HL 19 Quantum dots and wires: Optical properties II

Time: Tuesday 17:15–19:30 Room: HSZ 01

HL 19.1 Tue 17:15 HSZ 01

Influence of doping on the electronic and optical properties of Si nanocrystallites — •Luis Ramos[1], Elena Degoli[2], Stefano Ossicini[2], Jürgen Furthmüller[1], and Friedhelm Bechstedt[1] — [1]Institut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, D-07743 Jena, Germany — [2]Università di Modena e Reggio Emilia, via Fogliani, I-42100 Reggio Emilia, Italy

Silicon nanocrystallites (NCs) have been intensively studied in the last years, since they can confine holes and electrons and circumvent the indirect-gap character of the lowest-energy optical transitions of Si bulk. Besides quantum confinement, oxidation, oxygen-related defects,[1] and doping have been investigated. Recently, an increase of the photo luminescence (PL) intensity was observed for Si NCs doped with both group-III and group-V species. Since measurements for single NCs are difficult, *ab initio* theoretical investigations become important to suggest dopants and to clarify the mechanisms of PL in Si NCs. Our calculations are based on the density-functional theory, the generalized-gradient approximation, the projector-augmented wave method, and the pseudopotential approximation. The electronic structure and optical absorption spectra of free-standing doped Si NCs of different sizes and shapes are investigated in simple-cubic supercells. Besides the influence of shape and size on the impurity formation energies, bond lengths, and radiative lifetimes, significant changes in the optical absorption spectra are predicted for Si NCs doped with group-V impurities.

[1] L.E. Ramos, J. Furthmüller, and F. Bechstedt, Appl. Phys. Lett. **87**, 143113 (2005); Phys. Rev. B **71**, 035328 (2005)

HL 19.2 Tue 17:30 HSZ 01

Temperature dependent fluorescence quantum efficiency of cascaded energy transfer nanocrystal structures — •S. Rohrmoser, T. Franzl, T.A. Klar, A.L. Rogach, and J. Feldmann — Photonics and Optoelectronics Group, Physics Department and CeNS, Ludwig-Maximilians-Universität München

We present temperature dependent fluorescence studies of cascaded energy transfer (CET) structures made of CdTe nanocrystals. Funnel like band gap profiles are realized by applying layer-by-layer assembly to CdTe nanocrystals of distinct sizes. For high-energetic excitation, the CET structure comprising only one layer of red-emitting nanocrystals emits 4 times more red light than a reference sample of equal absorbance consisting of only red emitting nanocrystals, hence increasing the final excitation density by a factor of 28. To investigate the underlying process in more detail, temperature dependent and time resolved measurements have been performed. The results reveal an activation barrier involved in the energy transfer process and help to understand the long-lived feeding of the central layer.

1. T. Franzl, T.A.Klar, S. Schietinger, A.L. Rogach, J. Feldmann, "Exciton recycling in graded gap nanocrystal structures" Nano Letters, 4, 1599 (2004)

HL 19.3 Tue 17:45 HSZ 01

Structural investigations of MBE-grown InN Nano-Whiskers — •Ratan Debnath[1], Toma Stoica[1,2], Ralph Meijers[1], Thomas Richter[1], Raffaella Calarco[1], and Hans Lüth[1] — [1]Institute of Thin Films and Interfaces (ISG1) and CNI - Centre of Nanoelectronic Systems for Information Technology, Research Center Jülich,52425 Jülich, Germany — [2]INCDFM, Magurele, POB Mg7, Bucharest, Romania

Nanowires are intensively studied for future device applications of low-dimensional systems. GaN nanowhiskers were investigated in great detail showing for instance high crystalline quality and efficient luminescence. Investigations of InN nanowhiskers have been staying behind since it is more difficult to produce InN of good quality. However InN has interesting properties like high electron mobility, low bandgap and non-toxicity. InN was grown by plasma-assisted molecular beam epitaxy (PAMBE) on Si(111) substrates under N-rich conditions resulting in columnar morphology of the grown layers. Substrate temperature was considerably lower compared to GaN growth. The samples were investigated using scanning electron microscopy (SEM) as well as Photo- and Cathodoluminescence (PL and CL) spectroscopy. The growth was optimized to obtain uniform columns of good crystalline quality. An optical bandgap was found in the range 0.73-0.82eV and electron concentrations between 8×10^{17} and $6 \times 10^{18} cm^{-3}$ were determined.

