

# Tuesday Afternoon Poster Sessions

## Nanometer-scale Science and Technology

Room: Hall B - Session NS-TuP

### Nanometer-scale Science and Technology Poster Session

#### NS-TuP1 Photoluminescence Characterization of Crater-Typed Nanostructured Al Surfaces, *I. Atsuro, R. Hoshiya, H. Kato, S. Takemura, T. Hiramatsu*, Kanto Gakuin University, Japan

Fabrication of templates for creating nanoscale structures becomes an important subject for innovation of nanoscale devices. The authors proposed new types of nanoscale structures such as a linked-crater structure and highly-oriented line structure on Al surface by unique combination of chemical and electrochemical processes. In this study, the authors investigate the optical functionality of nanostructures by photoluminescence (PL) measurements. The nanoscale linked-crater structure was fabricated on an Al surface by treatment with Semi Clean, alkali surfactant, and successive electrochemical anodization in 0.37 N H<sub>2</sub>SO<sub>4</sub> solution creating a nanoscale finer linked-crater structure on the Al surface. The PL spectra of non-ripple and ripple patterns were observed by using Horiba Jobin-Yvon Spex Fluorolog-3 fluorimeter. In the case of non-ripple pattern, the PL spectrum showed that the main peak appeared around 400 nm with a long tail slope linearly downwards that stretched up to 550 nm regions. In the case of the ripple pattern, the PL spectrum exhibited a pattern composed of several ripple peaks in 350-550 nm range. The samples that exhibited rippled PL pattern were prepared under the optimized fabrication conditions: anodization current 7-9 mA for 40 min for the sample size of 10 mm×20 mm. The peak positions were invariant with the change of excitation wavelength through 300-420nm. Thus, the ripple pattern was originated from the nanostructure origin. The absorbance measurement was also conducted. The ripple absorbance peaks were observed and overlapped partially the rippled emission peaks. The absorbance peak positions were invariant with the change of excitation wavelength.

Non ripple-shaped emission peaks were observed in the case of the samples prepared under deviated conditions. The fabricated nanostructured surfaces were identified as alumina by Fourier transforms infrared spectroscopy (FT-IR). The FT-IR measurement showed that the difference between the ripple and non-ripple PL patterns might be attributed to the peak profiles and the intensity of Al-O mode. In the ripple emission and non ripple pattern, the intensity of Al-O mode at 1170 cm<sup>-1</sup> was different between two patterns. The lifetimes and the corresponding relative amplitudes were obtained by time-correlated single photon counting (TCSPC). In the case of ripple pattern, lifetimes and the relative amplitudes were definite values. On the other hand, in the non-ripple pattern, lifetimes and relative amplitudes were deviated from those values.

This work was aided by MEXT-supported Program for the Strategic Research Foundation at Private Universities.

#### NS-TuP2 Gallium Oxide and Gallium Nitride Nanoparticle Synthesis using Non-Thermal Plasma with O<sub>2</sub> and N<sub>2</sub> Gases, *J.H. Kim*, Korea Research Institute of Standards and Science, Republic of Korea, *K.H. You*, Korea Advanced Institute of Science and Technology, Republic of Korea, *S.J. You, J.I. Lee, D.J. Seong, Y.H. Shin*, Korea Research Institute of Standards and Science, Republic of Korea

Compounds of Ga, such as gallium oxide(Ga<sub>2</sub>O<sub>3</sub>) and gallium nitride(GaN), are of interest due to its various properties in semiconductor application. In particular, GaN has the potentially application for optoelectronic device such as light-emitting diodes(LEDs) and laser diodes(LDs). The Ga<sub>2</sub>O<sub>3</sub> is a promising material for high temperature stable gas sensing, catalytic and optoelectronic device applications[1,2]. Nanoparticle is an interesting material due to its unique properties compared to the bulk equivalents.

In this report, we develop a synthesizing method for the gallium oxide and gallium nitride nanoparticle using non-thermal plasma. For gallium source, the gallium is evaporated by induction heating Nitrogen and oxygen source for nanoparticle synthesis are supplied from inductively coupled plasma with N<sub>2</sub> and O<sub>2</sub> gas. The synthesized nanoparticles are analyzed using field-emission scanning microscope(FESEM), transmission electron microscope(TEM) and x-ray photoelectron spectroscopy(XPS). The synthesized particles are investigated and discussed in wide range of experiment conditions such as flow rate, pressure and RF power.

