HL 91: Poster Session: Quantum dots and wires: preparation & characterization & optical properties & transport properties

Presenters are kindly asked to be near their posters at least 17:00–18:00 or to leave a note at the poster indicating a time period of availability for discussions. — Beverages will be served starting at 18:00.

Time: Thursday 16:00–20:00 Location: Poster A

HL 91.1 Thu 16:00 Poster A

Fabrication and characterization of site-controlled quantum dots grown on pre-patterned GaAs substrates — •Patrick Krawiec, Muhammad Usman, Mohamed Benyoucef, and Johann Peter Reithmaier — Nanostructure Technologies and Analytics, CINSaT, University of Kassel, Heinrich-Plett-Strasse 40, 34132 Kassel, Germany

Semiconductor quantum dots (QDs) are attractive building blocks for scalable quantum information processing systems. In the last years, there has been an increasing need for the investigation of site-controlled QDs, which can be used as active elements in quantum devices such as single-photon sources. In this work, we present the growth of site-controlled InAs QDs on pre-patterned GaAs substrates using electron beam lithography, wet-chemical etching and molecular beam epitaxy. Large QD arrays with periodicities ranging from 0.5 μm to 8 μm were achieved. The single QDs obtained in this study present a high optical quality, which have been evaluated by micro-photoluminescence.

HL 91.2 Thu 16:00 Poster A

MBE-Growth of self-assembled uncapped InAs quantum dots on GaAs (001) surface — •Thomas Jost[1], Eddy P. Rugeramigabo[1,2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Abteilung Nanostrukturen, Leibniz Universität Hannover, Deutschland — [2]QUEST Centre for Quantum Engineering and Space-Time Research, Leibniz Universität Hannover, Deutschland

InAs quantum dots (QDs) are well known nanostructures which can be grown by molecular beam epitaxy (MBE). The electronic properties of an InAs QD depend on the form, external fields and the charges accumulated in the dot. For self-assembled uncapped InAs QDs we have studied the growth conditions to get well defined and reproducible parameters of QDs like: diameter, density of QDs and inter-dot distance.

To produce the InAs QDs we have grown two monolayers of InAs on a GaAs (001) surface under different conditions. We have shown that the density and inter-dot distance of QDs depends on the growth-rate and the annealing. The diameter of the QDs showed a dependence on annealing. Now we are able to produce QDs with a diameter of 50 nm, inter-dot distance of 70 nm and a density of around $2{\cdot}10^{10}$ QDs/cm^2, which will be used in transport experiments.

HL 91.3 Thu 16:00 Poster A

Growth of GaAs nanowires on GaAs (111)B substrates induced by focused ion beam — •Rüdiger Schott[1], Dirk Reuter[2], Arne Ludwig[1], and Andreas D. Wieck[1] — [1]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum — [2]Arbeitsgruppe für optoelektronische Materialien und Bauelemente, Universität Paderborn

Semiconductor nanowires are a promising system for applications in the areas of electronics and photonics as well as for exploring phenomena at the nanoscale. There are several approaches to grow nanowires at predetermined sites on the wafer. We report about growing GaAs nanowires on GaAs (111)B substrates via the vapor-liquid-solid (VLS) mechanism in an ultra-high-vacuum (UHV)-cluster consisting of a molecular beam epitaxy (MBE) and a focused ion beam (FIB) system. Our idea is to implant metal seeds for the nanowire growth using FIB. Due to the UHV transfer between the FIB and the MBE chamber, no further cleaning step of the substrate surface is necessary. We were able to grow single nanowires in user defined patterns on the wafer. Nanowire diameters below 20 nm were observed. The structural and optical properties of the nanowires were investigated by SEM, TEM and photoluminescence spectroscopy.

HL 91.4 Thu 16:00 Poster A

Correlation of electrical and structural parameters of single GaAs nanowires grown by MBE onto silicon substrate — •Genziana Bussone[1,2], Heiko Schäfer-Eberwein[3], Emmanouil Dimakis[4], Andreas Biermanns[2], Lutz Geelhaar[4], Peter Haring-Bolívar[3], and Ullrich Pietsch[2] — [1]ESRF, Grenoble, France — [2]Festkörperphysik, Universität Siegen, Germany — [3]Hochfrequenztechnik & Quantenelektronik, Universität Siegen, Germany — [4]PDI, Berlin, Germany

Semiconductor nanowires are possible candidates for future electronic application. Most of their properties strongly depend on structural parameters such as phase purity or lattice strain. Here we report on the correlation between electrical properties of single GaAs nanowires (NWs) grown by MBE on a highly doped silicon substrate (111) and their particular structural properties. Various single NWs, freestanding in their as-grown geometry onto the substrate, were measured using micromanipulators in a Focused Ion Beam (FIB) system at Siegen University (Germany), providing individual Current-Voltage characteristics. In order to understand the origin of the different electrical responses, the structure of the same nanowires were then investigated using a nano-focused beam of synchrotron radiation at beamline ID01 at the ESRF in Grenoble (France). All the NWs show mainly zinc-blende (ZB) structure units separated by stacking faults. The size of perfectly stacked ZB units differs among the measured NWs and correlates well with the differences of the respective Current-Voltage characteristics.

