HL 30: Poster: Quantum dots and wires: Preparation, characterization, optical properties and transport

Time: Monday 17:00–20:00 Location: P2

HL 30.1 Mon 17:00 P2

Raman and AFM Characterization of Ultrasmall CdS Nanoparticles Incorporated in Polymeric Matrix — •Dmytro Solonenko[1], Volodymyr Dzhagan[2], Oleksandra Raevska[3], Oleksandr Stroyuk[3], Ovidiu D. Gordan[1], and Dietrich R. T. Zahn[1] — [1]Semiconductor Physics, Technische Universität Chemnitz, Chemnitz, Germany — [2]E. Lashkaryov Institute of Semiconductor Physics, Kyiv, Ukraine — [3]L.V. Pysarzhevskiy Institute of Physical Chemistry, Kyiv, Ukraine

Semiconductor nanoparticles (NPs), or quantum dots, gain wide interest due to anumber of striking features: tunable and narrow features in photoluminescence (PL) and absorption spectra, high chemical and photophysical stability, and high PL quantum yields. Theunique properties of ultrasmall NPs include broadband PL. They can also be strongly influenced by environment and stabilizing ligands. However, both ordinary and ultrasmall NPs should be processed before their applicationin various optoelectronic devices. In this work we investigated the interactions between ultrasmall CdS NPs stabilized by mercaptoacetic acids and ammonia (N2H4) with polymers such as polyethyleneimine (PEI), polyethylene glycol (PEG), and surfactant sodium dodecyl sulfate (SDS) by Raman spectroscopy and AFM. Thin polymer films containing NPs were prepared by spin- and spray-coating. We concluded that neutral polymers such as PEG as well as SDS refrain from chemical interaction with the negatively charged NPs surface, while polycationic PEI chemically reacts with the NPs resulting in the formation of agglomerates in a colloidal phase.

HL 30.2 Mon 17:00 P2

Synthesis and characterization of quantum sized InP nanowires prepared by UTAM surface nano patterning and reactive-ion etching technique — •Lin Cheng, Kin Mun Wong, and Yong Lei — Ilmenau University of Technology, Institute of Physics & IMN MacroNano (ZIK) Prof. Schmidt-Str. 26, 98693 Ilmenau (Germany)

The electronic properties of ultra-small indium phosphide (InP) nanowires had been rarely investigated. When the size of the nanowires is smaller than its Bohr radius, due to the quantum confinement effects, there are many interesting properties in the nanowires. In this study, single crystalline InP nanowires with diameter smaller than its Bohr radius are synthesized by first preparing ultra-thin alumina mask (UTAM) in 0.3M Oxalic acid for 1 min. Then the UTAM was transferred onto a single crystalline InP substrate and the pore size of the UTAM was reduced by atomic layer deposition. Gold or titanium was deposited by physical vapor deposition at the bottom of the pore openings in the UTAM to be used as the mask on the top surface of the InP substrate. Finally, the UTAM was removed and reactive-ion etching was used to prepare the arrays of quantum sized InP single crystalline nanowires in a vacuum chamber. We predict that our quantum sized InP nanowires will have very interesting electronic and transport properties that will be verified with the first-principles simulations on the nanowires.

HL 30.3 Mon 17:00 P2

Characterization of InP-quantum dots in AlGaInP for integration in vertical-cavity surface-emitting lasers as active medium — •Sergey Gelhorn, Susanne Weidenfeld, Thomas Schwarzbäck, Roman Bek, Christian Kessler, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen and Research Center SCoPE, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany

With reduction of the dimensionality of the laser active media, differential gain increases which brings advantages like simultaneous low threshold current and high modulation bandwidth. Quantum dots (QDs) are zero-dimensional structures and their usage as laser active media can provide a temperature independent laser threshold current [1]. However, if the difference between QD-energy and bandgap of the surrounding barrier is small, carriers can be thermally excited from QD in the barrier. Therefore thermal stability of QD-layers needs to be controlled to allow their integration as active medium in a laser device. We report about spectral and thermal characterization of InP-QD layers, which were integrated in AlGaInP-barrier during metal-organic vapor-phase epitaxy. The integration of stacked InP-QD layers in vertical-cavity surface-emitting lasers is shown, where we took care that the averaged emission energy properly match the energy of the optical resonator. Finally, experiments to increase the energetic confinement of the InP-QDs are presented.

