HL 31: Poster II

Time: Tuesday 16:30–19:00 Location: Poster D

HL 31.1 Tue 16:30 Poster D

Temperature dependency of valence and conduction bands studied by means of synchrotron spectroscopic ellipsometry — •Christoph Cobet[1], Christoph Werner[1], Munise Rakel[1], Wolfgang Richter[2], and Norbert Esser[1] — [1]ISAS- Institute for Analytical Sciences, Department Berlin, Albert-Einstein-Str. 9, D-12489 Berlin — [2]Dipartimento di Fisica, Roma II (Tor Vergata), Via della Ricerca Scientifica 1, I-00133 Rome, Italy

A common experimental approach to study temperature effects on the electronic band structure is using spectroscopic ellipsometry. Thereby the energy shift and broadening of interband transition features in the dielectric function is determined. A major problem in the interpretation is related to the fact that the observed transitions correspond to pairs of valence and conduction bands i.e. the joint density of states. Therefore, only a sum of the respective contributions is measured. In the presented work we utilize the strongly localized semicore Ga3d states in GaN, which are almost unaffected by the electron-phonon interaction, as an energy reference. Excitations from these Ga3d levels to conduction bands occur in the dielectric function above 20eV. In this spectral range temperature related shifts and broadening of transition features thus only relate to changes in conduction bands. In a critical-point analysis we finally separate temperature effects i.e. electron phonon coupling constants for conduction and valence band states. These experiments can be used as a critical test for existing empirical models and newly developed parameter-free ab-initio calculations.

HL 31.2 Tue 16:30 Poster D

Indium-oxide polymorphs from first principles: Quasiparticle electronic states — •Frank Fuchs and Friedhelm Bechstedt — Institut für Festkörpertheorie und -optik and European Theoretical Spectroscopy Facility (ETSF), Friedrich-Schiller-Universität, Max-Wien-Platz 1, 07743 Jena, Germany

The electronic structure of In_2O_3 polymorphs is calculated from first-principles using density functional theory (DFT) and many-body perturbation theory (MBPT). DFT calculations with a local exchange-correlation (XC) functional give the relaxed atomic coordinates of the two stable polymorphs. Their electronic structure, i.e., the band structure, and density of states are studied within MBPT. The quasiparticle equation is solved in two steps. As the zeroth approximation for the XC self-energy the non-local potential resulting from a HSE03 hybrid functional is used. In the sense of a self-consistent procedure G_0W_0 quasiparticle corrections are computed on top. The calculated direct quasiparticle gaps at Γ amount to 3.3 eV (rhombohedral) and 3.1 eV (cubic). The rhombohedral polymorph is found to exhibit a near degeneracy of the valence-band maxima at the Γ point and on the Γ-L line, while the valence band maximum of the cubic polymorph lies close to Γ. This partially contrasts the results of a recent LDA+U study [1]. The results for gaps, *d*-band positions, density of states, and optical properties are compared with available experimental data.

[1] P. Erhart et al., Phys. Rev. B **75**, 153205 (2007).

HL 31.3 Tue 16:30 Poster D

Excitonic electroreflectance spectra of hexagonal GaN — •Steve Lenk and Erich Runge — Institut für Physik, Technische Universität Ilmenau, Germany

We calculate the bandstructure near the Γ-point of A-, B-, and C-excitons in hexagonal GaN in the presence of an external electric field. The parametrization of Chuang and Chang [1] is used. The importance of excitons for the interpretation of electroreflectance spectroscopy was emphasized by several experimental groups, but only recently theoretical calculations were presented [2]. We derive the imaginary part of the dielectric function from a numerical solution of the excitonic Schrœdinger equation in a finite field, taking into account the full 6x6 valence band structure. Via Kramers-Kronig-Relation the real part of the dielectric function is evaluated. The derivative of the dielectric function yields the ER spectra. In particular, we compare the theoretical field-dependent oscillator strengths with experimental data.

[1] S.L. Chuang, and C.S. Chang, Phys. Rev. B **54**, 2491 (1996).

[2] A.T. Winzer, G. Gobsch, and R. Goldhahn, Phys. Rev. B **74**, 125207 (2006).

HL 31.4 Tue 16:30 Poster D

Cascade of Y-shaped spin filters in InAs — •Jan Jacob[1], Sebastian Peters[1], Toru Matsuyama[1], Ulrich Merkt[1], Guido Meier[1], Aron Cummings[2], Richard Akis[2], and David Ferry[2] — [1]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Germany — [2]Center for Solid State Electronics Research, Department of Electrical Engineering, Arizona State University, Tempe, Arizona 85287-5706

For spintronic devices highly spin-polarized currents are required. While the theoretically predicted values for the injection rate of polarized currents in ferromagnet-semiconductor hybrid devices are low, Y-shaped all-semiconductor structures using the Rashba spin-orbit interaction are predicted to provide a high spin polarization at the outputs of these three-terminal devices [1,2]. The spin-filter effect has been shown by simulations [3] and we will present first measurements here. Quantum-point contacts formed by sidegates are employed to decrease the number of conductance channels in the two-dimensional electron system of an InAs channel inserted into an $In_{0.75}Al_{0.25}As/In_{0.75}Ga_{0.25}As$ structures. The devices with channel widths down to 100 nm are prepared by electron-beam lithography and reactive ion-etching to generate. Adding a second filter operating as a detector allows an all-electric measurement of the spin polarization. Cascading more filters will lead to a higher degree of polarization.

[1] M. Yamamoto et al., Phys. Rev. B **72**, 115321 (2005)
[2] M. Yamamoto et al., Physica E **32**, 462 (2006)
[3] A. Cummings et al., Appl. Phys. Lett. **89**, 172115 (2006)

HL 31.5 Tue 16:30 Poster D

Landauer-Büttiker study of transport in a two-dimensional electron gas with spin-orbit coupling — •maria silvia garelli and John Schliemann — Institut für Theoretische Physik, Universität Regensburg

We investigate spin transport properties in a two-dimensional electron gas in the presence of spin-orbit interaction. Using Landauer-Büttiker transport formalism in a four-probe arrangement we study the dependence of the anomalous Hall effect and the spin Hall effect on the size and geometry of the system.

HL 31.6 Tue 16:30 Poster D

Spin Injection in GaAs by Cleaved-Edge-Overgrowth — •Arne Ludwig[1], Carsten Godde[2], Sani Noor[2], Stephan Hövel[3], Dirk Reuter[1], Andreas D. Wieck[1], Ulrich Köhler[2], and Martin Hofmann[3] — [1]Lehrstuhl für Angewandte Festkörperphysik — [2]Experimentalphysik IV - AG Oberflächenphysik — [3]Arbeitsgruppe Optoelektronische Bauelemente und Werkstoffe, all Ruhr-Universität Bochum, D-44780 Bochum

Spin injection in semiconductors is still a challenging topic. Successful spin injection has been demonstrated by the detection of circularly polarized light, resulting from the recombination of spin polarized electrons and unpolarized holes in a n-i-p-diode. In a classic approach, the spins are injected from a ferromagnetic metal grown on top of the n-i-p diode. At the interface either a tailored Schottky barrier or an inserted MgO layer serves as tunnel-barrier into the n-doped region of the device. Some technical problems occur, e. g., protecting the semiconductor surface from impurities before depositing the metal/tunnelling barrier and the need for a magnetic material with out-of-plane anisotropy. In our approach, the sample is patterned and ohmic contacts are evaporated before transferring the sample to a metal-MBE, where it is cleaved under ultra high vacuum conditions. Then, the FM-contacts are evaporated in situ on the cleavage plane. In addition to Schottky barrier contacts, MgO tunnel-barriers have been prepared. We will discuss the properties of the different contact configurations.

HL 31.7 Tue 16:30 Poster D

Shear deformation and relaxed lattice constant of (Ga,Mn)As layers on GaAs(113)A — •Lukas Dreher, Joachim Daeubler, Michael Glunk, Wladimir Schoch, Wolfgang Limmer, and Rolf Sauer — Institut für Halbleiterphysik, Universität Ulm, D-89069 Ulm, Germany

The shear deformation and the relaxed lattice constant of compressively strained (Ga,Mn)As layers with Mn concentrations of up to

5%, pseudomorphically grown on GaAs(113)A and GaAs(001) substrates by low-temperature molecular-beam epitaxy, have been studied by high resolution X-ray diffraction (HRXRD) measurements. Rocking curves reveal a triclinic distortion of the (113)A layers with a shear direction towards the [001] crystallographic axis, whereas the (001) layers are tetragonally distorted along [001]. The relaxed lattice constants were derived from ω-2Θ scans for the symmetric (113) and (004) Bragg reflections, taking the elastic anisotropy of the cubic system into account. The increase of the lattice constant with Mn content has been found to be smaller for the (113)A layers than for the (001) layers, presumably due to the enhanced amount of excess As in the (113)A layers.

HL 31.8 Tue 16:30 Poster D

Spin-orbit coupling in InGaSb/InAlSb and InGaAs/InP 2DEGs — •Vitaliy A. Guzenko[1], Masashi Akabori[2], Thomas Schäpers[1], Sergio Estévez[1], Hilde Hardtdegen[1], Taku Sato[2], Toshi-kazu Suzuki[2], and Syoji Yamada[2] — [1]Institute of Bio- and Nanosystems (IBN 1), Research Centre Jülich, 52425 Jülich, Germany — [2]Center for Nano-Materials and Technology (CNMT), Japan Advanced Institute of Science and Technology (JAIST), 1-1 Asahidai, Nomi, Ishikawa 923-1292, Japan

Spin-orbit interaction in high-mobility two-dimensional electron gases (2DEGs) formed in high indium content InGaAs-based and InGaSb-based quantum wells was studied. Magnetotransort measurements were performed at low temperatures in a wide range of magnetic field. Characteristic beating pattern in the Shubnikov–de Haas oscillations as well as the enhancement of magnetoconductance at $B = 0$ T due to weak antilocalization (WAL) effect were observed. A comparison of the values of the Rashba spin-orbit coupling parameters estimated from analysis of the beatings with the ones obtained from the fit of the WAL curves showed a good agreement. A control over the strength of the Rashba coupling parameter in the InGaAs 2DEG was achieved by applying a gate voltage. We found that in particular range of the negative gate voltages no beatings can be observed anymore, whereas the weak antilocalization becomes more pronounced. Under such conditions analysis of the WAL is a reliable method to determine the strength of the spin-orbit interaction in 2DEGs.

