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

Nanoscience Division Poster Session

NS-ThP1 Gallium Nitride Nanoparticle Synthesis using Non-Thermal Plasma with N_2 Gas and Ga Vapors, ***Jung-Hyung 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, D.J. Seong, Y.H. Shin*, Korea Research Institute of Standards and Science (KRISS), Republic of Korea

Compounds of Ga, such as gallium oxide(Ga2O3) 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 UV- to blue-light-emitting diodes(LEDs) and laser diodes(LDs).[1] Nanoparticle is an interesting material due to its unique properties compared to the bulk equivalents. While bulk-GaN exhibits a band gap of 3.3 eV to 3.5 eV, nanoparticles show a size-depending band gap if the particle size falls below 10.0 nm.[2]

In this report, we develop a synthesizing method for gallium nitride nanoparticle using non-thermal plasma. For gallium source, the gallium is evaporated by induction heating. Nitrogen radicals for GaN nanoparticle synthesis are supplied from inductively coupled plasma with N2 gas. We use two plasma sources: one is for sufficient N radicals and the other is for in-situ plasma treatments. With this method, the post treatments such as annealing are not needed to get sufficient crystallinity. The synthesized nanoparticles are analyzed using field-emission scanning microscope(FESEM), transmission electron microscope(TEM) and x-ray photoelectron spectroscopy(XPS), and photo-luminescence(PL). The synthesized particles are investigated and discussed in wide range of experiment conditions such as flow rate, pressure and RF power.

References

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2. H. Morkoc, S. Strite, G. B. Gao, M. E. Lin, B. Sverdlov and M. Burns, J. Appl. Phys., 76, 1363, Review. 1994

NS-ThP3 Imaging and Spectroscopy of Infrared Absorption Enhancement in the Near-Field of Plasmonic Array with the PTIR Technique, ***Jungseok Chae***, *B. Lahiri, G. Holland, A. Centrone*, National Institute of Standards and Technology

Propagating light can interact efficiently with artificially fabricated metallic nanostructures through plasmonic excitations. In the infrared (IR) such light-matter interactions enables enhanced absorption in nanoscale volumes ("hot spots"), leading to sensitive IR detection. However, direct imaging of IR absorption hot spots is challenging because their size is several time smaller of the diffraction limit of the long IR wavelengths. Recently our group directly imaged and quantified the mid-IR absorption enhancement in polymer films coating asymmetric split ring resonators (ASSRs) using the photothermal induced resonance (PTIR) technique.[1] PTIR measures the transient thermal expansion caused by the absorption of light pulses in the sample with an atomic force microscope cantilever, leading to lateral resolution comparable to the AFM tip size P lasmonic arrays of different shapes (ASRR, C-shaped, crescent-shaped and U-shaped) and different lattices (square, hexagonal and rhombic) were fabricated by e-beam lithography on top of zinc selenide right angle prisms to enable PTIR characterization. Here I'll show how the different shapes and arrangements of the resonators impact the shape, distribution and intensity of IR absorption hot spots in the near-field. The experimentally and directly measured enhancement factors in PMMA film coating the plasmonic structures will be compared for the different cases and with the enhancements measured for a single resonator of each shape.

[1]. B. Lahiri, G. Holland, V. Aksyuk and A. Centrone, NanoLetters. **13**, 3218 (2013).

NS-ThP5 A Novel Method for the Formation of Pt Metal Nanoparticle Array on Dimpled Ta using Nanosecond Pulsed Laser Dewetting, ***Ebenezer Owusu-Ansah***, *C. Horwood,* University of Calgary, Canada, *H.A. El-Sayed,* Technische Universität, Germany, *V. I. Birss, Y. Shi*, University of Calgary, Canada