HL 91.5 Thu 16:00 Poster A

Structural and electronic and optical properties of Si_xGe_{1-x} alloy nanocrystals embedded in SiO_2: First-principles calculations — •Kaori Seino[1], Peter Kroll[2], Moritz Laubscher[1], and Friedhelm Bechstedt[1] — [1]nstitut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität Jena, Jena, Germany — [2]Department of Chemistry and Biochemistry, University of Texas at Arlington, Arlington, TX, USA

Silicon-Germanium (SiGe) technology is the driving force behind the explosion in low-cost, personal communication devices. Combining two major semiconductors, these alloys allow tailoring of the band gap and fundamental properties that depends on it in both bulk systems and nanocrystals (NCs). Recent advances in Group-IV semiconductor NCs have demonstrated their promise for optoelectronic and photovoltaic applications. Current developments of photonic devices focus on size control and ordered arrangements of NCs embedded in a SiO_2.

Our understanding of SiGe alloy NCs embedded in SiO_2 is, however, limited. Therefore, in this study we provide theoretical investigations of such systems. We study structural and electronic properties of Si_xGe_{1-x} alloy NCs with well-defined sizes embedded in silica glass by means of first-principles calculations. We investigate their electronic and optical properties and how their depends on the compositional parameter x of Si_xGe_{1-x} alloys.

HL 91.6 Thu 16:00 Poster A

Growth of InAs/InGaAs nanowires on GaAs(111)B substrates — •Sven Scholz[1], Rüdiger Schott[1], Dirk Reuter[2], Arne Ludwig[1], and Andreas D. Wieck[1] — [1]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum — [2]Arbeitsgruppe für optoelektronische Materialien und Bauelemente, Universität Paderborn

To investigate the structure and behavior of individual 1D-quantum structures, so called nanowires, we have grown single localized Au seeded InAs/InGaAs nanowires on GaAs(111)B substrate by molecular beam epitaxy. The Au-seeds are implanted by focused ion beam (FIB) technology. We developed a AuGa-LMIS to avoid the beam spread induced by using a Wien-Filter, which allows us to reduce the spot size of the focused ion beam and as consequence the number of implanted ions necassary to seed a wire. At present the growth of InAs nanowires is not fully understood and we have been working on optimizing the process. We identified an optimal growth temperature and arsenic to indium ratio for nanowire growth. Further investigations also aim at analyzing the influence of the growth rates and growth directions. We studied the morphology of the nanowires by SEM imaging and the optical properties with photoluminescence spectroscopy.

HL 91.7 Thu 16:00 Poster A

Compressive strain in MBE grown GaAs nanowires induced

by an Al_2O_3 shell prepared by atomic layer deposition — •Torsten Jörres[1,2], Torsten Rieger[1,2], Andreas Biermanns[3], Ullrich Pietsch[3], Detlev Grützmacher[1,2], and Mihail Ion Lepsa[1,2] — [1]Peter Grünberg Institut - 9, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]JARA-Fundamentals of Future Information Technology — [3]Universität Siegen, Festkörperphysik, Walter-Flex-Str. 3, 57072 Siegen, Germany

In the processing of nanowire (NW) based electronic devices, high-κ dielectrics are used to passivate the surface or as gate oxides for field effect transistor applications. In this sense, Al_2O_3 films prepared by atomic layer deposition (ALD) represent an alternative because it allows a precise control of the layer thickness and dielectric properties by choosing appropriate deposition conditions. However, at such a scale, any difference in thermal expansion coefficients might induce strain in the NW and therefore affect their electronic properties. Here, we show recent results on MBE grown GaAs NWs with diameter of 75 nm encapsulated in a 30 nm thick Al_2O_3 shell. High resolution XRD measurements were performed at the P08 beamline at the PETRA III synchrotron in Hamburg in order to measure the shell-induced strain in the NWs. A small, but measurable compressive strain in the GaAs NWs of 0.05% was observed. High resolution transmission electron microscopy images of these nanowires show the conformal deposition of the Al_2O_3 shell as well as a very small roughness.

HL 91.8 Thu 16:00 Poster A

Tunability of the confining potential of Quantum Point Contacts — •Jakob Schluck, Bernd Schüler, Mihai Cerchez, and Thomas Heinzel — HHU Düsseldorf

The energy spacing of allowed states for a particle confined in one dimension depends on the form of the confining potential. Well known cases are the equidistant spacing of the harmonic oscillator or the parabolic spacing in a hard wall confinement.

