HL 95: Poster IV B (Quantum dots and wires: Prepration, characterization, optical properties, and transport)

Presenters are kindly requested to be near their poster for at least one hour in the time between 16:00-18:00 or to leave a note about their availability for discussions.

Time: Thursday 14:00–20:00 Location: Poster B

HL 95.1 Thu 14:00 Poster B

Nanowire junctions grown on Si substrates — •Daniil Vakulov, Torsten Rieger, Sebastian Heedt, Daniel Rosenbach, Mihail Ion Lepsa, Thomas Schäpers, and Detlev Grützmacher — Peter Grünberg Institute (PGI-9) and JARA-Fundamentals of Future Information Technology, Forschungszentrum Jülich, 52425 Jülich, Germany

Nowadays nanowire junctions are attracting much attention due to many reasons, for example the search of Majorana fermions. We present the growth, structural characteristics and room temperature transport measurements of these junctions. InAs nanowires have been grown without the use of Au catalysts on Si (100) substrates patterned with V-grooves. The V-grooves have been produced by KOH etching. The nanowires grow perpendicular to the {111} side facets of the V-grooves. When two nanowires are grown on opposing V-groove facets, they can cross, grow together and form a nanowire junction. In this case three different basic configurations of nanowire junctions are obtained: a tip-to-tip junction (L-shape), tip-to-side junction (T-shape) and a side-to-side junction (X-shape). The junctions exhibit a uniform crystal structure. They have zinc blende crystal structure while the remaining parts of the nanowires show the expected high density of stacking faults. Preliminary room temperature transport measurements demonstrate that the resistivity across the junctions is similar to the resistivity of single InAs nanowires. The results demonstrate the excellent suitability of Au-free nanowire junctions for future nanoelectronic devices.

HL 95.2 Thu 14:00 Poster B

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

We have grown single localized Au seeded InAs NWs on GaAs(111)B substrate by molecular beam epitaxy, to investigate the morphology, structure and behavior of individual one-dimensional nanostructures, so called nanowires (NWs). 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. 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 95.3 Thu 14:00 Poster B

Focused ion beam induced growth of single GaAs nanowires on arbitrarily arranged sites — •Rüdiger Schott, Sven Scholz, Arne Ludwig und Andreas D. Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum

Semiconductor nanowires (NWs) are used as building blocks for a new generation of advanced devices intended for different applications in the field of nanoelectronics, nanophotonics and nanomechanics. NWs are near one-dimensional structures that typically have a high length-to-width ratio. This is the base of fascinating structural properties. Heterostructures of highly lattice mismatched materials can be combined without dislocations and metastable phases, unattainable in bulk materials like wurtzite GaAs, are feasible. We present focused ion beam (FIB) induced molecular beam epitaxy (MBE) grown single GaAs nanowires from site selectively deposited Au seeds. The possibility of maskless patterning makes focused ion beam lithography a powerful tool and an alternative to conventional lithography based methods in semiconductor processing. With an FIB system, equipped with an ExB filter and a liquid metal alloy ion source (LMAIS), most of the elements of the periodic table are accessible for ion implantation and patterning. Structural and optical properties of the nanowires are investigated by secondary electron microscopy, transmission electron microscopy, X-ray diffraction and photoluminescence spectroscopy.

HL 95.4 Thu 14:00 Poster B

Focused ion beam patterning of Si substrate for the growth of GaAs nanowires — •danial bahrami[1], heiko schäfer-eberwein[2], hanno küpers[3], faebian bastiman[3], lutz geelhaar[3], and ullrich pietsch[1] — [1]University of Siegen, Solid State physics, Siegen, Germany — [2]University of Siegen, Electronic and Information department, Siegen, Germany — [3]Paul Drude Institut für Festkörperelektronik, Berlin, Germany

Semiconductor nanowires (NWs) have been employed as light emitting diodes, transistors, anti-reflecting coating and other applications. For all of these applications, it is demanding to control density and position of NWs in a technically and economically efficient way. In most cases, NWs growth in Molecular Beam Epitaxy (MBE) onto silicon (111) substrates is realized onto a thin native silicon oxide throughout native openings providing a random distribution of NWs. Here we report on results of patterning the silicon substrates using a Focused Ion Beam (FIB) technique to define nucleation sites for further NWs growth. In particular, we created a 2D dot pattern of 1μm spacing. Optimum conditions for NWs growth are achieved by changing dose of the Gallium ions implantation. Implantation depth and the shape of implantation dots have been inspected by SEM and compared with the results of MBE NWs growth.