#### References

1. L. Li, E. Auer, M. Liao, X. Fang, T. Zhai, U. K. Gautam, A. Lugstein, Y. Koide, Y. Bando and D. Golberg, *Nanoscale*, 3, 1120, 2011.

2. H. Yang, R. Shi, J. Yu, R. Liu, R. Zhang, H. Zhao, L. Zhang and H. Zheng, *J. Phys. Chem. C* 113 (52), 21548, 2009 .

#### NS-TuP3 Embedded SiGe Alloy Nanoparticles formed by Co-sputtering of Si, Ge, *A. Hernández-Hernández*, CINVESTAV-IPN, Mexico, *L.A. Hernández-Hernández*, ESFM-IPN, Mexico, *F. De Moure-Flores*, UAQ, Mexico, *J.G. Quiñones-Galván*, ININ, Mexico, *M. Meléndez-Lira*, CINVESTAV-IPN, Mexico

Using magnetron co-sputtering of Ge and Si targets, Si:Ge films were fabricated for exploring the influence of SiO<sub>2</sub> roughness on formation, structure, and phonon properties of nanocrystalline Si<sub>1-x</sub>Ge<sub>x</sub> (nc-Si<sub>1-x</sub>Ge<sub>x</sub>). Structural characterization was carried out by grazing angle X-ray diffraction and atomic force microscopy. The electronic properties were studied by room temperature photoluminescence and Raman spectroscopies. Surface roughness was quantified by atomic force microscopy. X-ray diffraction show diffraction peaks due to SiGe alloy nanoparticles and no peaks due to elemental Si or Ge. The nanoparticle size estimated from XRD is around 7.5~12 nm. Raman spectroscopy was revealed that each optical vibration mode (Ge-Ge, Ge-Si, or Si-Si mode) is of evident phonon confinement effect. Photoluminescence emission in visible range it is associated to the quantum confinement. The roughness of the as-deposited amorphous SiO<sub>2</sub> films is an essential factor in determining the crystallization behavior and in controlling NCs size.

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#### NS-TuP4 Post-Annealing Effects on Germanium Nanocrystals Properties, *A. Hernández-Hernández*, CINVESTAV-IPN, Mexico, *L.A. Hernández-Hernández*, ESFM-IPN, Mexico, *F. De Moure-Flores*, UAQ, Mexico, *J.G. Quiñones-Galván*, ININ, Mexico, *M. Meléndez-Lira*, CINVESTAV-IPN, Mexico

As-grown light emitting self-assembled Ge nanocrystals (Ge-NCs) embedded in a SiO<sub>2</sub> matrix were produced by a sequential deposition process of SiO<sub>2</sub>/Ge/SiO<sub>2</sub> layers employing reactive radio frequency sputtering technique. Obtained Ge-NCs shown a crystallographic phase whose proportion, size, quality and specific orientation are determined by the oxygen partial pressure. Photoluminescence (PL) spectra indicate that the size distribution of Ge-NCs is reduced and centered at around 8 nm when higher oxygen partial pressure is employed, their sizes are consistent with estimates from PL measurements. After vacuum annealing it is observed the elimination of an instable high pressure tetragonal phase of germanium present in as-grown samples. In addition, the PL peaks shifted to higher energies indicating the formation of Ge-NCs probably from Ge dispersed within SiO<sub>2</sub> matrix. It was also found that the PL intensity increases drastically after annealing process. The strong size dependence of the PL spectra indicates that the observed PL originates from the recombination of electron-hole pairs confined in Ge-NCs. This samples exhibit photoresponse in near infrared range.

†: partially funded by CONACyT-Mexico.

#### NS-TuP5 Photoresponse and Electrical Characterization of Silicon Nanocrystals Embedded within a SiO<sub>2</sub> Matrix, *M.A. Melendez-Lira*, Cinvestav-IPN, Mexico, *E. Mota-Pineda*, ESIME-IPN, Mexico

Silicon nanocrystals (Si-NC) embedded within a SiO<sub>2</sub> matrix deposited on p type Si(111) substrates have been successfully produced through a reactive RF sputtering technique employing the ratio of oxygen to argon as parameter to modulate the Si-NC size distribution [1]. The Si-NC shown photoluminescence emission with characteristics dependent on its size. Characterization of the transversal I vs V response present a rectifying-like behavior. The spectral photoresponse curves shown a maximum around 1100 nm with a FWHM dependent on the Si-NC size distribution. The intensity of the spectral photoresponse shown a dependence on the electrical polarization applied on the contacts. The zero of the I vs V curves does not change with the illumination of the sample indicating the absence of a photovoltaic driving force. Results are analyzed taking in account the size and distribution of Si-NC in the SiO<sub>2</sub> matrix.

