Thursday Afternoon Poster Sessions

Nanometer-scale Science and Technology
Room: Central Hall - Session NS-ThP

Nanometer-scale Science and Technology Poster Session

NS-ThP1 Composites of Silicone Nanofilaments and TiO₂ Nanoparticles for Photocatalysis, *G.R. Meseck, R. Kontic, G.R. Patzke, S. Seeger*, University of Zurich, Switzerland

Secured access to clean water resources is a fundamental need of human society and nanoparticulate TiO_2 is amongst the most important materials for the photocatalytic degradation of organic pollutants. While TiO_2-nanoparticles (NPs) thus offer photocatalytically effective routes to wastewater treatment, separation of NPs from reaction media is difficult and catalyst recycling often impossible. Immobilization of TiO_2-NPs is therefore indispensable to facilitate handling as well as to control potential health and environmental hazards. We present silicone nanofilaments as a new flexible carrier type for TiO_2-NPs, because they can be deposited as thin carpets on a variety of substrates and their silicone nature renders them chemically and environmentally stable. We deposited TiO_2-NPs on thin carpets of silicone nanofilaments on glass slides in a convenient one-step reaction in ethanol/water mixtures from TiF_4 as precursor under mild conditions. The resulting nanocomposite material is characterized with a wide range of electron microscopy and other analytical techniques. The photocatalytic activity in the decomposition of methylene blue (MB) is proved and superior to TiO_2-NPs immobilized on bare glass supports. Furthermore, the substrates are reusable for several cycles without significant loss in activity.

NS-ThP2 Organic Vapor Adsorption on *In Situ* Grown Carbon Nanotube Films, *K. Bosnick, S. Ban, W.K. Hiebert, Z. Shi, C. Huang, R. Lister, M. Mleczko*, National Research Council of Canada

Organic vapor adsorption isotherms are measured on in situ grown carbon nanotube (CNT) films using piezoelectric $GaPO_4$ crystal microbalances as mass sensing substrates. The isotherms are Type IV and show adsorption / desorption hysteresis, consistent with a porous material. The measured porosity is 2%, a value surprisingly low given an over 90% void volume in the film estimated from density considerations. At low pressures ($p/p_0 < 0.25$) the isotherm is well fit by the Freundlich model and at intermediate pressures ($p/p_0 = 0.1–0.4$) by the Brunauer, Emmett, Teller (BET) model. Monte Carlo simulations show three consecutive adsorption processes: filling of the intratube micropores at low pressures, monolayer coverage of the CNT external surface at intermediate pressures, and capillary condensation in the intertube mesopores at high pressures. The simulation results validate the use of the BET model for surface area analysis in the experimental system. The average total accessible surface area is found to be 180 ± 100 mm² and the specific surface area is estimated to be 45 ± 25 m²/g. Further engineering of the CNT film microstructure should lead to much higher surface areas. [Carbon 49 (2011) 3639]

NS-ThP3 Integrated Ultra-High Vacuum Tip-Enhanced Raman Spectroscopy with Molecular-Resolution Microscopy of Large Polyatomic Molecular Adsorbates on Single Crystal Surfaces, *N. Jiang, E.T. Foley, J.M. Klingsporn, M.D. Sonntag, M.C. Hersam, R.P. Van Duyne*, Northwestern University

Multiple vibrational modes have been observed for copper phthalocyanine (CuPc) adlayers on Ag(111) using ultrahigh vacuum (UHV) tip-enhanced Raman spectroscopy (TERS). Several important new experimental features are introduced in this work that significantly advance the state-of-the-art in UHV-TERS. These include (1) concurrent sub-nm molecular resolution STM imaging using Ag tips with laser illumination of the tip−sample junction, (2) laser focusing and Raman collection optics that are external to the UHV-STM that has two cryoshrouds for future low temperature experiments, and (3) all sample preparation steps are carried out in UHV to minimize contamination and maximize spatial resolution. Further, density-functional theory calculations have been carried out that allow quantitative identification of eight different vibrational modes in the TER spectra. The combination of molecular-resolution UHV-STM imaging with the detailed chemical information content of UHV-TERS allows the interactions between large polyatomic molecular adsorbates and specific binding sites on solid surfaces to be probed with unprecedented spatial and spectroscopic resolution.

