HL 31: Poster I: Devices, Quantum Dots and Quantum Wires

Time: Tuesday 18:30–20:30 Location: Poster D1

HL 31.1 Tue 18:30 Poster D1

Quantum Electrodynamics on a Chip — •Peiqing Jin[1], Alessandro Romito[1], Jared Cole[1], Alexander Shnirman[2], and Gerd Schön[1] — [1]Institut für Theoretische Festkörperphysik, Karlsruhe Institute of Technology, 76131 Karlsruhe — [2]Institut für Theorie der Kondensierten Materie, Karlsruhe Institute of Technology, 76131 Karlsruhe

Circuit QED [1], where a superconducting qubit, playing the role of an artificial atom, is coupled to an on-chip superconducting resonator, provides novel methods for studying quantum optics in electrical circuits and for realizing elements for quantum computing. Recently, single qubit lasing and cooling were demonstrated in such a system [2].

We investigate extensions of the circuit QED concepts to situations where the electron spin of an ensemble of quantum dots is coupled to a microwave resonator. The total spin of the electrons in the ensemble can be controlled via a train of laser pulses, as shown in recent experiments [3]. We explore the possibilities offered by such a spin manipulation to achieve Sisyphus amplification and damping of the resonator.

Reference: [1] A. Wallraff, et al., Nature 431, 162 (2004) [2] M. Grajcar, et al., Nature Physics 4, 612 (2008) [3] A. Greilich, et al, Science 317, 1896 (2007)

HL 31.2 Tue 18:30 Poster D1

Small and large signal analysis of quantum dot lasers — •Roland Aust[1], Christian Otto[1], Joshua Horowitz[2], Kathy Lüdge[1], and Eckehard Schöll[1] — [1]Institut f. Theoretische Physik, Sekr. EW 7-1, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin — [2]Massachusetts Institute of Technology, Cambridge

In this work a quantum dot laser with an external cavity is modeled using a rate equation system treating electron and hole dynamics separately and including microscopically calculated carrier-carrier scattering rates. We show under which conditions the model reproduces the dynamics of an experimental setup perfectly, and, which additional effects are observed by introducing the external cavity. The laser's small signal response is discussed in detail as well as a large signal analysis in terms of eye diagrams.

HL 31.3 Tue 18:30 Poster D1

Cavity design and heat management in Vertical-External-Cavity Surface-Emitting Lasers (VECSELs) — •Jens Herrmann[1], Alexej Chernikov[1], Martin Koch[1], Tsuei-Lian Wang[2], Yushi Kaneda[2], Mike Yarborough[2], Jörg Hader[2], Jerome V. Moloney[2], Bernardette Kunert[1], Wolfgang Stolz[1], Sangam Chatterjee[1], and Stephan W. Koch[1] — [1]Faculty of Physics and Material Sciences Center, Philipps-Universität Marburg — [2]College of Optical Sciences, University of Arizona, Tucson, USA

Vertical-External-Cavity Surface-Emitting Lasers (VECSELs) represent a combination of high output power, high efficiency and good beam quality with compact design in the infrared spectral range. Furthermore large areas of the visible spectrum are accessible due to high-speed frequency-doubled SDLs. In high-power applications cavity design combined with heat management is very important.

We experimentally investigate a model high-power device at 1040nm. The linear cavity consists of the semiconductor chip and a spherical external output coupler. The performance dependence on the reflectance of the output coupler is discussed before we vary the pump spot with the help of the pump optics.

Following we compared the impact of different materials (copper and diamond) for the heat spreader and different heat management concepts. The performance of the device, spectrally resolved emission and the characteristic, curve is investigated under comparable high-power pump conditions and cavity design. In the end the impact of different cavity designs on the performance of the device is compared.

HL 31.4 Tue 18:30 Poster D1

Design and Characterisation of InGaN-based vertical external cavity surface emitting lasers — •Ralph Debusmann[1], Nacef Dhidah[2], Veit Hoffmann[3], Leonhard Weixelbaum[3], Uwe Brauch[2], Markus Weyers[3], Michael Kneissl[1], and Patrick Vogt[1] — [1]Institut für Festkörperphysik, TU-Berlin, EW 6-1, Hardenbergstr. 36, 10623 Berlin — [2]Institut für Strahlwerkzeuge, Universität Stuttgart, 70569 Stuttgart — [3]Ferdinand-Braun-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 4; 12489 Berlin

Optically pumped semiconductor disk lasers (SCDL) with external resonator allow the scaling of laser sources to higher output power levels with diffraction limited beam quality. This idea has already been successfully demonstrated in the infrared spectral region with SCDL based on the material system InGaAs. Here we present a SCDL emitting in the blue-violet wavelength region that is based on the material system InGaN. We have investigated different designs of the InGaN quantum well active region, in particular the application of a resonant periodic gain (RPG) structure and the influence of the cavity length onto the device parameters.

We will discuss implications for the design of the active region besides the presentation of basic device parameters i.e. output-power vs. pump-power, slope efficiency and the far- and near-field pattern.

Pumped by a pulsed nitrogen laser at 337 nm emission wavelength and pulse width of 3 ns the SCDL emits at a wavelength of 394 nm with a threshold power density of 700 kW/cm^2 and a peak output power of 300 W. The conversion efficiency is 3.5

HL 31.5 Tue 18:30 Poster D1

Micro-Printing Setup for Selective Biofunctionalization of Micro-Resonators — •Julian Fischer[1], Torsten Beck[1], Simone Schleede[1], Mario Hauser[1], Tobias Grossmann[1,2], Christoph Vannahme[2], Timo Mappes[2], and Heinz Kalt[1] — [1]Institut für Angewandte Physik, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany — [2]Institut für Mikrostrukturtechnik, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Optical resonators with rotational symmetry like micro-spheres and micro-toroids have been introduced for label-free biomolecule detection. Semiconductor fabrication methods in combination with reflow processes are used to build high-Q optical cavities made of silica or PMMA. Whispering gallery-modes that are excited in the resonators polarize molecules attached to the resonator. This leads to a shift of the mode frequencies. For the parallel detection of different types of bio-molecules, each resonator on a chip has to be functionalized for a specific type of molecules. Therefore a high-voltage micro-printer was set up. A pipette (tip diameter 10-50 μm) is fabricated by thermally extending a glass capillary tube using a standard glass tube puller. A shaped electric pulse is amplified to high voltage ($\sim$ 1kV). The amplifier is connected to the capillary as anode and the substrate holder as cathode. The high electric field due to the voltage pulse generates a droplet impinging on the substrate. The scope of this economic and robust technique, that allows the precise depletion of femto- to nanoliters droplets, is presented.

HL 31.6 Tue 18:30 Poster D1

Oxygen vacancies in ultrathin gate dielectric of MOSFETs and their influence on the leakage current: an ab initio investigation — •Ebrahim Nadimi[1,2], Philipp Plänitz[1,2], Christian Radehaus[2], and Michael Schreiber[1] — [1]Institut für Physik, Technische Universität Chemnitz, D-09107 Chemnitz, Germany — [2]GWT-TUD GmbH - Geschäftsstelle Chemnitz, Annaberger Str. 240, D-09125 Chemnitz, Germany

Oxygen vacancies are known to be the dominant defect in dielectric layer of the MOSFET transistors and are responsible for stress induced leakage current (SILC) as well as degradation of the the gate oxide. In this work a combination of density functional theory (DFT) within the generalized gradient approximation (GGA) and non-equilibrium Green*s function formalism (NEGF) as implemented in ATOMISTIX TOOLKIT 2.0 (ATK) has been applied to investigate neutral oxygen vacancies in the vicinity of Si/SiO_2 interface. The formation energy of single and double oxygen vacancies at different layers of the oxide, the correlation between the position of vacancies and the carrier tunneling probability as well as the tunneling probability through vacancy chains have been investigated. The single vacancies are shown to be energetically more stable at the Si/SiO_2 interface, where unfortunately they have destructive impact on the leakage current. The formation energies of different arrangements of two vacancies indicate an attractive interaction between them. A chain of five vacancies is shown to drastically increase the leakage and could build a percolation path which results in an electrical breakdown of the dielectric.