HL 19.4 Tue 18:00 HSZ 01

Storage of excitons in elongated semiconductor nanocrystals — •Robert M. Kraus[1], Pavlos G. Lagoudakis[1], Andrey L. Rogach[1], John M. Lupton[1], Jochen Feldmann[1], Dmitry Talapin[2], and Horst Weller[2] — [1]Photonics and Optoelectronics Group, Physics Department and CeNS, Ludwig-Maximilians-Universität München, Germany — [2]Institute of Physical Chemistry, University of Hamburg, Germany

Spherical CdSe nanocrystals capped by a CdS rod-like shell, referred to as nanorods, exhibit interesting spectral dynamics on the single particle level.[1,2] However, for the purpose of applications, the ensemble properties of nanorods are most interesting. We are especially interested in the behaviour of an ensemble of nanorods under the influence of an electric field, as this bears great relevance for future devices. We show here that by applying an electric field to an ensemble of nanorods in a vertical sample geometry a linear quantum-confined Stark shift of the order of 60 meV can be observed in the emission energy. During the application of the electric field the excitons are effectively hindered from radiative recombination and can be stored coulombically for up to 100 μs. Furthermore, modulation of the electric field leads to a modulation in both the wavelength and the spectral width of the nanoparticle emission.

[1] J. Müller *et al.*, Phys. Rev. Lett. 93, 167402 (2004)
[2] J. Müller *et al.*, Nanoletters 5, 2044 (2005)

HL 19.5 Tue 18:15 HSZ 01

Electric field induced photoluminescence quenching in CdSe nanocrystal doped SiO_2 on Si — •Helmut Karl, Alexander Achtstein, and Bernd Stritzker — Institut für Physik, Universität Augsburg, D-86135 Augsburg, Germany

Buried CdSe nanocrystals were synthesized by sequential ion implantation of Cd and Se in 500 nm thick thermally grown SiO_2 on p-doped silicon. The formation of the CdSe nanoclusters was initiated by a post-implantation thermal annealing step. Then an optically semitransparent thin Au gate electrode was evaporated on top of the SiO_2 forming a MOS capacitor structure. The embedded surface near CdSe nanocrystals show efficient steady state CdSe bandedge photoluminescence when excited by a cw-HeCd laser at a wavelength of 442 nm at room temperature. The silicon substrate was electrically contacted by indiffusion of an evaporated Al thin film. With this structure we observe strong electric field induced photoluminescence quenching when a voltage is applied between the Au gate electrode and the silicon substrate for temperatures between 10 K and room temperature. PL quenching of more than 80 % was found for an electric field variation between 0 and +/- $4x10^7$ V/m. CV-characteristics in conjunction with the electric field dependence of the PL quenching will be discussed.

HL 19.6 Tue 18:30 HSZ 01

Size dependence of the dynamics of the Mn $3d^5$ luminescence in wire-like arrangements of (Zn,Mn)S nanoparticles — •L. Chen[1], P.J. Klar[1], W. Heimbrodt[1], F.J. Brieler[2], and M. Fröba[2] — [1]Dept. Physics and WZMW, Philipps-University of Marburg, Germany — [2]Institute of Inorganic and Analytical Chemistry, Justus-Liebig-University of Gießen, Germany

(Zn,Mn)S nanoparticles with Mn concentrations ranging from 1% to 30% and in a wire-like arrangement were formed inside mesoporous SiO_2 matrices of various pore diameters. The nanoparticles were characterised using photoluminescence and excitation spectroscopy. It is found, that the Mn^{2+} ions are incorporated on cation lattice sites replacing Zn. The decay times of the internal Mn^{2+} ($3d^5$) luminescence are studied in detail by time resolved spectroscopy over more than 5 orders of magnitude in intensity. A concentration and a remarkable size dependence of the time behaviour has been observed indicating a geometry dependence of the energy-transfer processes within the Mn system.

