

Tuesday Afternoon Poster Sessions

Nanometer-scale Science and Technology

Room: Southwest Exhibit Hall - Session NS-TuP

Nanometer-Scale Science and Technology Poster Session

NS-TuP1 Fabrication and Characterization of Piezoelectric Polymer Nanostructure. *D. Kim, Y.-Y. Choi, H.W. Choi, M. Han, M. Park, G. Ahn, K. No*, Korea Advanced Institute of Science and Technology (KAIST), Republic of Korea

We show the microstructures and ferroelectric domains of 200nm diameter poly(vinylidene fluoride-trifluoroethylene), P(VDF-TrFE) with composition of 75/25 mol%, nanorods fabricated by a porous template technique. In order to characterize the piezoelectric properties of P(VDF-TrFE) nanorods, both nanoscale manipulation and polarization switching were studied using piezoresponse force microscopy (PFM). Ferroelectric domains and their properties were confirmed using X-ray diffraction and PFM analysis. The ferroelectric domains in the nanorods were homogeneously switchable below 5V. This offers our rationale for a promise in energy harvesting and switchability would be good for plastic electronics.

NS-TuP2 Uniform Printing of PEG Hydrogel Arrays by Dip-Pen Nanolithography[®]. *J.-W. Jang, P.L. Stiles, S.R. Nettikadan*, NanoInk Inc.

Dip Pen Nanolithography[®] (DPN[®]) is an established method of nanofabrication in which materials are deposited onto a surface via a sharp tip. DPN enables controlled deposition of a variety of materials with nanoscale registry onto various substrates. Recent advances in DPN technology has resulted in the ability to directly print larger, biologically relevant materials on to a variety of surfaces under ambient conditions.

A novel method for the construction of hydrogel patterns has been developed. Hydrogels are of great interest to tissue engineers and other biomedical researchers because of the versatility of PEG chemistry and excellent biocompatibility. Also the mechanical and swelling properties of PEG hydrogels can be easily tuned by controlling the degree of cross-linking and choosing the appropriate molecular weight. Patterning of hydrogels in submicron scale with defined mechanical properties is highly desirable as a scaffold for tissue engineering and *in vitro* cell culture studies.

We report a novel method for generation of hydrogel patterns at subcellular scales. Hydrogel precursors are directly deposited at defined location and then polymerized to form hydrogels. This method allows for rapid fabrication of high resolution patterns. We used a simple desktop nanolithography platform (NLP 2000[™], NanoInk, Inc.) for the deposition of the hydrogel precursors. The NLP 2000 consists of a stacked 3axis stage system with a travel range of 40 mm and a resolution of 25 nm. A high resolution optical microscope is available for monitoring the printing process. A custom fabricated array of cantilever based writing tools (M-Type, 12-pen, NanoInk, Inc.) were used to transport the hydrogel precursors on to the surface. Controlling the environmental conditions during the printing process allows for the transfer of defined volumes of hydrogel precursors. At 37°C, hydrogel domains of 6 μm were printed while at 25 °C 1.5 μm domains were printed. Patterning areas of 1 mm² with domains of less than 5 μm can be easily achieved in less than 30 min. AFM result confirmed the size and homogeneity of the printed hydrogel patterns.

NS-TuP3 Localized Surface Plasmons and Hot Spots from the Interstitial Sites in Linear Nano-Hole Array Structures of Gold Revealed by Near-Field Two-Photon Excitation. *S.I. Kim*, KAIST, Republic of Korea, *K. Imura*, Institute for Molecular Science, Japan, *S. Sehum Kim*, KAIST, Republic of Korea, *H. Okamoto*, Institute for Molecular Science, Japan

We analyzed spatial distribution of enhanced optical field at the gap between nano-holes in nano-hole array structures on gold thin film by near-field two-photon excitation imaging. We prepared linear chain-like array structures of circular nano-holes on gold thin film on a glass substrate, based on the method developed by Fischer [1]. A home-made scanning near field microscope [2] was used to observe two-photon excitation images for individual nano-hole array structures. We used a Ti:Sapphire laser (<100fs, 780 nm) to excite two-photon induced luminescence. Polarization dependences of the two-photon images were also measured. In the near-field two-photon excitation images of the nano-hole arrays, we found strong enhanced signal localized at interstitial sites between nano-holes, when the incident polarization is parallel to the chain axis of the array.