HL 31.7 Tue 18:30 Poster D1

High-gain integrated inverters based on ZnO MESFET technology — •Friedrich Schein, Heiko Frenzel, Alexander Lajn, Holger von Wenckstern, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut fürExperimentelle Physik II, Linnéstr. 5, 04103 Leipzig

We combine Schottky diodes and metal-semiconductor field-effect transistors (MESFETs), both based on ZnO and MgZnO thin films grown by pulsed-laser deposition, to fabricate integrated inverters. The MESFETs exhibit low switching voltages which are about one order of magnitude smaller than that for metal-insulator-semiconductor FETs, channel mobilities up to $27\,\mathrm{cm}^2/\mathrm{Vs}$ and with that faster switching speeds [1]. The integrated circuit design approach used here is known from GaAs technology as Schottky diode FET logic (SDFL) [2]. Our SDFL inverters show high peak gain values up to 197 at 3 V operating voltage and low uncertainty levels in the range of 0.13 V. By adding one additional Schottky diode, we successfully fabricated a NOR-gate, allowing the creation of a complete ZnO-based logic.

[1] H. Frenzel *et al.*, Appl. Phys. Lett., **92**, 192108 (2008)
[2] R. C. Eden *et al.*, IEEE JSSC **SC-13**, 419 (1978)

HL 31.8 Tue 18:30 Poster D1

Characterization of interface traps in stable and efficient Tb-implanted SiO_2 light-emitting devices — •Michael Seeger, Lars Rebohle, Jan Lehmann, Wolfgang Skorupa, Manfred Helm, and Heidemarie Schmidt — Forschungszentrum Dresden-Rossendorf e. V., Bautzener Landstr. 400, 01328 Dresden

The strong green electroluminescence from the Tb^{3+} ions in SiO_2 is excited by hot electrons from the conduction band of the SiO_2 matrix in metal oxide semiconductor light emitting devices (MOSLED)[1]. Charge trapping in the oxide layers and at the oxide layer-semiconductor interface cause a short lifetime of the MOSLED.

This has been investigated by means of frequency dependent admittance-voltage measurements to determine if the MOSLED will perform satisfactorily for different annealing times. Our results on unimplanted MOSLEDs reveal the largest interface trap density of 10^{13} $\mathrm{eV}^{-1}\mathrm{cm}^{-2}$ for 60 s rapid thermal annealing at 1000°C. Also the effect of Tb^+ implantation on interface trap properties in MOSLEDs containing double-stacked dielectric layers has been investigated. Quasistatic charge-voltage (QV) measurements have been used to probe the interface trap occupancy versus voltage.

[1] J. M. Sun, W. Skorupa, T. Dekorsy, M. Helm, L. Rebohle, T. Gebel, *Bright green electroluminescence from Tb^{3+} in silicon MOS devices*, J. Appl. Phys. **97**, 123513 (2005).

HL 31.9 Tue 18:30 Poster D1

Analyse der Verstärkungs- und Rekombinationsprozesse in blauen InGaN Laserdioden mittels Kleinsignalmodulationsmessungen — •Jens Müller, Manfred Scheubeck, Sönke Tautz, Georg Brüderl, Sarah Fröhlich, Dimitri Dini, Andreas Breidenassel, Teresa Lermer und Stephan Lutgen — OSRAM Opto Semiconductors GmbH, Leibnizstr. 4, 93055 Regensburg

Blaue InGaN-Laser mit Wellenlängen von 450nm dienen als Lichtquelle für mobile Projektionsanwendungen. Eine möglichst hohe Modulierbarkeit ermöglicht dabei eine größere Bildauflösung. Die Antwort des Laserlichts auf eine frequenzabhängige Kleinsignalmodulation des Stroms lässt sich dabei durch die gekoppelten Differenzialgleichungen für Ladungsträger- und Photonendichte im Laserresonator beschreiben. Als Lösung für die optische Leistung ergibt sich ein harmonischer Oszillator mit einer Resonanzfrequenz und einem Dämpfungsfaktor. Eine direkte Bestimmung der Resonanzfrequenz gestaltet sich aber aufgrund parasitärer Effekte schwierig. Durch Subtraktion zweier frequenzabhängiger Antwortfunktionen konnten jedoch Resonanzfrequenzen von 1-2GHz für blaue InGaN Laser ermitteln werden. Aus der Stromabhängigkeit der Resonanzfrequenz ließ sich darüber hinaus der Gewinnkoeffizient g0 des logarithmischen Gewinnmodells bestimmen. Hierzu wurde zunächst aus Abgleich eines einfachen Rekombinationsmodels mit Ladungsträgerlebensdauer- und Quanteneffizienzmessungen die Ladungsträgerdichte an der Laserschwelle sowie die Rekombinationsparameter bestimmt. Hiermit ergab sich ein Gewinnkoeffizient von 7500/cm.

HL 31.10 Tue 18:30 Poster D1

Crack-free AlGaN-based UV LED on Si(111) substrate — •P. Saengkaew, A. Dadgar, J. Bläsing, H. Witte, M. Müller, K. M. Günther, T. Fey, B. Bastek, F. Bertram, M. v. Kurnatowski, M. Wieneke, T. Hempel, P. Veit, R. Clos, J. Christen, and A. Krost — FNW/IEP/AHE Otto-von-Guericke-Universität Magdeburg

To achieve low-cost UV LEDs on large-diameter substrates it is a very interesting approach to grow AlGaN on low-cost Si substrates. Here, AlGaN layers and AlGaN LED structures grown on Si(111) were additionally monitored by in-situ curvature measurements. They show that with the insertion of AlN-based SL buffer layers and LT-AlN interlayers, the AlGaN layers are under compressive stress during growth enabling to compensate tensile stress after cooling. To characterize the crystalline quality, HR-XRD measurements were performed. Cross-sectional TEM to investigate dislocation propagation and annihilation. N- and p- conductivities were achieved by Si and Mg doping of the layers, respectively. By C-V and Hall-effect measurements, the maximum free-electron concentration of 2.6E+18 cm-3 and free-hole concentration of 2.4E+17 cm-3 by using a structure of Mg-doped GaN/Al0.1Ga0.9N multilayers for the latter were determined. A GaN/Al0.1Ga0.9N MQW structure showed near UV-luminescence around 350-360 nm. The optical and electrical properties of AlGaN-based LED samples were further characterized by I-V, EL, PL and CL measurements. The I-V measurements show forward-diode characteristics with turn-on voltage about 2.6-3.1 V.

HL 31.11 Tue 18:30 Poster D1

AlInN-BASIERTE HYBRIDE VCSEL STRUKTUREN — •Pascal Moser., Armin Dadgar, Alexander Franke, Jürgen Bläsing, Thomas Hempel, Jürgen Christen und Alois Krost — Institut für experimentelle Physik, Otto-von-Guericke-Universität Magdeburg

Hybride nitrid-basierte VCSEL Strukturen, welche mittels metallorganischer Gasphasenepitaxie gewachsen wurden, werden praesentiert. Die Strukturen wurden auf 2-Zoll c-achsenorientiertem Saphirsubstrat in einem AIXTRON 200/4 RF-S Reaktor gewachsen. Auf einer AlN/AlGaN-Keimschicht wurde ein ca. 2 mikrometer dicke GaN-Bufferschicht gewachsen. Dieser enthaelt eine Niedertemperatur AlN-Schicht, welche die im Spiegel auftretende Spannung kompensiert und eine SiN-Maske, um die Versetzungdichte zu reduzieren. Der darauf abgeschiedene epitaktische 30-40 fach Spiegel enthält die GaN und AlInN lambda/4-Schichten, welche entsprechend unserer Zielwellenlaenge von 430 nm eine Dicke von 47.1 nm für AlInN bzw. 43.2 nm für GaN aufweisen. Die mit einen In0.15Ga0.85N (2.1 nm) / GaN:Si (5.0 nm) Mehrfachquantengraben versehende 3/2 lambda Kavitaet wurde direkt auf dem Spiegel gewachsen, sodass abschließend ein oberer dielektrischer Ta2O5 / SiO2 Spiegel mit Elektronenstrahlverdampfung deponiert werden konnte.