HL 95.5 Thu 14:00 Poster B

Site-controlled InAs quantum dots on pre-patterned GaAs substrates: Growth and characterizations — •Patrick Krawiec, Mohammed Usman, Johann Reithmaier, and Mohamed Benyoucef — Institute of Nanostructure Technologies and Analytics (INA), Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Germany

The selective epitaxial growth through the use of the seeded self-ordering technique leads to the formation of quantum dots (QDs) at determined nucleation sites. Here, we present the fabrication and characterization of site-controlled (SC) InAs QDs on pre-patterned GaAs substrates. The nanoholes on GaAs substrate were obtained using electron beam lithography (EBL). The growth of SCQDs was realized by solid-source molecular beam epitaxy. Highly ordered InAs QDs with periodicities ranging from 0.5 μm to 4 μm and negligible dot formation between the nanoholes are realized. Relatively narrow light emission from single SCQDs down to 150 μeV is measured by micro-photoluminescence.

HL 95.6 Thu 14:00 Poster B

Altering the luminescence properties of self-assembled quantum dots in GaAs by focused ion beam implantation — •Charlotte Rothfuchs, Markus K. Greff, Arne Ludwig, and Andreas D. Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum

In the growing field of quantum information and technology there is an increasing demand on semiconductor quantum structures. Especially single quantum dots (QD) were shown to be promising for the generation of single photons for quantum information processes [1]. Thus, there is a need for the controlled fabrication of those QDs. One approach is the combination of molecular beam epitaxy (MBE) and focused ion beam (FIB) implantation. While the former enables the growth of well-defined self-assembled quantum dots in great quantity [2], FIB implantation is on the one hand shown to be a suitable method to initialize a site-selective growth of QDs [3]. On the other hand it could be a proper method for the post-selecting of the latter. We anticipate the mechanism for eliminating QD luminescence by introducing lattice disorders in the irradiated regions. As a first approach, we present a study on the parameter space allowing the alteration of QD luminescence in GaAs by FIB implantation. Different sets of ion species, their energies and fluences are investigated by photoluminescence measurements on the QDs before and after FIB implantation.

[1] I. Robert-Philip et al., J. Lumin. 102-103, 67-71, (2003).
[2] D. Reuter et al., Physica E 40(6), 1961-1964, (2008).
[3] M. Mehta et al., Physica E 40, 2034-2036, (2008).

HL 95.7 Thu 14:00 Poster B

Cadmium Selenide / Cadmium Sulfide Core-Shell Quantum Dots in Titanium Dioxide — •Beate Horn[1], Svenja Herbertz[1], Thomas Heinzel[1], and Klaus Schierbaum[2] — [1]Solid State Physics Laboratory, Heinrich-Heine-Universität Düsseldorf — [2]Material Science Laboratory, Heinrich-Heine-Universität Düsseldorf

Cadmium selenide (CdSe) quantum dots (QD) were synthesised following procedure described by[2]. The growth of the CdS-shell is done in another chemical reaction adapting the procedure from[1]. A red shift of about 20nm in the emission and absorption spectra and the enlargement of quantum yield from 6.7% to 51.2% prove shell formation around the QD-core. The CdSe/CdS QD's were redissolved in chloroform and inserted into porous titanium dioxide[4] using mercaptopropionic acid. Frontface-fluorescence spectroscopy indicated adsorption of CdSe/CdS QD's into the titanium dioxide . A lower fluorescence signal after annihilation of the CdSe/CdS titanium dioxide samples indicates direct contact between the titanium dioxide and the CdSe/CdS QDs. Photo current measurements further prove the adsorption of the CdSe/CdS QDs'. Finally the influence of the CdSe/CdS QDs' on hydrogen sensing is investigated (and compared to [3]), using a platinum-titanium dioxide Schottky barrier with inserted CdSe/CdS QDs. Moreover the effect of electroformation was investigated. [1] Yue Y., Chem. Res. Ch. Un. 2010, 26(6), 871-875 [2] Murray C., Norris D., J. Am. Chem. Soc. 1993, 115, 8706-8715 [3] Cerchez, M. Langer, H. El Achhab, M. Heinzel, T., Appl. Phys. 103, 033522 (2013) [4] Achhab E., Erbe A., 2014, Appl. Phys. A (2014) 116:20392044

HL 95.8 Thu 14:00 Poster B

Efficient calculaltion of the Coulomb coupling elements including monopole-monopole interaction and Förster transfer between quantum dots — •Anke Zimmermann and Marten Richter — Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, EW 7-1, Technische Universität Berlin, Hardenbergstrasse 36, 10623 Berlin, Germany

Coulomb coupled semiconductor quantum dots provide a great flexibility for controlling their optical properties. Due to the couplings between the quantum dots the individual characteristics of separated quantum dots are modified and new collective states are formed. Examples include dipole induced Förster coupling transfer and the monopole-monopole interaction.

The calculation of the Coulomb coupling involves the evaluation of a six dimensional integral of the diverging Coulomb potential. For applications in materials with different permittivity (e.g. quantum dots in a solvent) the numerical complexity can be greatly reduced by using solutions of the modified Poisson equation.