We tune the confining potential of a one-dimensional, ballistic quantum wire produced by AFM lithography on a Ga[Al]As heterostructure via a combination of in-plane gates and self-aligned top gates, also produced with an AFM. [1]

The level spacing is then determined by differential transconductance measurements allowing us to determine the shape of the confinement potential. [2]

[1] M. Sigrist, A. Fuhrer, T. Ihn, and K. Ensslin, Appl. Phys. Lett. 85, 3558 (2004)

[2] K. S. Pyshkin, C. J. B. Ford, R. H. Harrell, M. Pepper, E. H. Linfield, and D. A. Ritchie, Phys. Rev. B 62 15842 (2000)

HL 91.9 Thu 16:00 Poster A

Radical formation by photo-generated carriers at GaN nanowires - electrolyte interfaces — •Jan Martin Philipps, Gesche Mareike Müntze, Pascal Hille, Jörg Schörmann, Jörg Teubert, Detlev Michael Hofmann, and Martin Eickhoff — I. Physikalisches Institut, JLU Giessen, Germany

We investigated the transfer of photogenerated carriers from GaN nanowires into an electrolyte environment by electron paramagnetic resonance (EPR) and fluorescence-spectroscopy. Using 5,5-dimethyl-1-pyrroline-N-oxide (DMPO) as a spin trap and a neutral electrolyte (pH = 7) the formation of hydroxide radicals dominates, while for an electrolyte with a pH of 13.5 the superoxide formation becomes detectable. We explain this asymmetry for the two processes in the frame of the surface band bending model considering the redox potentials in the electrolyte and the conduction and valence band positions of the semiconductor.

HL 91.10 Thu 16:00 Poster A

Raman characterization of electrically biased polymer quantum dot composites — •Prahlad M Mohandas[1], Daniel Lehmann[1], Ovidiu D Gordan[1], Istvan S Todor[2], Christian Spudat[3], Jörg Martin[3], Michael Thomas Müller[4], Thomas Gessner[3], and Dietrich R. T. Zahn[1] — [1]Semiconductor Physics, Chemnitz University of Technology, D-09107 Chemnitz, Germany — [2]Department of Solid State Physics, Faculty of Physics, Babes-Bolyai University, Cluj-Napoca, Romania — [3]Fraunhofer-Institut für Elektronische Nanosysteme, Technologie-Campus 3, D-09126 Chemnitz, Germany — [4]Leibniz-Institut für Polymerforschung Dresden e.V., Polymerreaktionen und Blends, Hohe Straße 6, D-01069 Dresden, Germany

Thin films of a polymer/quantum dot composite are characterized using Raman and photoluminescence spectroscopy under electrically biased conditions in order to investigate the effect of voltage on the quantum dot charging behaviour. The quantum dots are CdSe/ZnS core/shell quantum dots, mixed homogeneously in polymethylmethacrylate (PMMA) polymer. The PMMA-CdSe/ZnS composite film was deposited on a glass substrate using spin-coating technique. The polymer quantum dot composites were biased between +48V and -48V. Peaks corresponding to CdSe longitudinal optical (LO) phonon and ZnS LO phonon were observed at 206 cm-1 and 272 cm-1, respectively. Quenching of phonon bands due to charging of quantum dots by the applied voltage is observed. The effect of quenching depends and varies based on the sign of the applied voltage.

HL 91.11 Thu 16:00 Poster A

Study of excitonic states in single InAs quantum dots by low-temperature SNOM — •Alexander Senichev[1], Vadim Talalaev[1,2], Jörg Schilling[2], George Cirlin[3,4,5], and Peter Werner[1] — [1]Max-Planck-Institut, Halle, Germany — [2]Martin-Luther-Universität, ZIK "SiLi-nano", Halle, Germany — [3]A. F. Ioffe Physico-Technical Institute, St. Petersburg, Russia — [4]St. Petersburg Physics and Technology Center for Research and Education, St. Petersburg, Russia — [5]Institute for Analytical Instrumentation, St. Petersburg, Russia

We report on near-field optical spectroscopy on InAs quantum dots embedded in a GaAs matrix. Quantum dot samples are grown by molecular beam epitaxy in different configuration of the active region. Sharp spectral lines corresponding to optical recombination in single quantum dots are selected. The spectral width of most resonances is quite narrow and comparable with the resolution of our monochromator (0.1 meV). Varying the excitation power density from 2W/cm2 to 300W/cm2 power dependence of photoluminescence (PL) parameters is investigated. For spatial PL imaging (spatial resolution 300 nm), the fiber probe is scanned across the sample surface, and a full PL spectrum is recorded at every pixel. The intensity of the observed emission lines shows approximately linear power dependence and saturate at the power of 100W/cm2. The results are discussed in respect to the capability of SNOM and provide a better understanding of the exciton behavior of individual QDs.

HL 91.12 Thu 16:00 Poster A

Temperature dependence of hole spin coherence measured by spin echo andspin mode locking in an ensemble of (In,Ga)As quantum dots — •Steffen Varwig[1], Alexandre René[1], Alex Greilich[1], Dmitri R. Yakovlev[1], Dirk Reuter[2], Andreas D. Wieck[2], and Manfred Bayer[1] — [1]Experimentelle Physik II, TU Dortmund, D-44221 Dortmund, Germany — [2]Angewandte Festkörperphysik, Ruhr- Universität Bochum, D-44780 Bochum, Germany

Electron and hole spins confined in quantum dots (QDs) are promising candidates for implementing qubits in semiconductors. One of the spin's most important properties for quantum information processing is its coherence time T_2. For electrons in (In,Ga)As QDs, T_2 is determined to be around $3\,\mu$s [1]; for holes it is in the order of $1\,\mu$s [2]. Although for electron spins the coherence time is mainly limited by hyperfine interactions with the QD's nuclei, for hole spins it is known that the coupling constant is about ten times weaker [3].