HL 31.12 Tue 18:30 Poster D1

Enhanced light emission from nitride based UV light-emitting diodes using multifinger contact geometry — •M. Hoppe[1], N. Lobo[2], H. Rodriguez[1], A. Knauer[1], V. Küller[1], P. Vogt[2], S. Einfeldt[1], M. Weyers[1], and M. Kneissl[1,2] — [1]Ferdinand-Braun-Institut für Höchstfrequenztechnik, Berlin, Germany — [2]Technische Universität Berlin, Institut für Festkörperphysik, Berlin, Germany

For ultraviolet LEDs, current crowding at the edges of large area contacts is a serious issue due to low mobility and low donor activation in the n-AlGaN current spreading layer resulting in a high resistivity. It is hence necessary to switch from a simple square contact to more sophisticated contact geometries. In this work, the influence of a multifinger contact geometry on the emission characteristics of 320 nm and 380 nm LEDs has been studied. The emission and the heating of LEDs with constant total contact areas but varying finger widths have been investigated. Experimental LI-curves and their thermal roll-over and wavelength shift are compared with simulations of current and heat distribution in the LEDs. Data shows that as the finger width decreases from 150 μm to 10 μm the maximum optical output power, which is limited by the self-heating of the unmounted device, increases by 50% for the 380 nm LED. For the 320 nm LED a rise in power of 44% is found when the finger width decreases from 100 μm to 20 μm. Corresponding simulations reveal that the maximum device temperature decreases with the finger width.

HL 31.13 Tue 18:30 Poster D1

Electrical characterization of metal contacts on p-doped Galliumnitride nanowires — •Jörg Kinzel[1], Ahsan Nawaz[1],

Jens Ebbecke[2], Raffaella Calarco[3], Toma Stoica[3], Hubert Krenner[1], and Achim Wixforth[1,4] — [1]Lehrstuhl für Experimentalphysik 1, Universität Augsburg, Germany — [2]NanoSYD - Mads Clausen Institute, University of Southern Denmark, Sønderborg, Denmark — [3]Institute of Bio- and Nanosystems (IBN-1), Research Centre Jülich GmbH, Germany — [4]Center for NanoScience, Ludwig-Maximilians-Universität, München, Germany

GaN nanowires as a Group III-nitride semiconductor offer an interesting potential for optoelectronics and nano-electronics devices running at ambient temperatures.

We report on recent investigations on the realization of electric contacts on p-doped GaN nanowires. After growth of the NW by molecular beam epitaxy with in situ Magnesium doping we define individual metal source-drain electrodes by electron-beam lithography. We study the characteristics of different metal contact material combinations. The fabricated contacts and the influence of rapid thermal annealing steps are characterized by IV-measurements at room temperature. We find that Ti/Au contacts commonly used for n-type GaN exhibit poor contact properties in contrast to combinations using Ag or Pd to contact the wire.

HL 31.14 Tue 18:30 Poster D1

Analysis of contact resistance for p-type GaN — •Majdi Salman, Uwe Rossow, and Andreas Hangleiter — Institut für Angewandte Physik, TU Braunschweig

The overall efficiency of optoelectronic devices such as light emitting diodes (LEDs) or laser diodes (LDs) is strongly affected by the contact resistance of metal contacts, in particular at high current densities. To measure the contact resistance, one typically uses the "transmission line method" (TLM) with rectangular contact geometry or Reeves' CTLM method with circular contacts. In this contribution we study the impact of the rather high resistivity of typical p-type GaN layers on the TLM or CTLM analysis. Using state-of-the-art MOVPE-grown p-type GaN layers with specific resistivities down to 0.8 Ωcm together with Ni/Au- and Pt-based contacts we investigate the influence of the contact geometry, the specific resistivity of the p-GaN layer, and the thickness of the p-type layer on the TLM results. We discuss a simple model explaining the experimental results.

HL 31.15 Tue 18:30 Poster D1

Combining shallow etched quantum wires and sub-micron top gates for acoustoelectric quantum devices — •Marcin Malecha[1], Hubert J. Krenner[1], Jens Ebbecke[2,3], and Achim Wixforth[1,3] — [1]Institut für Physik, Universität Augsburg, 86135 Augsburg — [2]Mads Clausen Institute, University of Southern Denmark, Alsion 2, DK-6400, Sonderborg — [3]Center for NanoScience (CeNS), Geschwister-Scholl-Platz 1, 80539 München

Nanostructures, such as quantum wires (QWRs) or quantum dots (QDs), are considered to be the future of the electronics and therefore widely under investigation. Basically the operation of such devices bases upon the controlling of electric potentials on mesoscopic lengthscales within the devices and the leads. We are investigating new sample designs on AlGaAs/GaAs heterostructures where two fabrication processes - shallow etched QWRs and sub-micron sized evaporated topgates - are combined. From this approach we expect a robust QWR definition by the etched structure and precision tuning of the potential landscape along the QWR by the topgates. The goal is a highly controllable system where we are able to transport single electrons e.g. via QD levels using surface acoustic waves. Here electrons are transported in potential valleys, which move along with the wave. We present first characterization experiments of devices combining both fabrication steps.

HL 31.16 Tue 18:30 Poster D1

Mg-doped GaN nanowires: Their optical and morphological properties — •Friederich Limbach[1], Toma Stoica[1], Roberta Caterino[1], Eike Oliver Schäfer-Nolte[1], Tobias Gotschke[1], Eli Sutter[2], and Raffaella Calarco[1] — [1]Institute of Bio- and Nanosystems (IBN-1), Research Center Jülich GmbH, D-52425 Jülich, Germany, and JARA-Fundamentals of Future Information Technology — [2]Center for Functional Nanomaterials, Brookhaven National Laboratory, Upton, New York 11973, USA

High crystal quality GaN nanowires doped by Mg were obtained using plasma assisted molecular beam epitaxy growth in N-rich conditions. The influence of the growth temperature on the morphology, structural and optical properties of NW growth is studied. An additional Mg flux increases the tendency of the wires to coalesce. The morphology of the doped wires with respect to their undoped counterpart is otherwise not changed. With decreasing substrate temperature the NW density decreases, at the same time the coalescence is enhanced.

The samples have been investigated by means of photoluminescence (PL) as well as Raman spectroscopy. By increasing the Mg doping and reducing the deposition temperature, the ultra violet (UV) luminescence band due to Mg doping increases with respect to the near band edge emission. In addition the dominance of D^0X_A emission of the near band edge peak is diminished and an increased contribution of the A^0X_A can be observed. Raman spectroscopy indicates that there is no significant degradation in material quality due to Mg supply during growth.

HL 31.17 Tue 18:30 Poster D1

Selective area growth of InAs nanowires by molecular beam epitaxy — •Christian Blömers, Mihail Ion Lepsa, Thomas Grap, Thomas Schäpers, Hans Lüth, and Detlev Grützmacher — Institute of Bio- and Nanosystems (IBN-1) and JARA - Fundamentals of Future Information Technology, Forschungszentrum Jülich GmbH, D-52425 Jülich

We report on the growth of InAs nanowires by selective area molecular beam epitaxy. Semiconductor nanowires are interesting for future nanoscale devices and furthermore provide an easy way to study quantum effects in one dimensional structures. InAs is particularly attractive because of its low direct band gap, low effective mass and high mobility making it suitable for electronic (charge and spin related) and optoelectronic applications. A critical issue for the fabrication of nanowire devices is the ability to control the position of the grown wires on the substrate. For this purpose, we have used a SiO_x (Hydrogen silsesquioxane, HSQ) mask with hole patterns. The nucleation of the nanowires takes place in the holes, leading to selectively grown nanowire arrays. Other methods use arrayed metal particles (e.g. Au) which catalyze the growth of the wires. In contrast, our method has the advantage that the wires are of high purity and without contamination of metal atoms. We show results obtained for different growth conditions (varying substrate temperature, beam-fluxes of In and As), different substrates (InP and GaAs) and different preparation methods of the holes in the HSQ.