NS-ThP4 An New One-step Synthesis Method for Generating Nanocarbon-supported Metal Nanoparticle, *J. Kang, L. Li, N. Zettsu, O. Takai, N. Saito*, Nagoya University, Japan

Introduction

Metal nanoparticles attract sustained attention due to their application in electrocatalysis for cell. Recently, many loading methods of nanoparticles on carbon material such as chemical reductions, electrochemical reductions, sol–gel polymerization and ultrasonic vibration have been reported for the generation of cell electrode. However, these methods generally require either reducing agent to reduce metal ions or removal of residues from the solution dispersed nanoparticles and it's dispersibility and loading amount is poor. To supplement these weaknesses, in this study, the Au, Ag, Pt, Au-Pt bimetallic alloyed nanoparticles were synthesized simultaneously with carbon nanoball (Au, Ag, Pt, Au-Pt/CNB) by our progressive method, Solution Plasma Process (SPP).

Experimental Procedures

Highly porous CNBs were synthesized from 200 ml of organic. The glow discharge in solution was produced by using a bipolar pulsed power supply operated at 1.6 kV of voltage, 15 kHz of pulse frequency, 0.7ms of pulse width, and 0.3 mm electrode distance, respectively and then NPs/CNB were annealed for improvement conductivity of CNB. The nanoparticle/carbon nanoball (NPs/CNB) were characterized by X-ray diffraction (XRD), transmission electron microscopy (TEM), scanning electron microscope (SEM) Brunauer–Emmett–Teller (BET) method and cyclic voltammetry (CV)

Results and Discussion

Approximately 500mg of CNB were generated by SPP of 200ml of organic solution in 15 minute process time. As evaluated by SEM, the diameters of CNB were in a range of 20 nm to 30nm and it showed that these carbon spheres have a ball-like and chain-like morphology, accompanied with a quite uniform diameter. The Scanning Transmission Electron Microscopy (STEM) image showed that the 1~2 nm diameter of Au, Pt, Au-Pt bimetallic alloyed nanoparticles were deposited on all of CNB with high loading and dispersion. The BET surface area and the pore volume of as obtained CNB were respectively, 120~130 m2/g and 0.8~0.9 cm3/g. The average pore size could be estimated approximately as 20~25nm. Subsequent heating of the CNB at 850℃ for 30 minutes under an Ar environment encouraged the increase of the BET surface area and pore volume of CNB to 250~300 m2/g and 1.1~1.3 cm3/g respectively. The average pore size was calculated around 15~16nm. These results strongly suggested that our newly developed process of NPs/CNB synthesis might be a potential method for a single-step production of nanocarbon-supported metal nanoparticle.

NS-ThP5 The Role of an Amorphous Carbon Layer on a Multi-Wall Carbon Nanotube Attached Atomic Force Microscope Tip in Making Good Electrical Contact to a Gold Electrode, *S.J. Ahn*, KRISS, Republic of Korea

Multi-wall carbon nanotube (MWNT) attached atomic force microscope (AFM) tips (MWNT tips) have good potential for use in AFM lithography. Good conducting MWNT tips are needed in such applications. However, characterizing the conductance of MWNT tips is nontrivial: making a good electrical contact between the MWNT and electrode is difficult. We observed that MWNT tips produced by hydrocarbon-deposition attachment usually do not make good electrical contacts to gold electrodes because of the thin and rough amorphous carbon layer on the MWNT that was unintentionally deposited during the attachment. We found that good contacts can be made if a more amorphous carbon layer is deposited to form a thick and smooth amorphous carbon layer on MWNTs. Good contact was made either by transformation of the amorphous carbon layer into a conducting or peel-off layer, exposing the bare MWNT surface. MWNT tips with an exposed MWNT surface showed the well-known high-current-flowing capacity and the stepped-cutting behavior of bare MWNTs. The peeling-off behavior of a thick amorphous carbon layer may be utilized in producing bare-surfaced MWNT tips that have good conductance and therefore are useful for applications.

NS-ThP6 Passivation Effects on Electrical Properties of SnO₂ Nanowires FET Treated by Nitrogen Plasma, *Y.H. Choi, P.S. Kang, J.H. Na, J.S. Kim*, Korea University, Republic of Korea*, S.-H. Choi*, Korea Institute of Science and Technology, Republic of Korea*, M.Y. You, G.T. Kim*, Korea University, Republic of Korea

SnO_2 (tin oxide) are used in various research fields such as thin film transistors (TFTs), flexible and transparent nanowire transistors, and gas sensors, because of large band gap of 3.6 eV, high electron mobility and a

high surface-to-volume ratio. However, the electrical characteristics of SnO_2 nanowires FETs are not so stable in ambient conditions due to the chemical reactions between oxygen molecules in air and oxygen vacancies in SnO_2 nanowires. To improve the device reliabilities of SnO_2 nanowires FETs, the N_2 plasma were treated. The N_2 plasma treatments on SnO_2 nanowires FETs led to the reduction of the hysteresis width in the transfer characteristics. Also the threshold voltage shifted to the positive direction. Even though the reliability of SnO_2 nanowires FETs is improved after the N_2 plasma treatment, unnecessary degradations can be induced with time in an ambient environment, requiring the passivation process. The PMMA and the carbon polymers deposited by CF_4 plasma treatments were used for the passivation of the SnO_2 nanowire FET devices. To investigate the effect of the passivation, the unpassivated and the passivated devices have been compared. The changes of the mobility and the carrier concentration were separately analyzed, indicating the different behaviors with or without the passivation.