To study the hole spin coherence in QDs we performed optical time-resolved pump-probe ellipticity measurements on the hole spin polarization in (In,Ga)As QDs. In particular we investigated the temperature dependence of the coherence time T_2, making use of the spin mode-locking effect, demonstrated in reference [2], and spin echo techniques similar to those in reference [4].

[1] A. Greilich et al., Science 313, 341 (2006)
[2] S. Varwig et al., Phys. Rev. B 86, 075321 (2012)
[3] E. A. Chekhovich et al., Phys. Rev. Letters 106, 027402 (2011)
[4] A. Greilich et al., Nat. Phys. 5, 262-266 (2009)

HL 91.13 Thu 16:00 Poster A

Shape dependence of excitonic states in self-assembled GaAs/AlGaAs quantum dots — •Andreas Graf[1], David Sonnenberg[1], Andrei Schliwa[2], Christian Heyn[1], and Wolfgang Hansen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, 20355 Hamburg, Germany — [2]Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany

Local droplet etching (LDE) allows for a molecular beam epitaxy compatible self-assembled patterning of semiconductor surfaces. Using LDE with aluminum droplets, nanoholes with a defined depth up to 100 nm are drilled in AlGaAs surfaces. With the arsenic flux and the temperature during the LDE the shape, depth and density of the nanoholes are controlled [1]. Partial filling of the nanoholes with GaAs

provides highly uniform strain-free quantum dots (QD). Their shape is defined by the nanohole profile and the GaAs-filling level [2]. We study the QD shape dependence of the excitonic states with single-dot photoluminescence spectroscopy and compare the results with calculated transition energies. For the calculation, a basis of single-particle wave functions is determined with $\boldsymbol{k}\cdot\boldsymbol{p}$ theory, and configuration interaction is used to determine excitonic states [3].

[1] Sonnenberg et al., APL **101**, 143106 (2012)
[2] Heyn et al., APL **94**, 183113 (2009)
[3] Schliwa et al., PRB **76**, 205324 (2007)

HL 91.14 Thu 16:00 Poster A

Excitons in double quantum dots: Phonon effects and spin-orbit coupling — •Jonas Daniels[1], Paweł Machnikowski[2], and Tilmann Kuhn[1] — [1]Institut für Festkörpertheorie, Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster — [2]Institute of Physics, Wrocław University of Technology, 50-370 Wrocław, Poland

We investigate theoretically excitons in a double quantum dot system. As a function of an external electric field, the absorption spectrum exhibits various anticrossings. These can be attributed to different coupling mechanisms such as tunnel-coupling, Coulomb interaction or spin-orbit coupling. The linewidth of the exciton transitions depends on the interaction of the excitons with the phononic environment, which causes phonon-assisted relaxation as well as phonon-assisted tunneling especially at an anticrossing.

We investigate these phenomena for a pair of lens-shaped vertically aligned InAs/GaAs QDs. A variational method is used to calculate single-particle states, while Coulomb interaction is included within configuration-interaction. We calculate phonon-assisted relaxation rates caused by the deformation-potential coupling to longitudinal-acoustic (LA) phonons and the piezoelectric coupling to LA and transverse-acoustic (TA) phonons. Spin-orbit coupling is considered by the Dresselhaus or k^3-term.

HL 91.15 Thu 16:00 Poster A

Impact of longitudinal acoustic phonons on the excitation of quantum dots driven by chirped laser pulses — •Sebastian Lüker[1], Krzysztof Gawarecki[2], Martin Glässl[3], Anna Grodecka-Grad[4], Doris E. Reiter[1], Vollrath Martin Axt[3], Paweł Machnikowski[2], and Tilmann Kuhn[1] — [1]Institut für Festkörpertheorie, WWU Münster, 48149 Münster — [2]Institute of Physics, Wrocław University of Technology, 50-370 Wrocław, Poland — [3]Theoretische Physik III, Universität Bayreuth, 95440 Bayreuth — [4]Niels Bohr Institute, University of Copenhagen, DK-2100 Copenhagen Ø, Denmark

We theoretically investigate the impact of phonons on the excitation of quantum dots (QD) driven by chirped (frequency-swept) laser pulses, referred to as adiabatic rapid passage (ARP). The QD is modeled in the strong confinement limit as a two-level system, which is coupled to longitudinal acoustic phonons via the deformation potential.

A chirped pulse drives the system adiabatically along the spectral branch of the dressed eigenstates. Without coupling to phonons this results in a robust population of the exciton state for positive as well as for negative chirps. Transitions between the dressed states can occur by emission or absorption of phonons, which reduces the fidelity of the ARP. Because absorption of phonons is negligible at low temperatures, an asymmetry with respect to the sign of the chirp appears.

We calculate the system dynamics using a fourth order correlation expansion and compare our results to a time-convolutionless method and to numerically exact path integral calculations.