To see the effects of Coulomb coupling on single excitons and biexcitons the double quantum coherence spectroscopy is used. It allows an investigation of the coupling mechanisms and a deeper insight into the involved processes. The characteristic optical signatures of quantum dots at different position with varying orientations can be calculated, for seeing more information about the spatial arrangement.

HL 95.9 Thu 14:00 Poster B

Optical Coupling of Whispering-Gallery Modes of Two Microdisks — •Tilmann John[1], Fabian Hargart[1], Matthias Paul[1], Michael Jetter[1], Tsung-Li Liu[2], Evelyn Hu[2], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart, Allmandring 3, 70569 Stuttgart — [2]School of Engeneering and Applied Sciences, Harvard University, 29 Oxford Street, Cambridge, MA 02138

Coupling dynamics between optical resonators generates much interest with possible applications e.g. in quantum information processing.

Microdisk dimers supporting high-quality and small mode volume whispering gallery modes are well suited candidates for the formation of photonic molecules.

Here, we investigate the coupling of two closely spaced GaInP microdisks with an inter disk separation below 100 nm. Local laser heating is used to overcome spectral mode detuning which results from the size mismatch of the two disks. To improve the local laser heating new structures with an additional heating layer are examined allowing the tuning of the cavity dimers independent of the excitation of single quantum dots coupled to the supermode.

In addition, by using a setup for imaging the dimers, we show an attractive way to observe the optical mode profile immediatedly.

To improve the coupling of the evanescent field of the WGMs between the disks, a new approach is to deform the disks to a more rectangular shape with rounded corners. We numerically investigate this approach using the Finite-difference time-domain method.

HL 95.10 Thu 14:00 Poster B

Two-photon interference measurements on photons from quantum dots excited via a two-photon excitation scheme — •Hüseyin Vural, Eva Schöll, Sascha Kolatschek, Markus Müller, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany

Indistinguishable photons are basic building blocks for quantum information processing and quantum communication. As single-photon sources, semiconductor quantum dots (QDs) are promising candidates for the generation of highly indistinguishable photons. In this work we investigate photons emitted by the biexciton state of a single InGaAs QD, which are generated via a pulsed, coherent and resonant two-photon excitation. The theory predicts the visibility of the two-photon interference to be given by the coherence time of the photons and the lifetime of the state. The measured two-photon interference of the biexciton photons provides a value of the visibility which fits the theory. Furthermore, the influence of the excitation laser pulse width on the visibility is investigated.

HL 95.11 Thu 14:00 Poster B

Single-Photon Emission of MOVPE-grown InGaAs-Quantum Dots at Telecom Wavelengths — •Katharina Zeuner, Fabian Olbrich, Jan Kettler, Matthias Paul, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Allmandring 3, 70569 Stuttgart, Deutschland

Semiconductor quantum dots (QDs) are promising candidates to be employed as single-photon sources for fiber-based communication networks. Although already established by molecular beam epitaxy (MBE), it has been challenging to achieve metal organic vapor phase epitaxy (MOVPE)-grown low-density InAs QDs with emission wavelengths suitable for widespread optical glass fibers.

In this contribution, we report on low-density MOVPE-grown InGaAs-QDs that are assembled on a GaAs substrate and on top of a 15-pair AlAs/GaAs distributed Bragg reflector (DBR). We demonstrate single-photon emission at the telecom O-band (1.3 μm). Furthermore, we investigate time-resolved and polarization-dependent photoluminescence to give an estimation of carrier lifetimes and fine-structure splittings.

HL 95.12 Thu 14:00 Poster B

Pressure-induced shift of energy levels and structural phase transition in CdSe/ZnS quantum dots — Jonas Tauch[1], •Johannes M. Braun[2], Janine Keller[1], Christopher Hinz[1], Johannes Haase[1], Denis V. Seletskiy[1], Alfred Leitenstorfer[1], and Alexej Pashkin[1,2] — [1]Department of Physics and Center for Applied Photonics, University of Konstanz, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

Electronic band structure of CdSe/ZnS quantum dots under high pressures is studied using fluorescence spectroscopy. We observe a strong blue shift of about 40 meV/GPa for the emission line at 655 nm. At moderate pressures (below 3 GPa) this shift is linear and it is dominated by increase of the fundamental band gap of CdSe under pressure [1,2]. In contrast to bulk CdSe where the fluorescence is quenched above 3 GPa as a result of the phase transition into the rock-salt structure [3,4], the CdSe/ZnS quantum dots remain structurally stable up to 6.5 GPa. This structural robustness together with the high fluorescence yield and the large pressure-induced line shift, exceeding that of bulk ruby crystals by a factor of 40, make CdSe quantum dots a promising candidate for precise pressure calibration at moderate pressures.