[1]. E. Mota-Pineda et al. *Journal of Applied Physics* 108, 094323(2010)

\*: The partial financial support of ICyT-DF and CONACyT-Mex is acknowledged

#### NS-TuP6 Nanoscopic I-V, Photoluminescence and Lifetime Characterization of Polyaniline Dot and Line Patterns, *S. Takemura, Y. Watanabe, T. Tomoya, H. Kato, T. Hiramatsu*, Kanto Gakuin University, Japan

Fabrication of templates for creating nanoscale structures becomes an important subject for innovation of nanoscale devices. Authors have

succeeded in fabricating unique nanostructures such as a line and crater structures on Al substrate surfaces using chemical treatments combining anodization. Polyaniline(PA) line pattern was fabricated on Si surface using these nanostructures as a template. The purpose of this study was to fabricate PA patterns on the Al template and investigate the possibility of optical devices. Nanoscopic polymerization of PA was performed nanoscopically in confined nanoscale structures fabricated on an aluminum surfaces by a chemical polymerization method. Polymerization of PA was carried out using as an oxidizing agent, ammonium peroxodisulfate (APS). Solution from 1 to 2  $\mu\text{l}$  contains aniline monomer, APS and HCl dropped on the nanostructures as a droplet utilizing micropipette and extended on the surface. PA patterns were successfully fabricated by this technique. The authors also conducted transfer of PA patterns formed on the nanostructured alumina to a Si wafer by a nano-contact method. A Si substrate was attached to the PA patterned Al substrate and was pressed for several ten seconds to transfer the PA pattern to the Si substrate. Then the Al template was removed and the Si substrate was dried naturally.

Photoluminescence (PL) spectra of the line-typed nanostructured Al surface and PA patterned Al surfaces were investigated by using Horiba Jobin-Yvon Spex Fluorolog-3 fluorimeter. Ripple-patterned PL peaks were observed for the line-typed nanostructured Al surface. PA line pattern was fabricated by dropping 1  $\mu\text{l}$  of PA on the line-patterned Al surface. The PL peak at 480 nm originated from the PA line overlapped the ripple pattern. For the densely deposited sample prepared by 10  $\mu\text{l}$  PA solution, a PL peak at 480 nm due to PA was clearly observed. PL lifetimes were measured by time-correlated single photon counting (TCSPC). Average PL lifetimes of PA deposited line-patterned Al surface were shorter than the original Al line-pattern. I-V characteristics of PA on the nanostructured Al surface and PA pattern-transferred Si wafer were obtained. Step-like curves were obtained in the PA pattern that the dots were linearly oriented. Negative resistance was observed in the PA pattern-transferred Si wafer.

This work was aided by MEXT-supported Program for the Strategic Research Foundation at Private Universities.

#### **NS-TuP7 Graphene Patterns on Line-Typed Nanostructured Al Surfaces by Carbon Drawing Techniques, K. Doi, T. Sugii, Y. Takarai, H. Kato, Y. Watanabe, S. Takemura, T. Hiramatsu, Kanto Gakuin University, Japan**

Recently, carbon materials are attracting researcher's attention for the development of next-generation devices. In the present study, the authors focused on grapheme film fabrication on non-flat surfaces. In the present work, the authors selected carbon drawing rather than the other methods such as taping method because carbon drawing is applicable to fabricate grapheme film on the non-flat surface. The aim of present study is to fabricate grapheme films on chemically and electrochemically processed nanostructured Al surface by carbon drawing.