[1] Y. Arakawa and H. Sakaki, Appl. Phys. Lett. **40**, 939 (1982)

HL 30.4 Mon 17:00 P2

Analysis of the nucleation behavior of quantum dots on planar and prepatterned GaAs substrates for the integration in single-photon devices — •Marc Sartison, Matthias Paul, Ulrich Rengstl, Elisabeth Koroknay, Susanne Weidenfeld, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen and Research Center SCoPE, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany

In the last decade, the potential of semiconductor quantum dots for the application in single-photon devices has been widely demonstrated. Most approaches deal with the self-assembly of the quantum dots, but for the functionalization into complex arrangements a precise positioning is essential. In this contribution, we show our routes for the fabrication of single addressable quantum dots (QDs). The growth of the QDs takes place in a metal-organic vapor-phase-epitaxy (MOVPE) system. We have concentrated on two approaches for prepatterning the GaAs substrates for different QD material systems. The first one is to produce a hexagonal hole pattern by microsphere photolithography and wet chemical etching, followed by an overgrowth with GaAs, InGaAs and InAs. The higher expected accumulation of In inside the holes, after InGaAs overgrowth, leads to strain effects changing the nucleation probability above. The second approach of site controlled nucleation of InP is done by wet chemical etched ridges and aperture oxidation. The resulting strain field is expected to support the nucleation probability of InP QDs above the aperture. Structural and optical characterization will show our first efforts.

HL 30.5 Mon 17:00 P2

InAs Quantum Dots at Telecom Wavelengths — •Fabian Olbrich[1], Jan Kettler[1], Matthias Paul[1], Katharina Zeuner[1], Sven Markus Ulrich[1], Michael Jetter[1], Matusala Yacob[2], Mohamed Benjoucef[2], Johann Peter Reithmaier[2], and Peter Michler[1] — [1]University of Stuttgart, Institut für Halbleiteroptik und Funktionelle Grenzflächen (IHFG), Allmandring 3, 70569 Stuttgart, Germany — [2]University of Kassel, Institute of Nanostructure Technologies and Analytics (INA), Heinrich-Plett-Str. 40, 34132 Kassel, Germany

Semiconductor quantum dots have proven to be bright, well-defined and controllable single photon sources with the possibility of creating entangled photon pairs by utilizing the biexciton-exciton-cascade.

Hence they are good candidates to serve as emitters of non-classical light in fiber-based quantum networks with possible applications for quantum cryptography and quantum computers.

Under these circumstances it is desirable for QDs to emit at 1.31 μm (telecom O-band) or 1.55 μm (telecom C-band), which show low absorption. In order to manipulate the emission range of our QDs, mainly three approaches have been made to tune the original GaAs/InAs QDs (920 nm) towards these telecom wavelengths: The deposit of a strain reducing layer, the incorporation of Ga or the usage of an InP substrate.

We are able to show that these QDs are excellent single photon sources and find strong indications for the biexciton-exciton-cascade.

HL 30.6 Mon 17:00 P2

Growth of site-controlled InAs nanowires induced by focused ion beam — •Sven Scholz, Rüdiger Schott, Arne Ludwig, and Andreas D. Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum

To investigate the morphology, structure and behavior of individual one-dimensional nanostructures, so called nanowires (NWs), we have grown single localized Au seeded InAs NWs on GaAs(111)B substrate by molecular beam epitaxy. The Au-seeds are implanted by focused ion beam (FIB) technology. Optimizing the growth process due to the growth parameter and material we were able to create monocristalline

NWs with nearly no stacking faults and on the other hand control the morphology down to a region of 20 nm in diameter to increase the aspect-ratio up to 300:1. Furthermore we investigate the axial and radial growth of heterostructures in our NWs, which leads to a promising approach for band gap modulation in single NWs. We studied the morphology of the NWs by SEM imaging and the crystalline structure with TEM imaging.

HL 30.7 Mon 17:00 P2

Indirect exchange interaction between quantum dots in a magnetic field — •Alexander W. Heine[1], Katharina Janzen[2], Gertrud Zwicknagl[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover, Germany — [2]Institut für Mathematische Physik, Technische Universität Braunschweig, 38106 Braunschweig, Germany

Quantum dots with an odd number of electrons have a non-zero spin which is a possible realization of a qubit in quantum information processes. An indirect exchange interaction between magnetic moments, the so-called Ruderman-Kittel-Kasuya-Yosida interaction, is a possible mechanism to control this spin qubit.