[1] W. Shan et al., Appl. Phys. Lett. **84**, 67 (2004).
[2] B. S. Kim et al., J. Appl. Phys. **89**, 8127 (2001).
[3] S. H. Tolbert and A. P. Alivisatos, J. Chem. Phys. **102**, 4642 (1995).
[4] S. H. Tolbert and A. P. Alivisatos, Science **265**, 373 (1994).

HL 95.13 Thu 14:00 Poster B

The role of band mixing for excitons and biexcitons in semiconductor quantum dots — •Matthias Holtkemper, Doris E. Reiter, and Tilmann Kuhn — Institut für Festkörpertheorie, Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

A detailed understanding of the electronic structure in semiconductor

quantum dots (QD) is a prerequisite to model dynamical processes in QDs relevant for quantum information processing. We analyse the structure of excitons and biexcitons by studying theoretically the influence of different coupling mechanisms. To be specific, we model the QD using a harmonic confining potential and consider valence band mixing using a four band Luttinger theory, direct Coulomb interaction as well as long- and short-range Coulomb exchange interaction. We discuss the dependence of specific coupling mechanisms on the QD size and shape. We find a different scaling of Luttinger and Coulomb couplings depending on the QD size, while varying the QD shape leads to jumps in Coulomb exchange couplings. Furthermore we extend our studies to a QD doped with a single Mn, where a six line signature on the lowest absorption line appears. The calculated spectrum shows additional features due to the consideration of Luttinger couplings which are in good agreement with experimental findings.

HL 95.14 Thu 14:00 Poster B

Temperature-dependent quantum optical properties of In(Ga)As quantum dots with emission wavelength above 1μm — •Fabian Olbrich, Katharina Zeuner, Jan Kettler, Matthias Paul, Michael Jetter, and Peter Michler — Universität Stuttgart, Institut für Halbleiteroptik und Funktionelle Grenzflächen (IHFG), Allmandring 3, 70569 Stuttgart

Promising single photon sources for the realization of fiber-based quantum communication networks are provided by semiconductor quantum dots (QDs). For this purpose QDs with emission wavelengths above 1 μm, in this case targeting the telecom O-band (1,3 μm), would provide the advantage of minimal absorption and dispersion of the transmitted signal.

Furthermore for the implementation of these QDs, an operation at higher temperatures is desirable, because of the reduced amount of required cooling and simpler handling.

In this work we study (quantum) optical properties of long-wavelength In(Ga)As-QDs at elevated temperatures such as the spectral behaviour, e.g. spectral broadening or the addressability of a single QD, the single photon emission via cw autocorrelation measurements and time-correlated photon counting measurements to gather information about decay times and refilling effects.

HL 95.15 Thu 14:00 Poster B

Ultrafast Dual Color Transient Absorption Spectroscopy with synchronized GHz-Oscillators — •Christian Dicken[1], Alexander Neufeld[1], Christian Wolpert[2], and Markus Lippitz[1] — [1]Experimental Physics III, University of Bayreuth, Germany — [2]Solid State Spectroscopy Group, Kyoto University, Japan

Nanooptics heads towards coherently coupled single emitters as ingredients in numerous applications. Knowledge of the coherent properties and optical control of the quantum state of the emitters are crucial points in designing such systems.

We demonstrated[1] recently that it is possible to detect, analyze and control a single semiconductor quantum dot in an optical far-field experiment, utilizing spectrally resolved transient absorption spectroscopy and coherent manipulation of the quantum dot state.

As a next step, we present an approach to increase the signal-to-noise ratio by an order of magnitude by switching to a fs-Ti:Sapphire oscillator with GHz repetition rate and acquisition of spectroscopic data with frame rates up to 126 kHz.

[1] *C. Wolpert et al, Nano Lett., 2012, 12 (1), pp 453-457.*

HL 95.16 Thu 14:00 Poster B

Inspection of Relaxation by Coherent Spectroscopy and Nanoplasmonics — •Markus Krecik, Mario Schoth, Sven M. Hein, and Marten Richter — Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Hardenbergstrasse 36, 10623 Berlin, Germany

Coherent multidimensional spectroscopy allows for analysis of exciton-phonon relaxation. Nanoplasmonics allows to dynamically induce gradient fields, which relax dipole selection rules.

Through the combination of coherent spectroscopy and nanoplasmonics, we provide a way for studying relaxation between dipole-forbidden and dipole-allowed states: A quantum emitter is placed in a plasmonic structure, an excitation pulse controls electric field gradients and thus excitation of dipole-forbidden states. Multidimensional spectroscopy with an appropriate choice of gradient and non-gradient pulses gives us enhanced control over the relaxation process.

The possibilities are illustrated on a CdSe quantum dot using photoelectron-emission detection.