HL 31.9 Tue 16:30 Poster D

Magnetotransport through lateral (001)-(Ga,Mn)As structures with nanoconstriction — •Markus Schlapps[1], Teresa Lermer[1], Daniel Neumaier[1], Rashid Gareev[1], Janusz Sadowski[2], Werner Wegscheider[1], and Dieter Weiss[1] — [1]Institut für Experimentelle und Angewandte Physik , Universität Regensburg, Germany — [2]Max-Lab, Lund University, Sweden

The resistance measured across a small (Ga,Mn)As island detached by nanoconstrictions from (Ga,Mn)As input leads displays unusual magnetoresistance (MR) behavior [1,2,3]. In previous studies [1,3] a huge magnetoresistance was found for nanoconstrictions in the tunneling regime. We have already reported on investigations of the angular dependence of the MR in such double-constricted devices and discussed its correlation with the Tunneling Anisotropic Magneto Resistance (TAMR) effect [4]. Here we focus on MR measurements carried out on (Ga,Mn)As wires with only one nanoscale constriction. Samples with different constriction-resistances are compared. Strongly nonlinear I-V characteristics depending on the magnetization orientation have been observed for a high resistive sample that also shows very large MR-effects of up to 6000%. We discuss the possibility of a metal-insulator transition being responsible for the observed effects.

[1] C. Ruester et al: PRL 91, 216602 (2003) [2] A. D. Giddings et al: PRL 94, 127202 (2005) [3] M. Schlapps et al: phys. stat. sol. (a) 203, No. 14, 3597 (2006) [4] M. Ciorga et al: New J. Phys. 9, 351 (2007)

HL 31.10 Tue 16:30 Poster D

TMR and highly anisotropic magnetoresistance effects in (Ga,Mn)As based trilayer structures — •Eva Brinkmeier[1], Rashid Gareev[1], Matthias Sperl[1], Ursula Wurstbauer[1], Janusz Sadowski[2], Dieter Schuh[1], Werner Wegscheider[1], and Dieter Weiss[1] — [1]Institut fuer experimentelle und angewandte Physik, Universitaet Regensburg, Germany — [2]Institute of Physics, Polish Acadamy of Sciences, Warsaw, Poland

We investigated tunneling trilayer structures built of (Ga,Mn)As as ferromagnetic electrode and GaAs or (Al,Ga)As as barrier materials. Tunnel stacks were fabricated for magnetoresistance measurements in a current-perpendicular-to-plane (CPP) geometry.

The Tunneling Magneto-Resistance (TMR) of the junctions shows a pronounced dependence on voltage and temperature. When the orientation of the magnetic field is being changed, a complex switching behaviour shows up which can be explained by the switching of the (Ga,Mn)As layers as it was also shown by previous studies for similar systems [1].

In trilayer systems containing a GaAs barrier a highly anisotropic junction resistance with respect to the orientation of a high external magnetic field appears. Detailed investigations of this tunneling anisotropic magnetoresistance show its strong dependence on voltage, temperature and strength of the applied magnetic field.

[1] Y. Higo et al. APL 89, 6745 (2001)

HL 31.11 Tue 16:30 Poster D

Characterization and Weak-Antilocalization measurements of InGaAs/InP quantum wire structures — •Markus Hagedorn, Masashi Akabori, Hilde Hardtdegen, Vitaliy Guzenko, and Thomas Schäpers — Institute of Bio- and Nanosystems (IBN-1) and Centre of Nanoelectronic Systems for Information Technology (CNI), Research Centre Jülich, 52425 Jülich, Germany

We report on the investigation of InGaAs/InP quantum wire structures with respect to a general characterization and spin-related effects such as weak-anti-localization (WAL) by performing magnetoresistance measurements at low temperatures. The thickness of the InGaAs channel layer (Indium content of 77%) is varied systematically in the range of 2 to 10 nm in order to study the influence of the quantum well width on the WAL and therefore on the spin-orbit-coupling. By means of a He3-cryostat, low temperature transport measurements (around 0.6K) were performed using e-beam written array wire structures which allow to study a set of different wire widths in the range of 100 to 1000nm. Additionally each structure has also a Hall bar to provide further analysis of beating pattern nodes and heterostructure properties such as mobility and carrier concentration. Analysis of the WAL on the one hand and the node position shift in the beating pattern observed in the Shubnikov-de Haas oscillations on the other hand, show clearly that the smallest channel layer thickness correspond to a large Rashba spin-orbit coupling.

HL 31.12 Tue 16:30 Poster D

Optical detection of spin polarisation in a lateral spin-transport device with (Ga,Mn)As injecting contacts — •Andreas Maurer, Michael Griesbeck, Thomas Kufner, Andreas Einwanger, Tobias Korn, Mariusz Ciorga, Dieter Schuh, Werner Wegscheider, Dieter Weiss, and Christian Schüller — Uni Regensburg

Understanding of spi-polarised injection into semiconductor materials and resulting spin-polarised transport is a crucial factor in developing future spintronic devices.

Here we report on the design and fabrication of a lateral spin injection/transport device using ferromagnetic GaMnAs contacts as spin injectors. As a channel we use slightly n-doped GaAs ($n = 2 \times 10^{16}$ cm^{-3}), where extremely long spin-lifetimes (> 100 ns) could be observed previously [1]. In order to be able to detect the spin polarization in the channel via optical microscopy, channel lengths of several hundred μm are used. In this device the lateral spin injection shall be monitored via Kerr microscopy in analogy to the experiment of Crooker *et al.* [2].

In this contribution, we report about the design, fabrication and characterisation of the spin injectors and the measurements of the spin lifetime in the channel material, employing time resolved Kerr experiments. We acknowledge financial support by the Deutsche Forschungsgemeinschaft via SFB689.

[1] Kikkawa et al., PRL **80** 4313 (1998)
[2] Crooker et al., Science **309** 2191 (2005)

HL 31.13 Tue 16:30 Poster D

SAW-mediated single-electron transport through carbon nanotubes — •Markus Regler[1,2], Jens Ebbecke[1,2,3], and Achim Wixforth[1,2] — [1]Lehrstuhl für Experimentalphysik 1, Institut für Physik, Universität Augsburg, Universitätsstr.1, 86159 Augsburg — [2]Center for Nanoscience, Geschwister-Scholl-Platz 1, 80539 München — [3]School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, EH14 4AS, UK

Carbon nanotubes (CNT) are ideal one-dimensional conductors. Depending on their chirality they behave metallic or semiconducting and with their size on the nanometer scale they are very promising candidates for future electronic devices.

Surface acoustic waves (SAW) are earthquake-like waves on a piezo-

electric substrate and are therefore always accompanied by an electric field. This lateral, dynamically induced potential can be used to manipulate charges as well as potential landscapes.

SAW and CNT combined provide novel prospects for future devices. For instance quantum dots can be created in a CNT just by contacting it with metal electrodes or by biasing gate electrodes on top of the CNT. The confining barriers of such quantum dot are manipulated by a properly designed SAW. The entrance and exit barriers are alternately modulatied and an electron can pass the lowered barrier easily. The resulting, SAW-driven few electron current turns out to be given by I=e*f with e: elementary charge and f: SAW-frequency. At high frequencies, it may reach nanoamperes. A current standard would be a possible application for these turnstile devices.

HL 31.14 Tue 16:30 Poster D

Local and remote bend resistance characteristics in the hot-electron regime — •Matthias Wiemann[1], Ulrich Wieser[1], Ulrich Kunze[1], Dirk Reuter[2], and Andreas D. Wiek[2] — [1]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [2]Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany

Nonlinear bend resistance characteristics are investigated in the hot-electron regime in a six-terminal mesoscopic ballistic GaAs/AlGaAs cross junction. The lateral geometry is given by a central orthogonal cross junction and two additional voltage probes which orthogonally merge into the vertical bar on both sides of the central junction. Non-equilibrium electrons are generated by a voltage drop across a gate-tunable quantum point contact (QPC) embedded in the vertical bar near the cross junction. If an input bias is applied between the vertical bar embedding the QPC and an orthogonal lead of the central cross junction, a negative bend resistance is found in the I-V transfer characteristic, where V describes the potential difference between the voltage probes opposite to the current leads (local configuration). The absolute value of the bend resistance enhances with increasing electron excess energy if the electrons are injected through the constriction. If the transfer voltage is detected between two orthogonal voltage probes far from the QPC (remote configuration) ballistic effects are observed only for small electron excess energies. Both, local and remote bend resistance characteristics show pronounced oscillations if the electrons are injected through the QPC constriction.

HL 31.15 Tue 16:30 Poster D

Imaging electron flow via magnetic focusing: Theory and Experiment — •Tobias Kramer[1,2], Eric Heller[1], and Robert Parrott[1] — [1]Department of Physics, Harvard University, USA — [2]Institut I: Theoretische Physik, Universität Regensburg

The theoretical description of magnetic focusing requires to obtain Green functions for the transport through impurity potentials and quantum point contacts in a magnetic field. By solving the time-dependent Schrödinger equation, we have developed an accurate and effective method to calculate the energy-dependent Green function [1]. From the Green function, we obtain the microscopic local current flow through the device. The theoretical method is very versatile and adapted to systems, where standard diagrammatic approaches diverge and periodic boundary conditions yield non-physical results. In combination with a sophisticated disorder model, the results are in excellent agreement with the experimental images obtained by Scanning Probe Microscopy [2].