NS-ThP7 Application of Rolling Circle Amplification and Thermal Dynamic Principle for Manipulating the Interparticle Spacing of Gold Nanopaticle Chains, *Y.P. Lu, M.Y. Lin, Y.-C. Ou*, National Applied Research Laboratories, Taiwan, Republic of China

Biomolecular nanotechnology draws a lot of attention in organizing DNA sequence, which can architecturally build up a nano-sized scaffold, because of their potential utility in nano-machines and biosensing. According to the DNA complementary base-pairing interactions and aptamer design, DNA backbone has further been used for the construction of a variety of geometric objects and anchoring sites for functionalized proteins or metals. A simple and applicable procedure to miniature nanostructures is expected to enhance the detection sensitivity of devices. It is important to construct the metallic nanoparticle chain with different interparticle spacing because the organized metallic nanoparticles self-assembled from DNA nanostructure may affect the photoelectric properties. We successfully generate well-controlled formation of long, flexible, one dimensional gold nanoparticle (AuNP) chains by employed DNA template for self-assembly AuNP based on rolling circle amplification (RCA) technique. For the purpose of controlling the interparticle spacing of AuNP, we report the construction of long chain DNA-AuNP with or without secondary structure of DNA scaffold by using of base-pairing strategy and thermal dynamic reaction. The heating process under appropriate temperature broke the intramolecular Watson-Crick interactions to form the hairpin structure. This ultimately allowed no AuNP modified primers to hybridize with the open region of single strand DNA backbone, hence increased the interparticle spacing between each AuNP. The effect of AuNP distance in optical and electronic properties can be designed by controlling the DNA sequence and thermal dynamic reaction, and thus changed the optical and electronically characters of AuNP-based nanostructures for many applications in optoelectronics and biosensing devices fabrication.

NS-ThP8 Synthesis of Gold Nanofluids for Improved Heat Transfer using Solution Plasma, *Y.K. Heo, M.A. Bratescu, N. Saito*, Nagoya University, Japan

In recent years, the development of high speed devices and their integrated circuits has facing some obstacles owing to localized heat generation in terms of safety and efficiency of devices. Nanofluids which were defined fluids containing nanometer-size particles, have been researched for their high and efficient heat transfer. It was reported that heat transfer enhancement was due to the Brownian motion of the nanoparticles contained in the fluids. Therefore, the diameter of nanoparticles in nanofluids is a key-factor in order to develop new heat transfer systems with higher energy-efficiency.

Recently our research group has developed a new synthesis method for well-defined nanoparticles in an aqueous solution, by solution plasma process (SPP). This process allows us to fabricate solutions containing high quantity of small monodispersed nanoparticles in order to obtain a heat transfer system with improved efficiency.

In this research, we aimed to reveal the heat transfer of nanofluids. The solution containing monodispersed gold nanoparticles was synthesized by SPP using a DC bipolar pulsed power supply. Gold nanofluids were synthesized with various concentrations of 0.1, 0.3, 0.6, 0.9 mM HAuCl4 and 4 times KOH of each HAuCl4 concentration in distilled water. The reaction time is 15 minutes. The solution plasma optical and electrical conditions were measured by OES and oscilloscope. The evaluation of the synthesized nanoparticles was performed by TEM analysis and UV vis spectroscopy. The dispersion stability was evaluated using zeta potential. In addition, KD2 pro & viscometer were used for heat transfer analysis of the synthesized nanofluids.

The decrease of the nanoparticles diameter from 13.8 ± 4.3 nm to 5.6 ± 1.4 nm was measured in dependence with the precursor concentration. The viscosity of the nanofludis increased with precursor concentration from 1.95

mPa·s to 2.05 mPa·s at 283 K (Viscosity of Di Water is 1.51 mPa·s.). A precursor concentration of 0.9 mM produced the smallest nanoparticles diameter of 5.6 ± 1.4 nm, and the highest increase of the thermal conductivity of 29.4 %.