HL 95.17 Thu 14:00 Poster B

GaAs/GaP Quantenpunkt-LEDs — •Christian Golz — Humboldt-Universität zu Berlin, Berlin, Germany

Im Rahmen der hier vorzustellenden Arbeit wird die Optimierung der Prozessierung von Leuchtdioden basierend auf GaAs Quantenpunkten eingebettet in einer GaP-Matrix präsentiert. Die hier verwendeten Proben wurden mittels Gasquellen-Molekularstrahlepitaxie hergestellt. Die ausreichende Gitterfehlanpassung von 3,6% zwischen GaAs und GaP ermöglicht die selbstorganisierte Bildung von Quantenpunkten im Stranski-Krastanow-Wachstumsmodus auf GaP. Die GaAs/GaP Quantenpunkte sind in einen p-n-Übergang eingebettet und zeigen optische Emission zwischen 1,8 und 2 eV. Untersucht wurden dabei insbesondere die Mikrostrukturierung und Kontaktierung der Probe zur Optimierung der Elektrolumineszenzausbeute. Mit Photolithographie- und Ätzschritten wurden dabei der Halbleiter und auch die Kontakte nach einem für diese Proben entworfenen Muster strukturiert. Auch die Optimierung der Kontaktierung durch Metallaufdampfen und Annealing der Proben wurde untersucht.

HL 95.18 Thu 14:00 Poster B

Theory of a QD-phonon laser — •Leon Droenner and Julia Kabuss — Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Berlin, Germany

The research area of nanophononics involves the investigation and manufactoring of phononic devices such as acoustic cavities, designed to confine a single acoustic phonon mode. These solid state based phonon cavities form the basis for different applications, such as the phonon laser or imaging.

External optical manipulation of the harmonic oszillator mode of the acoustic cavity can result in optical cooling or vibrational amplification. The proposed phonon laser is realized as a a two-level quantum dot-acoustic cavity-system, which is optically driven by a frequency detuned laser at the anti-Stokes resonance. This leads to a effective stimulated phonon emission based on the induced Raman-process.

Our study is focused on the generalisation of the one-quantum dot limes to an N-emitter system which can be reduced to an intuitive analytical treatment.

HL 95.19 Thu 14:00 Poster B

Metal-enhanced luminescence of CdSe and Au nanoparticles in colloidal solution — •Evelyn Röder, Nils Rosemann, Beatriz Pelaz, Wolfgang J. Parak, Sangam Chatterjee, and Nadeem Sabir — Faculty of Physics and Materials Science Center, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany

Cadmium selenide semiconductor nanoparticles (SNP) show a strong photoluminescence (PL) that can be tuned either by doping or changing the structure of the SNP [1]. Their emission is further enhanced by plasmonic effects in the vicinity of metals [2,3]. We investigate the origin of this interaction by studying a series of CdSe-SNPs mixed with Au-based metallic nanoparticles (MNP) in solution with varying concentration ratio of SNP and MNP by UV/VIS absorption and time-resolved photoluminescence (PL) spectroscopy. We find a non-linear dependence of the PL intensity on the concentration ratio along with a photon-energy-dependent quenching of the absorption.

[1] Gaponik et al., 2010, 2010, 6, 1364-1378
[2] Kulakovich et al., 2002, Nanoletters Vol.2, No. 12 1449-1452
[3] Okamoto et al., 2006, J. Opt. Soc. Am. B/Vol. 23, No. 8

HL 95.20 Thu 14:00 Poster B

Single-photon emission from a partly stimulated two-photon emission in semiconductor quantum dots — •Dominik Breddermann, Dirk Heinze, Artur Zrenner, and Stefan Schumacher — Physics Department and Center for Optoelectronics and Photonics Paderborn (CeOPP), University of Paderborn, Warburger Strasse 100, 33098 Paderborn, Germany

In the context of designing efficient single-photon sources, semiconductor quantum dots are widely studied. Besides the established cascaded biexciton-exciton emission - underlying most of the recent studies -, also a direct two-photon transition from the biexciton to the ground state is optically allowed. We show that this higher-order transition is a promising alternative starting point to realize a single-photon source. In our scheme, an external laser field excites the system into a virtual intermediate state located in the band gap. As the quantum dot relaxes to its electronic ground state via this virtual state, a single photon is spontaneously emitted (here into a cavity mode). The properties of the single photon can be controlled all-optically by the classical laser field

enabling the emission. In this contribution we introduce the scheme and focus on the calculation of photon correlation functions and investigate the spectral properties of the single photon emission.

HL 95.21 Thu 14:00 Poster B

Time-resolved photoluminescence of silicon nanoparticles — •Robert Niemöller, Daniel Braam, Günther M. Prinz, Martin P. Geller, and Axel Lorke — Experimentalphysik und CENIDE, Universität Duisburg-Essen

Bulk silicon is a poor light emitter, due to its indirect band-gap, hindering optical device integration into today's CMOS technology. Silicon nanoparticles could overcome this problem, as they exhibit bright luminescence and high quantum yield.