[1] An efficient an accurate method to obtain the energy-dependent Green function for general potentials T. Kramer, E. Heller, and R. Parrott submitted (2007)

[2] Imaging Magnetic Focusing of Coherent Electron Waves K. Aidala, R. Parrott, T. Kramer, R. Westervelt, E. Heller, M. Hanson, and A. Gossard Nature Physics, 3, 464-468 (2007)

HL 31.16 Tue 16:30 Poster D

Transport Through Single-Level Quantum Dots: Increase of Differential Conductance Peaks by Spin Relaxation — •Daniel Becker and Daniela Pfannkuche — I. Institut für Theoretische Physik, Universität Hamburg, Hamburg, GERMANY

Coulomb-blocked non-equilibrium transport through a single-level quantum dot at low temperatures is discussed. To calculate the occupation probabilities and the tunneling current including sequential tunneling, cotunneling and intrinsic spin-flip relaxation, we use a master equation approach based on the diagrammatic Keldysh formalism. The Coulomb diamond can be subdivided into parts differing in at least one of two respects: what kind of tunneling processes (i) determine the single-particle occupations and (ii) mainly contribute to the current. In the *core* and a *shell region* the single-particle occupations are determined by sequential and cotunneling, respectively. Therefore, no finite systematic expansions of the occupations and the current can be found that connects both regions. Alternatively, we construct a non-systematic solution, which is physically correct and perturbative in the whole cotunneling regime, while smoothly crossing-over between core and shell region. With this solution the impact of an intrinsic spin-flip relaxation on the transport is investigated. We focus on peaks in the differential conductance that mark the onset of cotunneling-mediated sequential transport and are located in the intermediate region between core and shell. It is shown, that these peaks are maximally pronounced at a relaxation roughly as fast as sequential tunneling

HL 31.17 Tue 16:30 Poster D

Full Counting Statistics of Electron Transport trough Quantum Dots — •Ingmar Neumann, Christian Fricke, Frank Hohls, and Rolf J. Haug — Institut für Festkörperphysik, Leibniz Universität Hannover, D-30167 Hannover, Germany

We study electric transport properties of quantum dots (QDs) by means of a quantum point contact (QPC). These devices are made of GaAs/AlGaAs-heterostructures containing a two-dimensional electron system. The QD and the QPC are defined with an atomic force microscope using local anodic oxidation. Charge fluctuations on the dot result in current fluctuations trough the QPC, this provides a noninvasive way of charge detection. We measure the timeresolved QPC current, which allows us to detect single electron tunneling events onto and of the dot. The full counting statistics (FCS) of the tunneling events provides additional information on the electron transport through the dot. Also, characteristic tunneling times for our systems are yielded, varying parameters such as gate-voltages or magnetic field.

HL 31.18 Tue 16:30 Poster D

Magnetotransport studies of tunneling mechanisms in vertical quantum dot — •Oleksiy B. Agafonov[1], Tomohiro Kita[2], Hideo Ohno[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Universität Hannover, Appelstraße 2, D-30167 Hannover — [2]Semiconductor Spintronics Project, ERATO, JST, Japan and LNS RIEC, Tohoku University, Japan

The electronic properties of a vertical quantum dot fabricated of an asymmetrical InGaAs/AlGaAs double-barrier resonant tunneling heterostructure are investigated using magnetotunneling spectroscopy. The magnetic field is oriented perpendicular to the plane of the tunnel barriers. At a temperature of 15 mK we have observed a series of small current peaks in the vicinity of a resonance peak corresponding to the tunneling over the ground state in the quantum well. The voltage positions of some current peaks are strongly dependent on the applied magnetic field and yield straight lines of a various slope, if represented versus the strength of the magnetic field. The appearance of these lines is related to the tunneling of electrons between the Landau levels in the source electrode and the quantum dot in the presence of the external magnetic field. The voltage positions of several other current peaks show a weaker field dependence. A part of these peaks are caused by the longitudinal optical phonon-assisted tunneling process. The origin of the other peaks is related to electrostatic effects (charging effects and Coulomb blockade). The presence of Coulomb blockade in this sample is confirmed through the observation of characteristic Coulomb-diamond pattern.

HL 31.19 Tue 16:30 Poster D

Spin-splitting in the magnetotransport of tunnel-coupled AlGaAs/GaAs quantum point contacts — •S. S. Buchholz[1], P. S. Zapp[1], S. F. Fischer[1], U. Kunze[1], D. Schuh[2], and G. Abstreiter[3] — [1]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum — [2]Experimentelle und Angewandte Physik, Universität Regensburg — [3]Walter-Schottky Institut, Technische Universität München

Spin-split subbands of one-dimensional electron systems are particularly interesting in order to investigate spin-related phenomena in coherent electron transport. In this work we study quantum point contacts (QPCs) prepared from double quantum well AlGaAs/GaAs-heterostructures by atomic force microscopy and wet chemical etching [1]. In such systems mode coupling can occur and be manipulated in longitudinal magnetic fields [2,3]. Here, we focus on transport properties and mode spectroscopy in perpendicular magnetic fields. A top gate voltage (V_{tg}) controls the occupation of 1D subbands in both stacked QPCs, a back gate voltage (V_{bg}) influences the occupation of

mainly the bottom QPC, and cooling under back gate voltage allows the tuning of the bottom QPC confining potential. We record the conductance and transconductance with respect to $V_{\rm tg}$, $V_{\rm bg}$ and magnetic fields. We observe a rich variety of level splittings and seek understanding of mode coupling between spin-subbands. [1] S.F. Fischer *et al.*, Nature Physics **2**, 91 (2006). [2] S.F. Fischer *et al.*, Phys. Rev. B **74**, 115324 (2006). [3] L.G. Mourokh *et al.*, Appl. Phys. Lett. **90**, 132108 (2007).

HL 31.20 Tue 16:30 Poster D

Suspended carbon nanotube quantum dots — •Andreas K. Hüttel and Herre van der Zant — Molecular Electronics and Devices, Kavli Institute of Nanoscience, Delft University of Technology, PO Box 5046, 2600 GA Delft, The Netherlands

The vibrational modes of single suspended carbon nanotubes (CNT's) are studied in low temperature transport measurements. The low-energy single electron tunneling excitation spectrum of the quantum dots embedded in a suspended single wall CNT displays harmonic excited states at an energy scale compatible to the longitudinal (stretching) mechanical mode. Agreement with Franck-Condon theory has been observed.

Our work targets this interplay of electrical and mechanical effects, also towards resolving the transversal (bending) mechanical mode of the nanotube in electronic transport. Several approaches in terms of sample geometry and fabrication technique are presented, e.g. using very short nanotube segments as single quantum dots to enhance level spacing, or using double quantum dots to enhance spectroscopic resolution. Measurements indicate for a certain nanotube suspension length range a current suppression at low bias, consistent with "phonon" or "distortion" blockade mechanisms due to the transversal vibration mode. Further data will be presented.

HL 31.21 Tue 16:30 Poster D

Top down processing and electrical characterisation of InAs nanocolumns — Jakob Wensorra[1], •Sonja Heiderich[1], Mihail Ion Lepsa[1], Klaus Michael Indlekofer[2], Hans Lüth[1], and Detlev Grützmacher[1] — [1]1Center of Nanoelectronic Systems for Information Technology (IBN-1), Forschungszentrum Jülich GmbH, D-52425 Jülich — [2]FH Wiesbaden, University of Applied Sciences Information Technology and Electrical Engineering, Am Brückweg 26, D-65428 Rüsselsheim

Semiconductor nanocolumns and carbon nanotubes have attracted large interest in recent years both for fundamental and application oriented research. Especially, nanocolumns from low band gap semiconductor materials like InAs, with high electron mobility and a surface accumulation layer, are possible candidates for novel nanodevice concepts. We report on a reproducible top-down processing technique of vertical InAs nanocolumns. With the help of electron beam lithography and using high resolution Hydrogen Silsesquioxan (HSQ) as mask material, vertical InAs columns with lateral dimensions down to 50 nm have been realized by ion beam and reactive ion etching. HSQ is also used to planarize and physically isolate the devices. For contacting the nanocolumns, Ti/Au ohmic contacts have been processed. The electrical transport properties of the resulting nanostructures have been analyzed by means of DC measurements at room temperature. The I-V characteristics is ohmic and indicate a very low resistance for all processed InAs nanocolumns. A linear dependence of the resistance on the lateral nanocolumn dimension has been observed.

HL 31.22 Tue 16:30 Poster D

Spin dependent transport in a lateral few electron quantum dot — •Theo Ridder[1], Maximilian C. Rogge[1], Dirk Reuter[2], Andreas D. Wieck[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Germany — [2]Lehrstuhl für Angewandte Festkörperphysik, Ruhr Universität Bochum, Germany

We investigate spin blockade effects on a lateral few electron quantum dot and observe the influence of the injection of spin polarized currents.

Our quantum dot is built on a GaAs/AlGaAs heterostructure with a 2DEG 57 nm below the surface. For the fabrication of our device we use electron beam lithography. We measure the differential conductance depending on the magnetic field with standard lock-in technique in a 4He/3He dilution refrigerator at a base temperature of around 30 mK.

We investigate the dot properties showing that one can tune the dot from zero to more than 40 electrons. The proof of the last electron is given by Coulomb diamonds measurements. In addition we show spin blockade effects in the few electron regime.

Spin polarization can be achieved in high magnetic fields in using metallic gates covering the leads of the dot. We investigate the transport properties of our quantum dot with regard to spin polarized currents.

HL 31.23 Tue 16:30 Poster D

Modelling of nanowiretransistors in Landauer-Büttiker formalism — •Paul Nicolae Racec[1,2] and Elena Roxana Racec[3,4] — [1]Weierstrass Institute for Applied Analysis and Stochastics, Mohrenstr. 39, 10117 Berlin, Germany — [2]National Institute of Materials Physics, PO Box MG-7, 077125 Bucharest Magurele, Romania — [3]Brandenburg Technical University Cottbus, Faculty 1, Postfach 101344, 03013 Cottbus, Germany — [4]University of Bucharest, Faculty of Physics, PO Box MG-11, 077125 Bucharest Magurele, Romania

We present a quantum mechanical modeling of I-V characteristics of a nanowiretransistor without gate leackage current. The model is suitable also for nanowire heterostructures, including a resonant structure along the nanowire. For the description of the quantum transport we use the Landauer-Büttiker formalism. The cylindrical symmetry of the nanowire has reguired a formulation of the scattering theory in cylindrical coordinates. The two dimensional (2D) many-channels scattering problem is solved efficiently within the R-matrix formalism. The interaction between electrons is considered in the Hartree approximation. We use analytical solutions for the three-dimensional electrostatic problem and also for the two-dimensional quantization on the transversal directions.

HL 31.24 Tue 16:30 Poster D

Diagrammatic Technique for Frequency-dependent Full Counting Statistics — •D. Marcos[1], C. Emary[2], T. Brandes[2], and R. Aguado[1] — [1]Departamento de Teoría de la Materia Condensada. Instituto de Ciencia de Materiales de Madrid, CSIC, Cantoblanco 28049. Madrid, Spain — [2]Institut für Theoretische Physik, Hardenbergstr. 36, TU Berlin, D-10623 Berlin Germany

The theory of Full Counting Statistics has recently emerged as a powerful tool to fully characterize correlations in nanoscopic transport problems [1,2]. In the same way, experiments have been reported, and the new information contained in high order current cumulants has become apparent [3]. In this work, we present results for the frequency-dependent second and third currrent cumulants in a single resonant level and a double quantum dot. To this end, we have worked out a physically-interpretable diagrammatic technique, based on the density matrix approach [4] and a projectors method [5], such that only the stationary solution of the problem is needed.