We investigate the exchange constant J of two localized moments mediated by the electrons in a large circular quantum dot in a perpendicular magnetic field. Our results for the effective interaction show signatures known for both, the exchange couplings in metals and in molecules. This is consistent with the fact, that the quantum dot is intermediate between a large molecule and a metal.

A second effect observed for the localized spin of a quantum dot is the Kondo effect. In our system of two quantum dots separated by an open conducting region the Kondo effect can be used as a spectroscopic tool to demonstrate the presence of the indirect exchange interaction. Measurements are performed in a temperature range of 25 mK to 900 mK. A high perpendicular magnetic field up to 5.5 T is applied. The temperature dependence of the differential conductance is analyzed for varying magnetic field.

HL 30.8 Mon 17:00 P2

Numerical determination of the non-equilibrium many-body statistical operator for a nanowire-based field-effect transistor — •Jose Maria Castelo and Klaus Michael Indlekofer — RheinMain University of Applied Sciences, IMtech / Faculty of Engineering, D-65428 Rüsselsheim, Germany

We present a numerical approach to construct a non-equilibrium many-body statistical operator ρ_{MB} for a semiconductor nanowire-based field-effect transistor (NWFET). As a constraint for ρ_{MB}, we assume that the single-particle density matrix ρ_1 is a given quantity, resulting from a non-equilibrium Green's function calculation for the NWFET for a given set of applied voltages. Two different ON eigenbases for ρ_{MB} are considered in this presentation: (i) a Slater determinant basis of natural orbitals (eigenstates of ρ_1) and (ii) the eigenbasis of the projected many-body Hamiltonian H_{MB} within a relevant Fock subspace of the system. As for the eigenvalues w_K of ρ_{MB}, we furthermore assume that w_K have a generalized Boltzmann form, parameterized by effective chemical potentials of natural orbitals and a given temperature. From the determined ρ_{MB}, in turn, one can calculate expectation values for any observable of the system. As an example, we analyze the electron density and the density-density correlation function for a set of representative equilibrium and non-equilibrium conditions of the NWFET.

HL 30.9 Mon 17:00 P2

Thermal noise in AlGaAs/GaAs-nanostructures — •Christian Riha[1], Philipp Miechowski[1], Sven S. Buchholz[1], Olivio Chiatti[1], Dirk Reuter[2], Andreas D. Wieck[3], and Saskia F. Fischer[1] — [1]Neue Materialien, Humboldt-Universität zu Berlin, D-10099 Berlin — [2]Optoelektronische Materialien und Bauelemente, Universität Paderborn, D-33098 Paderborn — [3]Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum

Transport properties of low-dimensional mesoscopic systems strongly differ from those of bulk materials. When the width of a conducting channel has the scale of the Fermi wavelength, these properties are dominated by the electron's wave characteristics and the channel is referred to as electronic waveguide. We investigate the heat transport through a one-dimensional quantum-wire ring structure fabricated from a AlGaAs/GaAs heterostructure in the presence of an electron temperature gradient at 4.2 K. The temperature gradient is established by the current heating technique. The experimental setup [1] enables the measurement of the Johnson noise and thus the detection of a change in the electron temperature. A global top-gate allows the change of the waveguide's conductance. We present and discuss the results of the heat transport in dependence of the participating one-dimensional transport modes.

[1] S. S. Buchholz, et al, Phys. Rev. B 85, 225301 (2012)

HL 30.10 Mon 17:00 P2

A New Structure for Time-Resolved Transport Spectroscopy of InAs-Quantum Dots — •Sergej Markmann, Patrick A. Labud, Arne Ludwig, Dirk Reuter, and Andreas D. Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum

Time-Resolved Transport Spectroscopy (TRTS) is a powerful method for the electrical investigation of Quantum Dots (QDs) and provides an access to the equilibrium and the non-equilibrium electron configurations in QDs. Typically the investigation of QDs with TRTS method is done on High Electron Mobility Transistor Structure in which QDs are embedded[1]. In this case, a time resolved conductivity change of the two-dimensional electron gas is an indicator for the charge configuration in the QDs. In this work, we demonstrate a new structure, which could be even more sensitive to charging and discharging events of the QDs. The new structure consists of p+-doped GaAs layer followed by an intrinsic GaAs layer in which InAs-QDs are embedded. On top of the intrinsic layer, a n+-doped GaAs layer is grown, which acts as a sensor for the QDs. Charging and discharging of QDs is controlled by the back-gate (p+-doped GaAs). With a top-gate, it is possible to deplete the channel (n+-doped GaAs layer) and hence control the conductivity of the channel such that the charged QDs may deplete the channel completely.

