

were developed in four different  $[PS]_m/[PAA]_n$  copolymers with block repeat unit ratios of 159/63, 140/17, 106/17, and 106/4, respectively, by first incorporating the  $ZnCl_2$  precursor in the copolymer in liquid phase, then spincoating on the surface and, upon solidification, converting the precursor into ZnO using an ozone based process. The resultant nanocomposite films contained self-assembled ZnO nanoparticles of spherical morphology in copolymer matrix but with size and density dependent on the respective copolymer parameters. The conversion process was evaluated by X-ray photoelectron spectroscopy (XPS), the physical properties of the self-assembly were examined by atomic force microscopy (AFM), the structural properties of the nanostructures were studied by X-ray diffraction (XRD) and the I-V characteristics of the nanoparticles were measured with an HP4145 semiconductor parameter analyzer. Analysis of XPS spectra obtained before and after conversion revealed the absence of chlorine in the converted films and a binding energy of the  $Zn2p_{3/2}$  electrons (1021.7 eV) consistent with full conversion into ZnO with minimal losses. AFM images showed smaller and denser particles formed with spherical morphology in the  $[PS]_{106}/[PAA]_{17}$  polymer. The size distribution of these particles was found to be 10-60 nm with an average density of  $2 \times 10^8 \text{ cm}^{-2}$ . The correlation between these nanoparticles and copolymer parameters will be discussed. In crystallographic evaluation, XRD patterns exhibited a dominant (100) diffraction peak for the nanoparticles formed on both (100) Si and (111) Si substrates, indicating self-assembly irrespective of the substrate crystal orientation. Effects of annealing on size and strain of the nanocrystals will be reported. The room temperature I-V characterization of the nanoparticles developed on p-type (100) Si exhibited rectifying junction properties. The charge transport mechanisms in the nanocomposite films and in the ZnO nanoparticle/Si junction analyzed from the electrical studies of the developed system will be also be discussed. Support of NSF grants ECS#9980794 and ECS#0302494 is acknowledged.

4:10 PM

**BB8, Electrical Properties of ZnO Nano-Particles Embedded in Polyimide:** Eun Kyu Kim<sup>1</sup>; JaeHoon Kim<sup>1</sup>; Hyung Gu Noh<sup>1</sup>; Young Ho Kim<sup>1</sup>; <sup>1</sup>Hanyang University

Quantum dots (QDs) are nano-sized zero-dimensional structures in which motion of electron is restricted all directions. In this region, quantum mechanical effects are dominantly appeared. Currently, the study of QDs is a main subject for quantum devices because the QDs are expected to be applied to quantum bit, single photon source and single-electron memory devices. In this view point, the electrical properties of metal-oxide nanoparticles embedded in polyimide matrix were studied with a nano-floating gated memory and a tunneling device structures. The metal oxide nanoparticles were formed by chemical reaction between metal and polyamic acid. The metal films were thermally evaporated on a semiconductor or insulator substrates, and then polyamic acid, precursor of polyimide, was spin-coated on these films. Finally, under the curing process below 400°C, nanoparticles were created by this chemical reaction and the particles dimensions were between 4 ~ 20 nm. Similarly, metal powder in the precursor also makes nanoparticles through curing process. This process is very simple and has some advantages for instance it takes some specific area is possible. Especially, ZnO nanoparticles are interested about applying to photon-electron interaction device based on energy band engineering by quantum size effect. The optical absorption due to quantum size effect was measured from the ZnO particles. It has a meaning that the particles are isolated by polyimide. The electrical properties of these particles embedded in polyimide were studied also. Electrical characteristics by charging in the quantum states and surface defects were examined from capacitance-voltage (C-V) measurement and temperature dependent C-V characteristics. For this study, a single electron transistor (SET) which have gold nano-patterns with 30 nm gap made by e-beam lithography were used. Here, ZnO nanoparticles were located in the nano-size gap and current-voltage (I-V) measurement was tried with varying gate voltage. In the SET sample, the tunneling current was observed and analyzed by multi-QDs tunneling process.

4:30 PM

**BB9, Excitons and Optical Phonons in Wurtzite ZnO Quantum Dots: Theory and Experiment:** Vladimir A. Fonoberov<sup>1</sup>; Alexander A. Balandin<sup>1</sup>; <sup>1</sup>University of California

ZnO quantum dots (QDs) have recently attracted significant attention due to proposed applications in ultraviolet (UV) light-emitting diodes, lasers, varistors, as well as QD-based nano-electronic components and low-voltage and short-wavelength electro-optical devices. At the same time, the properties of excitons and optical phonons in ZnO QDs still remain mainly unexplored. In this paper we carry out detailed theoretical and experimental

investigations of excitons and phonons in the wurtzite ZnO QDs. We have theoretically investigated the exciton radiative lifetime and the thickness of the dead-layer in ZnO QDs of 2-6 nm in diameter<sup>1</sup>. The small radiative lifetime and relatively thick dead layer found in ZnO QDs can be beneficial for device applications owing to better luminescence and isolation of the exciton from surface defects. The nature of the UV photoluminescence (PL) from ZnO QDs has been clarified by examining theoretically the optical properties of the ZnO QDs with and without ionized impurities at the surface<sup>1</sup>. It has been found that depending on the surface passivation technique, the UV PL in ZnO QDs can be attributed to either confined excitons or surface-bound ionized acceptor-exciton complexes. To interpret the optical response of ZnO QDs, we have calculated both interface and confined polar optical phonon modes in wurtzite ZnO QDs with spherical or spheroidal shape<sup>2</sup>. The origin of the Raman phonon frequency shifts in ZnO nanostructures is also not always understood. We have carried out resonant and non-resonant Raman spectroscopic measurements for ZnO QDs of 20 nm in diameter<sup>3</sup>. A comparison with the developed theory<sup>2</sup>, allowed us to clarify the origin of the phonon frequency shifts in ZnO QDs. It was found that the phonon confinement results in phonon frequency shifts of only few (1/cm). At the same time, the UV laser heating of the QD ensemble was found to induce a large red shift of phonon frequencies for up to 14 (1/cm). The authors acknowledge the partial support of SRC-DARPA MARCO and its Functional Engineered Nano Architectonics (FENA) Focus Center. <sup>1</sup>V.A. Fonoberov and A.A. Balandin, Phys. Rev. B 70, 195410 (2004); Appl. Phys. Lett. 85, 5971 (2004). <sup>2</sup>V.A. Fonoberov and A.A. Balandin, Phys. Status Solidi C 1, 2650 (2004); Phys. Rev. B 70, 233205 (2004); J. Phys.: Condens. Matter 17, to appear (2005). <sup>3</sup>K.A. Alim, V.A. Fonoberov, and A.A. Balandin, Appl. Phys. Lett. 86, 053103 (2004).