HL 31.18 Tue 18:30 Poster D1

Fabrication and electrical characterization of silicon nanowires synthesized via electroless etching method — •Guodong Yuan[1], Saskia F. fischer[1], Dennis König[2], and Alfred Ludwig[2] — [1]Fakultät für Elektrotechnik und Informationstechnik, Ruhr-Universität Bochum, Bochum — [2]Fakultät für Maschinenbau, Ruhr-Universität Bochum, Bochum

Silicon nanowires have attracted much attention recently due to their potential applications in future nanoelectronic devices and integrated nanosystems. A facile electroless etching method has been demonstrated for preparing large-area single crystalline silicon nanowire arrays[1]. This novel approach for silicon nanowires is fascinating with respect to the traditional chemical vapour deposition (CVD) method with vapour-liquid-solid (VLS) mechanism, which always needs high temperature, hazardous precursors, expensive source materials and complex vacuum furnace systems. With the catalysis of metallic Ag particle covering on the surfaces of silicon wafer, electroless etching was conducted in aqueous solution of HF and H_2O_2 at room temperature. The as-synthesized silicon nanowire arrays have an epitaxially single crystal structures, a diameter distribution of 50-300nm and controllable length up to 50μm. Electrical transport properties on single silicon nanowire are intestigated. [1] K. Q. Peng, et al, Angew. Chem., Int. Ed. 2005, 44, 2737.

HL 31.19 Tue 18:30 Poster D1

Individual GaAs nanorods imaged by coherent X-ray diffraction — Ullrich Pietsch[1], •Andreas Biermanns[1], Anton Davydok[1], Hendrik Paetzelt[2,4], Ana Diaz[3], Volker Gottschalch[2], and Hartmut Metzger[3] — [1]Universität Siegen, Germany — [2]Universität Leipzig, Germany — [3]ID01 beamline, ESRF, France — [4]IOM Leipzig, Germany

Semiconductor nanorods are of particular interest for new semiconductor devices because the nanorod approach can be used to form heterostructures of materials with a large lattice mismatch and to define nanorod arrays with tailored inter-rod distance. However, all applications require objects with uniform physical properties based on uniform morphology. Complementary to electron microscopy techniques, destruction free X-ray diffraction techniques can be used to determine structural and morphological details. Using scanning x-ray diffraction microscopy with a spot size of 220x600 nm^2 we were able to inspect individual GaAs nanorods grown by seed-free MOVPE through circular openings in a SiN_x mask in a periodic array with 3 μm spacing on GaAs[111]B. The focussed x-ray beam allows the determination of the strain state of individual rods and in combination with coherent diffraction imaging, we were able to characterize also morphological details. Rods grown at different positions in the array show significant differences in shape, size and strain state.

HL 31.20 Tue 18:30 Poster D1

Influence of SiO_2 matrices on electronic and optical properties of silicon nanocrystals — •Kaori Seino[1], Friedhelm Bechstedt[1], and Peter Kroll[2] — [1]nstitut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität, Jena, Germany — [2]Department of Chemistry and Biochemistry, University of Texas at Arlington, Arlington, TX, USA

In recent years, there has been considerable interest in nanostructured silicon since it is a promising material for quantum devices of next generations. Nanocrystals (NCs) have attracted much attention due to the effects of the quantum confinement. Effects due to the confinement of electrons and holes in a region of reduced dimensions promise to overcome the limitation of the indirect-gap semiconductor Si for optoelectronic applications.

We perform calculations of Si dots in SiO_2 matrices for various dot sizes by means of density functionary theory within the local-density approximation (DFT-LDA). Many theoretical results are available for isolated NCs, e.g. hydrogenated Si NCs or partially or fully oxidized Si NCs. On the other hand, theoretical studies for Si NCs embedded in SiO_2 are limited. In our approach amorphous SiO_2 is used as matrix region, which leads to first calculations of electronic and optical properties within a realistic model. We demonstrate the strong influence of SiO_2 matrix on the electronic and optical properties of nanocrystalline silicon.

HL 31.21 Tue 18:30 Poster D1

Ion beam doped semiconductor nanowires for energy applications — •Steffen Milz[1], Vladimir Sivakov[2], Gerald Brönstrup[2], Martin Gnauck[1], Raphael Niepelt[1], Silke Christiansen[2], and Carsten Ronning[1] — [1]Institute of Solid State Physics, University of Jena, Germany — [2]Institute of Photonic Technology, Albert Einstein Straße 9, D-07745 Jena, Germany

Semiconductor nanowires are attractive candidates for thermoelectric and photovoltaic devices due to an increased thermoelectric figure of merit (ZT-value) compared to bulk material and supreme light scattering and absorption performance. In both cases, p- as well as n-type doping is necessary, but doping of nanowires during growth is difficult and inaccurate. Ion implantation was used instead in order to overcome these limitations. However, ion implantation causes also damage, which can be removed by subsequent annealing procedures. In this presentation we report on simple thermoelectric devices based on etched Si nanowires, as well as on photovoltaic devices based on VLS grown Si and ZnO nanowires.

HL 31.22 Tue 18:30 Poster D1

Ion Beam Induced Alignment of Semiconductor Nanowires — Christian Borschel[1], •Susann Spindler[1], Raphael Niepelt[1], Sebastian Geburt[1], Christoph Gutsche[2], Ingo Regolin[2], Werner Prost[2], Franz-Josef Tegude[2], Daniel Stichtenoth[3], Daniel Schwen[4], and Carsten Ronning[1] — [1]Institute for Solid State Physics, University of Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [2]Institute for Semiconductor Technology, University of Duisburg-Essen, Lotharstraße 55, 47057-Duisburg, Germany — [3]II. Institute of Physics, University of Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [4]Department of Materials Science and Engineering, University of Illinois, 1304 W. Green St., Urbana, IL 61801, USA

Epitaxially grown GaAs nanowires were irradiated with different kinds of energetic ions. The growth substrates were <100> GaAs, and the nanowires grow under an angle of 35°. A bending of the nanowires was observed under ion beam irradiation, where the direction and magnitude of the bending depends on the energy, the species, and fluence of the incident ions. By choosing suitable ion beam parameters the nanowires could be realigned towards the ion beam direction. In order to understand the underlying mechanisms, computer simulations of the ion irradiation were done using a special version of TRIM which accounts for the geometry of the nanowires. The simulated distributions indicate vacancy and interstitial formation within the implantation cascade as the key mechanism for bending.

HL 31.23 Tue 18:30 Poster D1

Nanostructured Graphene Devices — •Jan Dauber[1], Bernat Terres[1], and Christoph Stampfer[1,2] — [1]JARA-FIT and II. Institute of Physics, RWTH Aachen, Germany — [2]Institute of Bio and Nanosystems, FZ Jülich, Germany

Graphene is the first real two-dimensional solid consisting of a hexagonal lattice of carbon atoms, revealing a high carrier mobility and quantum Hall effect even at room temperature. First graphene quantum devices have been recently demonstrated, such as graphene nanoribbons, quantum interference devices, graphene single electron transistors and quantum dots. Here, we report on the fabrication and characterization of nanostructured graphene devices based on width-modulated graphene nanoribbons. The graphene nanodevices are fabricated by mechanical exfoliation, lithography and dry etching techniques. We show that to a large extend the device functionality can be engineered by the shape of the nanostructured device. Finally, we discuss the electrostatic tunability of graphene nanodevices.