References

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NS-TuP4 Band and Dielectric Discontinuities of the Si_{1-x}Ge_x/Si_{1-y}C_y Superlattices. *T. Ohsugi, J. Nakamura*, The University of Electro-Communications (UEC-Tokyo), Japan

Si_{1-x}Ge_x and Si_{1-y}C_y alloys have attracted much attention from the perspective of the fabrication of novel devices, e.g., resonant tunneling diodes with strained alloys [1] and hetero bipolar transistors with double quantum wells [2]. It has been known that the lattice constants of these alloys are approximately proportional to their compositional ratios in accordance with Vegard's law [3]. Further, it has been reported that the band-gap of Si_{1-x}Ge_x, other than the lattice constant, changes with its composition [4]. In this study, we draw attention to the dependence of the dielectric constant on the composition of Si_{1-x}Ge_x and Si_{1-y}C_y as well as the dependence of other physical quantities such as lattice constants and band-gaps. We explore the band discontinuity and the spatial modulation of dielectric constants for the Si_{1-x}Ge_x/Si_{1-y}C_y superlattices as novel device structures, using first-principles ground-state calculations in external electric fields [5, 6].

We have adopted the cubic supercells containing 8 atoms for the Si_{1-x}Ge_x and Si_{1-y}C_y bulk models. It has been shown that the lattice constants of Si_{1-x}Ge_x and Si_{1-y}C_y alloys increase and decrease linearly with their compositions, respectively, obeying the Vegard's law. In contrast, the nonlinearity with the composition is found for the band gap and the dielectric constants. In our presentation we discuss the origin of the onset of the nonlinearity and report the band and dielectric discontinuities of the Si_{1-x}Ge_x/Si_{1-y}C_y superlattices from an atomic scale point of view.

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NS-TuP5 Single Domain Homogeneous Monolayer at the Water/Oil Interface and its Application for Surface Enhanced Raman Scattering. *S.I. Kim, P.S. Fabien, H. Song, S. Kim*, KAIST, Republic of Korea

We made mm-range closely packed monolayer by using the water/oil interface with Au nanoparticles whose nominal sizes are about 32 nm. We transfer this monolayer to the hydrophilic Si substrates by pulling up the sample softly and we measure the surface enhanced Raman scattering of Rhodamine 6G dye molecules. For this structure, we simulate the electromagnetic field enhancement when the laser light shines the sample whose unit cell is hexagonal structures ideally. We suggest that the strong field enhancement comes from the every interstitial gap among nanoparticles.

NS-TuP6 Synthesis of Ge Nanostructures by Reactive RF Sputtering. *A. Hernández-Hernández, F.J. De Moure-Flores, J.G. Quiñones-Galvan, K.E. Nieto-Zepeda, J. Santoyo-Salazar*, CINVESTAV-IPN, Mexico, *V.T. Rangel-Kuoppa, T. Plach*, Johannes Kepler Universitat, Austria, *M.A. Melendez-Lira*, CINVESTAV-IPN, Mexico

In this work we report the results of the synthesis and structural and optical characterization of heterostructures SiO_x/Ge/SiO_x by reactive RF sputtering. The characteristics of germanium along with its compatibility with silicon technology and the sensitivity of its band structure to confinement confer a high attractive to the synthesis of germanium nanostructures.

The samples were prepared on substrates of p-type Si monocrystalline (1 1 1) and commercial glass by reactive sputtering. The effect of the partial pressure of oxygen and Ge interlayer thickness on the electronic properties of the heterostructure is reported[1]. Structural characterization was carried out by grazing angle X-ray diffraction and atomic force microscopy. The electronic properties were studied by UV-Vis transmission, infrared and Raman spectroscopies. Surface roughness was quantified by atomic force microscopy. X-ray diffraction showed the amorphous characteristics of the heterostructures. UV-vis spectroscopy results do not presented relevant differences with respect to those from SiO₂ reference samples.

The Raman spectra shown modes associated to germanium indicating the formation of low dimensionality germanium particles embedded in an

amorphous phase. Ellipsometry and electronic transmission micrographs confirm the presence of Ge nanoparticles. Ohmic contacts were deposited in a van der Pauw geometry using AuSb. Temperature dependent Hall (T-Hall) measurements were done between 35K and 373K, using the van der Pauw method. The results indicate low resistivity values that could be explained due to the formation of a two dimensional electron gas or the presence of mini bands due to the quantum dots interaction.

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NS-TuP7 Spinel $M_xCo_{3-x}O_4$ Nanoparticles: Facile Low Temperature Solution Synthesis and Characterization. *D. Davis, M. Bencomo, T.N. Lambert, P. Lu, S. Limmer, W.G. Yelton*, Sandia National Laboratories

The synthesis and characterization of spinel $M_xCo_{3-x}O_4$ ($M = Mn, Fe, Ni, Cu$) nanoparticles was undertaken. Cobalt oxide-based nanoparticles doped with transition metals have a wide variety of potential applications, ranging from new material coatings for concentrating solar power applications to performing as cathode catalysts in fuel cells and metal-air batteries. We have recently demonstrated that $M_xCo_{3-x}O_4$ nanoparticles can be prepared using simple, low temperature solution precipitation methods, and that the final size and morphology of the nanoparticle depends on the extent of doping. These materials have been characterized by powder X-ray diffraction (P XRD), high-resolution transmission electron microscopy (HR-TEM), N_2 adsorption-desorption, and thermal gravimetric analysis/differential thermal analysis (TGA/DTA). The synthesis, characterization, as well as some potential applications of these materials, will be presented.