[1]B. Marquardt, M. Geller, B. Baxevanis, D. Pfannkuche, A. D. Wieck, D. Reuter and A. Lorke, Nature Commun. 2, 209 (2011).

HL 30.11 Mon 17:00 P2

Electron counting in a quantum dot system — •Timo Wagner, Eddy P. Rugeramigabo, and Rolf. J. Haug — Institut für Festlörperphysik, Leibniz Universität Hannover, 30167 Hannover, Germany

We study the properties of a topgate defined quantum dot in a GaAs/AlGaAs heterostructure. Besides electronic transport measurements through the dot, we perform charge measurements with an adjacent quantum point contact (QPC) that serves as sensitive detector. These methods allow the characterisation of the dot over a wide range of tunnel couplings and electron numbers.

The analysis of the charge stability diagram reveals a region of a second capacitively coupled quantum dot. In this region electron counting experiments were performed. We are able to detect signals for tunneling rates beween Hz and kHz and for temperatures up to 1.5 K. Further we analyse the stability of the signals.

HL 30.12 Mon 17:00 P2

Top-down fabrication and characterization of silicon nanowire RFETs — •Dipjyoti Deb, Artur Erbe, Manfred Helm, and Jochen Grebing — Helmholtz-Zentrum Dresden-Rossendorf, Center for Advancing Electronics Dresden

The following work illustrates top-down fabrication and characterization of reconfigurable, undoped silicon nanowire field effect transistor with Schottky junctions. The nanowires are fabricated on SOI wafer by electron beam lithography and oxidized for passivation. Two Nickel-Silicide Schottky junctions are formed by Nickel deposition and annealing from source and drain region creating silicide-silicon-silicide contacts. Diffusion of Ni-Si is precisely controlled by radial crystal orientation of the nanowire and annealing temperature. The Schottky junctions are electrostatically controlled by surround gates. Transport properties of these nanowires can be modulated by changing local electrostatic gradient at the gates. One gate can modulate the current density while the other gate can be electrostatically programmed to shift the polarity of the device from N-type to P-type and vice-verse. Nanowire performance is optimized by reducing the edge roughness of the nanowires (lowering the scattering) and accurate alignment of the metal gates.

HL 30.13 Mon 17:00 P2

Electronic Structure and Photoluminescence of Bare Core and Core/shell CdSe QDs — •Ghazal Tofighi[1], Martin Möbius[2], Jörg Martin[3], Christian Spudat[3], Thomas Otto[2], Thomas Gessner[2,3], Ovidiu D. Gordan[1], and Dietrich R.T. Zahn[1] — [1]Technische Universität Chemnitz, Semiconductor Physics, Chemnitz, Germany — [2]Technische Universität Chemnitz, ZfM, Chemnitz, Germany — [3]Fraunhofer Institute for Electronic Nano Systems, Chemnitz, Germany

CdSe quantum dots (QDs) exhibit interesting properties including narrow emission bands, good photostability, and bright photoluminescence (PL) which can be tuned by the size of QDs and surface ligands. Therefore, we can integrate them with piezoelectric materials in order to make extremely small film-based sensors. Electrical charges generated by mechanical stress within the piezoelectric film can be injected into QDs, resulting in quenching their photoluminescence. Subsequently, e.g. material failure could thus be detected at an early stage through a color change of the photoluminescence.

For this purpose, we prepared thin layers of CdSe (core) and CdSe/ZnS (core/shell) QDs on gold substrates using the Langmuir-Blodgett method and investigated the electronic structure of QDs by photoemission spectroscopy (PES) and inverse photoemission spectroscopy (IPS). Furthermore, PL measurement and Raman spectroscopy were also performed on the QD layers, and the optical band gap was compared to the electronic band gap achieved from the IPS/UPS measurements.