HL 91.16 Thu 16:00 Poster A

Carrier multiplication in a multi-level, colloidal quantum dot under the presence of phonons — •Mario Schoth, Franz Schulze, Andreas Knorr, and Marten Richter — Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Germany

Carrier multiplication (CM) in quantum dots (QD) has been proposed as a possible technique to further increase the efficiency of photovoltaic conversion [1,2]. In this process, the Auger-type Coulomb processes of impact ionization and Auger recombination lead to the creation of multiple electron–hole pairs per absorbed high–energy photon. The efficiency of such processes is reduced by competing relaxation channels, such as radiative recombination or relaxation via phonons [3]. In this contribution, we present a microscopically derived, dynamical model of CM in a single, multi-level, colloidal QD, where we consider the electron–electron- as well as the electron–phonon interaction. The finite size of the colloidal QD gives rise to a discretization of phonon modes, which we calculate for a spherical QD [4]. Using this parameter–free approach, we simulate the dynamics of exciton creation and annihilation, and investigate if CM is enhanced or suppressed by phonons.

[1] A.J Nozik, Physica E 14, 115 (2002)
[2] R.D. Schaller and V.I. Klimov, Phys. Rev. Lett. 92, 186601 (2004)
[3] F. Schulze, M. Schoth, U. Woggon, A. Knorr, and C. Weber, Phys. Rev. B 84, 125328 (2011)
[4] T. Takagahara, J. Lumin. 70, 129 (1996)

HL 91.17 Thu 16:00 Poster A

Time-resolved optical spectroscopy of colloidal quantum dots and gold nanoparticles with dye molecules — •Robert Malinowski, Uwe Kaiser, Mikko Wilhelm, Wolfram Heimbrodt, Faheem Amin, Dorleta Jimenez de Aberasturi, and Wolfgang Parak — Experimental physics of Philipps-University Marburg

We report about the opportunity to do multiplexed detection of different ionic species via ion-sensitive fluorophores. Multiplexed measurements can be made possible by coupling ion-sensitive fluorophores to different types of nanoparticles for biological sensor applications. These nanoparticles exhibit different radiative lifetimes and will act as donor for energy transfer to the ion-sensitive fluorophores as acceptors. As result the ion-sensitive fluorophores will obtain different effective lifetimes and can be read out in parallel via time-resolved detection of fluorescence. We investigate inorganic CdSe/ZnS core-shell quantum dots (QD) and gold nanoparticles (Au-NP) which are coated with amphiphilic polymers and functionalized by dye molecules. Main tasks are time resolved photoluminescence measurements of QD-dye and Au-dye mixtures in different concentrations. Using a laser (355nm) with pulse durations of a few nanoseconds, it is possible to characterize the time behavior of the photoluminescence decay of the dye molecules. By variation of the QD-dye to Au-dye ratio, the decay of the dye photoluminescence shows different behavior. The experimental results can be described and analyzed in the framework of a kinetic model. This opens up the possibility to determine the proportion of QD-dye and Au-dye for unknown mixing ratios by lifetime measurements.

HL 91.18 Thu 16:00 Poster A

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

Applying computational time dependent density functional techniques we analyse small structures of potential quantum dot material. In particular we focus on the absorbtion spectra as function of the cluster size, the composition, ligands and complexation.

HL 91.19 Thu 16:00 Poster A

Spatial resolved optical pH- and bias response of (In, Ga)N nanowires and quantum dots — •Sabrina Darmawi, Jens Wallys, Pascal Hille, Martin Eickhoff, and Peter J. Klar — I. Physikalisches Institut, JLU, Heinrich-Buff-Ring 16, 35392 Gießen

We present photoluminescence (PL) imaging measurements of GaN nanowire ensembles and InGaN quantum dots in electrolyte solutions of different pH in a three electrode setup. By application of external bias the PL intensity and its pH sensitivity can be controlled. A microscope system attached to the measurement chamber transfers a magnified image of the sample onto the slit of a subtractive double spectrometer which acts as a tunable band pass and allows for PL intensity imaging at different emission wavelengths with a CCD system. The response of the PL intensity of the sample to the pH value of the surrounding electrolyte and the applied bias will be discussed.

HL 91.20 Thu 16:00 Poster A

Photoluminescence intensity and lifetime of ordered arrays of GaN nanowires with different diameter and pitch — •Christian Hauswald, Oliver Brandt, Timur Flissikowski, Tobias Gotschke, Raffaella Calarco, Lutz Geelhaar, Holger T. Grahn, and Henning Riechert — Paul-Drude-Institut für Festkörperelektronik, Berlin

Selective-area growth (SAG) of nanowires (NWs) by molecular beam epitaxy constitutes an important step towards uniform III-V NW arrays on Si. Using this approach, the diameter and length distribution of self-induced GaN NWs can be significantly reduced as compared to the growth on non-patterned substrates.

In this work, we study the influence of different diameters and

pitches of selectively grown GaN NWs on their optical properties. The NWs have diameters and periods in the range of 110−260 nm and 0.3−1.0 μm, respectively. Time-integrated μ-photoluminescence (μ-PL) spectra at 10 K show a narrow linewidth, while the rather short decay times obtained by time-resolved PL measurements indicate a quite low internal quantum efficiency. We observe a monotonic decrease of the PL intensity with increasing NW diameter, although the PL decay times remain virtually constant. To investigate the origin of this effect, we use finite-element simulations to solve the Maxwell equations for the three-dimensional NW geometry. These simulations allow us to clarify whether the decrease in PL intensity is caused by a systematic change of the electromagnetic coupling to the ordered NW array.