This work is supported by the Department of Energy, Office of Basic Energy Science and the United States Department of Energy under contract number DE-AC04-94AL85000. Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed-Martin Company, for the United States Department of Energy.

NS-TuP8 UV Induced Synthesis and XPS Characterization of Gold Nanoparticle-PMMA Composites. *E. Yilmaz, S. Suzer*, Bilkent University, Turkey

Polymer-nanoparticles are technologically important composite systems, gaining increasing interest from many different fields of science in the last decade. Many procedures were introduced for synthesis of gold and other metallic NPs in solution and their integration to polymer films afterwards. But a more efficient approach is to synthesize nanoparticles directly inside the polymer matrix. Irradiation of polymer-metal precursor mixtures with energetic light is a practical method for this purpose. In this study, we present in-situ synthesis of gold nanoparticles within poly(methylmethacrylate) (PMMA) films by UV irradiation.

An advantage of synthesizing gold NPs within polymer films is the opportunity of photo-patterning. Films having patterns made of regions with and without gold NPs can be produced, using masks designed to cut off the UV radiation at desired places. Such patterned films were investigated with secondary electron microscope (SEM) and dark regions between irradiated regions and masked regions were observed. These dark regions are speculated to be "ion free regions", where gold ions diffuse through irradiated regions during UV irradiation. These regions of about 10 μm width, suggests a very large distance for gold ions to diffuse through a rigid matrix like PMMA, which is very interesting. Supporting evidence for the existence and the properties of these regions was obtained from fluorescence studies with Rhodamine 6G molecule and x-ray electron spectroscopy (XPS). In XPS the gold content gradient shows, the border of the irradiated region contains more gold than the middle of the irradiated region which supports the diffusion of gold ions from masked regions through the irradiated regions.

Additionally, the electrical properties of PMMA with and without gold nanoparticles were investigated using XPS, while applying external bias to PMMA films with and without gold nanoparticles to probe the charging properties of the films. We observe an enhancement of conductivity of PMMA films containing gold nanoparticles.

NS-TuP9 Fabrication of Ordered Nanodot Arrays Utilizing Anodic Aluminum Oxide Template Formed on Si Substrate. *N.Y. Kwon, N.K. Kim, J.K. Yeon, G.Y. Yeom, I.S. Chung*, Sungkyunkwan University, Republic of Korea

We have fabricated anodic aluminum oxide (AAO) with two types of structures, namely, hexagonal and matrix arrays of pores. At first, Al thin

films with the thickness of 2 μm grown on Si (100) substrates were anodized in 0.3 M oxalic acid under conditions of 4 $^{\circ}C$ at 40 V. Then the hexagonal AAO templates with the thickness of 300 nm were obtained using two-step anodization. Alternatively, AAO template with a matrix pores was prepared utilizing focused ion beam milled indent. The size of pores was controlled between 30 nm and 60 nm by immersing in 5 % phosphoric acid at 20 $^{\circ}C$. In order to obtain smaller size of pores, the barrier layer was removed by neutral ion beam etching. Finally, we successfully fabricated hexagonal and matrix AAO templates with the pore sizes between 10 nm and 60 nm. The Si surfaces at the AAO pore bottoms were cleaned with dilute hydrofluoric acid after annealing at 900 $^{\circ}C$ in Ar gas. We then fabricated ordered Au and Ni nanodots arrays with controllable size between 10 nm and 60 nm. Scanning probe microscopy (SPM) and field emission secondary electron microscopy (FE-SEM) were used for characterization on shape of AAO and nanodots arrays.

NS-TuP10 On the Photoluminescence of Zn_2GeO_4 Nanorods Synthesized by a Simple Solution Route. *M.Y. Tsai*, National Applied Research Laboratories, Taiwan, Republic of China, *T.P. Perng*, National Tsing Hua University, Taiwan, Republic of China