HL 30.14 Mon 17:00 P2

Capacitance-Voltage Spectroscopy of InAs Quantum Dots Under External Applied Strain — •Sascha René Valentin[1], Arne Ludwig[1], Dirk Reuter[2], and Andreas D. Wieck[1] — [1]Lehrstuhl für Angewandte Festkörperphysik, Ruhr Universität Bochum — [2]Department Physik, Universität Paderborn

Self-assembled InAs quantumdots (QDs) are integrated in a variety of interesting optical and electronical devices and are also highly interesting from a fundamental point of view. Electric fields are often used to tune the optical and electronical properties of QDs. Recently it has been shown that external applied strain can reversibly shift the optical emission energy of QDs. Theoretical calculations indicate that the shift in the emission energy originates in the changed coulomb interaction between the charge carriers as well as in the shift of the energy levels themselves. In this project we want to measure the dependence of the interaction energies of the carriers on externally applied strain using capacitance voltage (CV) spectroscopy. In the device we present, a thin electrically contacted CV-membrane is bonded to a PMNPT-piezoelectric actuator. This allows to apply strain to the QDs and at the same time it enables electrical measurements on a QD ensemble.

HL 30.15 Mon 17:00 P2

All optical approach to determine the spatial extension of bound wave functions in semiconductor quantum dots using intraband spectroscopy — •Sandra Kuhn, Judith Specht, Andreas Knorr, and Marten Richter — Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Hardenbergstrasse 36, 10623 Berlin, Germany

Self-assembled semiconductor quantum dots are one of the most extensively studied nanostructures and a variety of applications are based on them. High quality devices require precise information about the structural quantum dot properties, especially about the quantum dot shape and size. However, sophisticated experimental methods such as electron microscopy to identify the quantum dot size have several significant drawbacks.

We propose an all optical spectroscopic pump-probe method to determine the spatial extension of nanoscale electron wave functions in semiconductor quantum dots. In particular, we use intraband transitions between unbound continuum states in the host medium and the bound states to adress the extension of the quantum dot wave function. The developed theoretical scheme is readily applicable to quantum dots embedded in bulk material and can be applied to quantum dots embedded in two dimensional host materials as well with slight modifications. We present an analytical and easy to use formula to extract information about the spatial extension of bound quantum dot states from pump-probe experiments.

HL 30.16 Mon 17:00 P2

Theory of simultaneous time- and frequency-gated fluorescence and Raman spectroscopy in quantum dots — •Anke Zimmermann, Marten Richter, and Andreas Knorr — Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Hardenbergstrasse 36, 10632 Berlin, Germany

Time-dependent light scattering and fluorescence of quantum dots are in the focus of current experimental and theoretical research. In particular the combination of time- and frequency-resolved fluorescence allows to inspect dephasing and relaxation mechanisms specifically for single quantum dot spectroscopy. Here, we study the interaction of a laser pulse with the dominant excitonic transition in a quantum dot coupled to phonons.

To determine simultaneously frequency and time-resolved emission properties, a spectral filter is combined with temporal gated detection.

In this way, it is possible to investigate the time and frequency gated fluorescence and the Raman signal including the interaction of electrons and phonons. The resulting equations and numerical evaluations are applied to different kinds of excitation conditions and filters.

HL 30.17 Mon 17:00 P2

Simulation of Correlation Measurements of Exciton and Trion Recombination in Single Quantum Dots, Coupled to a Two-Dimensional Electron Gas — •Benjamin Merkel[1], Annika Kurzmann[1], Arne Ludwig[2], Andreas D. Wieck[2], Axel Lorke[1], and Martin Geller[1] — [1]Faculty of Physics and CeNIDE, University of Duisburg-Essen, Lotharstr. 1, 47057 Duisburg, Germany — [2]Chair of Applied Solid State Physics, Ruhr-Universität Bochum, Universitätsstr. 150, 44780 Bochum, Germany

For optical spectroscopy and coherent exciton state control, self-assembled quantum dots (QDs) are often embedded in a diode structure with a n-doped back contact that allows fast electron tunnelling from the reservoir into the dot states. We use here a different sample structure to investigate the slower electron tunnelling between a single QD and a two-dimensional electron gas and simulate the correlation measurements between the exciton and trion lines.