HL 31.24 Tue 18:30 Poster D1

Magnetotransportmeasurements on epitaxially grown GaAs/(Ga,Mn)As core-shell nanowires — •Christian Butschkow, Stefan Geissler, Silvia Schmidmeier, Andreas Rudolph, Dieter Schuh, Elisabeth Reiger, Matthias Kiessling, Christian Back, and Dieter Weiss — Institut für Experimentelle und Angewandte Physik , Universität Regensburg, Deutschland

We performed magnetotransport measurements on epitaxially grown GaAs/(Ga,Mn)As core-shell nanowires to investigate the magnetic anisotropies of individual nanowires. We found an uniaxial anisotropy with a magnetic hard axis perpendicular to the axis of the nanowire in agreement with SQUID characterizations done on an ensemble of identically grown nanowires. Depending on the direction of magnetization with respect to the nanowire axis, a single domain-switching process takes place at applied fields between 200 mT (parallel configuration) and 1.7 T (near perpendicular configuratian). For saturating the nanowire in the perpendicular configuration a magnetic field of more than 3 T is required. Sweeping the applied magnetic field to high values we observe a rather high negative magnetoresistance if compared to(Ga,Mn)As-films. Furthermore, we determined a Curie-Temperature of about 18K by transport measurements, which is consistent with the results of the SQUID characterizations.

HL 31.25 Tue 18:30 Poster D1

Phonon-mediated vs. Coulombic Back-Action in Quantum Dot circuits — •Daniel Harbusch[1], Daniela Taubert[1], Peter Tranitz[2], Werner Wegscheider[3], and Stefan Ludwig[1] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany — [2]Institut für Experimentelle Physik, Universität Regensburg, Regensburg, Germany — [3]Laboratory for Solid State Physics, ETH Zürich, Zürich, Switzerland

Biased quantum point contacts (QPC) are commonly employed to detect the charge states of qubits composed of coupled quantum dots (QD). Although a biased QPC can be a very sensitive charge detector, it emits energy that can be reabsorbed by the nearby QDs and thereby cause unwanted decoherence. We investigate such back-action of a QPC charge detector on coupled QDs.

Our nano-devices are defined by means of Schottky gates on the surface of a GaAs/AlGaAs heterostructure containing a two-dimensional electron system with an electron temperature of T $\approx$ 100 mK.

Here we observe indirect back-action of a biased QPC onto a double QD. Energy is emitted by non-equilibrium charge carriers in the leads of the biased QPC. Part of this energy is reabsorbed by the double QD where it causes charge fluctuations. The latter can be observed under certain conditions in the stability diagram of the double QD. By investigating the spectrum of the absorbed energy, we identify two different mechanisms mediating the back-action, namely acoustic phonons and Coulomb interaction. Depending on coupling constants and the geometry of the device either of the two mechanisms can be dominant.

HL 31.26 Tue 18:30 Poster D1

Scattering of hot electrons in 1D versus 2D — •Daniela Taubert[1], Georg Schinner[1], Hans-Peter Tranitz[2], Werner Wegscheider[3], and Stefan Ludwig[1] — [1]Center for NanoScience and Fakultät für Physik, Ludwig-Maximilians-

Universität, Geschwister-Scholl-Platz 1, 80539 München, Germany — [2]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany — [3]Solid State Physics Laboratory, ETH Zurich, 8093 Zurich, Switzerland

We measure the energy relaxation of excited electrons in high mobility two-dimensional electron systems (2DES). If hot electrons scatter with the cold degenerate Fermi sea, they exite additional electrons which leave behind conduction band holes. In a suitable three-terminal device, injection into one contact followed by separation of electrons and holes by a gate-defined barrier can lead to an amplification of the injected electron current. From this amplification effect, we extract information about the scattering processes in form of e.g. energy and power dependence.

By applying a perpendicular magnetic field, we observe the crossover from scattering in two dimensions to electrons moving in 1D edge channels.

For energies above 36 meV, emission of optical phonons becomes a relevant scattering process. In a high magnetic field, electron-electron scattering is reduced but electrons relax very efficiently by emission of optical phonons, which can be observed as a periodic reduction of the amplification effect with a period of 36 meV, up to 11th order.

HL 31.27 Tue 18:30 Poster D1

Temperature dependent study of counting statistics of electron transport through a quantum dot — •Nandhavel Sethubalasubramanian, Lukas Fricke, Christian Fricke, Frank Hohls, and Rolf J Haug — Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstr. 2, 30167 Hannover, Germany

Study of fluctuations in current through a semiconductor device provides information about the transport dynamics of the charges involved in transport through the device. The fluctuations are indirectly and discretely measurable using Quantum Point Contacts as charge detectors. Full counting statistics of mean, variance and higher moments are determined, which provide new information about the system. The work to be presented investigates the effects of temperature and asymmetric tunneling rates across the dot and the evolution of the counting statistics due to these effects. The device under investigation is fabricated through local anodic oxidation on a GaAs/AlGaAs heterostructure. The current study also investigates the statistics of transport through the dot, due to excited electrons.

HL 31.28 Tue 18:30 Poster D1

Noise measurements of a quantized charge pump — •Lukas Fricke[1], Niels Maire[1], Frank Hohls[1], Bernd Kästner[2], Christoph Leicht[2], Philipp Mirovsky[2], Hans Werner Schumacher[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstr. 2, 30167 Hannover — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

Delivering a quantized number of electrons per cycle in a reliable fashion and at high repetition rate could satisfy the need for a current-quantum standard. A promising candidate is the non-adiabatic electron pump in semiconductor nanostructures, especially considering parallelization of these devices for higher current outputs.

We performed low frequency ($f_n < 10$ kHz) current-noise measurements [1] of such a device at a pumping frequency of $f_p = 600$ MHz. We observe a strong suppression of the noise power when the current is quantized in good agreement with a prediction for an ideal pump whereas in the intermediate region between two quantization plateaus an enhanced noise power can be measured. With these measurements different pumping processes can be distinguished.

[1] N.Maire et al., Appl. Phys. Lett. 92, 082112 (2008)

HL 31.29 Tue 18:30 Poster D1

Wave Packet Propagation and Transport Phenomena in Multi-Terminal Nanodevices — •Christoph Kreisbeck[1] and Tobias Kramer[1,2] — [1]Institute for Theoretical Physics, University of Regensburg, 93040 Regensburg, Germany — [2]Department of Physics, Harvard University, Cambridge, MA 02138, USA

We introduce a time dependent approach to describe stationary transport in multi-terminal semiconductor nanostructures. The Landauer-Büttiker formalism relates current voltage-characteristics to transmission amplitudes. Using wave packet propagation the scattering matrix can be computed efficiently for a large energy range (up to 27000 transmission amplitudes with a single wavepacket run), even for complicated potential geometries.

The investigated time dependent approach enables the simulation of recent experiments on 4-terminal Aharonov-Bohm (AB) rings etched in GaAs/AlGaAs semiconductors. The phase of the AB oscillation shows a strong dependency on the Fermi energy. Even though the phase should be continuously adjustable in a four terminal setup, strong phase rigidity prevails in the local setup. In order to explain this behavior one has to go beyond simplified 1D models and the 2D scattering potential has to be modeled realistically. This requires to include depletion effects as well as rounded lead-ring junctions. Under these conditions, the experimentally observed phase change can be reproduced within the Landauer-Büttiker framework. Finite temperature and finite bias voltage does break symmetry in the local setup and the phase rigidity is slightly lifted.