The unique properties of metal nanoparticle arrays (MNAs) depend on their sizes and geometries, and they differ considerably from the individual atoms and the bulk material.MNAs have been at the frontier in fabrication of materials with enhanced optical, magnetic, plasmonic, and mechanical properties, in biosensors as well as in catalysts with optimized selectivity. Lithographic techniques are the major conventional methods used to generate MNAs, however, the processes are sophisticated and time consuming. The formation of sub-50-nm nanoparticle sizes has become increasingly difficult using lithography. Recently, thermal dewetting has been successfully used to form nanoparticle arrays of Au on dimpled Ta (DT) substrate, however, the major setback associated with this method is the deformation of the substrate when applied to high-melting point metals such as Pt. Pulsed laser dewetting is able to generate well-defined MNAs with the unique advantage of very little or no thermal damage to the substrate. Within the short width of the laser pulse, typically in the range of 7–12 ns, the laser energy is instantaneously converted into heat to dewet only the thin metal film with minimal or no heat transfer to the underlying substrate. We report here the results from our study on the formation of Pt MNAs using laser dewetting of Pt thin films on DT substrate under high vacuum condition. The DT substrate was fabricated using electrochemical anodization in highly concentrated H_2SO_4/HF solution. It has been demonstrated that dewetting occurs only at and beyond the threshold fluence. Beyond this threshold a single laser pulse was enough to achieve complete dewetting. The effect of several key parameters, including laser fluence, irradiation time, and film thickness, on the nanoparticle sizes and distribution was studied. To better characterize the MNA features, the percentage of dimples occupied by Pt nanoparticles was determined. As high as 80% of dimpled Ta occupancy can be achieved using pulsed laser dewetting. This study shows that laser dewetting is a novel method capable of annealing thin films of high-melting point Pt metal to achieve well-defined MNAs with narrow particle size distribution without subsequent damage to the DT substrate.

NS-ThP7 Dielectrophoretic Manipulation of Nickel Nanowires, ***MarcosVinicius Puydinger dos Santos***, *R. Mayer, K.R. Pirota, F. Beron, S. Moshkalev, J.A. Diniz*, University of Campinas, Brazil

Nanowires have received much attention because their high aspect ratio, shape anisotropy, relatively large surface area and particular electron transport properties. Furthermore, given to the low electrical current level usually present in the nanowires and their high sensitivity to the environment, they can be used as sensors devices. Dielectrophoresis (DEP) is a deposition method of electrically neutral particles based on the application of alternating electric field between electrodes. In this work, 80 nm–thick aluminum electrodes were deposited on a 300 nm–thick SiO_2 layer grown on n^+– type silicon wafer using optical lithography and lift-off. After electrodes fabrication, nickel nanowires (NiNW) (length of 4 µm and diameter of 35 nm), obtained by electrodeposition, were manipulated and defined between the electrodes using DEP. Electrical parameters of DEP deposition – like frequency, electric potential, NiNW concentration and process time – as well as electrodes geometry were studied to investigate deposition efficiency. Preliminary results show best selection of electrical parameters and electrodes geometry that optimizes the nanowires deposition. For suitable parameters, the efficiency of DEP deposition is up to 90%. To characterize NiNW electrical properties, electrical current through the nanowires was measured as the voltage between electrodes. Initially, a Schottky-like contact is present and contact sintering under forming gas (92% of N_2 and 8% of H_2) at 450 ^oC was taken to reduce the eletrodes-NiNW contact resistance down to the NiNW resistance (~ 1k Ω). Finally, this method for nanowire deposition and electrical contact reduction has a suitable throughput and is a key for electric characterization of nanowires and fabrication of nanowire-based devices.

NS-ThP9 Electron Tunneling in Weak Coupled Triple Quantum Dots: Sensitivity to Symmetry Violation, ***Igor Filikhin***, *B. Vlahovic*, North Carolina Central University

The electron localization and tunneling in the triple quantum dots (TQD) is studied in relation to their spectral properties. Modeled are lateral InAs/GaAs TQDs using single sub-band effective mass approach with the effective potential simulating the strain effect [1]. As an approximation, two-dimension quantum wells (QW) are considered. Dynamics of electron localizations in TQD over whole spectrum is studied by varying the inter-dot distances. To consider tunneling between localized-delocalized states selected was a QD pair (DQD). In isolated DQD, such tunneling goes consecutively from high energy levels to the ground state when the inter-dot distance decreases [2]. The electron spectrum is separated by three parts: localized states, delocalized states, and states with different probability for localization in the left and right QDs. The electron localization demonstrates extreme sensitivity to small variations of DQD shape, which violate Left-Right symmetry. The effect of adding third quantum dot to DQD is considered for weak coupling triple system. We show that presence of the third dot increases tunneling in weakly coupled DQDs. The star and chain configurations of TQDs are considered. The effect of violation of reflexing symmetry in TQD was studied. We found that the tunneling is highly sensitive to a small violation of the geometry symmetry.

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