The occupation of the QD can be controlled with single charge resolution by an applied gate voltage and monitored by measuring the exciton and trion transition line, respectively. However, under non-resonant excitation, different excitonic recombination lines from different charge states can be observed simultaneously in a wide range of gate voltages. We use a model, which describes the capture and escape of QD charges as well as the recombination of exciton states by rate equations. Based on the model, we can simulate correlation measurements of the emitted radiation and are able to reproduce the experimental results.

HL 30.18 Mon 17:00 P2

Simulation and characterisation of an integrated optical beamsplitter based on multimode GaAs/AlAs waveguides with embedded InGaAs/GaAs quantum dots — •Markus Oster[1], Ulrich Rengstl[1], Klaus D. Jöns[1,2], Samir Bounouar[1], Sven M. Ulrich[1], Michael Jetter[1], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany — [2]Kavli Institute of Nanoscience Delft, Quantum Transport, Delft University of Technology, PO Box 5046, 2600 GA Delft, The Netherlands

The miniaturization and high-density integration of electronic logic elements into single chip architecture has been a revolutionary development for electronic data processing in the past decades. Nevertheless, in the future perspective to create novel all-optical types of quantum logic structures, the integration of tailored quantum emitters as non-classical light sources into dedicated optical waveguide structures is one of the major aims of research in this field.

Here we report on investigations on multimode GaAs/AlAs waveguides using integrated single InGaAs/GaAs quantum dots as light sources to study the light propagation and beamsplitter operation of the waveguide structures. Our studies reveal waveguide losses of $\alpha = 15.7\,\mathrm{cm}^{-1}$, wavelength-dependent beamsplitter ratios around 0.5/0.5, and a photon polarisation of over 90 %. These results represent an important step towards the realization of semiconductor based integrated photonic quantum circuits.

HL 30.19 Mon 17:00 P2

Spectroscopy and photon-statistics of InP/AlGaInP quantum dots with reduced spatial density — •Mario Schwartz, Christian A. Kessler, Elisabeth Koroknay, Thomas Schwarzbäck, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Allmandring 3, 70569 Stuttgart, Germany

We investigate the optical properties of self-assembled InP/AlGaInP quantum dots (QDs) with a reduced spatial QD density grown by metal-organic vapor-phase epitaxy. We examine how effective an interruption in the phosphine flow (PH_3-stop) during the growth decreases the spatial QD density, with the aim of finding background free single emission lines without any pre- or postprocessing of the samples. The influence of the PH_3-stop on the decay dynamics of the QD emission is also investigated. They exhibit a second large decay time which arises from a second excitation of the QD due to carriers trapped in the vicinity of the QDs. We found that the magnitude of the second decay channel reduces using lower excitation energies in the range of the band gap of the AlGaInP barrier. In second order correlation measurements performed at low excitation energies $g^{(2)}(0) = 0.015$ is achieved when background emission is neglected.

HL 30.20 Mon 17:00 P2

Simulating SiGe/Si Self-Assembled Quantum Dots — •Torsten Wendav[1], Inga Fischer[2], and Kurt Busch[1,3] — [1]Humboldt Universität zu Berlin, Institut für Physik, AG Theoretische Optik & Photonik, Berlin, Germany — [2]Institute for Semiconductor Engineering, University of Stuttgart, Stuttgart, Germany — [3]Max-Born-Institut, Berlin, Germany

The integration of optoelectronic functionality into Silicon-based devices has been of interest for quite some time. However, this has proven to be difficult, mainly due to material properties of Silicon [1]. A promising approach to circumvent these difficulties is the integration of Germanium quantum dots into Silicon.

While it is easy to grow Germanium quantum dots on Silicon it is hard to experimentally tune their optoelectronic properties, largely due to the sheer amount of growth parameters [3].

In order to obtain a deeper understanding of the relationship between growth parameters and optoelectronic properties of Germanium quantum dots, numerical simulations were performed. Combing both experimental and numerical results leads to a consistent physical picture of SiGe/Si self-assembled quantum dots [4].

[1] R. A. Soref, Proceedings of the IEEE **81**, 1687 (1993).
[2] Y.-H. Kuo, *et al.*, Nature **437**, 1334, 2005.
[3] M. Brehm, *et al.*, J. Appl. Phys. **109**, 123505-1, 2011.
[4] I. Fischer, *et al.*, (In preparation).