HL 19.7 Tue 18:45 HSZ 01

Optical properties of implanted single ZnO nanowires — •Daniel Stichtenoth[1], Sven Müller[1], Carsten Ronning[1], Lars Wischmeier[2], Chegnui Bekeny[2], and Tobias Voss[2] — [1]II. Institute of Physics, University of Göttingen, Germany — [2]Institute for Solid State Physics, University of Bremen, Germany

Doping of semiconductor nanostructures via ion implantation processes offers the advantage of precise control of the doping concentration in both lateral and depth direction beyond any solubility limit. In this study, single crystalline ZnO nanobelts and -wires were synthesized according to the VLS mechanism and subsequently dispersed on top of Si substrates. The nanowires were implanted either with ^{14}N, ^{31}P, ^{14}N & ^{31}P, or ^{20}Ne ions. Nitrogen and Phosphorous are potential acceptors in ZnO; whereas, the objective of the Ne-implantation was to monitor the implantation induced damage. The range of the ions, set by the ion energy, matched the diameter of the nanowires, and post-implantation annealing procedures were done under vacuum conditions in order to remove the introduced damage. The treated nanowires were individually investigated by temperature-dependent μ-PL measurements; correlations between the optical spectra and the implanted species as well as the implantation parameters are discussed.

HL 19.8 Tue 19:00 HSZ 01

Nitrogen implanted ZnO nanowires — •Sven Müller, Daniel Stichtenoth, Daniel Schwen, and Carsten Ronning — 2nd Institute of Physics, University Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

Single crystalline ZnO nanowires were grown via a chemical vapor deposition process: ZnO powder was placed into a horizontal tube furnace and heated up to 1350°C. The vapour was transported by an Ar gas flow to the substrates in a temperature zone between 1000 - 1180°C. Prior growth the Si substrates were covered with a thin gold layer, which acts as a catalyst for the vapour-liquid-solid (VLS) mechanism. The wurtzite ZnO nanowires grew along the c-axis and had a belt-like shape in the nanometer range. These ZnO nanowires were implanted with 50 keV nitrogen ions (as a potential acceptor) in order to change the electrical and optical properties. Directly after the implantation process, the properties were dominated by the radiation damage, which was subsequently healed by annealing in vacuum or in an oxygen atmosphere. The nitrogen implantation generated three new luminescence transitions at energies of 3.35 eV, 3.32, and 3.235 eV. The origin of these features will be discussed in respect to their temperature- and power-dependencies.

HL 19.9 Tue 19:15 HSZ 01

Optical Spectroscopy on Silicon Nanoparticles — •Stephan Lüttjohann[1], Cedrik Meier[1], Andreas Gondorf[1], Axel Lorke[1], and Hartmut Wiggers[2] — [1]Laboratorium für Festkörperphysik, Universität Duisburg–Essen, 47048 Duisburg — [2]Institut für Verbrennung und Gasdynamik, Universität Duisburg–Essen, 47048 Duisburg

The optical properties of silicon nanoparticles have been studied by photoluminescence and Raman spectroscopy. The particles are fabricated in a low pressure microwave reactor by decomposition of silane.

We have investigated particles in a size range of between d=4.2nm and 60nm. For particles with diameters smaller than 30nm, quantum effects become relevant and are observed in Raman spectra as well as in photoluminescence spectra. The Raman spectra show the phonon confinement effect which redshifts the energy of the observed phonons.

The PL emission wavelength (between 600nm and 1000nm) shifts towards lower wavelengths with decreasing particle sizes. Investigations of the PL intensity as a function of the temperature reveal an interesting behaviour. The PL intensity has a maximum at about T=80K and decreases for higher as well as lower temperatures.

To get a better understanding about the origin of these effects, microphotoluminescence is employed. First results showing sharp emission lines (FWHM ≈ 1meV) originating from excitonic and biexcitonic recombination are presented. As a result of the strong Coulomb interaction in the particles the spectra show a remarkable high exciton to biexciton energy splitting of 32meV.