During the past decade, there has been increasing interest in ternary oxide nanomaterials due to their unique electronic, optical, and chemical properties. In the present study, Zn_2GeO_4 nanorods exhibiting intense white blue-green luminescence were synthesized using a reflux method. Stoichiometric GeO_2 (1 mmole) and zinc acetate (2 mmole) were pre-dissolved in deionized water separately, and the solution mixture was subsequently refluxed at 160 $^{\circ}C$ with the aid of magnetic stirring. From scanning electron microscopic observation, the obtained product (denoted as sample A) was an aggregation of short nanorods. The diameter of nanorod ranges from 30 to 50 nm, and the length is approximately 300 nm. X-ray diffraction (XRD) analysis reveals that these nanorods exhibit a pure Zn_2GeO_4 phase of phenacite structure. If the concentration of reactants were increased by 5 times, the nanorods became longer and tended to aggregate to form bundles (denoted as sample B). Further, the full width at half maximum (FWHM) of XRD peaks measured from sample B was smaller than that of sample A, indicating a larger mean grain size. Since Zn_2GeO_4 is a self-activated phosphor, the photoluminescence (PL) of these two specimens was also measured. An intense white blue-green light emission was observed from sample A, and the broad PL band distributed from 400 nm to 600 nm, with the peak at 475 nm. The PL band profile of sample B was similar to that of sample A. However, the peak position red-shifted to 490 nm. The PL from Zn_2GeO_4 nanorods was quite different from that of sintered Zn_2GeO_4 powder which not only exhibited green PL peaked at 530 nm but also had a narrower FWHM. The luminescence of nanorods was rather likely associated with the native defects, and the red-shift phenomenon of PL peak may be correlated with the larger grain size.

NS-TuP11 Fabrication of Vertically Aligned Si Nanowires on Si (100) Substrates using AAO. *N.K. Kim, N.Y. Kwon, J.H. Lee, D.M. Whang, I.S. Chung*, Sungkyunkwan University, Republic of Korea

Vertically aligned Si nanowires were grown on using ordered AAO. At first anodic aluminum oxide (AAO) templates with both hexagonal pores and matrix pores were prepared. 2 μm Al thin film grown on Si (100) substrates were anodized in 0.3 M oxalic acid under conditions of 4 $^{\circ}C$ at 40 V. Then, the hexagonal AAO template with the thickness of 300 nm was obtained using a two-step anodization. On the other hand, AAO template with a matrix pores was obtained utilizing focused ion beam milled indent and anodization process. AAO template with pore sizes of 30 nm and that of 60 nm were obtained by immersing the AAO in 5 % phosphoric acid at 20 $^{\circ}C$ for 30 min and 60 min, respectively. The Si surfaces at the AAO pore bottoms were cleaned with dilute hydrofluoric acid after annealing at 900 $^{\circ}C$. Then, Si was deposited using LPCVD on AAO templates grown on Si substrate. The mixture gas with SiH_4 and HCl was used for Si deposition. Finally, we can obtain vertically aligned Si nanowires by removing AAO template using 1.8 wt% H_2CrO_4 and 7.4 wt% H_3PO_4 at 65 $^{\circ}C$ for 120 min.

NS-TuP12 Controlled Hybrid Bioactive Nanostructures by Integrating Gold Nanoparticles and Peroxidase to the ssDNA Nanotemplate. *M.-Y. Lin, F.H. Ho, Y.S. Yang*, National Applied Research Laboratories, Taiwan, Republic of China

Controlled positioning of metallic nanoparticles to assembly nanostructure has drawn interests in the field of nano-architecture, because of their electronic and optical properties. To achieve this, scientists have adopted various materials and methods for "bottom-up" and "top-down" fabrication of nanostructures. DNA nowadays is more than just a carrier for genetic codes, but it has also been used as novel materials for building nano-architectures. In this study, we aim to assemble the long, periodic single-stranded DNA nanotemplate (ssDNA) on the silicon-based substrate covalently and couple the supramolecules into a functional bioactive system. The preparation of ssDNA nanotemplates is based on the aptameric

recognition of tumor marker: platelet-derived growth factors and rolling circle amplification (RCA) technology. Because of the periodic, repeated sequence with secondary structures on the ssDNA nanotemplate, the supramolecules, including gold nanoparticles and peroxidase enzyme will be incorporated on the specific sites of the ssDNA nanotemplate based on the Watson-Crick base-pairing strategy in a programmable way. The distance between the gold nanoparticles and peroxidase enzyme can be controlled by manipulating the sequence on each repeat. In addition, the distance can also be increased merely by thermal treatment (around 80 °C) to open up the secondary structure on the ssDNA nanotemplate. Gold nanoparticles and peroxidase were periodically allocated precisely on each repeating sequence. The property of the peroxidase was affected by the gold nanoparticles and demonstrated by the luminescence measurement. In this study, we attempt to incorporate the gold nanoparticles on the ssDNA nanotemplate through hierarchical self-organization. The gold nanoparticle chains integrated with ssDNA nanotemplate were confirmed and visualized by the atomic force microscopy. We anticipate this study will pave a way for assembling novel bioactive materials with metallic nanoparticles for the development of modern electronic devices.