HL 31.30 Tue 18:30 Poster D1

Transient characteristics of a parabolic quantum wire quenched by one or two QPCs — •Cosmin M. Gainar[1], Valeriu Moldoveanu[2], Andrei Manolescu[3], and Vidar Gudmundsson[1] — [1]Science Institute, University of Iceland, Dunhaga 3, IS-107 Reykjavik, Iceland — [2]National Institute of Materials Physics, P.O. Box MG-7, Bucharest-Magurele, Romania — [3]School of Science and Engineering, Reykjavik University, Kringlan 1, 103 Reykjavik, Iceland

We describe theoretically the time-dependent transport through a "sample system" defined as a parabolic quantum wire of a finite length coupled to two semi-infinite leads. The sample may also include one or two embedded quantum point contacts (QPCs) created with Gaussian potentials. The coupling between the leads and the sample is described by a non-local kernel connecting the wave functions from both sides and by a time-dependent coupling function with a smooth onset at the initial moment $t = 0$. Starting with an initial occupation of the sample we calculate the time-dependent currents by solving the generalized master equation of the reduced density operator in the presence of a bias. We investigate and discuss the charge accumulation in the sample, the transient currents along the leads, and the final steady state. We use various initial states of the sample and various coupling functions. The embedded QPCs may considerably slow down the transient processes and affect the shape of the propagating signal.

HL 31.31 Tue 18:30 Poster D1

Quantum point contacts in quantum wire systems — •E. Sternemann[1], S.S. Buchholz[1], S.F. Fischer[1], U. Kunze[1], D. Reuter[2], and A.D. Wieck[2] — [1]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum — [2]Angewandte Festkörperphysik, Ruhr-Universität Bochum

Quantum point contacts (QPCs) attract high interest for applications as magnetic focussing, beam splitting (quantum Hall edge states), spin filtering and electron thermometry. Here, we investigate QPCs in complex quantum wire (QWR) systems such as quantum rings. The QPCs were realized by lithographical definition of a short (150 nm) constriction (170 nm width) in (a) a 540 nm wide QWR and (b) 520 nm wide QWR leads of a QWR ring as in [1]. Nanogates on top of the constrictions allow for the control of occupied modes in the QPCs. The devices are based on a GaAs/AlGaAs heterostructure with a 2DEG 55 nm below the surface, patterned by electron beam lithography and wet-chemical etching. Two- and four-terminal conductance measurements at temperatures between 23 mK and 4.2 K were performed using lock-in technique. Our measurements reveal that QPCs in 1D nanostructures can be prepared to show subband separations of 6 meV, clear conductance quantization as well as the 0.7 anomaly. We further show that electron injection across a QPC into a QWR ring allows for electron interference (Aharonov-Bohm effect).

[1] S.S. Buchholz, S.F. Fischer, U. Kunze, D. Reuter, A.D. Wieck, APL **94**, 022107 (2009).

HL 31.32 Tue 18:30 Poster D1

Nanoscale ferromagnetic gates on shallow etched quantum wires — •Lakshmy Ravindran[1], Rasmus Ballmer[1], Saskia F. fischer[1], Ulrich Kunze[1], Dirk Reuter[2], and Andreas Wieck[2] — [1]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [2]Angewandte Festkörperphysik, Ruhr-universität Bochum, D-44780 Bochum, Germany

The effect of magnetic fringing fields on electron transport is a focus of worldwide research because of the promising aspect of utilizing the electron spin for logic operations in spin- and magnetoelectronics (spintronics). Recently, large magnetoresistance phenomena have been reported for nanoscale ferromagnetic gates placed on ballistic quantum channels [1]. We are investigating such a ferromagnetic/semiconductor device with a Permalloy(Py) finger gate only 35nm apart from the GaAs/AlGaAs channel. We define the nanostructures using electron-beam lithography. Patterning of the quantum wire is done by shallow wet-etching. The Py finger gate is fabricated by thermal evaporation and lift-off processing. We have performed the two-terminal conductance measurements using a lock-in-amplifier at a low temperature of 4.2 K. We are investigating the sample with respect to applied gate voltages, cooling top gate bias and magnetic field.

[1] J.-U Bae et al. IEEE Trans, Magn, 44, 4707, (2008).

HL 31.33 Tue 18:30 Poster D1

Ladespektroskopie unter optischer Anregung an InAs-Quantenpunkten — •Patrick Labud, Dirk Reuter, Arne Ludwig, Ashish Kumar Rai und Andreas Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr Universität Bochum

Die Ladespektroskopie an InAs-Quantenpunkten (QDs) findet ihren Anfang im Jahre 1991, als Drexler et al. zum ersten Mal mittels Kapazitäts-Spannungs-Messungen (C(V)-Messungen) das gezielte Beladen von QDs mit einzelnen Elektronen nachweisen konnten. Anhand der Resultate wurde eine schalenartige Energieniveaustruktur nachgewiesen, weshalb man bei QDs auch von "künstlichen" Atomen spricht.

Während die Standard-C(V)-Spektroskopie mit n-Typ Proben nur Informationen über die Energiestruktur im Leitungsband gibt, sollten Messungen unter optischer Anregung auch Informationen über das Valenzband geben. Hierzu werden QD-Halbleiterproben verwendet, auf denen transparente ITO(Indiumzinnoxid)-Gates aufgedampft sind.

In diesem Beitrag werden wir das Konzept erläutern und erste Ergebnisse präsentieren.

HL 31.34 Tue 18:30 Poster D1

Ladungsträgerdichtesteuerung in einer invertierten $GaAs/Al_xGa_{1-x}As$ **Heterostruktur mit eingebetteten InAs Quantenpunkten mittels Rückseitengate.** — •Sascha Valentin, Arne Ludwig, Dirk Reuter und Andreas Wieck — Lehrstuhl für angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätsstrasse 150, D-44780 Bochum

InAs Quantenpunkte (QDs) gekoppelt an ein zweidimensionales Elektronensystem (2DES) sind bereits in größerem Umfang studiert worden, aber die Ladung in den QDs ließ sich bei diesen Experimenten, die nur mit einem Oberflächengate durchgeführt wurden, nicht einstellen, ohne auch die Dichte im 2DES zu ändern. In diesem Beitrag stellen wir eine Struktur mit einem zusätzlichen Rückseitengate vor, so dass sich die Beladung der QDs unabhängig von der Dichte der QDs einstellen lässt. Außerdem erlaubt diese Zweigate Struktur, den Abstand zwischen QDs und Elektronenwellenfunktion elektronisch zu beeinflussen, und damit in Abhängigkeit davon den Transport zu studieren.

HL 31.35 Tue 18:30 Poster D1

Investigations of the conductance anomaly in strongly confined Si/SiGe quantum wires — •J. von Pock[1], D. Salloch[1], G. Qiao[1], U. Wieser[1], U. Kunze[1], and T. Hackbarth[2] — [1]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, D-44780 Bochum — [2]DaimlerChrysler Forschungszentrum Ulm, D-89081 Ulm

We investigate the influence of temperature and high parallel magnetic field ($B \leq 15$ T) on a conductance anomaly observed below the first conductance plateau at $G_0 = 4e^2/h$ in Si/SiGe quantum wires. The quantum wires are fabricated from a high-mobility Si/SiGe heterostructure with an electron density of $n = 8.4 \cdot 10^{11}$ cm^{-2} and a mobility of $\mu = 207,000$ cm^2(Vs)$^{-1}$ at 4.2 K. The constriction of the wires is realised by an etch transfer in a low-damage CF_4/O_2 plasma, which provides a strong 1D confinement. The linear transport measurements are performed in a temperature range between 400 mK and 4.2 K. Besides the first regular conductance plateau at G_0 an additional anomal plateau is observed near 0.6 G_0 at $B = 0$ T. With increasing magnetic field the anomal plateau shifts to 0.5 G_0 indicating the Zeeman splitting. Our results agree well with the behaviour of the 0.7 anomaly reported in AlGaAs/GaAs quantum point contacts and quantum wires [1]. For $T = 500$ mK we do not observe a zero-bias anomaly [2] in the subband spectroscopy around the conductance anomaly.