HL 30.21 Mon 17:00 P2

Quantum coherence in semiconductor quantum dot molecules — •Stephan Michael[1], Weng Wah Chow[2], and Hans Christian Schneider[1] — [1]Department of Physics, University of Kaiserslautern, P.O. Box 3049, 67653 Kaiserslautern, Germany — [2]Sandia National Laboratories, Albuquerque, NM 87185-1086, USA

Quantum coherence effects such as electromagnetically induced transparency and amplification without inversion are well known in atomic few-level systems. Quantum dots, which are arguably the closest realization of an atomic-like system in semiconductors, are natural candidates for the realization of quantum coherence phenomena in solids. However, typical room temperature dephasing times limit the achievable quantum coherence effects. We present theoretical results of electromagnetically induced transparency and group-velocity slowdown for optical pulses in InGaAs-based double quantum dot molecules. These are designed to exhibit a long lived coherence between two electronic levels whereby a V-type pump-probe scheme for the investigation of quantum coherence effects is achievable. We apply a many-particle approach including microscopic scattering and dephasing based on realistic semiconductor parameters that allows us to calculate the spatio-temporal material dynamics coupled to the propagating optical field. The dependences of slowdown and shape of the propagating probe pulses on lattice temperature and pump intensities are investigated. The probe pulse slowdown in the double quantum dot molecule is shown to be substantially higher than what is achievable from similar transitions in typical InGaAs-based single quantum dots.

HL 30.22 Mon 17:00 P2

Computational study of CdSe and PbSe quantum dot structures — •Farzana Aslam and Christian von Ferber — AMRC, Coventry University, Coventry, UK

Applying computational time dependent density functional techniques we analyse small structures of potential quantum dot material. In particular, we focus on the optical properties of these dots observing the effects of cluster size, the cluster composition, capping ligands and complexation.

HL 30.23 Mon 17:00 P2

Optical Spectroscopy of Site-Controlled InAs Quantum Dots — •Julia Susan Wiegand[1], Ramin Dahbashi[1], Christian Mayer[2], Jens Hübner[1], Daniel Schaadt[2], and Michael Oestreich[1] — [1]Leibniz Universität Hannover, Institut für Festkörperphysik, Abteilung Nanostrukturen, Appelstraße 2, D-30167 Hannover, Germany — [2]Technische Universität Clausthal, Institut für Energieforschung und Physikalische Technologien, Leibnizstraße 4, D-38678 Clausthal-Zellerfeld, Germany

Site-controlled quantum dots (SCQDs) are well suited candidates for a number of future applications in quantum-optronics. For device applications with novel functionalities - such as deterministic single photon sources - controlled positioning of QDs with high structural and electronic quality is desirable for scalable fabrication. We investigate SCQDs grown by molecular beam epitaxy on pre-patterned GaAs substrates [1] by optical high precision low-temperature micro-photoluminescence spectroscopy. The optical spatial resolution shows the successful controlled nucleation at the predefined sites. The photoluminescence spectra yield a measure of the SCQDs' optical quality which is influenced by defects created in the prepatterning process.

[1] Helfrich *et al.*, Growth and characterization of site-selective quantum dots, Phys. Stat. Sol. A **209**, 2387 (2012).

HL 30.24 Mon 17:00 P2

Investigation of CdS nanowire lasing emission — Robert Röder[1], •Max Riediger[1], Daniel Ploss[2], Adrian Kriesch[2], Ulf Peschel[2], and Carsten Ronning[1] — [1]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena — [2]Institut für Optik, Information und Photonik, Friedrich-Alexander Universität Erlangen-Nürnberg, Staudstraße 7, 91058 Erlangen

Nanophotonic on-chip integrated components are a promising approach to overcome forthcoming limitations of electronic integrated circuits. Optical data transmission and processing by exploiting semiconductor nanowires, which offer efficient waveguide properties and mark the lower size limit of photonic laser systems, builds a possible route to overcome these challenges. High quality cadmium sulfide nanowires (CdS NW) open up the green spectral range around 2.4 eV acting as Fabry-Pérot laser resonators with a remarkable low threshold of 10 kW/cm^2 at room temperature [Geburt et al, Nanotechnology 23, 365204 (2012)] and operating even in cw emission mode [Röder et al, Nano Letters 13, 3602 (2013)]. Since optical processing is specified by the direct emission of the device, a head-on setup was developed to investigate the light output originating from the end facet of a single nanowire laser. This setup is suited to determine super luminescence (ASE) as well as lasing emission dependent on the polarization of the optical pump beam. Furthermore the angular distribution of nanowire lasing emission can be measured.

