

Tuesday Afternoon, October 16, 2007

Electronic Materials and Processing

Room: 612 - Session EM+NS-TuA

Semiconductor Nanostructures for Electronics and Optoelectronics II

Moderator: S.E. Mohny, The Pennsylvania State University

1:40pm **EM+NS-TuA1 Epitaxial NiFe Contacts on GaAs via Electrodeposition**, Z.L. Bao, K.L. Kavanagh, A.S. Arrott, Simon Fraser University, Canada, A.A. Talin, Sandia National Laboratories

We report the electrodeposition of epitaxial $\text{FeNi}(1-x)$ films on n-GaAs (001) substrates from aqueous metal ammonium sulphate solutions. Structural measurements using x ray diffraction show that the films have single crystalline BCC or FCC structure at Fe and Ni-rich compositions, respectively. The ratio of Fe concentration in the FCC films to that in the electrolyte is surprisingly close to unity (1.1). BCC $\text{FeNi}(1-x)/\text{GaAs}$ diodes have constant Schottky barrier heights independent of Fe composition consistent with a constant interfacial composition while the FCC Ni-rich alloys barriers increase with increasing Ni composition consistent with room temperature reactions.

2:00pm **EM+NS-TuA2 Medard W. Welch Award Lecture - Growth of Semiconductor Nanostructures: Simple Models for Complex Behavior**, J. Tersoff*, IBM T.J. Watson Center **INVITED**

Epitaxial islands and wires can "self assemble" during growth, producing quantum dots and nanowires with sub-lithographic dimensions. Such growth exhibits many remarkable and puzzling features, which must be understood in order to grow well controlled nanostructures. I will describe simple models that can explain many of the phenomena observed during growth of quantum dots in strained-layer heteroepitaxy, and also some recently discovered phenomena in growth of nanowires via the vapor-liquid-solid mechanism.

2:40pm **EM+NS-TuA4 Fast Synthesis Method for Binary and Ternary alloy Quantum Dots**, N. Shukla, M.M. Nigra, A.J. Gellman, Carnegie Mellon University

We have developed a one step synthesis process for binary and ternary alloy quantum dots with photoluminescence ranging from the red through to the violet region of the solar spectrum. This synthesis method allows us to control particle size and composition of quantum dots. We have also studied the effect of solvent boiling point and the addition of various chemical precursors on the synthesis and the photoluminescence properties of quantum dots. The photoluminescence peak in this synthesis method can be controlled by using different reaction time to produce quantum dots of different sizes. Photoluminescence peaks can also be controlled through varying composition of the chemical precursors. In addition, we have also studied the effect of solvent boiling point and the type of solvent on the physical and photoluminescence properties of these quantum dots. The type of solvent plays an important role in the photoluminescence properties of quantum dots. High boiling point non-polar solvents shift the photoluminescence peak to higher wavelength and low boiling point polar solvents shift the photoluminescence peak to lower wavelength.

3:00pm **EM+NS-TuA5 Zinc Oxide Nanowalls and its Optical and Field Emission Properties**, D. Pradhan, K.T. Leung, University of Waterloo, Canada

Vertically grown ZnO nanowalls, with typical dimensions of 40-80 nm thick and several micrometers wide, were electrodeposited on an ITO-glass substrate at 70 °C. XRD study shows that these nanowalls have the wurtzite structure and are highly crystalline. The corresponding Raman and photoluminescence spectra further indicate the presence of oxygen deficiency. These ZnO nanowalls exhibit excellent field emission performance, with not only a considerably lower turn-on field of 3.6 V/ μm (at 0.1 $\mu\text{A}/\text{cm}^2$) but also a higher current density of 0.34 mA/ cm^2 at 6.6 V/ μm than most of ZnO nanowires and other one-dimensional nanostructures reported to date. We will also discuss a plausible growth mechanism for these nanowalls, and our recent work on the growth of these and other novel ZnO two-dimensional nanostructures on ITO-plastics.

4:00pm **EM+NS-TuA8 Bright and Color-Saturated Light Emitting Devices Based on Colloidal Nanocrystal Quantum Dots**, J. Xu, Pennsylvania State University, Q. Sun, University of Dayton, T. Zhu, Pennsylvania State University, A. Wang, Ocean NanoTech LLC., Y. Li, Chinese Academy of Science, China **INVITED**