Carbon drawing is a nanofabrication method by gently pushing bulk graphite on the surface and drawing it. In the present study, the authors used HOPG for carbon drawing which was performed on a line-typed nanostructured Al substrate. The line-typed nanostructured Al template was fabricated by chemically and electrochemically processes. In the present study, carbon drawing was performed in the vertical direction to the paralleled lines on the line-typed Al template. Fabricated structures after carbon drawing were analyzed and characterized by atomic force microscopy/current imaging tunneling spectroscopy (AFM/CITS), dynamic force microscopy (DFM), optical microscopy with differential interference contrast (DIC) and laser Raman spectroscopy. The DFM image demonstrated that triangular structures of 1  $\mu\text{m}$  were created along the line structure and the triangular structures with a different thickness overlapped each other. The image in the large area of this sample obtained by optical microscopy with differential interference contrast (DIC) also showed that films with a different thickness overlapped each other. In the DFM image, terrace-like structures also appeared on the aluminum surface. Some characteristics peaks in the Raman spectrum were observed for this sample. A peak at  $1600\text{cm}^{-1}$  can be assigned to G band due to carbon. A peak at  $1360\text{cm}^{-1}$  can be assigned to D band. A peak at  $2700\text{cm}^{-1}$  can be assigned to G' band. The current image in the AFM/CITS measurements showed that the current flows on the overall area. In point-contact measurements, current flows differently at the different points. Quantum conductivity such as step-type was observed. At the different area, wrinkles of thick films were formed on the surface in the AFM image. High conductivity was observed in the hill area whereas the valley area shows low conductivity. In the point-contact measurements, current flows on the overall area. Step-like conductivity was obtained in the I-V characteristics by point contact measurements.

This work was aided by MEXT-supported Program for the Strategic Research Foundation at Private Universities.

#### **NS-TuP8 Nanopatterning of Cup-stack Carbon Nanotubes using Nanostructured Al Templates, Y. Watanabe, R. Takeuchi, H. Kato, S. Takemura, k. Shimada, T. Hiramatsu, Kanto Gakuin University, Japan**

The authors intend to develop a patterning method of cup-stack carbon nanotubes (CSCNTs) on a nanostructured Al surface and characterize the patterns by scanning probe microscopy (SPM), scanning electron microscopy (SEM), laser Raman spectroscopy and x-ray photoelectron spectroscopy (XPS). A nanostructured line-typed Al template for patterning was fabricated by combined process of chemical treatments and anodization. CSCNTs dissolved in distilled water under the ultra sonic wave to separate the bundles of carbon nanotubes. Then droplets of this solution were dropped on the Al template or a single crystal Si wafer utilizing micropipette. Dynamic force microscopy (DFM) and SEM images of dispersed CSCNT densely deposited on a line-typed Al template and a Si wafer surface show net-work patterns on the nanostructured Al surface and the Si wafer. Highly oriented CSCNT pattern was also obtained on the line-typed Al template. CSCNT molecules were highly oriented along the line of the template. In the measurement of I-V characteristics for this sample by point contact measurements, quantum conductivities such as step-type and negative resistance were observed. The proposed method can be applied to the CNT arrangements on different surfaces such as Si and glass substrates by a nanoscale imprinting method. The nano-contact transcription was performed according to the following steps: The CSCNT patterned Al template was attached on a silicon substrate and was pressed for 30 sec. Then the Al template was removed. Using a 50 ml solution that contained CSCNT 0.02g, a networking-pattern of CSCNTs was demonstrated to be transferred to a Si wafer. In the case of 50 ml solution that contained CSCNT 0.01g, a single isolated CSCNT that was bending and twisting was obtained by DFM. In the measurement of laser Raman spectroscopy, carbon nanotube's specific peak such as G band was observed. Radial breathing mode (RBM) was not observed because of large diameters of cup structures. In the case of SWCNT, several RBM peaks were observed between  $400\text{-}100\text{cm}^{-1}$ . Furthermore, the intensity of D band was higher than that of the G-band because boundaries of cup structures. Binding energy components due to CSCNT were appeared in the C 1s core level spectra for CSCNTs dropped Si wafer by XPS. A lower binding energy component at 281.5eV and higher binding energy components at 283-290eV appeared in the C 1s core level spectra of CSCNTs assigned to CSCNTs. Furthermore, the authors performed a composite patterning of dye molecules and CSCNT as the next research step. This work was aided by MEXT-supported Program for the Strategic Research Foundation at Private Universities.

#### **NS-TuP9 Optical Properties of Carbon Nanotube Forests with Various Growth Structures, K. Sekiya, H. Koji, H. Furuta, A. Hatta, Kochi University of Technology, Japan**

Carbon Nanotubes (CNTs) have attracted particular attention because of their unique properties in various application fields. Especially, CNTs are strong candidate for the anisotropic opt-material in the future optical devices. Some unique optical properties of CNTs have been reported, such as polarization dependent absorption of vertically aligned (VA) short length SWNTs[1], and black body behavior of VA long length SWNTs[2].