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HL 31.25 Tue 16:30 Poster D

Micro-Raman studies of the formation of ternary and quaternary II-VI nanocrystals in borosilicate glass — •Yuriy Azhniuk[1], Vasyl Lopushansky[1], Yuriy Hutych[1], Ivan Turok[1], Larysa Prots[1], Alexander Gomonnai[1], and Dietrich R T Zahn[2] — [1]Institute of Electron Physics, Uzhhorod, Ukraine — [2]Chemnitz University of Technology, Chemnitz, Germany

Diffusion-limited growth in a silicate glass is a well-elaborated technique for obtaining II-VI semiconductor nanocrystals (NCs). The dependence of NC size on the growth conditions (heat treatment duration and temperature) has been studied extensively. Much less investigated is the variation of the chemical composition of ternary and quaternary II-VI NCs with heat treatment parameters. This can effectively be performed using Raman scattering.

Here we present resonant micro-Raman studies for an extensive set of NCs of the ternary $CdS_{1-x}Se_x$, $Cd_{1-x}ZnS_x$, $CdSe_{1-x}Te_x$ and quaternary $Cd_{1-y}Zn_yS_{1-x}Se_x$ systems grown in borosilicate glass by thermal treatment at 625 to 700^{o}C. Measurements were performed using a Dilor XY 800 spectrometer and different Ar^+ laser lines for excitation. For $CdS_{1-x}Se_x$ NCs the content of Se is shown to grow with the heat treatment duration and temperature. For zinc-containing ternary and quaternary NCs the Zn content increases with heat treatment duration and temperature up to 0.3 due to the migration of Zn atoms from the matrix to the NCs. Raman features observed at the initial stages of heat treatment as well as at elevated heat treatment temperatures are discussed in view of possible selenium cluster segregation.

HL 31.26 Tue 16:30 Poster D

Electrical integration of semiconductor nanowires — •Katharina Wegener[1], Sven Müller[1], Daniel Stichtenoth[1], Wilma Dewald[1], Carsten Ronning[1], Christoph Gutsche[2], Andrey Lysov[2], Kai Blekker[2], Werner Prost[2], and Franz Josef Tegude[2] — [1]II. Institute of Physics, University of Göttingen, Germany — [2]Solid-State Electronics Department, University of Duisburg-Essen, Germany

Nanowires have a very high surface-to-volume ratio and are therefore very promising candidates for sensing applications. Configured as a field-effect transistor (FET) with their surfaces acting as gates, nanowires exhibit a strong conductivity change in response to surface variations. The binding of a certain molecule can therefore be detected with very high sensitivity.

When building a sensor, the electrical integration of the nanowires is an important step. Two contacting methods will be compared: (1) platinum patterns have directly been written using a focused ion beam system and (2) leads have been deposited via e-beam lithography with subsequent metal deposition and lift-off technology. First results of the electrical measurements will be shown. Furthermore, we have implemented zinc oxide nanowires into FET devices. The carrier type and mobility could be extracted by fitting a long channel metal-insulator-semiconductor FET model to the experimental results.

HL 31.27 Tue 16:30 Poster D

Growth and faceting of self-assembled GaAs quantum dots — •Andrea Stemmann, Christian Heyn, Andreas Schramm, and Wolfgang Hansen — Universität Hamburg, Institut für Angewandte Physik, Jungiusstrasse 11, 20355 Hamburg

Strain-free GaAs quantum dots (QDs) are grown in a self-assembled fashion by applying Ga droplet epitaxy. Dependent on growth temperature and Ga flux, QDs with different size and density are grown. The QDs are studied using electron diffraction (RHEED) and atomic force microscopy. We find two distinct regimes for the QD shape. QDs whose volume exceeds approximately 3x10^5 Ga atoms are shaped like truncated pyramids with side facets having an angle α of about 55° corresponding to (111)-type side facets. Smaller QDs are pyramid like with $\alpha = 25°$ and (113)-type facets.

HL 31.28 Tue 16:30 Poster D

Magnetization measurements on field-effect induced quantum dots — •G. Stracke[1], N. Ruhe[1], J. Topp[1], S. Mansfeld[1], Ch. Heyn[1], D. Heitmann[1], M.A. Wilde[2], and D. Grundler[2] — [1]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung der Universität Hamburg, Jungiusstr. 11, D-20355 Hamburg — [2]Physik Department E10, Technische Universität München, D-85748 Garching

We have studied the de Haas-van Alphen (dHvA) effect of field-effect induced quantum dots at temperatures down to 300 mK. The dots were formed by depleting a two-dimensional electron system (2DES) with a large-area field-effect electrode. This metallic gate covered in particular a periodic array of PMMA nanocolumns on a modulation-doped GaAs/AlGaAs heterostructure. Each column had a diameter of 280 nm and a height of 120 nm. The dot density was $4.6 \cdot 10^8$ cm^{-2}. Using a fiber-optics based magnetometer we measured the dHvA effect as a function of, both, carrier density n_s and magnetic field B up to 10 T. The high sensitivity of $4.5 \cdot 10^{-16}$ J/T at $B = 10$ T allowed us to detect the dHvA signal for n_S ranging from $3.2 \cdot 10^{11}$ cm^{-2} in the 2DES down to 20 electrons per dot. In this way, we report for the first time magnetization data which reflect the crossover from a 2D to a 0D electron system.

The authors thank A. Schwarz for experimental support, the DFG for financial support via SFB 508 and the German Excellence Initiative for financial support via the "Nanosystems Initiative Munich (NIM)".

HL 31.29 Tue 16:30 Poster D

Molekularstrahlepitaxie-kompatible Nanostrukturierung von GaAs durch Lokale Anodische Oxidation mit einem Rasterkraftmikroskop — •Daniel Laipple, Andrea Stemmann, Christian Heyn und Wolfgang Hansen — Institut für Angewandte Physik, Universität Hamburg

Bei der anodischen Oxidation dient der natürliche Wasserfilm auf der Substratoberfläche als Elektrolyt und Sauerstoffreservoir. Zur gezielten lokalen Oxidation wird mit einem kommerziellen Rasterkraftmikroskop (AFM) an eine leitfähige Spitze eine, bezüglich dem zu oxidierenden GaAs Wafer, negative Spannung angelegt. Bei einer relativen Luftfeuchtigkeit von ca. 40% entstehen Oxidstrukturen von bis zu 25nm Höhe.

Nach thermischer Desorption des Oxids unter Vakuum invertieren die aus der Oberfläche ragenden Strukturen zu Gräben in der Oberfläche. Die Grabentiefe ist ähnlich der Höhe der ursprünglichen Oxidstrukturen. Interessanterweise werden auch vom Oxid eingeschlossene Flächen bis zu einer gewissen Größe abgetragen.

In einem weiteren Schritt werden durch thermische Desorption in der Wachstumskammer erzeugte Grabenstrukturen mittels Molekularstrahlepitaxie mit GaAs überwachsen, wodurch Stufenkanten, z.B. für die laterale Anordnung von selbstorganisierten InAs Quantenpunkten, entstehen.

HL 31.30 Tue 16:30 Poster D

Low contact resistance for dielectrophoretically aligned carbon nanotubes — •Anindya Majumder[1], Markus Regler[1,2], and Achim Wixforth[1,2] — [1]Lehrstuhl fuer Experimentalphysik 1, Institut fuer Physik, Universitaet Augsburg, Universitaet. 1, 18569 Augsburg — [2]Center fir Nanoscience, Geschwister-Scholl-Platz 1, 80539 Muenchen

Reduction of contact resistance between carbon nanotubes (CNT) and metal electrodes holds significance for its application in nanoscale electronic devices. Presently, this resistance is very high for samples where dielectrophoresis (DEP) for CNT alignment between contact electrodes is employed. Thus, we need to have more transparent contacts.

In this work, electrodes of different material (Pd, Au, Ti, Al) were processed on a piezoelectric LiNbO3- substrate. The CNT have been aligned between them by DEP. These were subjected to annealing in the temperature range of 300-700° C in vacuum and different background gases. The resistance was then measured at room temperature, where a significant change in the contact resistance between the CNT and the electrodes was found. The goal was to optimize the annealing parameters, improve stability and reproducibility and look for other probable techniques.

HL 31.31 Tue 16:30 Poster D

Kapazitätsspektroskopische Untersuchungen an doppel- und mehrfachlagigen Quantenpunkten — •Sascha Bohse[1], Andreas Schramm[2], Christiane Konetzni[1], Andrea Stemmann[1], Christian Heyn[1] und Wolfgang Hansen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Germany — [2]Optoelectronics Research Center, Tampere University of Technology, Finland

Wir untersuchen die elektronische Struktur von doppel- und mehrfachlagigen Quantenpunkten (QP) in Abhängigkeit vom Lagenabstand. Die QP werden mittels Molekularstrahlepitaxie im Stranski-Krastanov Wachstumsmodus hergestellt und sind in eine Schottkydiode aus n-dotiertem GaAs eingebettet. Die von uns verwendeten Untersuchungsmethoden sind die Kapazitäts-Spannungs-Spektroskopie (CV-Spektroskopie), die Deep Level Transient Spectroscopy (DLTS) und die Tunnel Transient Spectroscopy (TTS). Mit der CV-Spektroskopie kann der Ladezustand der QP in unterschiedlichen Schichten in Abhängigkeit von der angelegten Gatespannung beobachtet werden. Mittels DLTS werden die Energien der QP-Niveaus bestimmt. Von besonderem Interesse ist dabei wie sich die quantenmechanische Kopplung zwischen QP aus verschiedenen Lagen bei Variation des Lagenabstandes und eines angelegten elektrischen Feldes ändert. Weiterhin werden Spektren von TTS-Messungen gezeigt. TTS wird bei Temperaturen T=5K durchgeführt, um thermische Emissionsprozesse aus den QP weitestgehend zu unterdrücken. Dadurch wird eine Betrachtung allein der Tunnelprozesse aus den QP möglich.