HL 30.25 Mon 17:00 P2

Intense intra-3d luminescence and waveguide properties of single Co doped ZnO nanowires — Sebastian Geburt[1], •Markus Schwiderke[1], Robert Röder[1], Uwe Kaiser[2], Wolfram Heimbrodt[2], and Carsten Ronning[1] — [1]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, D-07743 Jena — [2]Fachbereich Physik, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg

The transition metal Co is well-known as optically active luminescence center in semiconductors. Cobalt doped nanowires would therefore take advantage of their morphology in providing photonic waveguiding for new optoelectronic nano-devices such as nanowire LEDs or nanolasers. Homogeneous doping of ZnO nanowires (NW) with transition metal Co is achieved by ion implantation and subsequent annealing procedures provide excellent optical activation of the luminescence centers. Excitation of the Co ions was observed by either resonant absorption or by energy transfer from the ZnO host with lifetimes of ~ 8 ns. The waveguide properties of single doped NWs were characterized using spatially resolved microPL-measurements [Geburt et al, Phys. status solidi (RRL), 10/2013, 886].

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InGaN/GaN nanowire heterostructures as optical probes for oxygen-related surface processes — •Pascal Hille[1], Marius Günther[1], Paula Neuderth[1], Pascal Becker[1], Jörg Teubert[1], Jörg Schörmann[1], Matthias Kleine-Boymann[2], Mariona Coll[3], Jordi Arbiol[3,4], Jürgen Janek[2], Bernd Smarsly[2], and Martin Eickhoff[1] — [1]I. Physikalisches Institut, Justus-Liebig-Universität Gießen, Germany — [2]Physikalisch-Chemisches Institut, Justus-Liebig-Universität Gießen, Germany — [3]Ciencia de Materials de Barcelona,CSIC, Campus de la UAB, 08193 Bellaterra, CAT, Spain

— [4]ICREA, Campus de la UAB, 08193 Bellaterra, CAT, Spain

InGaN/GaN nanowire heterostructures (NWHs) show a high sensitivity of their photoluminescence (PL) intensity to the ambient atmosphere rendering them as promising candidates for gas-sensor applications with all-optical readout in the visible spectral range. InGaN/GaN NWHs were grown by plasma-assisted molecular beam epitaxy. Exposure to ppm-concentrations of oxygen leads to a quenching of the PL intensity. This PL response behaviour is investigated for undoped and Ge-doped InGaN/GaN NWHs. A comparison with GaN NWs yields much longer (≈10x) response times of undoped InGaN/GaN NWHs. These time constants, however, can be significantly reduced by Ge-doping. Possible mechanisms will be discussed. Additionally, InGaN/GaN NWHs covered with CeO_2 were investigated in order to assess the potential of NWHs for an optical detection of ad-/desorption processes at catalytic materials.

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Optical Properties of Rare-Earth doped InAs Quantum Dots
— •Markus K. Greff, Arne Ludwig, and Andreas D. Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany

Opto-electronical devices like LEDs or lasers are included in nearly every technical product nowadays. One point that has led to their importance, is the broad tunability of optical properties of these devices. For example, by doping Gallium-Nitride (GaN) with rare-earth materials (RE) it is now possible to build full-colour LEDs and lasers. Here, we concentrate on systems with a lower bandgap: Combining RE with spintronics, exploiting both charge and spin of carriers, will allow to tune the optical and electrical properties of these devices further. In this work we show the successful doping of Indium-Arsenide (InAs) Quantum Dots (QDs) in a Gallium-Arsenide (GaAs) matrix with the rare-earth element Europium (Eu). We assume that the doping significantly shifts the photoluminescence (PL) spectrum of the QDs towards higher energies (blue shift) due to a diffusion-driven process in which a new sub-ensemble of Eu-doped QDs is formed during an additional annealing step. This is a first step towards further optical and electrical experiments and future spintronic applications of these QDs.