Nanometer Structures
Room: Exhibit Hall B2 - Session NS-WeP

Nanometer Structures B

NS-WeP1 Electrostatic Force Spectroscopy of Pure InP and Self-assembled InAs/InP Quantum Dots Studied by Non-contact Atomic Force Microscopy, ***R.-P. Stomp***, McGill University, Canada, *S. Studenikin, P. Poole, A. Sachrajda,* National Research Council, Canada, *P. Grutter,* McGill University, Canada

The purpose of this work is to develop a low-temperature, non-contact Electric Force Microscope (EFM) technique to image semiconductor dots embedded in a dielectric matrix. Non-contact Atomic Force Microscope (nc-AFM) is a very versatile tool to study conductive as well as non-conductive surfaces without damaging them. Our microscope operates at 4.5K with a built-in heater and the possibility of applying a magnetic field up to 8T.[1] In this study we use samples of self-assembled InAs quantum dots embedded in InP grown by chemical beam epitaxy.[2] In the present study, we are investigating the change in resonance frequency of the AFM tip as function of tip-sample bias voltage, or electrostatic force spectroscopy, of bare InP and InAs/InP quantum dot. In case of bare InP an asymmetric frequency-voltage dependence was observed that enabled us to determine the charge sign of the carrier and to deduce the work function potential of the material. This is an on going work, and results on the quantum dot samples will be presented and discussed. It has been previously demonstrated that quantum dot spectra can be measured by EFM, where we can observe the filling of energy levels at low temperature.[3]

[1] M. Roseman., P.Gruetter, Rev. Sci. Instr. 71, 3782 (2000)
[2] J. Lefebvre, P.J. Poole et al., J. Cryst. Growth, 234, 391 (2002)
[3] D. Aykutlu, Y. Yamamoto, cond-mat/0103125 (2001) .

NS-WeP2 Defects in Cylindrical Multi-shell Copper Nanowires, ***J.W. Kang***, *J.J. Seo, H.J. Hwang,* Chung-Ang University, Korea

We have performed atomistic simulations for cylindrical multi-shell (CMS)-type Cu nanowires containing defects. Our investigation has revealed some physical properties that have not been detected in previous studies that have considered defect-free nanowires. Since the vacancy formation energy is lowest in the core of a CMS-type nanowire, a vacancy formed in the outer shell of a CMS-type nanowire naturally migrates toward the core. The maximum of the formation energy of an adhered atom on the surface of a CMS-type nanowire was modeled using a 16-11-6-1 nanowire. The formation energy of an adhered atom decreased when the diameter of the CMS-type nanowire was either above or below the diameter of the peak energy maximum. This investigation found three recombination mechanisms for the vacancy-adhered atom pairs: (i) by direct recombination, (ii) by a kick-in recombination, and (iii) by a ring recombination. Vacancy formation energy calculations show that an onion-like cluster with a hollow was formed, and molecular dynamics simulations for various CMS-type nanowires found that vacancies migrated towards the core. From these, we obtained basic information on the formation of hollow CMS-type metal nanowires (metal nanotubes).

NS-WeP3 Dispersion Relation of the Electromagnetic Waves in the Strong-coupling Superconductive Nano-disk, *V.Z. Lozovski*, ***D.V. Reznik***, Institute of Semiconductor Physics NAS of Ukraine

The investigated system consists of the superconductor disk on the surface a dielectric substrat. We study the dispersion relations of the electromagnetc waves which can be excited in the system. The dimensions of the disk is order of 100-1000 Å. We take into account the strong coupling of the superconductor in the framework of the enhanced u-v- transformations method which was developed in.[none 1] The dispersion relation are determine by the pole part of the effective susceptibility. The susceptibility is calculated by solution of Lipman-Shwinger self-consistent equation. This equation is solved by exact summation of iteration procedure series proposed in.[2] The initial receptivity was written in terms of u-v-coefficients. One takes into consideration strong-coupling. We take into account the despersion of the phonon energy and perturbation of the electron energy spectrum at Fermi level by electron-phonon interaction. The proposed approach allows us to calculate the effective nonlocal susceptibility for the both weak and strong coupling superconductors. As it is shown in[2] the effective susceptibility can be rewritten as the tensor product of the initial susceptibility and inverse mass operator. Then the electromagnetic waves dispersion relations are determined by the roots of the real part of the determinant of the effective susceptibility inverse matrix. The dispersion curves depend on the electromagnetic properties of the substrate and disk material, the strength of the coupling in superconductor and the geometry of the system (thickness and radius of the disk). Moreover, dispersion depends on coordinate in which electromagnetic field is investigated.