There are few reports for the optical properties of CNT forests with controlled structures. We focused on the early growth stage of the CNT forests whose heights are near the light wavelength. In this paper, we investigated optical properties of CNTs having various lengths with controlled structure parameters, such as vertical alignment.

Fe/Al or Fe/AlO multi-layered catalyst films were prepared on Si substrates by magnetron sputtering method. CNT forests were grown on the substrates with the catalyst films by thermal CVD method from  $\text{C}_2\text{H}_2$  source gas at  $730^\circ\text{C}$ . The CNT growth height was controlled precisely at the order of micro meter by adjusting synthesis period using electronic valves with electric circuits. Optical properties of CNTs were observed by a reflectance spectroscope (HITACHI U-3900).

Two different CNT forest samples were prepared by controlling CVD condition, one is highly oriented VA CNTs (Sample high-VA) with the average diameter of about 15 nm and the other is relatively low-oriented CNT forest (Sample low-VA) with the average diameter of about 13 nm. The average growth height of Sample high-VA and low-VA were controlled at about 1, 2, and 3  $\mu\text{m}$ . Their growth densities of sample high-VA and low-VA were almost same at  $10^{11}/\text{cm}^2$ , which were estimated from the cross-sectional SEM images. From the diffuse reflectance spectra, it was found that the CNT forests had low reflectivity with the diffusion reflectance below 5%. From specular reflectance, it was found that the specular reflectance was reduced with increase of forest height for both of sample high-VA and low-VA. It is noted that specular reflectance of sample high-VA was lower than sample low-VA at the same growth height. Absorption coefficients per 1 $\mu\text{m}$  calculated from the specular reflectance of sample low-VA were lower than that of sample high-VA.

In conclusion, those anisotropic optical properties of CNT forests were considered caused by their unique anisotropic structural parameters of vertical orientation and diameters.

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[1] Y. Murakami *et al.*, Carbon. 43(13) (2005) 2664–2676.

[2] K. Mizuno *et al.*, PNAS 106 (2009) 6044–6047.

**NS-TuP10 Silicone Nanotube Coating, S. Oliveira, S. Seeger, University of Zurich, Switzerland**

Artificial superhydrophobic surfaces have generated considerable attention in the last two decades due to their significant potential for industrial and scientific applications. We introduced silicone nanofilaments (SNF) which grow on a variety of technologically important substrates via a convenient gas or solvent phase process. Coated substrates exhibited superhydrophobic behavior with contact angles higher than 160°. The simple one step production process includes only low cost starting materials and is ecologically friendly because it does not contain any fluorine compounds. Therefore it is of high interest for industrial applications. Until recently a drawback of the process was the release of hydrochloric acid which restricts the coating to acid-resistant substrates. Therefore we developed a similar solvent phase coating procedure using different starting materials to reduce the acid formation tremendously. Acid sensitive substrates were coated with SNF and also Silicone Nanotubes (SNT) without any damages to the material. In particular modified surfaces covered with homogenous SNT showed extreme water repellent properties with contact angles over 175° and sliding angles below 4°. The nanotubes were up to several micrometers long with diameters between 80 - 100 nm and channel diameters between 10-20 nm (Fig.1). This new acid-reduced process extends the number of materials suitable for superhydrophobic coating. Furthermore a convenient gas phase process for the fabrication of SNT-modified surfaces was developed. The process includes chemical vapor deposition at room temperature. The structure of the tubes can be easily controlled by adjusting the relative humidity in the reaction chamber. Such surfaces showed also superhydrophobic properties with contact angle higher than 179° and sliding angles below 1°. To the best of our knowledge the production of silicone nanotubes is reported for the first time. This new structures opens the opportunities in the field of silicone chemistry and might be of interest for potential applications.

**NS-TuP11 Towards the Heat Dissipation in Suspended Self-heated Nanowire Sensors, J. Zhang, Southern Illinois University Carbondale, E. Strelcov, Oak Ridge National Laboratory, A. Kolmakov, Southern Illinois University Carbondale**

