synthesized by inert-gas condensation in a sputtering reactor. Techniques described include those based on percolation, aggregation, and oxidation of nano-clusters [1]. We then review the application of cluster techniques to designs of functional nanostructured devices [2-4]. The high retention nonvolatile memory (nanofloating gate memory) with nanostructure composed of clusters of different sizes. And we fabricated a nanofloating gate memory based on ZnO-TFT for transparent and flexible nano-electronic devices. Plasmon-sensitive device is facilely fabricated by depositing copper clusters to the brink of percolation. The results prove that photon-induced surface plasmons contribute to electron transport between clusters. Therefore, the device can detect the surface plasmon resonance by simply monitoring the current. Graphene gas sensors (specifically for nitrogen dioxide) are fabricated using a process based on the oxidation of tin clusters. The reduced graphene oxide (rGO) without cluster showed p-type semiconducting behavior towards the gas, but there was little recovery. As the stannic oxide nanocluster deposition time increased to the percolation, the recovery increased. This is because the rGO forms Schottky junctions with n-typed stannic oxide clusters. However, after the percolation threshold, another pathway through stannic oxide clusters was formed between the contacts. Finally, both of the sensitivity and the recovery decreased. As a solar application, the graphene has multi-functions, such as a component of Schottky junction, hole transporting layer, and transparent electrode and nanoclusters have the light trapping not only by scattering but also by the excitation of localized surface plasmons. [1] I.-S. Kang et al., J. Nanosci. Nanotechnol. 10, 3671 (2010). [2] K. Y. Yang et al., Opt. Express 18, 16379 (2010). [3] I.-S. Kang et al., Nanotechnology 22, 254018 (2011). [4] I.-S. Kang et al., Appl. Phys. Lett. 98, 212102 (2011).

CC13.11

Embedded Nanoscale Metamaterial for Enhanced Optical Absorption in Ultrathin Silicon. Fan Ye, Michael Burns, Stephen Shepard and Michael J. Naughton; Boston College, Chesnut Hill, Massachusetts.

A nanoscale metallic metamaterial embedded into an ultrathin silicon film is shown to substantially increase optical absorption. Computer simulations on 20 nm-thick metal patterns embedded in ~80 nm-thick amorphous silicon films find more than 100% increase in integrated absorption in the visible regime (400-800 nm), the majority of which occurs in the red/NIR. In experiments on samples with these same thicknesses, we find ~50% increase in wavelength-integrated absorption. These results may prove useful in thin film, and especially ultrathin film, photovoltaics. Computer simulations are done with varied embedding depth, film thicknesses, and metamaterial shapes and patterns in efforts to optimize absorption. Moreover, different metals are employed in both simulations and experiment to obtain information on whether and to what extent (if any) plasmonic effects contribute to the observed effects.

CC13.12

Study of CdSe/Zns Quantum Dots for Thermal History Sensing Application. Nitin C. Shukla[1], Gang Chen[1], Taofang Zeng[1], Yucheng Lan[2] and Zhifeng Ren[2]; [1]M. I. T., Cambridge, Massachusetts; [2]Physics Department, Boston College, Chesnut Hill, Massachusetts.

In this work, we aim to develop quantum dot based thermal history sensors for recording temperature profile of extreme thermal events such as explosion, combustion, and geothermal events. In general, temperature profile of a thermal event is recorded in real time using conventional sensors such as thermocouples. However, this strategy may not work in extreme thermal environments due to the fact that sensor will be destroyed by the extreme nature of the event. We adopt a two step strategy in such here: i) we use temperature induced mass-diffusion/reaction process in core-shell quantum dots to record the temperature profile during the thermal event, and ii) use photoluminescence (PL) spectroscopy to measure this mass-diffusion subsequent to the thermal event. The temperature field can be extracted from the PL data by assuming a moving boundary mass-diffusion approach where core is shrinking. We used CdSe/ZnS core-shell type colloidal quantum dots of ~5-10 nm size with peak emission wavelength in the range of ~600-650 nm. It is very important to accurately determine time and temperature dependence on the PL energy shift. In the experiment, we accurately controlled the time and the temperature of the quantum dots by using well prepared thin wires as a heater and a temperature sensor. We observed that PL energy blue-shifts with temperature, a clear indication of mass-diffusion process. The time and temperature PL data show that the mass-diffusion process follows an Arrhenius type of kinetic process. Using PL data, we determined key parameters for the mass-diffusion process such as activation energy, diffusion coefficient and time exponent. We also conducted annealing experiments in vacuum to validate the mass-

energy, diffusion coefficient and time exponent. We also conducted annealing experiments in vacuum to validate the mass-diffusion/reaction process. Finally, we used transmission electron microscopy (TEM) to quantitatively relate mass-diffusion with the PL energy shift.