[1] B.I. Khudik, V.Z. Lozovski, A.B. Nazarenko, Phys. Stat. Sol.(b) 148, 297-303 (1988).
[2] V.Z. Lozovski, Physica E, 9, 642-651 (2001).

NS-WeP4 Zinc Sulfide Coating on Carbon Nanotubes, ***H.S. Kim***, University of Florida

Mophological study on zinc sulfide (ZnS) synthesized by a solid state reaction on the outermost shells of multiwalled nanotubes (MWNT) is presented. It was found that ZnS coats the surface of CNTs in the forms of ultrathin films, quantum dots, and nanorods. ZnS nanorods were grown on the surface of MWNTs without the presence of catalyst suggesting the vapor-liquid-solid (VLS) mechanism is not applicable for the here shown growth process. The average diameter of nanorods on MWNTs is about 140 nm and the length is around 250 nm.

Zinc Sulfide Coating on Carbon Nanotubes.

NS-WeP5 Gas Sensor Based on Metal and Metal Oxide Individual Nanowires and Nanowire Arrays, ***Y. Zhang***, *A. Kolmakov, G. Cheng, M. Moskovits*, University of California, Santa Barbara

We report on the approach, which can constitute a novel versatile platform for micro- and nanosensor application. Arrays of nanowires with tunable diameters and length in the range of 10-100 nm and 5-200 micrometers, respectively, were fabricated from the catalyticaly active materials inside close-packed nanochannel alumina templates. Electrodes deposited on the surfaces of these nanostructures provides electrical contacts which with the incorporated heaters determines the device architecture. In particular, metal (Cu, Ag, Pb, Pd) and metal oxide (SnO_2) individual nanowires and their arrays were tested using HRTEM, XPS and Auger spectroscopy. Chemical reactivity and gas sensitivity toward hydrogen and carbon monoxide of individual and assemblies of Pd and SnO_2 nanowires were assessed using conductivity measurements and TPD analysis. These structures based on single nanowires and nanowire arrays offer full range of options useful to gas sensing, including robustness, high surface-to-volume ratio, small size if required, functionalization via doping, integrability into other devices.

NS-WeP6 Switching Behavior of Plasma Polymer Thin Films Containing Metal Nanoparticles, ***A. Kiesow***, Fraunhofer-Institute for Mechanics of Materials Halle, Germany, *J.E. Morris,* Portland State University, *C. Radehaus,* Technical University Chemnitz, Germany, *D. Katzer, A. Heilmann*, Fraunhofer-Institute for Mechanics of Materials Halle, Germany

The nanostructures of plasma polymer thin films containing silver-particles are characterized by particle size and particle shape distribution and have been investigated by means of transmission electron microscopy (TEM). The electrical properties have been determined and correlated with the nanostructures. Three different nanostructural types could be observed: metallic, percolation, and dielectric region. While for the metallic and dielectric regions, respectively, metallic conduction and thermally activated tunneling can be identified as the dominant conduction mechanisms, a switching effect was observed for the region near percolation. These drastic abrupt changes in the current (I) -voltage (V) behavior (of up to 6 orders of current magnitude) are reversible, and can be defined as threshold bistable switching. The threshold voltage is dependent on the switching frequency.

NS-WeP7 Frequency Dependence of Local Electronic Properties: Nanoimpedance Spectroscopy, *S.V. Kalinin,* ***R. Shao***, *D.A. Bonnell*, University of Pennsylvania

Progress in nanoelectronics necessitates an understanding of the structure and properties of materials on the local level. While substantial advances have been made in local property measurement particularly based on scanning probes, they have accessed either dc properties or ac properties at a single frequency. The ability to probe the frequency dependence of local electronic properties would lead directly to mechanistic considerations of trap states at defects, scattering at interfaces, etc., in nano or molecular electronics. We have developed a local spectroscopy that determines tip-surface impedance directly over a wide frequency range (40 Hz - 110 MHz) with nanometer spatial resolution. This approach is generalized to spatially resolved nanoimpedance spectroscopy and imaging. The technique will be illustrated on 2-D structures, an atomically abrupt interface and a nano wire; and a 3-D structure, a nano particle on a substrate.

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