NS-ThP9 Post Ion-Implant Growth of Epitaxial Graphene on 6H-SiC, *J. Seo, H. Shin, J.-H. Park, J.R. Ahn*, Sungkyunkwan University, Republic of Korea

Graphene, a two-dimensional sheet of sp^2-bonded carbon arranged in a honeycomb lattice has attracted significant attention due to its interesting characteristics such as high carrier mobility, optical transparency, mechanical strength, and possible applications in various fields. Among the techniques developed for producing graphene, epitaxial growth on silicon carbide (SiC) is a promising method for large-scale production. Ion implantation is also a mature technology in large-scale electronic industry, which can take the epitaxial graphene into the semiconductor foundries.

Here we studied post ion-implant growth of epitaxial graphene on 6H-SiC substrates according to ion fluences, acceleration voltages, and substrate temperatures. N^+ ions at 40-145keV were implanted with fluences of 1×10^{17} N^+/cm^2 and 3×10^{17} N^+/cm^2 into 6H-SiC substrates under room temperature (RT) and 650°C. The ion distributions and structural variations in the implanted samples have been studied using secondary ion mass spectrometry (SIMS) and transmission electron microscopy (TEM) both before and after the graphene growth. This study revealed that the implanted N^+ ion distributions in 6H-SiC are robust up to ~1330°C at which the epitaxial graphene begins to grow on Si-face of 6H-SiC and the graphene is formed only when the substrates are maintained at 650°C during ion implantation. This is believed to be due to the prominent damage recovery of 6H-SiC in high temperature implantations. The high crystallinity of the epitaxial graphene grown on the damage-recovered 6H-SiC was confirmed by photoelectron spectroscopy and low-energy electron diffraction.

NS-ThP11 Preparation of Metal Nanoparticles within Mesoporous Silica via Solution Plasma Process (SPP), *W. Yaowarat, N. Saito*, Nagoya University, Japan

Recently, nanoparticles within mesoporous silica have been extensively studied due to their significant physicochemical characteristic. It is widely used in various applications such as instant microbial inhibition, sensor, catalyst, and electronic devices. As previously reported that nanoparticles within mesoporous silica could be synthesized by chemical treatment and calcination. However, high temperature and long time treatment must be required.

Solution plasma process (SPP) is a new plasma system which could be used to synthesis metal nanoparticles. SPP is superior to other conventional methods, in term of ease of handling, low temperature, and short time treatment. It is therefore of our interest to apply the solution plasma process to prepare metal nanoparticles within mesoporous silica. The voltage, frequency and pulse width of solution plasma conditions were fixed at 1.6 kV, 15 KHz, and 2 μs, respectively. 1 mM of AgNO3 solution with 0.2 g mesoporous silica was treated with solution plasma for 15 minutes. The plasma-treated sample was filtrated prior to air dry for overnight. The dried sample was characterized by transmission electron microscopy (TEM). The TEM results showed that the silver nanoparticles could be performed during solution plasma treatment and filled within nanoscale channels of mesoporous silica matrix. This suggested that the solution plasma process could be a potential method for prepare metal nanoparticles within mesoporous silica.

NS-ThP12 The Electrical Property of the Interface Between Dielectrophoresis (DEP)-Aligned Single-Walled Carbon Nanotubes and Semiconductors, *M. Hines, Z. Xiao*, Alabama A&M University

The dielectrophoresis (DEP) method was used to align and deposit single-walled carbon nanotubes for the fabrication of high-performance single-walled carbon nanotube field-effect transistors (CNTFETs). Semiconducting materials such as silicon and germanium were used as the source/drain contact material in the fabrication of CNTFETs for improving the device electrical performance. The DEP-aligned carbon nanotubes were mesh networks interconnecting with metallic nanotubes and semiconducting nanotubes. The vacuum-based deposition such as e-beam evaporation and sputtering deposition was used to grow the silicon and germanium thin films, and clean room-based microfabrication techniques such as UV lithography was used to fabricate the CNTFETS. The electrical property of fabricated CNTFETs were measured and characterized. The semiconductors can significantly increase the ratio of the switch-on/off electrical currents in the fabricated CNTFETS. The electrical property of the interface between the single-walled carbon nanotubes and the semiconductors and the fabricated CNTFETs will be reported in the conference.

NS-ThP14 Field Emission Based Hydrogen Sensing Characteristics from Carbon Nanotubes Synthesized on Catalytical Substrates, *C. Dong*, Wenzhou University, Republic of China

A new hydrogen sensing concept is demonstrated based on the field emission form multi-walled carbon nanotubes. The low emission currents rise in proportional to hydrogen partial pressures above from 10^{-9} to 10^{-5} Torr. Catalytic Ni participated C-H reactions in low emission regime are considered the key factor of the sensing behavior. Simple setup, tiny structure, high sensitivity, and fast recovery make this innovative technique attractive to build miniature low cost hydrogen sensors for low pressure applications.

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