HL 31.32 Tue 16:30 Poster D

Vergleich von transienten Kapazitätsspektroskopie-Methoden an selbstorganisierten Quantenpunkten — •Christiane Konetzni[1], Andreas Schramm[2], Christian Heyn[1] und Wolfgang Hansen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Germany — [2]Optoelectronics Research Center, Tampere University of Technology, Finland

Die Ladungsträgeremission sowie -Injektion in selbstorganisiert gewachsene InAs Quantenpunkte (QP) wird mit transienter Kapazitätsspektroskopie studiert. Die QP sind in Schottkydioden aus n-dotiertem GaAs eingebettet, die mittels Molekularstrahlepitaxie auf GaAs-(001)-Oberflächen hergestellt worden sind. Um an diesen Heterostrukturen die s- und p-artigen Quantenpunktniveaus sowie der Wettinglayerzustände zu studieren verwenden wir neben der konventionellen Deep Level Transient Spectroscopy (DLTS) verschiedene Methoden transienter Kapazitätsspektroskopien: die so genannte Reverse Deep Level Transient Spectroscopy (RDLTS) und die Constant Capa-

citance Deep Level Transient Spectroscopy (CC-DLTS) sowie die Tunneling Transient Spectroscopy (TT-DLTS). Die Kapazitätstransiente wird in den DLTS-, CC-, und TT-DLTS-Messungen von der Emissionsrate der in den QP befindlichen Ladungsträgern bestimmt, bei RDLTS-Messungen hingegen von deren Einfangrate. Wir vergleichen Spektren dieser Messverfahren und stellen die Vorteile der verschiedenen Messmethoden für unsere Untersuchungen vor.

HL 31.33 Tue 16:30 Poster D

Very small ZnO nanoparticles and their organic ligands studied by Raman spectroscopy and X-ray diffraction — •Maxim Raskin[1], Marcel Schumm[1], Nicole Pfeiffer[2], Julia Harz[2], Khellil Bouamama[3], Reinhard B. Neder[2], and Jean Geurts[1] — [1]Physikalisches Institut, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany — [2]Institut für Mineralogie, Universität Würzburg, Am Hubland, 97074 Würzburg — [3]Département de physique, Université Ferhat Abbas, 19000 Sétif, Algeria

ZnO nanoparticles were synthesized with a new wet-chemical method, using 1,3,5-Pentanetrione as ligand molecules. Refinement fits of X-ray powder diffraction diagrams of the particles reveal the expected Wurtzite structure. They also show a nearly spherical particle shape with 2.2 nm diameter, the smallest value for ZnO nanoparticles achieved up to now. The inter-atomic distances match ZnO bulk without relaxation. To study the interface between the ZnO core and the Pentanetrione ligand, we use Raman spectroscopy. The vibration spectra of the ligands bound to the particles differ significantly from the pure ligand ones, i.e. the binding changes the molecule vibration eigenmodes. To interpret these changes in detail, we apply DFT calculations for the structure and the vibration modes of the ligands. The calculations show that (i) the middle oxygen atom in the ligand molecule occupies an exposed position, and (ii) the modes involving this exposed atom are predominantly attenuated by the bonding. This insight into the bonding should allow a systematic selection of further ligand candidates for ultra-small nanoparticle synthesis.

HL 31.34 Tue 16:30 Poster D

Memory effect in MOS structures containing amorphous or crystalline silicon nanoparticles — •Sebastian Meier[1], Rudolf Brüggemann[1], Gottfried Heinrich Bauer[1], Nicola Nedev[2], Emmo Manolov[3], Diana Nesheva[3], and Zelma Levi[3] — [1]Institute of physics, Carl von Ossietzky University Oldenburg, D-26111 Oldenburg, Germany — [2]Istituto de Ingenieria, Universidad Autonoma de Baja California, Benito Juarez Blvd., s/n, C.P. 21280, Mexicali, Baja California, Mexico — [3]Insitute of solid state physics, Bulgarian Academy of Science, 72 Tzarigradsko Chaussee Blvd., 1784 Sofia, Bulgaria

Amorphous and crystalline silicon nanoparticles (Si-NPs) embedded in a SiO_2 matrix are fabricated by thermal annealing of Metal/SiO_2/SiO_x/c-Si structures (x= 1.15) at 700°C or 1000°C in N_2 atmosphere for 30 or 60 minutes. High frequency C-V measurements show that the samples can be charged negatively or positively by applying a positive or negative bias voltage to the gate. A memory effect, due to the Si-NPs in the SiO_2 matrix, is observed. The method of measurement with open circuit between two measurements leads to the retention characteristic where the structures retain about 50% of negative charge trapped in Si-NPs for 24 hours. A second method, where the flat-band voltage is applied as bias voltage, shows shorter retention characteristics. There the Si-NPs retain 50% of their charge after 10 hours.

HL 31.35 Tue 16:30 Poster D

Kinetics of Si quantum dot formation in thermally deposited SiO_x layers upon vacuum annealing — •Bert Stegemann, Daniel Sixtensson, Andreas Schöpke, and Manfred Schmidt — Hahn-Meitner-Institut Berlin, Abt. Silizium-Photovoltaik, Kekuléstraße 5, 12489 Berlin

Si quantum dots embedded in an amorphous SiO_2 matrix were prepared under ultrahigh vacuum conditions by thermal annealing of evaporated substoichiometric SiO_x (x = 1.3) layers with thicknesses between 3 and 10 nm. By codeposition of Si or O atoms the initial amount of O was varied between x=0.9 and 1.5. An ultrathin SiO_2 capping layer grown by plasma oxidation with atomic oxygen turned out to prevent SiO_x sublimation upon annealing. The kinetics of the decomposition of the constituting suboxides into Si and SiO_2 was analyzed by X-ray photoelectron spectroscopy as a function of the post deposition annealing temperature. Peak analysis of the Si 2p transition revealed the evolution of relative fractions of the different oxidation states Si^{n+} (n = 0...4) with increasing temperature. For all investigated initial compositions phase separation started at about 600°C and was completed at 850°C. Annealing temperature also controls the quantum dot structure: crystallization sets on above 800°C as evidenced by cross-sectional TEM and photoelectrical measurements.

HL 31.36 Tue 16:30 Poster D

Cd-loss of CdSe quantum dots in ZnSe during MBE growth — •Utz Bass, Jean Geurts, Fabian Eschenbach, Suddhasatta Mahapatra, and Karl Brunner — Universität Würzburg, Physikalisches Institut, Experimentelle Physik III, Am Hubland, 97074 Würzburg

CdSe quantum dots (QD) on ZnSe grown by a special MBE technique are distinct QDs with lateral sizes up to 50 nm in AFM, a necessary property for application as single photon sources. In contrast, those QDs when capped with ZnSe appear significantly smaller in TEM-Images, indicating a severe segregation of Cd during overgrowth. This behaviour was analyzed by X-ray diffraction and Raman spectroscopy.

A detailed analysis by X-Ray interferometry for a series of samples with $0<d_{CdSe}<3$ ML reveals an increasing loss of Cd (Δd_{CdSe}) up to 0.7 ML for d_{CdSe} of 2.6 ML within the Cd(Zn)Se layer.

The segregation of Cd into the ZnSe layer was also evaluated by Raman spectroscopy. The frequency shift of the ZnSe LO phonon amounts to 3 cm^{-1} for $\Delta d_{CdSe} = 0.7$ ML, corresponding to a Cd content of 20%. This result indicates a strongly inhomogeneous segregation, resulting in Cd-rich regions above the QDs, which contribute predominantly under our nearly resonant Raman excitation conditions.

The combined analysis gives a congruent picture of Cd segregation in the ZnSe capping layer.

HL 31.37 Tue 16:30 Poster D

Polarisation properties of single lateral InGaAs quantum dot molecule photoluminescence — •Marcus Witzany[1], Claus Hermannstädter[1], Gareth Beirne[1], Lijuan Wang[2], Armando Rastelli[3], Oliver Schmidt[3], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart, Allmandring 3, 70569 Stuttgart — [2]Max-Planck-Institut für Festkörperforschung, Heisenbergstr. 1, 70569 Stuttgart — [3]Institut für Integrative Nanowissenschaften, IFW Dresden, Helmholtzstr. 20, 01069 Dresden

The photoluminescence of single lateral InGaAs quantum dot molecules (QDM) grown by a unique combination of molecular beam epitaxy and in-situ etching has been investigated with respect to polarisation. The molecules are composed of two quantum dots that are coupled along the [1-10] crystal direction via electron tunneling. An electric field along the coupling axis can be applied in a lateral geometry by depositing lithographically processed gold electrodes on the sample surface. An anomalous Stark shift and a change in relative intensities of the excitonic emission lines may be obtained by applying an electric field parallel to the molecule axis. This has been shown to indicate that the coupling mechanism (electron tunneling) can be controllably manipulated [Phys. Rev. Lett. 96, 137401]. We have performed linear polarisation dependant PL measurements on single molecules under the influence of different field strengths and directions. The degree of linear polarisation observed substantiates that the electronic wavefunction is elongated along the molecule axis.

HL 31.38 Tue 16:30 Poster D

Measurements of the second order intensity correlation of quantum dots in GaAs/AlGaAs microcavities — •Marc Assmann, Thorsten Berstermann, and Manfred Bayer — Experimentelle Physik II, TU Dortmund, 44221 Dortmund

The second order intensity correlation function g_2 as defined by optical coherence theory is one of the main tools to classify photon emitters. We present g_2-measurements of the emission of an ensemble of InGaAs quantum dots embedded as an active medium in high-Q micropillar laser structures. With increasing excitation density a transition into the lasing regime can be observed as a decrease of photon bunching from a value of $g_2(0)$=1,84 towards a value of $g_2(0)$=1. A change from Bose-Einstein statistics towards Poissonian statistics in the underlying photon number distribution can be seen as well. The results also show a strong dependence of the emission characteristics on the microcavity diameter. The experimental setup involves a streak camera which is modified such that a signal at fixed wavelength can be monitored after each pulsed laser excitation. The correlations are evaluated by averaging over an ensemble of such pulses. From these measurements insights into the quantum optical properties of light emission from semiconductor nanostructures can be taken.

HL 31.39 Tue 16:30 Poster D

Influence of spin-orbit coupling and crystal-field splitting on the electronic and optical properties of nitride quantum dots with a wurtzite structure — •Stefan Schulz[1], Stefan Schumacher[2], and Gerd Czycholl[1] — [1]Institute for Theoretical Physics, University of Bremen — [2]College of Optical Sciences, University of Arizona, Tucson, USA

In recent years, semiconductor quantum dots (QDs) have been the subject of intense experimental and theoretical research. As a new material system, group-III nitride based devices are of particular interest due to their wide range of emission frequencies from infrared to ultraviolet and their potential for high-power electronic applications.

We present an sp^3 tight-binding model for the calculation of the electronic and optical properties of InN/GaN quantum dots (QDs). The tight-binding model takes into account piezoelectricity, spin-orbit coupling and crystal-field splitting. Excitonic absorption spectra are calculated using the configuration interaction scheme. We study the electronic and optical properties of InN/GaN QDs and their dependence on structural properties, crystal-field splitting, and spin-orbit coupling.