[1] K. J. Thomas *et al.*, Phys. Rev. Lett. **77**, 135 (1996)
[2] S. M. Cronenwett *et al.*, Phys. Rev. Lett. **88**, 226805 (2002)

HL 31.36 Tue 18:30 Poster D1

Geometry Dependent Transport Properties of Undoped InAs Nanowires — •H. Yusuf Günel[1], Christian Blömers[1], Kamil Sladek[1], Andreas Penz[1], Hilde Hardtdegen[1], Martina Luysberg[2], Steffi Lenk[1], Jürgen Schubert[1], Thomas Schäpers[1], and Detlev Grützmacher[1] — [1]Institute of Bio- and Nanosystems (IBN-1) and JARA-Fundamentals of Future Information Technology, Research Centre Jülich GmbH, 52425 Jülich, Germany — [2]Institute of Solid State Research and Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons, Forchungszentrum Jülich, 52425 Jülich, Germany

In recent time nanowire (NW) structures attracted much attention, for electronics, optoelectronics and fundamental quantum properties. On account of different application purposes basic transport properties are crucially important at room temperature as well as low temperatures. In this respect InAs NWs are particularly important due to the low band gap and high carrier concentration.

We characterized the basic transport parameters of undoped InAs NWs at room temperature, which were grown on GaAs (001) substrate by MOVPE without catalyst. The NWs that we used in this work had diameters ranging from 25 nm to 200 nm and lengths up to 3.5 μm. Basic transport parameters, such as carrier concentration and mobility, were determined by using two- and four-terminal measurement configuration. The carrier concentration could be controlled by a SiO_2 -isolated back-gate structure. By analyzing the transfer characteristics of the NW FET, we observed very good gate controllability.

HL 31.37 Tue 18:30 Poster D1

Electrical Properties of CVD-grown in situ doped silicon nanowires using silane as a precursor — •Björn Hoffmann, Uwe Hübner, Gerald Brönstrup, Vladimir Sivakov, Florian Talkenberg, and Silke Christiansen — Institut für Photonische Technologien e.V., Abt. Halbleiter-Nanostrukturen, 07745 Jena

In order to use silicon nanowires (SiNWs) for photovoltaic or sensor devices, defined electrical properties are needed. We use electron beam lithography to prepare up to 20 ohmic contacts to one single wire. Thereby we are able to measure the resistivity along the wire in a 4-point-probe-measurement setup. By using a highly doped thermally oxidized Si-substrate as a back gate, we can produce single nanowire FETs.

Doping of SiNWs is performed in situ by adding diborane or phosphine into the CVD-chamber during growth.

Furthermore we use atomic layer deposition (ALD) of aluminium oxide to passivate the wire surface in order to reduce the surfaces recombination rate and thus enhance the carrier lifetime.

HL 31.38 Tue 18:30 Poster D1

Optical manipulation of a Mn spin in a quantum dot via light hole exciton transitions — •Doris E. Reiter[1], Giselmar Hemmert[1], Vollrath Martin Axt[2], and Tilmann Kuhn[1] — [1]Institut für Festkörpertheorie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster — [2]Theoretische Physik III, Universität Bayreuth, 95440 Bayreuth

The coherent manipulation of a single spin is of great interest in the field of quantum computing. One very promising candidate for an ultra fast spin manipulation is a single Mn spin doped into a single semiconductor quantum dot. The goal is an all-optical manipulation of the Mn spin, which becomes possible via the optical manipulation of the quantum dot exciton. The exciton couples to the Mn via a strong exchange interaction. When transitions of the heavy hole excitons are considered, only a spin transfer from the electron to the Mn spin is possible, while the heavy hole is pinned. In contrast, if light hole excitons are excited both electron and hole can transfer spin to the Mn, which opens up the possibility for an efficient spin control. In this contribution different switching schemes for a coherent manipulation of the Mn spin in a CdTe quantum dot are presented either to address well defined eigenstates or create coherent superposition states. Two different kinds of dots are studied. In a neutral dot the Mn spin can be changed by two while excitons are only in the system during the switching. In a negatively charged dot an inversion of the Mn spin can be achieved. The optical signal in a pump probe setup should be well suited to monitor the dynamics of the Mn spin.

HL 31.39 Tue 18:30 Poster D1

Electrical spin-injection into single InGaAs quantum dots: circular polarization degree of light from different excitonic complexes — Pablo Asshoff, •Gunter Wüst, Andreas Merz, Michael Hetterich, and Heinz Kalt — Karlsruhe Institute of Technology (KIT) and DFG Center for Functional Nanostructures (CFN), 76131 Karlsruhe, Germany

Quantum dots embedded in spin light-emitting diodes (spin-LEDs) can be charged with spin-polarized electrons and unpolarized holes. The subsequent radiative recombination leads to a circular polarization of the emitted light, revealing the excitonic spin state inside the quantum dot. Spin-injection efficiencies are very high for individual quantum dots [1]. Pulsed electrical injection shines light on the temporal evolution of the spin polarization [2]. Here, we compare the power-dependent behavior of single quantum dot emission lines due to recombination of different excitonic complexes, when optical and electrical pumping are used, respectively. This allows for measuring the circular polarization degree related to different excitonic species during all-electrical spin-injection.

[1] M. Hetterich et al., in Advances in Solid State Physics, edited by R. Haug (Springer, Berlin, 2009), Vol. 48, p. 103; [2] P. Asshoff et al., Appl. Phys. Lett. 95, 202105 (2009)

HL 31.40 Tue 18:30 Poster D1

Electric Field and Excitation-Power Dependent Micro-Photoluminescence Spectroscopy of Single In(Ga)As Quantum Dots — •Florian Stockmar, Daniel Rülke, Daniel M. Schaadt, Heinz Kalt, and Michael Hetterich — Institut für Angewandte Physik and DFG Center for Functional Nanostructures (CFN), Karlsruhe Institute of Technology (KIT), Wolfgang-Gaede-Str. 1, 76131 Karlsruhe, Germany

We investigate the excitation-power dependent photoluminescence (PL) of In(Ga)As quantum dots embedded in reversed GaAs micropyramids. The pyramidal resonators are fabricated with molecular-beam epitaxy and a combination of e-beam lithography and wet-chemical etching, taking advantage of an AlAs sacrificial layer.By placing the quantum dot layer close to the tip of the pyramids these resonators offer an easy access to the emission of single quantum dots which makes them promising candidates for the realization of single photon sources. Furthermore, we investigate the quantum-confined Stark effect (QCSE) due to laterally applied electric fields. To reveal current-induced thermal contributions to the observed shifts in quantum-dot PL, temporally modulated electric fields are applied in our experiments.

HL 31.41 Tue 18:30 Poster D1

Control of the charge state of quantum dots and quantum posts by surface acoustic waves — •Florian J. R. Schülein[1], F. Knall[1], S. Völk[1], D. Reuter[2], A. D. Wieck[2], T. A. Truong[3], H. Kim[3], J. He[3], P. M. Petroff[3], A. Wixforth[1], and H. J. Krenner[1] — [1]Lehrstuhl für Experimentalphysik I, Universität Augsburg, Universitätsstr. 1, 86159 Augsburg, Germany — [2]Lehrstuhl für Angewandte Festkörperphysik, Universitätsstr. 100, 44780 Bochum, Germany — [3]Materials Department, University of California, Santa Barbara, CA 93106, United States

We demonstrate that surface acoustic waves (SAW) can be used to control the carrier capture dynamics into zero-dimensional semiconductor nanostructures. Sharp emission lines from a single self-assembled quantum dot (QD) are identified which change dramatically under the influence of a SAW: We observe the switching between different emission lines as the SAW power is increased. We observe both red and blue spectral shift which allows us to exclude heating effects as the underlying mechanism. In a defined SAW power range, we observe switching between the two emission lines of positively charged and neutral excitons. For QDs, we observed a hysteretic behavior during SAW sweeps attributed to carrier localization and release from shallow traps in the surrounding wetting layer by the SAW. Switching between negatively charged and neutral excitons was also observed for self-assembled quantum posts (QP) which are embedded in a lateral matrix quantum well. These QPs exhibit an even sharper switching behavior without hysteresis at lower SAW power compared to QDs.