HL 91.21 Thu 16:00 Poster A

Optical properties of organically-linked ZnO nanoparticles — •Carsten Kruska[1], Wolfram Heimbrodt[1], Christine Chory[2], Ingo Riedel[2], and Jürgen Parisi[2] — [1]Philipps-Universität Marburg — [2]Energy and Semiconductor Research, Oldenburg

To improve the efficiency of organic bulk heterojunction solar cells, accurate control of the nanoscale morphology is required. Due to phase segregation, controlling the morphology of normal solution-processed semiconductor blends is difficult. ZnO nanoparticles offer a sufficiently high electron affinity to replace the normal absorber in such systems. This study uses UV-Vis absorption and temperature-dependent photoluminescence measurements to investigate the optical properties of solution-processed three dimensional networks of ZnO nanoparticles. The covalent links between the ZnO nanoparticles and the bifunctional organic molecules could be observed for two different linker molecules. An organically linked network of ZnO nanoparticles was formed. Linking of nanoparticles with organic molecules yields an new material system which is relatively easy to process and have some promising properties as an absorber in semiorganic bulk heterojunction solar cells.

HL 91.22 Thu 16:00 Poster A

Group-IV nanocrystals: Spin-orbit coupling and optical properties from first principles — •Sebastian Küfner, Lars Matthes, Jürgen Furthmüller, and Friedhelm Bechstedt — Institut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, D-07743 Jena

The electronic structure of materials significantly changes due to spatial confinement. Consequently, nanostructures are interesting objects for manipulating electronic and optical properties. We use density-functional theory within local density approximation to calculate the electronic structure of α−Sn, Ge, and Si nanocrystals (NCs). We investigate the spin-orbit splitting of the highest occupied state and show that its size dependence appears to be not monotonic in case of Ge and Sn. We identify the spin-orbit splitted states by the degree of degeneracy and the symmetry of the wave-functions. In addition, we show how the size dependence of the electronic structure influences the optical absorption- and emission properties of the nanodots. Calculating the oscillator strengths, we identify the transitions resulting in the main contributions to the absorption spectra. Applying the ΔSCF method which considers many-body effects and screened Coulomb interaction, we calculate the optical Stokes-shifts depending on the NC-diameter as the difference between the lowest electron-hole excitation and recombination energy. We also give values for the corresponding radiative lifetimes.

HL 91.23 Thu 16:00 Poster A

Quantum emitters in whispering gallery mode resonators — •Assegid Flatae[1], Tobias Grossmann[1], Torsten Beck[1], Thomas Laue[2], Halald Fuchs[2], and Heinz Kalt[1] — [1]Institute of Applied Physics, Karlsruhe Institute of Technology (KIT), Wolfgang-Gaede-Str.1. 76131 Karlsruhe, Germany — [2]Institute of Nanotechnology, Karlsruhe Institute of Technology (KIT), Hermann-von-Helmholtz-Platz 1. 76344 Eggenstein-Leopoldshafen.

The high Q-factor and the small modal volume of whispering gallery mode resonators play an important role for the study of the interaction between the cavity mode and quantum emitters (e.g. semiconductor quantum dots (QDs)). We fabricated goblet shaped micro-resonators with high Q-factor of ten million using polymers and standard fabrication techniques. We attach QDs to single and coupled resonators using nanotechnological tools (e.g. dip-pen and fountain-pen nanolithography techniques) for the study of weak coupling (Purcell effect), lasing and possibly strong coupling between the emitters and the cavity photons.

HL 91.24 Thu 16:00 Poster A

Single-photon time-delayed feedback: a way to stabilize intrinsic quantum cavity electrodynamics — •Franz Schulze[1], Alexander Carmele[1], Julia Kabuss[1], Stephan Reitzenstein[2], and Andreas Knorr[1] — [1]Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Germany — [2]Institut für Festkörperphysik, Optoelektronik und Quantenbauelemente, Technische Universität Berlin, Germany

The control of non-classical photon states is of great importance in quantum information science and can be addressed, for example, by extrinsic [1] and intrinsic methods. We apply an intrinsic control scheme to cavity quantum electrodynamics (cQED) by utilizing quantum optical time-delayed self-feedback in the single-photon limit. In particular, we investigate theoretically how a single-emitter cavity system, operating initially in the weak coupling regime, is driven into the strong-coupling regime by introducing time-delayed optical self-feedback via an external mirror. This peculiar transition from weak to strong coupling manifests in Rabi oscillations, which start to emerge in the coupled cavity field dynamics. Our method treats the correlation between the external and the internal cavity photon field on a non-Markovian level. This quantum optical approach to time-delayed self-feedback opens new ways to experimentally control features of cQED in the single-photon limit.