HL 31.40 Tue 16:30 Poster D

Optical Bloch equations for coupled nanosystems: linear spectra, saturation dynamics and pump-test spectra — •Marten Richter[1], Thomas Renger[2], and Andreas Knorr[1] — [1]Institut für Theoretische Physik, AG Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Germany — [2]Institut für Chemie und Biochemie, Freie Universität Berlin, Germany

Bloch equations for optical and electronic processes in Coulomb-coupled nanostructures (like pigments in pigment protein complexes or semiconductor quantum dots) are presented. The theory includes Förster coupling induced excitation transfer between the nanostructures, electron-vibrational coupling between the nanosystems and their environment as well as the interaction with arbitrary strong external optical fields. The theory is based on many particle Liouville and correlation expansion techniques. In the case of photosynthetic antenna complexes the parameters of the theory are derived from crystal structure data. As a typical example, a comparison of simulated data and experimental results for the intensity dependent fluorescence yield of the light harvesting complex of photosystem II is discussed.

HL 31.41 Tue 16:30 Poster D

Theory of quantum light harvesting of coupled quantum dot systems — •Alexander Carmele, Marten Richter, and Andreas Knorr — Institut für Theoretische Physik, AG Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

Within a density-matrix approach for the coupled electron-photon dynamics, we compare the excitation of Coulomb-coupled quantum dots [1] with classical and non-classical light [2]. The theory evaluates the impact of the different photon-statistics of the exciting light (e.g. sub-poissonian or squeezed light) on the creation and annihiliation of optically active excitons. In particular, to understand the light harvesting dynamics of Förster-coupled nanosystems under realistic conditions we examine the exciton generation via thermal light.

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[2]M. Kira, S.W. Koch, Phys. Rev. A 73, 013813 (2006)

HL 31.42 Tue 16:30 Poster D

Time-resolved electroluminescence (TREL) measurements of InAs quantum-dot spin-injection LEDs — •H. Flügge, W. Löffler, P. Asshoff, C. Gohn, M. Hetterich, and H. Kalt — Institut für Angewandte Physik, Universität Karlsruhe (TH) and DFG Center for Functional Nanostructures, CFN, D-76128 Karlsruhe, Germany

We investigated the temporal behavior of the electro-luminescence in InAs quantum-dot spin-injection light-emitting diodes. We have recently demonstrated near-unity spin-injection fidelity in some quantum dots using a semi-magnetic spin aligner. To better understand the observed dependence of the polarization degree on emission energy we study the temporal characteristics of the polarized luminescence. In contrast to all-optical devices, where the relevant time-scale is the pico-second range, in electrical devices capacitive effects (among other things) come into play. We describe the time-correlated single-photon counting setup for the time-resolved measurements in the near infrared under pulsed current pumping. We expect the TREL technique to be able to reveal the dynamics of the relevant relaxation channels.

HL 31.43 Tue 16:30 Poster D

Effective-bond-orbital-Modellierung von Halbleiter-Quantenpunkten — •Daniel Mourad und Gerd Czycholl — Institut für Theoretische Physik, Universität Bremen

Die Berechnung elektronischer Einteilchenzustände von niederdimensionalen Strukturen (z.B. Halbleiter-Quantenpunkten) erfolgt häufig entweder mit Kontinuumsmodellen wie dem $\mathbf{k}\cdot\mathbf{p}$-Modell oder sogenannten empirischen Tight-Binding-Modellen (ETBM), die von lokalisierten atomaren Orbitalen ausgehen. Beide Ansätze wählen zweckmäßigerweise eine Parametrisierung, welche innerhalb gewisser Grenzen die Bulk-Bandstruktur der betreffenden Materialien reproduziert. Das ETBM passt die Bandstruktur selbstkonsistent an, während das $\mathbf{k}\cdot\mathbf{p}$-Modell einen festen Satz von Materialparametern verwendet, allerdings in seiner Anwendbarkeit prinzipiell auf einen kleinen Bereich der Brillouin-Zone beschränkt ist. Das Effective-Bond-Orbital-Modell (EBOM) ist ein Tight-Binding-Modell, welches die atomare Basis des Festkörpers vernachlässigt und das elektronische Problem auf dem unterliegenden Bravais-Gitter diskretisiert, allerdings mit Hilfe der $\mathbf{k}\cdot\mathbf{p}$-Parameter. Es liefert befriedigende Resultate für die gesamte Brillouin-Zone. Wir benutzen das EBOM mit übernächster-Nachbar-Kopplung zur Berechnung der Einteilchenzustände von in Zinkblende-Struktur kristallisierenden Halbleiter-Quantenpunkten (CdSe in ZnSe und GaN in AlN). Zusätzlich wird aufgezeigt, dass die Vernachlässigung kleiner Spin-Bahn-Wechselwirkungen nicht ad hoc gerechtfertigt werden kann.

HL 31.44 Tue 16:30 Poster D

Many-body model for the simulation of few-electron THz response in gated nanowires — •Radoslav Németh and Klaus Michael Indlekofer — CNI/JARA, IBN-1, Research Center Jülich GmbH, D-52425 Jülich, Germany

We consider a THz probe technique for the spatially resolved analysis of electronic spectra in nanowire-based transistors employing a multi-segment gate design [1]. We simulate the THz response of few-electron quantum states within the nanowire channel by use of a recently developed numerical many-body technique [2,3]. The discussed example demonstrates that signatures of Wigner-like charge density waves can be identified by use of this method, which lies beyond the scope of standard meanfield approaches. As such, the proposed multi-gate THz probe technique might prove useful in a future experimental realization as a means to characterize nanoscale devices which are dominated by quantization and few-electron Coulomb effects.

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HL 31.45 Tue 16:30 Poster D

Optical Investigations of the Temperature Behavior of InP Quantum Dots Embedded in Different Shaped (Al_xGa_{1-x})InP Barriers — •Moritz Bommer, Matthias Reischle, Wolfgang Michael Schulz, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart, Allmandring 3, 70569 Stuttgart

InP quantum dots (QD) are promising sources of single photons in the red part of the visible spectrum, and thus in the range of the highest sensitivity of current silicon detectors. Providing a single–photon source working at temperatures achievable by thermo–electric–cooling is the main goal of our current work.

The QDs were grown by self assembled metal organic vapor phase epitaxy and afterwards processed with chromium masks or mesas to allow for μ–PL measurements on single QDs. We have investigated the influence of aluminum (Al) containing barriers, raising the confinement of charge carriers in the QDs, to allow for operation at higher temperatures. Therefore, we have compared different barrier confinement potential shapes for different Al contents. With this approach we obtained single–dot photoluminescence at temperatures up to 140 K and could measure antibunching above liquid nitrogen temperature.

HL 31.46 Tue 16:30 Poster D

Inhomogeneous broadening of Raman LO/TO line in silicon nanowire samples — •Harald Scheel, Sevak Khachadorian, and Christian Thomsen — Institut für Festkörperphysik, Technische Uni-

versität Berlin, 10623 Berlin, Germany

We studied the Raman spectra of silicon nanowires as a function of excitation power, and find red-shifted and inhomogeneously broadened lines with increasing laser excitation power. A study of the local temperature by Stokes to anti-Stokes intensity ratios in our Raman spectra is inconsistent with temperatures determined by the Raman peak position considering anharmonic effects. We discuss this inconsistency and present an approach to merge the different results.

HL 31.47 Tue 16:30 Poster D

Influence of the Coulomb interaction on linear and nonlinear optical properties of single-wall carbon nanotubes — •Matthias Hirtschulz[1], Frank Milde[1], Ermin Malic[1], Stefan Butscher[1], Christian Thomsen[2], Stefanie Reich[3], and Andreas Knorr[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Germany. — [2]Institut für Festkörperphysik, Technische Universität Berlin, Germany. — [3]Fachbereich Physik, Freie Universität Berlin, Germany.

We present an optical Bloch equation approach to linear and nonlinear optical properties of single-wall carbon nanotubes. Within a density matrix theory the equations of motion for the coherent interband transitions and electron band occupations are obtained. The electron-electron interaction is treated on both the mean-field (screened Hartree-Fock approximation) and the correlation level. This approach allows to describe linear absorption as well as ultrafast nonlinear dynamics of these quasi one-dimensional systems. Linear excitonic absorption spectra are used to benchmark our approach. We find a band renormalization and the formation of excitons in carbon nanotubes on the mean-field level. To elucidate ultrafast and nonequilibrium effects, we will give several examples for the ultrafast nonlinear dynamics including the optical Stark effect. Finally, we will give an outlook on the influence of Coulomb scattering on the nonlinear optical properties of carbon nanotubes.

HL 31.48 Tue 16:30 Poster D

Optical Control of electron spin qubit in InAs self-assembled quantum dots — •Clive Emary[1] and Lu Jeu Sham[2] — [1]TU Berlin, Sekr. PN 7-1, Institut für Theoretische Physik, Hardenbergstr. 36, D-10623 BERLIN, Deutschland — [2]Department of Physics, University of California San Diego, La Jolla, California 92093, USA

The spin of an electron trapped in a self-assembled quantum dot is viewed as a promising quantum bit. We present here a theory of the control of such qubits using short laser pulses to excite virtual trion states within the dots. We describe mechanisms for qubit initialisation and for performing universal one and two qubit operations. We show that, for InAs dots, initialisation can be achieved on the nanosecond time-scale, and that coherent operations can performed with laser pulses with durations of tens of picoseconds. These results are of direct relevance to current experiments.

HL 31.49 Tue 16:30 Poster D

Enhanced charge carrier confinement in quantum dots and wires fabricated by cleaved edge overgrowth — •Jörg Ehehalt, Christian Neugirg, Dieter Schuh, and Werner Wegscheider — Universität Regensburg, Germany

The Cleaved Edge Overgrowth technique (CEO) is used to fabricate quantum wires and dots with precisely controlled sizes and positions. These structures are formed by quantum mechanical bound states at the intersection of two or three perpendicular quantum wells.

Confinement energies of up to 54 meV for wires and 10 meV for dots have been reported. However, a larger confinement is needed in oder to study excited states, apply external fields without loosing confinement and for application in room-temperature devices. This can be achieved by asymmetric intersections and tensile strain between materials with different lattice constants.

Using a combination of these techniques, the confinement energy can be significantly improved. The properties of these nanostructures are studied by photoluminescence and photoluminescence excitation spectroscopy and the results compared to theoretical simulations.