NS-TuP13 Magnetic Properties of Fe-O Nanonetworks, C.V. Ramana, C.G. Franco, K.B. Karuppanan, University of Texas at El Paso

Nanostructures of Fe oxides and hydroxides with varying morphologies were prepared in aqueous media by precipitation of iron nitrate and ammonium hydroxide. The synthesis was carried out at room temperature (RT) involving two stages. The first stage is the precipitation of goethite and the second stage corresponds to the structural modification due to acetic acid. Initially, 250 ml of 3.52N NH₄OH was added to 250 ml of 1N Fe(NO₃)₃·9H₂O under magnetic stirring for 30 min at RT. The precipitates were washed with de-ionized water and maintained in water at 1.25N AcOH was added to obtain three different concentrations: 2.4, 9.1, and 16.7 vol %. Powders were obtained heating the sols at 373 K until dry, and oxides were obtained by heat treatment at 773 K for 2 h. The samples with acetic acid addition show hematite (α -Fe₂O₃) with average size of 20 nm. Temperature variation of magnetization measurement was carried out for all the samples and the Curie temperature values for the 2.4, 9.1, and 16.7 vol % AcOH added samples were found to be 1004 K, 1024 K and 982 K respectively. Magnetization measurement was carried out at up to the magnetic field of 1000 Oe for 2.4 and 16.7 vol % AcOH added samples at room temperature as well as at higher temperatures. Magnetization value was found not to saturate at 1000 Oe for both the samples. For 16.7 vol % AcOH added sample, the saturation magnetization value at 300 K was calculated from Honda plot (1/H vs M plot) and it is found to be 38 emu/g. Coercive field value was found to be 255 Oe at 300 K. In the case of 2.4 vol% AcOH sample, magnetization measurements were carried out at different temperatures (from 300 K to 800 K) and the coercive field value was found to decrease with increasing temperature (130 Oe to 10 Oe).

NS-TuP14 Charge Transport across Phosphonate Molecular Wire-Indium Tin Oxide Junctions, D.M. Rampulla, J.G. Kushmerick, National Institute of Standards and Technology

Current-voltage analysis and transition voltage spectroscopy were used to measure the charge injection properties of monolayers of bithiophene phosphonate, quarterthiophene phosphonate, and decylphosphonate covalently bonded to an indium tin oxide surface. Hysteresis was observed for all three phosphonates, which is possibly explained by charge retention in the phosphonate. As compared to similar thiol/Au molecular junctions, there is no significant difference between the charge injection barriers of the three phosphonates, indicating that the phosphonate moiety dominates the observed charge injection properties.

NS-TuP16 Extreme Luminescent Signature of Coalesced Cd_xZn_{1-x}Se Quantum-Rod Alloys, M. Plaisant, P.H. Holloway, University of Florida

Common ion semiconductor alloys in quantum structures such as dots and rods have the added benefit of control of the electron affinity of the material in addition to the fundamental spectral control provided by quantum confinement. Such alloys could be useful in mixed-material devices such as organic/inorganic photovoltaic cells, since inorganic valence and conduction energy levels can be appropriately matched to the HOMO/LUMO levels of the compatible organic phase. In this research we have synthesized common anion II-VI alloys consisting of a large band-gap core/small band-gap shell. We have been able to achieve a spectral signature ranging up to 200nm over the visible spectrum by a one-pot synthesis of Cd_xZn_{1-x}Se alloys. The morphology of the alloy (supported by TEM, XRD and PL characterization) was a prolate rod-like quantum structure resulting from coalesced quantum dots consisting of three regions, each of which provides for a specific spectral signature. The 440nm PL peak was from ZnSe, while intermediate wavelengths were due to alloyed Cd_xZn_{1-x}Se, and a peak at 640nm was due to a CdSe rich shell. With the judicious control of time and temperature of reaction, it was possible to

create a multi-region quantum structure that mimicked the spectral characteristics of a selected alloy composition, i.e. achieve emission over a much larger range of the electromagnetic spectrum.

NS-TuP17 Au-catalyzed Self Assembly of Ge-Sb-Te Nanowires by Metalorganic Chemical Vapour Deposition, M.L. Longo, C. Wiemer, O. Salicio, R. Fallica, CNR-IMM, Italy, M. Fanciulli, CNR-IMM and University of Milano Bicocca, Italy, L. Lazzarini, L. Nasi, E. Rotunno, CNR-IMEM, Italy

The Metalorganic Chemical Vapor Deposition (MOCVD), already promising for its potentialities in the scaling down of phase change memories (PCM, PRAM), was adopted for the Au-catalyzed self assembly of NanoWires (NWs) formed by Ge-Sb-Te alloys on SiO₂/Si substrates; the employed metalorganic precursors were tetrakisdimethylaminogermanium, trisdimethylaminoantimony and diisopropyltelluride; the process gas was N₂.

The NW properties were studied by X-ray Diffraction (XRD), Total Reflection X-ray Fluorescence (TXRF) and Scanning Electron Microscopy (SEM) observations. Local measurements were carried out on single nanostructures by High Resolution and Analytical Transmission Electron Microscopy (TEM).