CC13.13

Abstract Withdrawn

CC13.14

Seeded Growth of Shape-Controlled Wurtzite CdSe Nanocrystals: Cubes, Platelets, and Bullets. Katherine Rice, Mark Stoykovich and Aaron Saunders; Chemical and Biological Engineering, University of Colorado, Boulder, Colorado.

Previous investigations into the synthesis of wurtzite CdSe nanocrystals have given rise to well-developed methods for producing particles with anisotropic shapes such as, rods, tetrapods and wires; however, the synthesis of other anisotropic shapes has proved challenging. Here, we demonstrate the use of a seeded-growth approach to produce colloidal, shape controlled wurtzite CdSe nanoparticles with previously unobserved morphologies. The synthesis, which makes use of small CdSe nanocrystals as nucleation sites for subsequent growth, can be tuned to selectively yield colloidal CdSe cube- and hexagonal platelet-shaped nanocrystals, in addition to previously observed rod- and bullet-shaped particles. We characterize the structure and discuss possible growth mechanisms for these new shapes, and demonstrate a quantitative analysis technique for shape classification based on Fourier descriptors obtained from transmission electron micrographs.

CC13.15

Postfocused Nanocrystal Diameter Tuning through Control of the Reaction Rate and the Solubility: Experiment vs. Realistic Modeling. Bram De Geyter[1,2,3], Sofie Abe[1] and Zeger Hens[1,3]; [1]Physics and Chemistry of Nanostructures, Inorganic and Physical Chemistry Departement, Ghent University, Gent, Belgium; [2]Photonics Research Group, INTEC, Ghent University IMEC, Gent, Belgium; [3]Center for Nano- and Biophotonics (NB-Photonics), Ghent University, Gent, Belgium.

We show that adjusting the reaction rate and solubility through ligand engineering in a hot injection synthesis is a viable strategy to tune the diameter of colloidal nanocrystals at the end of the size distribution focusing, i.e., the post-focused diameter. The approach is introduced by synthesis simulations, which describe nucleation and growth of colloidal nanocrystals from a solute or monomer that is formed in-situ out of the injected precursors. We present a coupled set of continuous rate equations, including monomer generation, nucleation and growth in one model. Instead of dimensionless parameters, we use common dimensions of diameter, time and concentration to keep comparison with experiments straightforward. We explore a three dimensional parameter space by adjusting the reaction rate for monomer generation, the solubility and the temperature. These simulations indicate that the post-focused diameter is reached at almost full yield, and that it can be adjusted by the rate of monomer formation or the appropriate choice of ligand. We implement this size tuning strategy using a particular CdSe quantum dot synthesis that shows excellent agreement with the model synthesis. After demonstrating that the reaction rate depends in first order on the Cd and Se precursor concentration, the proposed strategy of size control is explored by varying the precursor concentration. This enables the synthesis of colloidal nanocrystals with a predefined size at almost full yield and sharp size distributions, which is highly relevant especially in the context of reaction upscaling and automation. Moreover, the results obtained challenge the traditional interpretation of the hot injection synthesis, in particular the link between hot injection, burst nucleation and sharp size distributions.

CC13.16

Localized Defects of SiGe/Si Superlattice Structures for Sensor Application Using Ion Beam Bombardment. Patrick V. Grayson[1,2], Claudiu Muntele[1,2] and Cydale Smith[1,2]; [1]Department of Physics, Alabama A&M University, Normal, Alabama; [2]Center for Irradiation of Materials, Alabama A&M University, Normal, Alabama.