These results are also applied to fabricate novel electrically-pumped quantum wire lasers operating at higher temperatures and lower threshold currents. In addition, single and coupled CEO quantum dots with higher confinement energies are promising candidates for research in areas like quantum information processing.

HL 31.50 Tue 16:30 Poster D

Theoretical investigations of the photoluminescence from Si nanocrystals — •Davoud Pouladsaz[1], Michael Schreiber[1], and Reinhard Scholz[2] — [1]Institut für Physik, Technische Universität Chemnitz — [2]Walter Schottky Institut, Technische Universität München

The photoluminescence (PL) of H-passivated tetrahedral silicon nanocrystals up to a diameter of 2.5 nm has been investigated by optimizing the geometries in the electronic ground state and in the relaxed excited state with density functional theory (DFT) and time-dependent DFT, respectively. In the excited state, the modified occupation numbers of the frontier orbitals define an anisotropic change of the electronic charge density, so that the deformation in the relaxed excited state consists of a symmetry conserving part and a tetragonal distortion. From a comparison of our calculations with measured PL bands obtained on clusters with known size distribution, we find an agreement of the PL energies within better than 0.2 eV. Moreover, our calculated PL lineshapes give clear evidence that the large linewidth of the PL band is an intrinsic property of each individual cluster, not the result of an average over an ensemble of different cluster geometries. In the relaxed excited geometries, some low-frequency e-symmetric vibrations are elongated so strongly that their broad Poisson progression inhibits the observation of distinct vibronic subbands of modes at high frequencies.

HL 31.51 Tue 16:30 Poster D

Coupling of quantum-dot excitons with nanoantennas — •Markus Pfeiffer[1,2], Thomas Zentgraf[1,2], Markus Lippitz[1,2], and Harald Giessen[1] — [1]4. Physikalisches Institut, Universität Stuttgart — [2]Max Planck Institut für Festkörperforschung, Stuttgart

Our goal is to increase the coupling efficiency of single quantum systems to light with optical nanoantennas. As particle plasmon polaritons in metal nanostructures show a strong coupling to the light field, they seem to be promising candidates for this. We try to engineer the emission properties of quantum objects, such as excitons in semiconductor quantum dots, by utilizing the local field enhancement of metal nanostructures. For the experimental investigation of the emission rate, we use a streak camera which provides spectral and temporal resolution of the photoluminescence of the quantum dots. From such measurements the ensemble luminescence lifetime can be determined with an (multi)exponential fit of the spectrally integrated intensity profile. The goal is to increase the radiative decay rate of the excitons in the quantum dots by designing the local field enhancement of metal nanostructures. For different quantum dot systems, the dependence of the coupling process on the thickness of the capping layer between quantum dots and metal structures is studied. We will demonstrate limitations of these ensemble measurements and show first steps towards characterization of well defined single quantum dot–nanoantenna pairs.

HL 31.52 Tue 16:30 Poster D

Structural Change and Power Factor Enhancement of Thermoelectric p-type Films — •Katrin Rothe[1], Matthias Stordeur[2], Hartmut Leipner[1], Frank Heyroth[1], and Bernd Engers[2] — [1]Interdisziplinäres Zentrum für Materialwissenschaften, Martin-Luther-Universität 06099 Halle — [2]angaris GmbH, Heinrich-Damerow-Str. 1, 06120 Halle

By sputter-deposition thin films of the thermoelectric effective p-type compound semiconductor $(Bi_{0.15}Sb_{0.85})_2Te_3$ were prepared. For the first time a distinct increase of the electrical conductivity σ was observed after heating of the as-deposited films and afterwards cooling. For the enlightenment of this typical behavior, which seems to be similar found for phase change materials consisting of (Ge, Sb, Te)-alloys, also the Seebeck (S) and the Hall coefficient were measured. It was established that the increase of the electrical conductivity is not connected with an expected decrease of the Seebeck coefficient, because the charge carrier density is reduced but at the same time the hole mobility is increasing. Corresponding analytical investigations by XRD, EDX, and REM shows that besides a grain growth in the polycrystalline films a Te-rich phase appears after the heat treatment. The increase of the electrical conductivity at nearly unchanged Seebeck coefficient can be exploited for the enhancement of the film power factor ($S^2\sigma$). This is important for the efficiency of thermoelectric thin films devices as miniaturized coolers, generators, and sensors. Nevertheless for a quantitative interpretation of the presented new experimental results further investigations and theoretical considerations are required.

HL 31.53 Tue 16:30 Poster D

Electrical and Mass transport in multi-wall carbon nanotubes — •Markus Löffler, Uhland Weissker, Thomas Mühl, Thomas Gemming, Rüdiger Klingeler, and Bernd Büchner — IFW Dresden, D-01069 Dresden, Germany

Electrical transport and concomitant mass transport in multi-wall carbon nanotubes (MWCNT) has been studied in a transmission electron microscope (TEM) using the tip of an in-situ scanning tunneling microscope (STM). Mass transport driven by electromigration has been observed. Contact resistances, which are of great influence in 2-point measurement setups, have been reduced by current-driven annealing. Furthermore, breakdown current densities of empty MWCNT have been determined. This work presents a starting point for measuring important electronic and electromechanical properties of filled and/or doped carbon and oxide-based nanoscale materials.

HL 31.54 Tue 16:30 Poster D

Substrate induced low-dimensionality in few-layer graphene — •Jörg Kinzel[1], Jens Ebbecke[1,2,3], and Achim Wixforth[1,2] — [1]Lehrstuhl für Experimentalphysik 1, Universität Augsburg, Germany — [2]Center for NanoScience, München, Germany — [3]School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, United Kingdom

Since the first fabrication of few- and single-layer graphene many surprising properties have been discovered in this material.

By using a special technique for exfoliation, we were able to produce few-layer graphene (FLG) on top of a rather rough SiO_2 surface. Such FLG devices already exhibit some of the extraordinary properties of a single-layer graphene flake. In our case, surface roughness induced humps locally distort the graphene layers and bend their nearly flat hexagonal topology, inducing local strain and stress modulations.

Conduction measurements at liquid helium temperatures exhibit the typical graphene V shaped conductivity with a minimum at finite gate bias which, however, is superimposed by Coulomb blockade like oscillations.

HL 31.55 Tue 16:30 Poster D

Lateral electrical contacts to single bismuth-selenide nanowires — •Saskia F. Fischer[1], Markus Wahle[1], Shadyar Farhangfar[2], Jana Sommerlatte[2], and Kornelius Nielsch[2,3] — [1]Electronic Materials and Nanoelectronics, Ruhr-University of Bochum, D-44780 Bochum, Germany — [2]Max-Planck Institute of Microstructure Physics, D-06120 Halle, Germany — [3]Institute of Applied Physics, University of Hamburg, D-20355 Hamburg, Germany

Nanoscale thermoelectric materials are of high interest to science and technology dealing with the conversion of heat to electricity, and vice versa. Recent increases in thermoelectric efficiency have been achieved in sub-micrometer scaled structures [1-3]. Bismuth telluride and bismuth selenide are particularly interesting for applications at room temperature [4]. Bismuth selenide nanowires arrays were grown by electrochemical deposition into anodic alumina templates with pore diameters of 25 nm, 50 nm, and 100 nm and lengths of 2 μm up to 10 μm. Subsequently the anowires were dissolved from the template in an aqueous NaOH solution and applied to prepatterned Si_2O/Si substrates. Single nanowires were laterally contacted in four-terminal geometry by electron-beam lithography, Ti/Au electron-beam evaporation and lift-off processing. Electrical characterizations of the nanowire arrays and single nanowires are currently in progress. [1] R. Venkatasubramanian et al., Nature 413, 597 (2001), [2] T.C.Harman, et al. Science 297, 2229 (2002), [3] Y.-M. Lin and M.S. Dresselhaus, Phys. Rev. B 68, 075304 (2003). [4] H.J. Goldsmid, Thermoelectric Refrigeration (Plenum New York, 1964).

HL 31.56 Tue 16:30 Poster D

Carbon doped high mobility 2D hole gas in GaAs/AlGaAs heterostructures — Christian Gerl, •Marika Kubová, Dieter Schuh, and Werner Wegscheider — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D 93040 Regensburg

Carbon as an acceptor in GaAs/AlGaAs heterostructures provides significant advantages in comparison with Si and Be acceptor materials. C-doped structures exhibit high mobility of two-dimensional hole gases (2DHGs) beyond 10ˆ6 cmˆ2/Vs. It is possible to prepare structures in standard growth directions (in the (001) and (110) crystal plane) in contrast to Si-doped GaAs (311)A. Utilizing a carbon filament doping source, ultra high mobility quantum wells and modulation doped single interface structures in the GaAs/AlGaAs material system were prepared by molecular beam epitaxy (MBE). Hole mobility strongly depends on quantum well width and spacer thickness. Both parameters were optimised. Magnetotransport measurements at low temperatures show hole mobilities of 1.2*10ˆ6 cmˆ2/Vs on GaAs (001) substrates. The carrier density reveals a hysteretic behaviour when tuned with an external electric field.