Recently, the development of low cost, solution-based synthesis of monodisperse, well characterized colloidal quantum dots (QDs) has generated a new class of material for the next generation-light emitting devices. Electroluminescent (EL) devices have been fabricated from thin films of colloidal QDs and exhibit saturated colors and broad wavelength coverage. Emission of EL devices can be easily tuned by varying the size and/or the material composition of nanoparticles during the synthesis process, while their chemical properties remain largely the same. Therefore, one device fabricating procedure can be adopted for different nanocrystals to produce emissions over a broad wavelength, covering the visible (0.4 μm – 0.8 μm) and NIR (0.8 μm - 2.5 μm) regions of the spectrum. In addition to the broad wavelength tunability, high fluorescence quantum yield and photochemical stability can be achieved by careful modification of the nanocrystal surface, and this may favor the efficiency of the EL device. All these unique properties have made semiconductor NQDs promising candidates for a broad range of applications, including flat panel display (FPD), light illumination, lightwave communication, and bio/chemical sensing. In this talk we present our work on the design and optimization of colloidal quantum dot (QD)-based light emitting diodes (LEDs) by tailoring the structure and layer thickness of the emissive QDs in the LED active region, the device configuration, as well as the electrode composition. The maximum brightness of red ($\lambda_{\text{peak}}=619\text{nm}$), orange ($\lambda_{\text{peak}}=595\text{nm}$), yellow ($\lambda_{\text{peak}}=575\text{nm}$), and green ($\lambda_{\text{peak}}=526\text{nm}$) QD-LEDs were measured to be 9064 cd/m², 3200 cd/m², 4470 cd/m², and 3700 cd/m², respectively, representing the highest brightness reported for QD-based EL devices. These devices were characterized with low turn-on voltages (3-4 V), high efficiency (1.1-2.7 Cd/A), and longer operation time at high brightness ($t_{50\%}=300\text{hrs}$ at 1100 cd/m²), indicative of the superior radiative properties and adequately-tailored carrier-injection and transport functions of the QD-active region in the LEDs.

4:40pm **EM+NS-TuA10 Ligand Quenching of CdSe Quantum Dot Photoluminescence Investigated by Single Molecule Spectroscopy**, A.M. Munro, I. Jen-La Plante, D.S. Ginger, University of Washington

Colloidal quantum dots are a unique class of solution processable chromophores with high photoluminescence quantum yields, good photostability, and narrow, size-tunable emission spectra that make them potentially useful for many optoelectronic and photonic applications. Surface chemistry strongly affects the optical and electrical properties, as well as the solubility and stability of the quantum dots. However, many properties of ligand-quantum dot interactions remain unresolved. For instance, it is not known exactly how different ligands alter quantum dot photoluminescence and a better understanding of ligand effects is necessary in order to tailor quantum dot surface chemistry for specific applications. We investigate changes in the photoluminescence of colloidal CdSe quantum dots as we bind different ligands to quantum dot surfaces using both single-molecule and ensemble averaged spectroscopy. Using single-molecule spectroscopy, we monitor the photoluminescence of single CdSe quantum dots over time in the presence of varying concentrations of octadecanethiol and determine the average quantum dot intensity, the average number of emissive quantum dots, and the blinking statistics of the quantum dots. This allows us to determine that the binding of a single thiol molecule to the surface of a CdSe quantum dot creates a trap state that decreases the photoluminescence intensity of the individual quantum dot by a significant amount, but that there is no change in the quantum dot blinking rate. We use this single-molecule data to refine our previously reported Langmuir isotherm quenching fits to ensemble solution photoluminescence spectra. By modeling the effects of octadecanethiol on CdSe quantum dots, we develop a better general understanding of ligand exchange and ligand binding to quantum dots.

5:00pm **EM+NS-TuA11 Controlling the Electronic Structure of Graphene Layers**, T. Ohta, LBNL; Fritz-Haber-Institut der Max-Planck-Gesellschaft, Germany, A. Bostwick, LBNL, J.L. McChesney, LBNL; Montana State University, T. Seyller, Univ. Erlangen-Nürnberg, Germany, K. Horn, Fritz-Haber-Institut der Max-Planck-Gesellschaft, Germany, E. Rotenberg, LBNL

Much recent attention has been given to the electronic structure of graphene, the honeycomb carbon sheet which is the building block of graphite, carbon nanotubes, C₆₀, and other mesoscopic forms of carbon. Following recent developments in synthesizing or isolating graphene films,

* Medard W. Welch Award Winner

experiments have revealed many interesting and physical properties, including an anomalous quantum Hall effect, ballistic electron transport at room temperature, and micron-scale coherence lengths. These unconventional properties are the direct consequence of graphene's peculiar and structure, with massless "Dirac Fermions" as charge carriers at the Fermi level. We have determined the layer-dependent electronic properties of graphene sheets prepared on silicon carbide, using angle-resolved photoemission spectroscopy. We examine this unique two-dimensional system in its development from single layers to multilayers in the π band, the highest occupied state, and the dispersion relation in the out-of-plane electron wave vector in particular.¹ By exploiting the sensitivity of graphene's electronic states to the charge carrier concentration, changes in the on-site Coulomb potential leading to a change of π and π^* bands can be examined. We demonstrate that, in a graphene bilayer, the gap between π and π^* bands can be controlled by selectively adjusting relative carrier concentrations, suggesting a potential application in switching functions in electronic devices.²

¹T. Ohta, A. Bostwick, J. L. McChesney, T. Seyller, K. Horn, E. Rotenberg, Phys. Rev. Lett., 2007, in press.

²T. Ohta, A. Bostwick, T. Seyller, K. Horn, E. Rotenberg, Science 313, 951, 2006.

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