Self-heating is a prospective power-efficient energy delivery channel to the conductometric chemical sensors that require elevated temperatures for their operation. Strong temperature dependence of the electrical conductivity in semiconductors was employed with a self-heated n-doped silicon nanowire resistor whose surfaces were passivated with native oxide layer. The conductivity in such a device depends on heat dissipation and partitioning inside the device what was studied comparatively for both suspended and supported device architectures. The onset of the exhaustion region in the temperature-dependent resistivity of a Joule-heated nanowire was used as a temperature marker for implementation of the quasi-constant temperature operation mode. As the thermal conductivity of the environment around the nanowire changing upon analyte admission into the chamber, the semiconductor nanowire temperature changes and as a result, an electrical conductivity alters as well. In such a case a nanowire is inert toward the used analytes, the sensing action due to analyte-induced heat dissipation variations can be extracted. Our approach is close to the effort to create membrane-based ultra-sensitive Pirani type thermal pressure sensor with significantly enlarged pressure range and very recent nanowire Pirani gauge. At low pressures, the sensor is idle due to dominating heat dissipation from the nanowire to the substrate and/or electrodes. Above ca 10 Torr the sensitivity to gases has strong dependence on pressure as well as type of the gas and is determined by heat exchange between nanowire surface and ambient. Unlike classical Pirani sensors, we found that the sensitivity of this nanowire pressure sensor does not exhibit the saturation behavior at subatmospheric pressure thanks to nanoscopic size of the nanowire and microchannel architecture of the device. Additionally, the sensitivity of the sensor to reactive gases depends on the effectiveness of the particular endothermic/exothermic reaction at the surface of the nanowires and was explored for the case of acetone-air mixture with Pt decorated silicon nanowire devices suspended across ca 20  $\mu$ m wide trench of Si/SiO<sub>2</sub> substrate. Strong coupling of the electrical and thermal properties in the individual Joule heated semiconducting nanowire allows fabrication of power-efficient multi-parametric nanoscopic gas/pressure sensors that are analog of Pirani and pellistor type detectors.

**NS-TuP12 Thermal Stability and Optical Properties of Vertically Aligned Ag, Au, and Ag/Au Alloy Nanorods Synthesized by the Electrodeposition, M.I. Nandasiri, S. Vilayurganapathy, G. Coffey, A. Joly, P. El-Khoury, T. Varga, A. Devaraj, S.A. Thevuthasan, W.P. Hess, Pacific Northwest National Laboratory**

One dimensional metal nanostructures such as nanorods and nanowires have a wide range of applications in electronic, photonic and sensing devices due to their interesting linear and non-linear optical properties. The optical properties of these nanostructures are dominated by localized surface plasmon resonance (LSPR), which results from the oscillations of conduction electrons in response to an external field. The LSPR frequency of the electrons depends strongly on the size, shape, and distribution of the particles and the surrounding dielectric medium. Hence the electronic and optical properties of these nanostructures can be tuned by controlling the physical and chemical properties. In this study, Ag, Au and Ag/Au alloy nanorods with well controlled aspect ratios were grown on anodized aluminum oxide (AAO) templates by the electrodeposition method. One side of the AAO templates was coated with an Ag or Au layer to obtain a good electrical conductivity. The electrodeposition was carried out in the galvanostatic mode by varying the current and deposition time to optimize the properties of nanorods. Following the electrodeposition, the AAO template was etched away using 1M NaOH solution leaving behind free standing and vertically aligned nanorods. These nanorods were imaged using scanning electron microscopy (SEM) to study the size, shape, and distribution as a function of the deposition time. The length of the nanorods varied as a function of deposition time allowing an excellent control over the aspect ratio. The nanorods were further characterized using x-ray diffraction and transmission electron microscopy. The as-grown nanorods were also annealed at high temperatures in vacuum and characterized by x-ray photoelectron spectroscopy and SEM to study their thermal stability. The optical measurements of Ag, Au, and Ag/Au alloy nanorods carried out using surface enhanced Raman scattering and photoemission electron microscopy will also be discussed. This work was supported by the Laboratory Directed Research and Development (LDRD) program of Pacific Northwest National Laboratory. The work was conducted in the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL), a national scientific user facility sponsored by DOE's Office of Biological and Environmental Research and located at PNNL. PNNL is operated by Battelle for the DOE under Contract DE-AC05-76RLO1830.