The time-resolved photoluminescence (PL) of silicon nanoparticles with different functionalisations such as fluor or dodecene is studied using micro-photoluminescence. We performed PL-measurements at low temperatures to determine the line width of single nanoparticles, which was found to be in the range of several millielectron volts. In time resolved measurements on particle ensembles, this enables us to address a sub-set with a specific diameter by taking into account only a small spectral range of the inhomogeneously broadened Pl spectrum.

We present data of such sub-sets of particles for different laser excitation powers and temperatures and find PL decay characteristics, which can be fitted by bi-exponential or stretched exponential functions. We observe decay-times of up to 300 μs, decreasing below 50 μs for increasing PL energy, an effect, which we attribute to an increasing quantum confinement for smaller nanoparticles. This shows the high technological potential of silicon nanoparticles as their lifetime can be controlled by size.

HL 95.22 Thu 14:00 Poster B

Numerical Investigation of the Nonlinear Optical Properties of Quantum Dot Molecules (QDM) — •Peter Kölling and Jens Förstner — Universität Paderborn, Germany

We theoretically study the optical properties of epitaxially grown InAs quantum dot molecules which are integrated in Schottky diode structures. From optical experiments one knows that the electronic states inside the single quantum dots are coupled [1]. Applying gate voltages at these diode structures allows manipulation of the relative energies inside the single quantum dots as well as manipulation of carrier tunneling between the dots [2,3]. This in turn can be used to achieve switching between electronic states at nano- or picosecond time scales. Nonlinearities arise due to the excitation of exciton complexes with variable numbers of electrons and holes.

To fully understand and control these processes one has to understand the electronic structure of the coupled systems as well as the excitation dynamics within these systems. We investigate single particle eigenenergies and eigenstates by means of k·p-theory with the nextnano^3 software package [4]. Results from these calculations are then used as input paramters for Heisenberg equations of motion for a reduced density operator.

[1] G. Ordner et al., Phys. Rev. Lett. **94**, 157401 (2006)
[2] E. A. Stinaff et al., Science **311**, 636-639 (2006)
[3] M. Schreibner et al., Solid State Comm. **149**, 1427-1435 (2009)
[4] http://www.nextnano.de/nextnano3/

HL 95.23 Thu 14:00 Poster B

Spin switching in Mn-doped quantum dots using detuned and chirped laser pulses — •Sebastian Lüker[1], Doris E. Reiter[1,2], Vollrath Martin Axt[3], and Tilmann Kuhn[1] — [1]Institut für Festkörpertheorie, WWU Münster, Wilhelm-Klemm-Str. 10, 48149 Münster — [2]Blackett Laboratory, Imperial College, London, UK — [3]Theoretische Physik III, Universität Bayreuth

When a manganese (Mn) ion is doped into a CdTe quantum dot (QD), the photoluminescence spectrum shows six lines corresponding to the six Mn spin states. This is caused by the exchange interaction which couples the Mn spin to the spin of the exciton in the QD. This coupling enables the control of the Mn spin via the optical manipulation of the exciton. For excitation with circularly polarized laser pulses, the complete system can be reduced to a bunch of three level systems, consisting of the ground state with Mn spin in a given orientation, the bright exciton state with unchanged Mn spin, and the dark exciton state with flipped Mn spin.

We present a theoretical analysis of two different switching protocols for the Mn spin. The first one uses an ultrashort resonant laser pulse which excites the exciton. By applying a second pulse, which is detuned from the exciton transition energy, the relevant states are shifted into resonance, resulting in an occupation transfer between the Mn spin states. An alternative switching protocol uses chirped, i.e., frequency modulated laser pulses. In this case, one pulse is sufficient to manipulate the Mn spin. During the pulse, the state of the system is driven adiabatically into the desired Mn spin state.

HL 95.24 Thu 14:00 Poster B

Computational analysis of CdSe and PbS quantum dot structures — •Farzana Aslam and Christian von Ferber — Coventry University, UK

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

HL 95.25 Thu 14:00 Poster B

Electrical properties of free-standing GaAs nanowires by multi-tip scanning probe microscopy — •Ilio Miccoli[1,2], Frederik Edler[1], Nico Lovergine[2], Paola Prete[3], Christoph Tegenkamp[1], and Herbert Pfnür[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, DE — [2]Dept. Innovation Engineering, Salento University, IT — [3]IMM-CNR, Lecce, IT