[1] X. Zhou *et al.*, Phys. Rev. Lett. **108**, 243602 (2012)

HL 91.25 Thu 16:00 Poster A

Thermoelectric Properties of a Strongly Coupled Double Quantum Dot — •Holger Thierschmann[1], Michael Henke[1], Johannes Knorr[1], Wolfgang Hansen[2], Hartmut Buhmann[1], and Laurens W. Molenkamp[1] — [1]Physikalisches Institut, Experimentelle Physik 3, Universität Würzburg — [2]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg

We study the thermoelectric properties of a double quantum dot (DQD) in the low temperature regime under a temperature difference of a few 10 mK. Our sample consists of a lateral DQD system defined electrostatically by gate electrodes on top of a GaAs/AlGaAs-HEMT structure. By measuring the serial conductance of the DQD we yield a stability diagram from which we can extract the charging and coupling energies. We infer that the system is in the strong tunnel-coupling regime. For thermopower measurements we use the current heating technique to establish a temperature difference of approx. 20 mK across the DQD structure [1]. Measuring the thermovoltage across the serial DQD, we obtain a thermopower stability diagram. We find maximum thermovoltage in the corners of each stability region. In the vicinity of a tripel point we observe a strong asymmetry of the thermovoltage signal. This can be traced back to an asymmetric distribution of energy levels with respect to the Fermi-energy in the DQD system which is consistent within a simple DQD model.

[1] L.W. Molenkamp, H. van Houten, C.W.J. Beenakker, R. Eppenga, C.T Foxon, PRL 65, 1052(1990)

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Time-resolved transconductance spectroscopy: Towards all electrical spectroscopy of a single self-assembled quantum dot — •A. Beckel[1], D. Zhou[1], A. Kurzmann[1], B. Marquardt[1], A. D. Wieck[2], D. Reuter[2], M. Geller[1], and A. Lorke[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen, Lotharstraße 1, 47057 Duisburg, Germany — [2]Chair for Applied Solid State Physics, Ruhr-Universität Bochum, Universitätsstraße 150, 44780 Bochum, Germany

We have shown recently an all electrical preparation and probing of non-equilibrium (i.e. excited) states in an ensemble of self-assembled quantum dots (QDs) using a time-resolved measurement scheme [1,2].

In our high electron mobility transistor structure a two-dimensional electron gas (2DEG) is used as detector and reservoir for the QD states. Using a 2DEG offers sensitive, time-resolved detection via transconductance as well as ideal scaling properties to address a single self-assembled QD.

Electron beam lithography has been applied to process samples containing only $\sim$ 100 QDs. We present devices and measurements which show enhanced energy resolutions, beyond the inhomogeneous broadening of the QD ensemble. The additional information of the time-resolved measurement is used to attribute the measured spectrum to a set of QD sub-ensemble as well as attribute the tunneling processes to the shell structure of the involved QD states.

[1] B. Marquardt et al., Appl. Phys. Lett. **95**, 22113, (2009).
[2] B. Marquardt et al., Nature Commun. **2**, 209 (2011).

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Two-path Transport Measurements with Bias Dependence on a Triple Quantum Dot — •Monika Kotzian, Maximilian C. Rogge, and Rolf J. Haug — Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany

We present transport measurements on a lateral triple quantum dot with a star-like geometry and one lead attached to each dot. [1] The research on triple quantum dots is motivated by fundamental physics and by the fact that it can work as a single qubit. [2] Our sample design allows to simultaneously measure the conductance along two different paths with two quantum dots in each path. The structure is made with local anodic oxidation by AFM on a GaAs/AlGaAs heterostructure. By controlling the potentials quadruple points with all three dots in resonance can be established. [3,4] Using two of the leads as source and one lead as a drain contact, signatures of three dots can be detected in both transport paths. This setup provides the possibility of applying different bias voltages to the sources of the two paths and detecting excited states of the dots. Transport measurements in one path while varying the source-drain voltage on the other path show interesting features and prove interaction between the transport paths. The measurement results are compared with a simulation of the electrostatics of the triple dot system.

[1] M. C. Rogge, et al., Phys. Rev. B 77, 193306 (2008).
[2] P. Hawrylak, et al., Solid State Comm. 136 (2005), pp. 508-512.
[3] L. Gaudreau, et al., PRL 97, 036807 (2006).
[4] M. C. Rogge, et al., New Journal of Physics 11, 113037 (2009).

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Magnetic field modulation of RKKY interaction between quantum dots — •Alexander W. Heine[1], Katharina Janzen[2], Brendan Coughlan[2], Daniel Tutuc[1], 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

The spin of a quantum dot is proposed as a possible realization of a qubit in quantum information processes. One possible mechanism to control the spin of a quantum dot beyond the nearest neighbour approach is the Ruderman-Kittel-Kasuya-Yosida (RKKY) interaction, an indirect exchange between magnetic moments. To probe the RKKY interaction between two quantum dots, we use the Kondo effect as spectroscopic tool. At low temperatures between 25 mK and 900 mK and high magnetic field of 5 T we measure the differentieal conductance of the quantum dots. In the presence of RKKY interaction we observe a qualitative change of the temperature dependence with variation of the magnetic field.

Modelling our system and calculating the interaction strength by evaluating the Lindhard function yields the variation with magnetic field of the indirect exchange. We theoretically analyze the magnetic-field tuning of the Kondo singlet formation in a double-dot system.