Ge-Sb-Te (GST) NWs exhibited a mean diameter distribution centered on 35 nm and a length up to 1 μm. Two types of GST NWs were identified: i) "big" NWs, featured by mean cross size > 50 nm and aspect ratio (AR = length/mean width) distribution centered around 5 and ii) "small" NWs, featured by mean cross size < 50 nm and AR distribution centered around 12. Measurements indicated that GST NWs are compatible with both the Ge₁Sb₂Te₄ and Ge₁Sb₄Te₇ compositions and crystallographic phases.

The typical diameter of the GeTe NWs resulted to be around 50 nm and their length up to 4 μm. The structural measurements showed that both the cubic and rhombohedral crystalline phases of GeTe are present in the obtained NWs, whereas the compositional analyses yielded a Ge₃₆Te₆₄ composition. In particular, TEM observations revealed that the *fcc* wires are single crystals, 110 oriented.

NS-TuP19 Folate Functionalized Hollow Silica Nanoshells: Synthesis, Characterization and Application as an Intracellular Delivery Container, A. Liberman, S. Sandoval, J. Yang, S. Aschemeyer, J.G. Alfaro, D. Martin, M. Makale, A.C. Kummel, W.C. Troglor, University of California, San Diego

An important area of biomedical nanotechnology is based on the interaction of living systems with inorganic and organic materials at the nanoscale. Silica nanospheres (NS) are attractive biomaterials because of their advantages as readily functionalized transport and imaging devices: the porous amorphous structure of silica colloid allows small molecule storage; the surface of silica can be modified easily with trimethoxysilyl reagents; silica has low biotoxicity and good biocompatibility. Silica nanospheres potentially have multiple biomedical applications as imaging agents, targeted drug delivery agents or gene transferring motherships. A simple method to fabricate hollow silica nanospheres with 100 nm or 200 nm diameters has been developed and tested. Amino polystyrene beads were used as templates and a 5-10 nm thick silica gel coating was formed by the sol-gel reaction. After removing template by calcinations, porous dehydrated silica gel nanoshells of uniform size were obtained. The porous structure of silica shell wall was characterized by transmission electron microscopy measurements, while particle size and zeta potentials of the particles suspended in aqueous solution were characterized by dynamic light scattering. The surfaces of the NS have been functionalized with folic acid in order to specifically target cancer cells. Folic acid, also known as vitamin B₉ or Folate, is essential for the synthesis of nucleotide bases and binds with high affinity to Folate receptors, which are frequently over-expressed in tumor cells and epithelial lined tumors such as ovarian carcinomas. With the use of confocal and two-photon microscopy, it was found that as the amount of folate on the surface of the NS was increased, a higher amount of NS endocytose into HeLa cancer cells, a cervical cancer cell line. Cytotoxicity studies will quantify the effectiveness of using folate coated silica shells for enhancing endocytosis of chemotherapy drugs in cell lines and in animal studies.

NS-TuP20 New Insights to Coarsening Phenomena and Nanoparticle-Mediated Surface Patterning: Pt/TiO₂(110), F. Behafarid, A. Naitabdi, B. Roldan, University of Central Florida

Two technologically important aspects for the applications of metal nanoparticles in the fields of catalysis, molecular electronics, and plasmonics are discussed here: (i) the influence of the nanoparticle synthesis method and support morphology on thermally-driven coarsening phenomena, (ii) the high-temperature growth of oxide nanowires with tunable width, orientation, and spacing seeded by micellar metal nanoparticles (NPs). Along those lines, a comparison of the mobility of

evaporated Pt NPs supported on pristine TiO₂(110) and on polymer-modified TiO₂(110) and micelle-based Pt NPs is established. To gain additional insight into the NP coarsening mechanisms, simulations were conducted following the two most coarsening routes: (i) diffusion-coalescence, and (ii) Ostwald ripening. Some changes were introduced in these models to guarantee the correct temperature dependence and proper energetics in the diffusion model, and a new formulation of the critical radius in the Ostwald ripening model is introduced to satisfy the mass balance without the need to use very small time steps.

Furthermore, the growth of TiO₂ nanowires at high temperature starting from micellar Au and Pt nanoparticles supported on TiO₂(110) is discussed.

NS-TuP21 Some Effects of Iron Doping on Titanium Dioxide Nanoparticles, *D. González-Sánchez, J.L. González-Solis, G. Toriz, C.R. Michel-Uribe, G. Gómez-Rosas, A. Pérez-Centeno, M.A. Santana-Aranda,* Universidad de Guadalajara, Mexico

Iron doped titanium dioxide nanoparticles were synthesized using the sol-gel method. Solution was prepared in propanol, diluting Tween 80 surfactant (as pore directing agent), acetic acid and finally titanium tetrapropoxide (TTP); constantly stirred with a motor driven Teflon® palette. Doping iron was introduced by dissolving iron (III) chloride in propanol and adding to the solution; in the required amount to obtain 0.25; 0.5; 0.75; 1.0; 1.25 and 1.57 mol% iron with respect to titanium. Employed proportions of Tween80/PrOH/acetic acid/TTP were defined mostly following the values reported by Dionysiou's group on pure TiO₂ [1]. We obtained nanoparticles with sizes around 9 nm; being larger for lower iron content and smaller for higher iron content, as observed by electron microscopy and calculated from the full width at half maximum (FWHM) of X ray diffraction peaks, using Scherrer's formula. Raman spectroscopy and X ray diffraction measurements showed the presence of additional features, possibly related to a foreign phase into an almost pure anatase powder, increasing along with iron content.