Free-standing III-V nanowires (NWs) represent the forefront of materials science, and it is expected they will impact several technological fields, ranging from nanoelectronics to nano-photonics. Huge progress has been made in the vapour-liquid-solid growth by MOVPE technology of III-V NWs. However, further efforts are needed for the precise control of their electrical properties, especially in terms of dopant concentration and distribution profiles. Even more critical, the NW current-voltage (I-V) analysis usually requires the multi-step and time-consuming EBL/FIB-assisted fabrication of NW-based FET devices, which often alter the genuine NW transport properties. Recently, single-tip scanning tunnelling microscope (STM) has proven to be a versatile tool for the structural and electrical characterization of free-standing NWs, although the I-V characteristic is often dominated by the metal-catalyst/NW Schottky interface. Here, we show that the use of a multi-probe STM allows for the rapid sub-nanometric placement of three probe tips on free-standing n-/p-doped GaAs NWs. The NW transport properties are studied as function of NW diameter and along the NW lateral facet, and finally correlated with growth conditions.

HL 95.26 Thu 14:00 Poster B

Resonant tunneling current through energy levels of strain induced quantum dots — •Daming Zhou, Andreas Beckel, Martin Geller, and Axel Lorke — Faculty of Physics and CENIDE, University of Duisburg-Essen, Lotharstraße 1, 47057 Duisburg, Germany

Strain-induced quantum dots (SIQD) confine electrons and holes to a lateral potential minimum within a nearby quantum well (QW) layer. The potential minimum can be introduced by a self-assembled quantum dot layer. SIQD have a much weaker confining potential than the self-assembled quantum dots. Their discrete energy levels have been demonstrated by optical measurements previously.

In this experiment, we pattern a two-dimensional electron gas with adjacent quantum dots into a field-effect transistor structure, in which a pair of metal split gates define the conduction channel in the QW layer. We observe a group of resonant current peaks when the free electrons in the constriction are depleted completely by application of deep negative voltage. Firstly, we can determine the SIQD space locations between the slit, by scanning the active area from one side to another using an antisymmetric bias contribution applied to the sides of the split gates. Furthermore, by varying the symmetric gate voltage contribution we can align the energy levels in the SIQD with the Fermi energy to allow transport through the SIQD. This way, we can study not only how one resonant energy level follows the two side gates, but also, from the energy level space, it is possible to learn about the Coulomb blockade effect of electrons inside the dot.

HL 95.27 Thu 14:00 Poster B

Determination of the inelastic diffusion length in GaAs/AlGaAs heterostructures by hot electron thermopower — •Oliver Kreiter[1], Ulrich Wieser[1], Arne Ludwig[2], Andreas Dirk Wieck[2], and Ulrich Kunze[1] — [1]Lehrstuhl für Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [2]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany

Precise determination of material parameters such as the charge carrier scattering length gain a growing interest in theoretical modelling of nanostructures for reliably predicting the appropriate device characteristics. On GaAs/AlGaAs (electron density $n = 3.04 \cdot 10^{11}\mathrm{cm}^{-2}$, mobility $\mu = 7.70 \cdot 10^5\mathrm{cm}^2(\mathrm{Vs})^{-1}$ at 4.2 K), we measured hot-electron thermopower (HETP) in quantum point contacts (QPCs). The sample consists of a symmetric cross junction of 600 nm wide channels, one supplied by a heating current and the other equipped with a series of split-gate contacts forming QPCs at distances ranging from 625 nm to several microns. We recorded the HETP signal at fixed heating current while one of the QPCs is tuned from positive gate voltages into pinch-off and all the others are kept open. At $T = 4.2$ K apart from quantum oscillations reflecting the QPC subband structure the HETP signal exhibits a maximum close to the threshold voltage. From the exponential decay of this maximum as a function of distance we extract the inelastic diffusion length. At temperatures above 10 K this length rapidly decreases due to lattice vibrations.

HL 95.28 Thu 14:00 Poster B

Signal addition in a dual-stage ballistic rectifier — •Joeren von Pock[1], Sandra Rudnik[1], Ulrich Wieser[1], Thomas Hackbarth[2], and Ulrich Kunze[1] — [1]Lehrstuhl für Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, D-44780 Bochum — [2]DaimlerChrysler Forschungszentrum Ulm, D-89081 Ulm