**NS-TuP13 Optical Properties of InN/InGaN/GaN Dot-in-a-Nanowire Heterostructure, M.D. Kim, Chungnam National University, Republic of Korea**

During the last few years, light sources have been investigated with application potential for the implementation of quantum information technologies. In this research field, quantum dots (QDs) have attracted considerable interest both as single photon light sources and high efficiency light sources. Single photon emission from semiconductor QDs has been reported for many different material systems covering different wavelengths and maximum operation temperatures. Group-III-nitrides have the prospect that the emission energy can be engineered over a wider spectral range by varying their alloy contents. In this study, we report a near infrared (IR) emission of InN/InGaN(In~11%)/GaN dot-in-a nanorods (NRs) grown by plasma-assisted molecular beam epitaxy (PAMBE) on Si(111) substrate. Catalyst-free InN/InGaN/GaN dot-in-a NRs were grown in holes of a patterned Si(111) substrate. Arrays of nano-holes with diameter of 80 nm on the Si substrate were obtained by reactive ion etching of polystyrene beads as a nano-hole mask. Scanning electron microscopy, X-ray diffraction, micro-photoluminescence (PL), and high-resolution transmission electron microscopy (HRTEM) were performed to investigate the NRs shape, micro-structural and optical characterizations. Fig. 1(a) show the TEM images of the InN/InGaN/GaN dot-in-a-NRs heterostructure. It is seen that the InN dot height is about 10 nm, which is much smaller than the wire diameter with around 30 nm. It is also show that the InN/InGaN dots aligned along growth direction of the GaN NRs. Fig. 1(b) and (c) show sharp and isolated single exciton emission line in the near IR spectral range (1131 nm) was observed. Radiative and nonradiative lifetimes are also measured in the NRs by time resolved PL measurements. The experimental results are comparable with the data obtained by numerical simulation (by APSYS (CROSS-LIGHT)) of near IR emission. Based on the experimental data, we will present a schematic model of the InN/InGaN NRs formation and the probability of application of light emitting diode and single photon light source for the optical communication.

Fig. 1. (a) TEM images of the active region of an InN/InGaN/GaN dot-in-a-nanorods heterostructures. The (b) and (c) show the micro-photoluminescence on the InN/InGaN/GaN dot-in-a-nanorods heterostructures.

**NS-TuP15 Refreshable Pt-TiO<sub>2</sub> Nano-Composite for Direct Methanol Oxidation**, C.-T. Lin, Y.-C. Yeh, M.H. Shiao, C.-N. Hsiao, National Applied Research Laboratories, Taiwan, Republic of China

Direct Methanol Fuel Cell (DMFC) has been deemed as one of the many feasible candidates for the portable power supply of the next generation. However, the slow process of methanol oxidation has been the root problem in the development of DMFC. Platinum based alloys have been widely developed and commonly utilized as the catalyst in methanol oxidation. In another field of technology, metal-titanium oxide composite has been adopted in distillation for decades due to the improved photo-catalytic capability resulting from the prolongation of recombination time between electrons and holes thereof. In this paper, Pt-TiO<sub>2</sub> composite nanostructure was deposited on carbon cloth by a one-step photo-deposition process in the atmospheric condition. Various surface compositions of Pt-TiO<sub>2</sub> nano composites were prepared. Also, a comparative study was conducted aiming at assessing the enhancement on the oxidation current of methanol, the suppression of CO poison, and the durability in acidic surrounding among the aforesaid Pt-TiO<sub>2</sub> nano composites. Furthermore, the electrochemical characteristics of photo enhanced methanol oxidation were studied via cyclic voltammetry and chronoamperometry under various illumination conditions. More than 40% of enhancement on the oxidation current density was found on the Pt-TiO<sub>2</sub> modified carbon cloth under UV illumination. The photo induced hydrophilicity also contributed to the local mass transfer on the surface of the aforesaid composite catalyst during the durability test. Moreover, the durability test also suggests the dispersion of TiO<sub>2</sub> NPs and the adhesion between TiO<sub>2</sub> NPs and carbon fibers play crucial roles in the performance of DMFC. In summary, the preliminary results suggest, with proper design on the surface composition, the Pt-TiO<sub>2</sub> nano-composite exists a great potential to serve as the anodic catalyst in DMFC.

**NS-TuP16 Redox Signal Enhancement using Nanogap Electrodes via Control of Gap Distance**, D.K. Park, J. Park, S. Kim, W.S. Yun, Sungkyunkwan University, Republic of Korea

We report on a redox signal enhancement using nanogap electrodes (NGEs). The distance between NGEs was controlled from 1 μm to a few tens of nanometer where NGEs was narrowed by chemical deposition of reduced Au ion on the pre-defined electrodes. Enhanced redox current of ferri/ferrocyanide was obtained by redox cycling between the two working electrodes. The faradaic current is amplified about a thousand times in this redox system by narrowing the gap distance about 200 nm to 30 nm. The experimental results were discussed on the basis of the cyclic voltammetry (CV), atomic force microscope (AFM) and scanning electron microscope (SEM) measurements.