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SESSION CC1: Optical, Electronic, and Magnetic Functionalities Using Novel Semiconductor Nanocrystal Synthesis
Chair: Kurtis Leschkies
Monday Morning, November 28, 2011

Room 207 (Hynes)

8:30 AM *CC1.1

Silicon and Copper Selenide Nanocrystals for Biological Applications. Colin M. Hessel, Michael Rasch and Brian A. Korgel; Department of Chemical Engineering, University of Texas at Austin, Austin, Texas.

Semiconductor and metal nanocrystals have been extensively studied for use in biological applications, for both disease detection and therapy. This research, however, has focused on a relatively narrow range of materials, primarily on gold and silver nanocrystals in the case of metals and Cd-based nanocrystals in the case of semiconductors. In recent years, the nanocrystal "tool kit" has been expanding, including light-emitting silicon nanocrystals and more recently, transition metal chalcogenides like copper selenide for plasmonic heating. Here, we present recent research on the synthesis and surface functionalization of silicon nanocrystals for biological applications, including their inclusion in liposomes. We will also present our efforts on the synthesis and use of copper-deficient copper selenide nanocrystals for photothermal heating. Ligand-stabilized Cu2-xSe nanocrystals were synthesized by a colloidal hot injection method and coated with amphiphilic polymer. The nanocrystals readily disperse in water and exhibit strong near infrared (NIR) optical absorption with a high molar extinction coefficient. The NIR absorption is due to a plasmonic resonance related to the high free carrier density in the nanocrystals due to copper vacancies. When excited with 800 nm light, the Cu2-xSe nanocrystals produce significant photothermal heating with a photothermal transduction efficiency of 22%, comparable to nanorods and nanoshells of gold (Au). In vitro photothermal heating of Cu2-xSe nanocrystals in the presence of human colorectal cancer cell (HCT-116) led to cell destruction, demonstrating the viability of Cu2-xSe nanocrystals for photothermal therapy applications.

9:00 AM CC1.2

An All-Gas-Phase Approach for the Fabrication of Silicon Quantum Dot Light Emitting Devices. Rebecca Anthony[1], Kai-Yuan Cheng[2], Zachary C. Holman[1], Russel J. Holmes[2] and Uwe R. Kortshagen[1]; [1]Mechanical Engineering, University of Minnesota, Minneapolis, Minnesota; [2]Chemical Engineering and Materials Science, University of Minnesota, Minneapolis, Minnesota.

Quantum dots offer unique advantages for the manufacture of light emitting devices including their size tunable optical luminescence, and compatibility with device fabrication on low-cost, flexible substrates that may open up routes to roll-to-roll manufacturing. To date, the fabrication of light emitting devices using quantum dot luminophores exclusively has relied on colloidal chemistry for the quantum dot synthesis, surface treatment, and deposition. In this presentation we demonstrate, to our knowledge for the first time, an all-gas-phase approach for the formation of light emitting devices from silicon quantum dots. In a single gas phase reactor, silicon quantum dots are synthesized, their surfaces functionalized with organic ligands, and deposited onto glass substrates carrying a transparent conductive oxide bottom contact. Production of silicon nanocrystals is achieved through plasma decomposition of the mono-silane precursor, leading to the formation of monodisperse silicon nanocrystals. Quantum dot surfaces are functionalized with organic monolayers by injecting the vapor of various alkenes into the afterglow of the synthesis plasma. Inertial impaction of the functionalized silicon nanocrystals is used to form dense nanocrystal films. Devices are completed by metal evaporation of a top contact. The approach presented here completely avoids the use of solvents and allows the formation of electroluminescent quantum dot devices with as little as three deposition steps for the top and bottom contact layers and the silicon quantum dot layer. Primary support for this work was received from the National Science Foundation (NSF) Award Number ECCS-0925624. Partial support was also received from the NSF MRSEC Program under Award Number DMR-0819885. R.J.H. would also like to acknowledge support from 3M Company through a Non-Tenured Faculty Grant.

9:15 AM CC1.3

Pyrite Nanocrystals: Shape-Controlled Synthesis and Tunable Optical Properties via Reversible Self-Assembly. Wei Li[1], Markus Doeblinger[2], Aleksandar Vaneski[3], Andrey L. Rogach[3], Frank Jaeckel[1] and Jochen Feldmann[1]; [1]Photonics and Optoelectronics Group, Faculty of Physics and Center for Nanoscience, Ludwig-Maximilians-Universität