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NS-TuP22 Study on High-Current-Density CNT Field Emitter: Current Enhancement with Titanium Micro-powders, *V. Chouhan,* The Graduate University for Advanced Studies, Japan, *T. Noguchi,* KEK-High Energy Accelerator Research Organization, Japan, *H.R. Liu,* Mie University, Japan, *S. Kato,* KEK-High Energy Accelerator Research Organization, Japan

CNT film field emitters (FFE) with a high current density up to a couple of 100 A/cm² and a high total current up to 100 mA are applicable to electron sources such as accelerators and high intensity X-ray sources for medical and security examinations. Based on our previous work of FFE, it turned out that one of the most crucial factors for high current and long time operation is to select appropriate CNT junction and substrate materials so as to maintain high thermal and electric conduction with high tensile strength. Our FFE was prepared by dispersing MWCNTs over a titanium film deposited on a metallic substrate by magnetron sputtering technique followed with rooting of MWCNTs into the titanium film at high temperature. In this study, use of titanium micropowders was attempted to sprinkle on the dispersed MWCNTs. This powder would allow to enhance reaction for better carbide formation. This paper describes the detailed procedures and the experiments to achieve the high emission current density from the FFE.

NS-TuP23 Role of the pH Obtaining Microstructures and Size-Controlled SnO₂ Nanocrystals by the Precipitation Method. *C.E. Marín-Pineda, M.A. Santana-Aranda, C.R. Michel-Uribe, G. Gómez-Rosas,* Universidad de Guadalajara, Mexico, *O.E. Contreras-López,* Universidad Nacional Autónoma de México, *A. Pérez-Centeno,* Universidad de Guadalajara, Mexico

In this work we present the results of the pH effect on the synthesis of SnO₂ by precipitation. This simple chemical route allowed us to obtain SnO₂ nanocrystals whose grain size depends linearly on the pH, ranging from 3 to 8nm, from basic to acid solutions, respectively. The most important, microstructures were also fabricated by this simple method, mainly whiskers and long fibers. The crystalline quality and the morphology were confirmed by X-ray diffraction and electron microscopy. The samples showed high-energy optical absorption as observed by UV-Vis measurements.

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NS-TuP25 Nanoscale Roughness Analysis through System Evaluation by Atomic Force Microscopy, *C.Y. Su, Y.H. Lin, S.S. Pai, P.L. Chen, N.N. Chu, C.C. Yang, C.C. Chen, M.H. Shiao,* Instrument Technology Research Center, NRL, Taiwan, Republic of China

Atomic Force Microscopy (AFM) has become an essential tool in various applications of nanotechnology. Although roughness inspection is one of the most important and most common measurement since scanning probe microscopes (SPMs) have been invented, there is lack of international comparison on this application and it is in the early stage of prototype testing up to now. By combining a high precise three-axis closed-loop feedback scanner stage with the AFM, the mapping capability of surface roughness distribution from the sample topography with the sub-angstrom resolution is achievable. In this study, a procedure has been designed to optimize AFM parameters such as inspection area size, target amplitude, drive frequency, set-point, scan rate, integral gain, proportional gain, look-ahead gain and so forth for optimized surface roughness inspection. System evaluation of the measurement uncertainty is compliant to ISO, Guide to the Expression of Uncertainty in Measurement and ISO 5436-2:2001/Cor 2:2008, Geometrical Product Specifications (GPS) - Surface texture: Profile method; Measurement standards - Part 1: Material measures. Key factors such as repeatability, non-linearity, straightness, noise, probe deformation error, numerical error, system long-term stability and sample uniformity have been included for evaluation. By carefully control of probe deformation error, measurement uncertainty can be suppressed effectively.

NS-TuP26 Absorption based Model of Porous Silicon Photoluminescence, *C.G. Lowrie, S.B. Earles,* Florida Institute of Technology

Irradiating porous silicon with a 532 nm laser produces a photo luminescent (PL)

peak at 722 nm. This peak corresponds to the (3,1,1) absorption level of a cubic silicon

nanocrystal 3.79 nm in length.

