of $Mn_{4-x}Ga_xN$ are strongly related to the composition values x. A complicated magnetic intermediate phase behaves the two kind competing antiferromagnetic interactions as well as the possibility of the Mn(I) moment disappearance at certain conditions. We grew Mn doped GaN using a single GaN precursor at the substrate temperature of 620 ℃ via MBE in different Mn cell effusion temperature (T_{Mn}) in the range of 900 – 1000 ℃ and study the magnetism of the films. At the same time, the perpendicular magnetic anisotropy and magnetic transition resulting from the $Mn_{4-x}Ga_xN$ precipitates were observed and discussed.

Kp-094 **Physical Properties of Co, Mn, Fe, Nb doped ZnO Ceramics** KIM Saes Byul, KIM Yu Sung, PARK Hui Jin, KIM Eun Ji, JUN Byeong Eog[1], PARK Jong Ho[2], CHOI Byung Chun (*Pukyong National University.* [1]*Basic Science Research Institute, Pukyong National University.* [2]*Jin Ju National University of education.*) ZnO with hexagonal wurtzite structure is a wide-band-gap semicondutor with numerous application, for instance in varistor, phosphors, and sensors. Recent theoretical development has shown that wide band gap semiconductors are the most promising candidates for achieving high curie temperature. In this study, we investigated the dielectirc properties of Mn, Fe, Co, Nb doped ZnO ceramics which were prepared by using the conventional soild reaction methods. The doped ZnO ceramics were chacterized microscopically by using SEM and XRD. The frequency dependent dielectric constants were measured with the impedance analyser at the temperature range of -50 ℃~300 ℃.We observed that the doped matierials were very soluble to the ZnO structures with the small change of lattice constants of the wurtzite structure.

Kp-095 **Photoluminescence of Zinc Telluride Measured by Home-Built Photoluminescence Spectrometer** LEE Cheol Eui, PARK Jun Kue, KWEON Jin Jung, LEE Kyu Won(*Department of Physics, Korea University.*) The photoluminescence (PL) spectra were investigated by using the home-built PL spectrometer including a Oriel 77200 monochromator and SR-830 DSP Lock-In Amplifier. The excitation source is Argon Ion laser radiation (λ =488.0 nm) of power 0.65 W, operating in continuous conditions. The radiation of ZnTe pellet is recorded at an angle of 45° to the incident beam and perpendicular to the plane of layer. The radiation of ZnTe pellet is measured on the normal temperature for this experiment.

Kp-096 **Growth of p-type ZnO Thin Film Using Nitrogen Diffusion Mechanism from WN Layer** LEE Jonghyun, HA Jaehwan, HONG Jinpyo(*New Functional Materials and Device Lab, Department of Physics, Hanyang University, Seoul 133-791, KOREA.*) High quality p-type (Al,N) co-doped ZnO films are efficiently fabricated on glass substrates by allowing nitrogen atoms from pre-grown tungsten-nitride (WN) film to be activated and diffused into pure ZnO film during in situ post-thermal annealing process. The p-type (Al,N) co-doped ZnO film exhibits reproducible electrical properties of hall concentration of 1.4×10^{18} cm^{-3}, mobility of 2.4 cm^2/V_s, and resistivity of 15 Ωcm at room temperature, together with the corresponding structural results. SIMS measurements show the increment of nitrogen ratio vs Zn, Al, and O atoms as increasing annealing temperature. Further investigation through ZnO p-n homojunctions with pure ZnO film and (Al,N) co-doped ZnO film displays excellent I-V characteristics with a turn-on voltage of about 5 V, demonstrating that our p-type ZnO growth process is distinct to simply realize the formation of ZnO p-n homojunction device.

Kp-097 **RF 마그네트론 스퍼터링 기법으로 제작된 NiO 박막의 광학적 및 전기적 특성 연구** 박 준우, 최 광남[1], 백 승호, 정 관수[1], 이 호선(*경희대학교 일반대학원 물리학과.* [1]*경희대학교 일반대학원 전자공학과.*) RF 마그네트론 스퍼터링 방법을 이용하여 다양한 조건에서 NiO 박막을 성장시켰다. 즉 200W의 파워로 혼합가스의 산소비를 0% ~ 30% 까지 변화시켰으며, 여러 가지 열처리방법을 이용하여 NiO 박막을 증착하였다. 열처리 방법은 열을 가하면서 증착하는 방법과 상온에서 성장 후 열처리를 하는 방법, 비교적 낮은 온도에서 증착 후 높은 온도로 열처리해서 버퍼층을 생성시킨 후 같은 온도로 다시 증착한 방법을 이용하였다. 광학적 특성은 타원분광해석기를 이용하여 유전함수를 측정하였으며 Standard Critical point 모델을 이용한 이차미분 도함수을 이용하여 광학적 밴드갭에너지와 broadening을 구하였다. 성장 조건과 열불림 조건에 따른 광학적 특성의 변화를 논하였으며, ReRAM 특성을 조사하기 위해서 IV 특성과 광특성과의 상관 관계를 조사하였다. 또한 DC sputtering에 의해 성

장시킨 NiO 박막과 광학적 및 전기적 성질을 비교분석하였다.

Kp-098 **Effects of Oxygen Plasma Treatment on Electrical and Optical Characteristics of ZnO-Nanowire Thin Film Grown by Solution Method.** 김 민석, QURASHI Ahsanulhaq, 차 옥환, 양 하용, 우 승희, 박 대성, 윤 창주, 서 은경, 한 윤봉, 이 정수(*전북대학교, 반도체화학공학부.*) 본 연구에서는 ZnO 나노선 박막의 전기적 특성을 분석하기 위해 4-point probe 형태의 소자 구조를 제안하고, 이를 이용하여 ZnO 나노선 박막의 특성 분석 및 Oxygen 플라즈마 처리에 따른 영향을 평가하였다. 제안된 소자 구조는 후속 공정의 추가없이 직접적인 전기적 특성 분석을 가능케 한다. 먼저 SiO_2/Si(100) 기판위에 RF 스퍼터링을 이용하여 Seed layer로 50 nm 두께의 ZnO 박막을 증착한 후 반도체 공정을 이용하여 4-point probe 패턴의 금속 전극을 형성하고, Solution method을 이용하여 ZnO 나노와이어 박막을 성장시켰다. ZnO의 성장을 위해 zinc nitrate hexahydrate[$Zn(NO_3)_2 \cdot 6H_2O$]와 hexamethylenetetramine[HMT, $C_6H_{12}N_4$]를 사용하였다. FE-SEM 분석 결과, 성장된 ZnO 나노선 박막의 두께는 1um 정도로 측정되었고, 박막 내 각 나노선의 지름은 50-100nm 정도로 측정되었다. 상온에서 전기적 특성을 측정한 결과, as-grown 샘플은 ~100MΩ 정도의 값을 나타냈으며, 플라즈마 처리시간이 증가함에 따라 ~10GΩ까지 증가하는 경향을 보였다. 상온 PL (Photoluminescence) 측정 결과, as-grown 샘플은 UV emission peak(~384nm)에서의 반치폭(FWHM)이 약 24 nm로 측정되었으며, Oxygen 플라즈마 처리를 행함에 따라 반치폭은 16.5 nm 까지 감소하였고, 그 후 플라즈마 처리시간이 증가함에 따라 다시 증가하는 경향을 나타냈다. 이러한 결과는 Oxygen 플라즈마 처리가 ZnO 나노선 박막의 특성 개선에 효과적임을 의미한다.