**NS-TuP17 Construction of a Spin Lab Measurement System to Enable Measurement of Spin Carrier Transport in Materials**, W. Nolting, A. Jayanthinarasimham, A. Matsubayashi, V.P. LaBella, College of Nanoscale Science and Engineering

Measuring electron spin transport metrics of materials and devices is becoming increasingly important as there is a great desire to fabricate devices that utilize the spin of the electron as well as its charge. This creates a need to measure ultra-low current without creating an increase in the signal-to-noise ratio with variable temperature and magnetic fields. In this poster we will present our custom built spin transport measurement system called the "Spin Lab Measurement System" (SLMS). This system can perform spin relaxation time measurements using non-local spin detection with spin precession (i.e. Hanle technique), along with other standard measurements such as Hall Effect, spin Hall Effect, Kondo Effect and other transport measurements. We will also describe how to measure spin Hall effect (SHE) using the SLMS. Two Primary measurements are able to be carried out, the spin Hall effect and non-local spin detection with spin precession.

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Hernández-Hernández, A.: NS-TuP3, **1**; NS-TuP4,

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Hernández-Hernández, L.A.: NS-TuP3, **1**; NS-TuP4, **1**

Hess, W.P.: NS-TuP12, **3**

Hiramatsu, T.: NS-TuP1, **1**; NS-TuP6, **1**; NS-TuP7, **2**; NS-TuP8, **2**

Hoshiya, R.: NS-TuP1, **1**

Hsiao, C.-N.: NS-TuP15, **4**

## — J —

Jayanthinarasimham, A.: NS-TuP17, **4**

Joly, A.: NS-TuP12, **3**

## — K —

Kato, H.: NS-TuP1, **1**; NS-TuP6, **1**; NS-TuP7, **2**; NS-TuP8, **2**

Kim, J.H.: NS-TuP2, **1**

Kim, M.D.: NS-TuP13, **3**

Kim, S.: NS-TuP16, **4**

Koji, H.: NS-TuP9, **2**

Kolmakov, A.: NS-TuP11, **3**

## — L —

LaBella, V.P.: NS-TuP17, **4**

Lee, J.I.: NS-TuP2, **1**

Lin, C.-T.: NS-TuP15, **4**

## — M —

Matsubayashi, A.: NS-TuP17, **4**

Meléndez-Lira, M.: NS-TuP3, **1**; NS-TuP4, **1**

Melendez-Lira, M.A.: NS-TuP5, **1**

Mota-Pineda, E.: NS-TuP5, **1**

## — N —

Nandasiri, M.I.: NS-TuP12, **3**

Nolting, W.: NS-TuP17, **4**

## — O —

Olveira, S.: NS-TuP10, **3**

## — P —

Park, D.K.: NS-TuP16, **4**

Park, J.: NS-TuP16, **4**

## — Q —

Quiñones-Galván, J.G.: NS-TuP3, **1**; NS-TuP4, **1**

## — S —

Seeger, S.: NS-TuP10, **3**

Sekiya, K.: NS-TuP9, **2**

Seong, D.J.: NS-TuP2, **1**

Shiao, M.H.: NS-TuP15, **4**

Shimada, k.: NS-TuP8, **2**

Shin, Y.H.: NS-TuP2, **1**

Strelcov, E.: NS-TuP11, **3**

Sugii, T.: NS-TuP7, **2**

## — T —

Takarai, Y.: NS-TuP7, **2**

Takemura, S.: NS-TuP1, **1**; NS-TuP6, **1**; NS-TuP7, **2**; NS-TuP8, **2**

Takeuchi, R.: NS-TuP8, **2**

Thevuthasan, S.A.: NS-TuP12, **3**

Tomoya, T.: NS-TuP6, **1**

## — V —

Varga, T.: NS-TuP12, **3**

Vilayurganapathy, S.: NS-TuP12, **3**

## — W —

Watanabe, Y.: NS-TuP6, **1**; NS-TuP7, **2**; NS-TuP8, **2**

## — Y —

Yeh, Y.-C.: NS-TuP15, **4**

You, K.H.: NS-TuP2, **1**

You, S.J.: NS-TuP2, **1**

Yun, W.S.: NS-TuP16, **4**

## — Z —

Zhang, J.: NS-TuP11, **3**