We investigate a ballistic rectifier consisting of 220 nm wide channels on a high mobility Si/SiGe heterostructure ($\mu_{2\mathrm{D}} = 18.3\ \mathrm{m}^2\mathrm{V}^{-1}\mathrm{s}^{-1}$, $n_{2\mathrm{D}} = 6.3 \cdot 10^{15}\ \mathrm{m}^{-2}$ at 1.4 K). The rectifier geometry is formed by a straight voltage stem with contacts U and L and two pairs of injector branches (contacts 1-2 and 3-4) inclined with respect to the stem by 45°. A Pd gate electrode covers the whole structure. At $T = 4.2$ K, under gate voltages $V_\mathrm{G} \geq 0.3$ V solely ballistic transport determines the output voltage [1]. Each of the rectifier stages nearly exhibit a parabolic characteristic, i.e. $V_{\mathrm{UL},ij} = (\alpha_{ij} \cdot I_{ij})^2$, where ij refers to the contacts 12 or 34, respectively, and $\alpha_{12} \approx \alpha_{34}$ represents the individual rectifier sensitivities. If the injector pairs are separated by at least 450 nm the individual output voltages add up, $V_{\mathrm{UL,tot}} = V_{\mathrm{UL},12} + V_{\mathrm{UL},34}$. At smaller separation $V_{\mathrm{UL,tot}}$ exceeds the sum by up to 80%. We interpret this synergy gain by a gradual transition from voltage to current addition. Pure current addition should occur if both injector pairs are connected to the stem at the same position leading to $V_{\mathrm{UL,tot}} = (\alpha_{12} \cdot I_{12} + \alpha_{34} \cdot I_{34})^2$, which is twice that of pure voltage addition.

[1] D. Salloch *et al.*, Appl. Phys. Lett. **94**, 203503 (2009).

HL 95.29 Thu 14:00 Poster B

Capacitance-Voltage Spectroscopy of InAs Quantum Dots Under External Applied Strain — •Sascha R. Valentin[1], Arne Ludwig[1], Dirk Reuter[2], and Andreas D. Wieck[1] — [1]Angewandte Festkörperphysik, Ruhr-Universität-Bochum — [2]Optoelektronische Materialien und Bauelemente, 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 95.30 Thu 14:00 Poster B

Narrow-gap semiconductor nanstructures in the quantum Hall regime — •Olivio Chiatti[1], Chistian Riha[1], Johannes Boy[1], Christian Heyn[2], Wolfgang Hansen[2], and Saskia F. Fischer[1] — [1]Neue Materialien, Institut für Physik, Humboldt-Universität zu Berlin, 12489 Berlin, Germany — [2]Institut für Angewandte Physik, Universität Hamburg, 20148 Hamburg, Germany

One of the most prominent phenomena in modern solid state physics is the quantum Hall effect (QHE). The quantum Hall edge channels (QHECs) are central to our understanding of the underlying physics of the QHE. Most research has been directed at GaAs/AlGaAs heterostructure systems, but there has been little work directed at understanding the role of spin-orbit interaction (SOI) in this phenomenon. We have combined quantum point contacts (QPCs) with in-plane gates and Hall-bars in a narrow-gap semiconductor heterostructure with strong SOI. The constriction was fabricated by micro-laser photolithography and wet-chemical etching from an InGaAs/InAlAs quantum well with an InAs-inserted channel [1]. The two-dimensional electron gas (2DEG) is at about 53 nm depth and has a carrier density of about $3 \cdot 10^{11}\ \mathrm{cm}^{-2}$ and mobility of about $7.5 \cdot 10^4\ \mathrm{cm}^2/\mathrm{Vs}$, in the dark. We have performed transport measurements of the combined QPC and Hall-bar structures in magnetic fields perpendicular to the 2DEG. We observe conductance quantization through the QPC when QHECs are formed. We discuss the transmission and reflection of QHECs as a function of symmetric and asymmetric in-plane gate voltages.

[1] Chiatti *et al.*, arXiv:1410.8588v2 [cond-mat.mes-hall] (2014).

HL 95.31 Thu 14:00 Poster B

Controlling ballistic heat conduction in a four-terminal nanoring — Christoph Kreisbeck[1], •Tobias Kramer[1,2], Christian Riha[1], Olivio Chiatti[1], Sven S. Buchholz[1], Andreas D. Wieck[3], Dirk Reuter[3,4], and Saskia F. Fischer[1] — [1]Neue Materialien, Institut für Physik, Humboldt-Universität zu Berlin, 12489 Berlin, Germany — [2]Mads-Clausen Institute, University of Southern Denmark, 6400 Sonderborg, Denmark — [3]Angewandte Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany — [4]Optoelektronische Materialien und Bauelemente, Universität Paderborn, 33098 Paderborn, Germany

The transport in a one-dimensional (1D) waveguide is dominated by the wave-like character of electrons. In simple ballistic 1D waveguides electric and thermal conductance are quantized and follow the Wiedemann-Franz law. The question is how the mode-dependent heat transfer evolves in networks of extended 1D waveguides, such as Aharonov-Bohm rings.

We show experimental data and theoretical calculations for ballistic heat transfer in a four-terminal nanodevice. By applying a gate voltage, the heat flux is distributed to different leads according to the scattering states at the wire junctions. The theoretical analysis relies on a computationally efficient wavepacket technique to model the flux through the device over a large transport window. At finite temperatures and Fermi energies we identify a strong ballistic component of the electric and heat currents, which opens the prospects to actively control the heat flux close to the quantum threshold.