HL 31.42 Tue 18:30 Poster D1

Optical spectroscopy on single charge tunable InGaAs/GaAs quantum dots — •Jan Kettler[1], Claus Hermannstädter[1], Petr Siyushev[2], Fedor Jelezko[2], Jörg Wrachtrup[2], Lijuan-Wang[3], Armando Rastelli[3], Oliver G. Schmidt[3], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Allmandring 3, 70569 Stuttgart, Germany — [2]3. Physikalisches Institut, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [3]Institut für Integrative Nanowissenschaften IFW Dresden, Helmholtzstraße 20, 01069 Dresden, Germany

We investigate optical properties of self-assembled InGaAs quantum dots. Those are embedded in a n-i-Schottky diode structure, placed on top of a distributed Bragg reflector to increase the photoluminescence (PL) extraction. The application of a bias voltage allows deterministic charging of single quantum dots. Furthermore, a magnetic field, provided by a superconducting magnet in Faraday geometry, as well as a microwave field can be applied to the sample. The latter is achieved by pulling a wire over the sample surface that is covered by an insulation layer. We monitor the excitonic states and the deterministic charging of single quantum dots using micro-PL and excitation spectroscopy. Selective excitation of a negatively charged exciton with a particular spin configuration is aimed at by using a narrow-band laser tuned in to resonance with an excited state of the charged exciton.

HL 31.43 Tue 18:30 Poster D1

Temperature Dependent Photoluminescence of Wet Chemically Etched Silicon Nanowires — •Viktor Gerliz[1], Vladimir Sivakov[2], Silke Christiansen[2], Felix Voigt[1,2], and Gottfried H. Bauer[1] — [1]University of Oldenburg, Institute of Physics, Carl-von-Ossietzky-Str.9-11, D-26129 Oldenburg, Germany — [2]Institute of Photonic Technology, Albert Einstein Str.9, D-07745 Jena, Germany

Silicon nanowire (Si-NW) samples were prepared by Wet Chemical Etching of crystalline silicon wafers. The diameters of these Si-NWs ranged from 30 to 200 nm. Photoluminescence (PL) measurements were performed with excitation at 458 nm and a laser power of 3.2 mW with 1.1 mm beam diameter. According to the Si-NW diameter size $>$ 10 nm, from quantum confinement theory no shift in PL peak energy compared to crystalline silicon is expected. However, PL measurements show peak emission energies in the range 1.4 to 1.6 eV. After further treatment of the samples with HF, substantial PL emission was still detectable and the measured PL peak was pinned at 1.4 eV, irrespective of etching time. For samples treated such way the high energy wing of the steady state PL spectra show a linear behavior in the log-PL vs. photon energy plot pretending - according to Planck′s generalized law - a temperature of 10^3 K. By temperature PL-experiments we are able to discriminate between the influence of temperature on the slope of the high energy Pl wing and a distribution of sites with individual, say, non-overlapping wave functions which also leads to exponentially decaying PL emission.

HL 31.44 Tue 18:30 Poster D1

Growth, Characterization and Lasing of CdS Nanostructures — •Julian Kühnel[1], Sebastian Geburt[1], Christian Borschel[1], Michael Kozlik[1], Amanda McDonnell[1], Kristen Sunter[2], Federico Capasso[2], and Carsten Ronning[1] — [1]Institute for Solid State Physics, University of Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [2]School of Engineering and Applied Sciences, Harvard University, Cambridge, Massachusetts, USA

CdS is a direct II-VI semiconductor with a band gap of 2.42 eV at room temperature, making it a promising material for optoelectronics and photovoltaic applications. Their geometry and optical properties allow the integration as building and functional elements for nanodevices.

CdS nanowires are synthesized by CVD using the VLS mechanism. The morphology and stoichiometry was investigated by SEM and EDX. Dependent on temperature and pressure conditions during growth, an experimental phase diagram was developed. Straight nanowires with diameters around 200 nm and lengths up to several 10 μm have been synthetisized. TEM measurements confirm the high quality of the single crystalline nanowires. CL measurements were performed to study the optical properties of the nanowires and allow a correlation with their morphology. μPL on single nanowire was utilized to investigate the luminescence at high excitation powers. The CdS nanowires show a broad band edge emission with a linear intensity increase up to 2 MW/cm^2. At higher excitation powers, sharp peaks with defined spacing are evolving. The power dependence clearly shows lasing action in single CdS nanowires above the threshold of 2.5 MW/cm^2.

HL 31.45 Tue 18:30 Poster D1

Optical properties of transition metal doped ZnO nanowires — •Sebastian Geburt, Christian Borschel, and Carsten Ronning — Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena

Semiconductor nanowires (NWs) offer ideal properties as building elements for next generation optoelectronic devices as e.g. waveguides, LEDs or nanoscaled lasers. Optically pumped ZnO nanowire lasers have already been realized; nevertheless, the lasing threshold of 300 kW/cm^2 is too high for realistic device integration. A solution to lower the threshold could be the change from the quasi-2-niveau system of undoped ZnO to a 4-niveau system of ZnO with optically active impurities like transitions metals (Fe and Co). To cope with the unsolved problem of doping during VLS growth, ZnO nanowires were ion implanted with Fe and Co (0.05 to 8 at%). The ion induced lattice damage was reduced by annealing in different atmospheres. The structural properties were investigated by SEM, TEM and EDX. The optical properties are studied by spatial resolved CL as a function of annealing environment, impurity concentration, temperature and excitation power. The luminescence of single NWs gives insights to the correlation between morphology and light emitting properties.

HL 31.46 Tue 18:30 Poster D1

Optical spectroscopy of ZnO nanowires — •Nils Neubauer[1], Martin Lange[2], Marius Grundmann[2], and Frank Cichos[1] — [1]Molecular Nanophotonics Group, University of Leipzig, Linnéstraße 5, 04103 Leipzig — [2]Semiconductor Physics Group, University of Leipzig, Linnéstraße 5, 04103 Leipzig

Semiconductor nanowires are promising building blocks for nanoscale light emitting devices. Especially, ZnO has gained much attention due to its large exciton binding energy and energy bandgap, offering the possibility for room temperature nanoscale light emitters in the blue and UV spectral region as well as in the visible region caused by deep level defect emission. Among different synthesis methods, PLD enables defined nanowire shapes and allows the growth of nanoheterostructures, which is important for device applications, defining optical and electronic properties. We have investigated low area-density, homogeneous core/shell ZnO/ZnMgO quantum well structured nanowires grown by a two step PLD process. Optical studies were carried out in a confocal photoluminescence setup, enabling one and two photon excitation. Spectroscopic studies as well as the study of the emission characteristics were done to investigate the optical properties of these nanowires.

HL 31.47 Tue 18:30 Poster D1

Electrically active dopant profiles in individual silicon nanowires — •Pratyush Das Kanungo[1], Xin Ou[1,2], Reinhard Kögler[2], Peter Werner[1], Ulrich Gösele[1], and Wolfgang Skorupa[2] — [1]Max Planck Institute of Microstructure Physics, Weinberg 2, Halle D-06120, Germany — [2]Institute of Ion Beam Physics and Materials Research, Forschungszentrum Dresden-Rossendorf e.V., P.O. Box 510119, 01314 Dresden, Germany

Controlled doping and profiling of electrically active dopants in individual silicon nanowires (Si NWs) are two important factors that can decide the use of Si NWs as future building blocks in nano-electronics. We have investigated individual Si NWs doped either by ion implantation or by in-situ dopant incorporation during growth via molecular beam epitaxy, by scanning spreading resistance microscopy (SSRM). In case of the phosphorus ion-implanted and subsequently annealed NWs the SSRM profiles revealed a radial core-shell distribution of the activated dopants. The maximum carrier concentration close to the surface of a phosphorus-doped NW was found to be by a factor of 6-7 higher than the value in the core, and on average only 25% of the implanted phosphorus was electrically active. In contrast, for the in-situ boron-doped NW, the activation rate of the boron atoms was significantly higher than for phosphorus atoms, and the carrier profile was relatively flat over the NW diameter.