NS-TuP27 Comparative Study on the Properties of ZnO Nanowires and Nanocrystalline Thin Films, *E. Broitman,* Carnegie Mellon University, *C. Bojorge,* CINSO-CITEFA-CONICET, Argentina, *F. Elhordoy, V. Kent,* Universidad de la Republica, Uruguay, *G. Zanini Gadioli,* Carnegie Mellon University, *R.E. Marotti,* Universidad de la Republica, Uruguay, *H. Canepa,* CINSO-CITEFA-CONICET, Argentina, *E.A. Dalchiele,* Universidad de la Republica, Uruguay

Nanostructures made of wurtzite ZnO, such as dots, nanobelts, nanowires, and nanocrystals, have recently attracted attention due to their proposed applications in electronic and optoelectronic devices. Here we present a comparative study on the properties of ZnO thin films containing nanocrystals and nanowires.

ZnO nanocrystalline (NC) films, obtained by the sol-gel process, were deposited from a precursor solution using zinc acetate dehydrate in ethyl alcohol. After a four-layer spin-coating on crystalline substrates, the films were transformed into nanocrystalline films by a thermal treatment at 370 °C during 3 hours. ZnO nanowires (NW) were electrochemically grown onto a ZnO seed layer sol-gel spin-coated using a conventional three electrode cell, with the substrate as the cathode, a Zn sheet as the counter electrode and a saturated calomel electrode (SCE) as the reference one. The electrolyte was an aqueous solution of the Zn²⁺ precursor (1 mM zinc acetate) and a supporting electrolyte (0.1 M sodium acetate), saturated with bubbling oxygen. The electrodeposition was carried out at 70 °C under potentiostatic conditions at two different potential values (-0.900 and -1.000 V vs. SCE) and during 70 min. The initial pH was adjusted to 6.76. Both, NC and NW samples, were deposited onto crystalline quartz substrates covered by a Au or Ag electrode, and ready to use in a quartz crystal microbalance (QCM).

Samples microstructure was characterized by X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), and Optical Diffuse Reflectance Spectroscopy (DRS). XRD measurements show in both cases a typical diffraction pattern of ZnO wurtzite structure. SEM micrographs of NC films have a smooth surface, while the NW sample reveal the presence of nanowires with hexagonal section and diameters ranging from 40 to 100 nm. No specific structure was observed by the DRS measurements on the seed layer, probably due to the fact that these films were not thick enough as required by the technique. For the NW onto seed layer samples, the optical characterization reveals the presence of ZnO with bandgap energy

between 3.22 eV (for the ones grown onto Au metallic contacts) and 3.29 eV (for the Ag metallic contacts).

A QCM placed in a vacuum chamber was used to measure the water adsorption of the samples. Water vapour was introduced through a leak valve while a capacitance manometer was used to measure the partial pressure of water in the range 10^1 - 10^5 Pa. The mass of water adsorbed on the surface of the quartz crystal was calculated using the Sauerbrey equation. The NW drastic increase of the surface area was revealed through a higher amount of water adsorption.

NS-TuP28 Effects of Surface-Sulfurization on Field Emission Characteristics of Al-doped ZnO Nanorods, T. Hirate, T. Kaneshiro, T. Satoh, Kanagawa University, Japan

ZnO is a promising material for ultraviolet (UV) and white light-emitting diode (LED) applications, because of its large exciton binding energy of 60 meV relative to the thermal energy of 25 meV, as well as its large band gap of 3.37 eV at room temperature. In the past several years, the fabrications and characterization of one-dimensional ZnO nanostructures have been extensively investigated for their applications, such as LEDs, gas sensors, field emission devices, nanolasers and photovoltaics. We have studied on application of vertically aligned ZnO nanorods grown by CVD to field emission devices. In this paper we report on surface-sulfurization of Al-doped ZnO nanorods and the effects on the field emission characteristics.

Al-doped ZnO nanorods are grown by low-pressure thermal CVD cooperated with 10Hz Nd-YAG pulsed laser ablation of Al₂O₃ target, which is developed by us. Precursors for CVD are Zn vapor and O₂. Substrates are n-Si(111) wafers. ZnO nanorods are grown in two stages. In first stage of growth no laser ablation is used to grow aligned ZnO nanorods and in second growth stage laser ablation is used to grow Al-doped ZnO layer on ZnO nanorods grown in 1st stage. Concentration of Al in ZnO nanorods is controlled by laser power. Finally surface-sulfurization is performed in H₂S atmosphere. It is revealed that the conditions of sulfurization have very complex effects on field emission characteristics. An example of the conditions are 39.6 Pa of H₂S partial pressure, 550 C and 5 min. Field emission characteristics are measured in vacuum of 10^{-4} Pa using 12.7mm diameter metal ball as anode electrode with separation of 160 micron meter.

When laser power is high (2.0W), the low initial electric field of 4 V/micron meter for emission is obtained. In this case, however, ZnO nanorods with sharp tips are grown due to high laser power, thus the reason of improvement of field emission characteristics is not clear at present. We are studying on this point. We estimate that the surface-sulfurization of ZnO nanorods are effective to improve the field emission characteristics because the electronic affinity of ZnS is lower than ZnO.

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