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Thermal noise measurements of low-dimensional electron gases — •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 in low dimensional mesoscopic systems strongly differ from those of bulk material. We investigate the transport properties in 1D and 2D electron gases in the presence of temperature gradients. We apply Johnson noise thermometry to measure the spectral noise density in GaAs-AlGaAs heterostructures at temperatures below 10 K. The current heating technique allows us to create temperature gradients in 2D electron gases as well as in quantum point contacts. The cross-correlation technique and an improved measurement setup [1] enable a strong reduction of perturbation signals generated in ohmic contacts and leads. Non-local noise measurements on 1D electron gases at low temperatures have shown heat transport which is only carried by electrons. Our findings in local noise measurements differ from the expected Joule's law due to an anomaly in thermal noise as a function of heating current. We observe time dependence of Johnson noise in structures that fulfill certain conditions. We present the results of systematic measurements and discuss possibilities of their physical origin.

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

HL 91.30 Thu 16:00 Poster A

Study of Phase-Coherent Transport in Differently Doped InAs Nanowires — •Thomas Gerster[1], Sebastian Heedt[1], Isabel Wehrmann[1,2], Kamil Sladek[1], Hilde Hardtdegen[1], Detlev Grützmacher[1], and Thomas Schäpers[1,3] — [1]Peter Grünberg Institut (PGI-9) and JARA-Fundamentals of Future Information Technology, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]OSRAM Opto Semiconductors GmbH, 93055 Regensburg, Germany — [3]II. Physikalisches Institut, RWTH Aachen University, 52056 Aachen, Germany

We report on differently doped InAs nanowires grown epitaxially by selective area metalorganic vapor phase epitaxy. The nanowires are individually contacted with Ω-shaped top-gates using high-k dielectrics to investigate the low-temperature electronic transport properties. The band profile and the carrier concentration of the nanowires can be manipulated by the application of a gate voltage. At small current-bias, phase-coherent transport occurs and gives us the ability to determine the phase-coherence length l_ϕ and the spin relaxation length l_{so}. In our measurement setup, phase-coherent transport is investigated for temperatures down to 30 mK and magnetic fields up to 10 T. To extract l_ϕ and l_{so}, we make use of an analytical model for the low-field quantum conductivity correction. This model considers spin relaxation under linear Rashba and linear and cubic Dresselhaus spin-orbit coupling for diffusive wires with diameters smaller than l_ϕ. The impact of doping on the electron spin lifetime is studied for InAs nanowires fabricated under various doping conditions.

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Single-particle-reduced entropy for few-electron states in gated semiconductor nanowires — •Jose Maria Castelo[1], Klaus Michael Indlekofer[1], and Joerg Malindretos[2] — [1]RheinMain University of Applied Sciences, IMtech / Faculty of Engineering, D-65428 Rüsselsheim, Germany — [2]Georg-August-Universität Göttingen, IV. Physikalisches Institut, D-37077 Göttingen, Germany

We consider electronic transport within a coaxially-gated nanowire field-effect transistor (FET) in the Coulomb blockade regime by means of a non-equilibrium Green's function technique. Two different approaches are considered for the description of the Coulomb interaction: a many-body multi-configurational technique and a mean-field approximation. This allows us to calculate the single-particle density matrix ρ_1 of the nanowire channel for non-equilibrium conditions. In turn, we derive the single-particle-reduced entropy $S_1 = -Tr(\rho_1 \log_2 \rho_1)$ of the system as a function of the applied bias and gate voltages. S_1 can be interpreted as a measure of deviation from a single Slater-determinant. Within the multi-configurational approach, the numerically obtained entropy diagrams exhibit diamond-shaped structures, resembling the Coulomb diamonds present in the current-voltage characteristics in this transport regime. Finally, we compare the results with those which are obtained within the mean-field approximation.

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Torque magnetometry on doped semiconductor nanowires — •Susanne Goerke[1], Florian Herzog[1], Marc Wilde[1], Eleonora Russo-Averchi[2], Anna Dalmau-Mallerqui[2], Daniel Rüffer[2], Anna Fontcuberta i Morral[2], and Dirk Grundler[1,3] — [1]Physik.-Dep. E10, TU München, D-85748 Garching — [2]LMSC, IMX, EPF Lausanne, CH-1015 Lausanne — [3]STI, EPF Lausanne, CH-1015 Lausanne

Filamentary semiconductor nanocrystals exhibit novel electronic properties due to their large surface-to-volume ratio and strong one dimensional confinement. We intend to investigate the magnetic properties of ensembles of free-standing GaAs and InAs nanowires, grown on (111) Si substrates by molecular beam epitaxy. Due to doping, the nanowires contain charge carriers. At low temperature, magnetic quantum oscillations (de Haas-van Alphen effect) are expected which allow one to extract scattering times, electron densities, and information on electron-electron interaction. We report on our on-going experiment aiming at torque magnetometry on doped nanowires at 260 mK. Financial support by the DFG via GR1640/3 in SPP 1285, NIM, the SNF, QSIT and the ERC is gratefully acknowledged.