HL 31.57 Tue 16:30 Poster D

Magnetic properties of amorphous, p-type conducting $CuCr_{0.95}Mg_{0.05}O_2$ and $CuCr_{0.93}Mg_{0.05}Mn_{0.02}O_2$ — •Qingyu Xu[1], Heidemarie Schmidt[1], Shengqiang Zhou[1], Kay Potzger[1], Manfred Helm[1], Holger Hochmuth[2], Michael Lorenz[2], Christoph Meinecke[2], and Marius Grundmann[2] — [1]Forschungszentrum Dresden-Rossendorf, Institut für Ionenstrahlphysik und Materialforschung,Bautzner Landstraße 128, 01328 Dresden, Germany — [2]Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik II, Linnéstrasse 5, D-04103 Leipzig, Germany

$CuCr_{0.95}Mg_{0.02}O_2$ is p-type oxide semiconductor with the highest conductivity [1]. We prepared conductive, polycrystalline and amorphous $CuCr_{0.95}Mg_{0.05}O_2$ and $CuCr_{0.93}Mg_{0.05}Mn_{0.02}O_2$ films on a-plane sapphire substrates by pulsed laser deposition under different O_2 partial pressure and substrate temperature. Hall measurements were performed to study the majority free charge carrier type in these films. The polycrystalline $CuCr_{0.95}Mg_{0.05}O_2$ and $CuCr_{0.93}Mg_{0.05}Mn_{0.02}O_2$ films are n-type conducting up to 290 K, while in amorphous $CuCr_{0.95}Mg_{0.05}O_2$ and $CuCr_{0.93}Mg_{0.05}Mn_{0.02}O_2$ films the type of majority free charge carriers changes from n-type to p-type around 270 K. The antiferromagnetic to paramagnetic transition was observed in both polycrystalline and amorphous $CuCr_{0.95}Mg_{0.05}O_2$ films at 25 K, while the $CuCr_{0.93}Mg_{0.05}Mn_{0.02}O_2$ films revealed no antiferromagnetic ordering. [1] R. Nagarajan et al. J. Appl. Phys. 89, 8022 (2001)

HL 31.58 Tue 16:30 Poster D

Transport Measurements of Graphene — •Hennrik Schmidt, Patrick Barthold, Thomas Lüdtke, and Rolf J. Haug — Institut für Festkörperphysik, Leibniz Universität Hannover, D-30167 Hannover, Germany

We study electronic transport properties of few layer graphene. Similar to a mono layer, even a small stack of a few layers exhibits a strong field effect while changing the type and amount of charge carriers by applying a backgate voltage. Our samples are made by micromechanical cleavage of natural graphite and are deposited on top of a silicon wafer with a 330 nm thick silicon oxide. The flakes are contacted using electron-beam lithography and structured using plasma etching. Our measurments have been carried out in a bath cryostat with temperatures down to 1.5 Kelvin. The electric field effect is measured while changing temperature and magnetic field. Magneto-transport with a applied field up to 13 Tesla shows Shubnikov-de Haas oscillations depending on the backgate voltage and thereby on the carrier concentration. Additionally, the Hall effect was measured. The change of the type of charge carriers from electrons to holes and of their density is observed in both measurements.

HL 31.59 Tue 16:30 Poster D

Classical ballistic transport in a triangular shaped cavity — Roland Ketzmerick and •Martin Richter — Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany

Recent magneto-resistance measurements on semiconductor heterostructures with a triangular shaped gate revealed unexpectedly detailed features in R(B) [D. Maryenko et al., unpublished] beyond simple commensurabilities. We explain this by classical ballistic transport and demonstrate the importance of the phase-space structure, the width of the openings, and the softness of the potential.

HL 31.60 Tue 16:30 Poster D

Magneto-Transport in Two-Dimensional Electron Systems beneath Ferromagnetic Nanostructures — •Ralf Dinter[1], Holger Stillrich[1], Christian Heyn[1], Andreas Frömsdorf[2], Hans Peter Oepen[1], and Wolfgang Hansen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg — [2]Institut für Physikalische Chemie, Universität Hamburg, Bundesstr. 45, 20146 Hamburg

We study the magneto-transport of two-dimensional electron systems (2DEG's), which are subjected to laterally modulated magnetic fields. Our goal is to investigate the energy splitting of the Landau lev-

els due to field modulations with periods less than 100 nm. Shallow GaAs/AlGaAs High Electron Mobility Transistors are grown with MBE, where the 2DEG's are located down to less than 20 nm beneath the sample surface. In order to achieve a modulated magnetic potential, a nano-structured Co/Pt multilayer is prepared directly on the samples. Hereby, a monolayer of micelles, consisting of diblockcopolymers, is used as a template. The micelles arrange in a hexagonal lattice with short-range order. The magnetic properties of the ferromagnetic material are studied with the magneto-optical Kerr effect. The magneto-transport is investigated in Hall bar geometry at temperatures between 4.2 K and 20 mK. We present magneto-transport measurements on Hall bars with a modulated magnetic potential.

HL 31.61 Tue 16:30 Poster D

Structural, optical and electrical properties of novel phase change alloys — •Sarah Gindner, Michael Woda, Stephan Kremers, Michael Klein, and Matthias Wuttig — I. Physikalisches Institut (1A), RWTH Aachen, 52056 Aachen

Phase Change Materials (PCM) are Te or Sb containing alloys, which show a remarkable property combination. They possess a very large property contrast, e.g. electrical resistivity and optical reflectivity between the amorphous and crystalline state. At the same time they can be switched between these two states very rapidly on a ns timescale using either a laser or current pulse. Hence they are used in rewriteable optical storage media such as DVDs and Blue-ray disks and are promising candidates for non-volatile electronic memories such as Phase Change Random Access Memory (PCRAM). From a scientific point of view it is important to determine their structural properties. In this study possible new PCM including $CuInTe_2$ and $Ge_3Sb_6Te_5$ are investigated by a variety of techniques to understand the effect of stoichiometric change upon physical properties. From these techniques the suitability of new materials for phase change application is derived and will be discussed. Temperature dependent resistivity is investigated with the van der Pauw technique. XRD measurements reveal the structural properties of the amorphous and crystalline state. The structural changes causing changes in film thickness and density are measured with x-ray reflectometry. Optical properties (0,02 eV to 5.3 eV) of the PCM are determined by FTIR and ellipsometry measurements.

HL 31.62 Tue 16:30 Poster D

Experimental verification of the lens effect of a fractal structured LHM in the microwave regime — •Ernst Lenz, Benjamin Meier, and Heino Henke — TU Berlin, Fachgebiet Theoretische Elektrotechnik EN-2, Einsteinufer 17, 10587 Berlin, Germany

Left-handed material (LHM) is a novel artificial structure with outstanding properties, such as the predicted lens effect [1,2,3]. In this presentation we show experimental data, confirming the lense effect for the microwave regime. The used test structure was originally suggested by Ziolkowski et al. [4].

The experimental proof of the lens effect was achieved by a variation of the angle of incidence of the electromagnetic radiation. In addition we investigate a new constructed metamaterial where we have replaced the split ring resonator by Koch snowflakes [5,6]. The data emphasize the changes in the scattering, diffraction, and absorption behavior compared to the test structure.

[1] V. G. Veselago, Sov. Phys. Usp. **10**, 509 (1968). [2] J. B. Pendry, Phys. Rev. Lett **85**, 3966 (2000). [3] N. Engheta et al., IEEE-TMTT **53**, 1535 (2005). [4] R. W. Ziolkowski, IEEE-TAP **51**, 1516 (2003). [5] J. B. Pendry et al., IEEE-TMTT **47**, 2075 (1999). [6] K. J. Falconer, *Fraktale Geometrie*, Spektrum, Berlin (1990).

HL 31.63 Tue 16:30 Poster D

Resonant behavior of fractal shaped metamaterials — •Benjamin Meier, Ernst Lenz, and Heino Henke — TU Berlin, Fachgebiet Theoretische Elektrotechnik EN-2, Einsteinufer 17, 10587 Berlin, Germany

Resonant fractal meta structures are investigated with the aim of drastically reducing the resonance frequency. A Koch snowflake is used as fractal structure [1]. We show that an essential reduction of resonant frequency in the microwave regime could be achieved for fractals of higher orders without changing the maximal spatial extent.

This offers the possibility of higher homogenization of metamaterials by using smaller unit cells [2,3]. Consequently scattering and diffraction of the impinging electromagnetic waves are reduced.

As an example the dispersion curve for the fourth order fractal meta structure is calculated, resulting in the typical metamaterial behavior [4].

[1] K. J. Falconer, *Fraktale Geometrie*, Spektrum (1990). [2] A. Semichaevsky et al., Prog.ER **71**, 129 (2007). [3] M. G. Silveirinha, PRB **75**, 115104 (2007). [4] D. R. Smith et al., PRL **84**, 4184 (2000).

HL 31.64 Tue 16:30 Poster D

Mix-and-Match process for ballistic devices on epitaxial few-layer graphene — •Sonja Weingart[1], Claudia Bock[1], Ulrich Kunze[1], Konstantin V. Emtsev[2], Thomas Seyller[2], and Lothar Ley[2] — [1]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, D-44780 Bochum — [2]Lehrstuhl für Technische Physik, Universität Erlangen-Nürnberg, D-91058 Erlangen

In this work we demonstrate a technique for the preparation of ballistic devices with precise geometric definition from epitaxial few-layer graphene. The technique combines the basic strategies for the fabrication of a strongly confined low-dimensional system: a) positive definition of nanostructures, b) a simple mix-and-match process for definition of contact areas and leads, c) a low-damage single-step plasma etch transfer. Starting material is few-layer graphene grown epitaxially on SiC(0001) by graphitization of the surface [1]. In a first process step alignment marks are realized by conventional UV-lithography and lift-off technique. Nanostructures are defined in a 70 nm-thick negative-tone resist (ma-N 2401) by high-resolution e-beam lithography. In the following process-step the geometries of the contact areas and leads are realized by conventional UV-lithography. The resulting resist structure is transferred by low-damage plasma etching using an inductively coupled O_2/He plasma. A minimal line-width of 30 nm was achieved reproducibly. The reliability of the process is shown by the fabrication of cross-junctions formed by orthogonal adiabatically shaped leads.

[1] Th. Seyller et al., Surface Science **600**, 3906 (2006).

HL 31.65 Tue 16:30 Poster D

Electrically induced phase transition in GeSbTe alloys — •Gunnar Bruns, Carl Schlockermann, Michael Woda, and Matthias Wuttig — I. Physikalisches Institut Ia, RWTH Aachen, 52056 Aachen

While phase change materials have already successfully been applied in rewriteable optical data storage, they are now also promising to form the basis for novel non-volatile electrical data storage devices. To understand the physical concepts of these so-called Phase Change Random Access Memory (PCRAM) it is mandatory to gain a deeper insight into the switching process between the highly resistive amorphous and the lowly resistive crystalline phase.

The fast phase transitions between the amorphous and crystalline state of GeSbTe-based alloys has so far often been studied using pulsed laser irradiation. In this work an alternative approach is employed to investigate this transition. Electrical pulses are used to rapidly and reversibly switch between the two states.

For these experiments a setup was built with a specially designed contacting circuit board to meet the requirements of electrical measurements on a nanosecond timescale. The influence of the pulse parameters on the change of device resistance was determined for different initial states. Furthermore the high time resolution of 0.4 ns allows investigation of transient electrical effects like the so-called threshold switching first described by Ovshinsky in the late 1960s. [S.R. Ovshinsky. Reversible Electrical Switching Phenomena in Disordered Structures. *Physical Review Letters*, 21(20):1450-1453, 1968.]

HL 31.66 Tue 16:30 Poster D

Investigation of charge transfer in organic-inorganic hybrid composites — •Marc Daniel Heinemann, Karsten von Maydell, Ingo Riedel, Joanna Kolny-Olesiak, Holger Borchert, and Jürgen Parisi — Energy- and Semiconductor Research Laboratory, Department of Physics, University of Oldenburg, Carl-von-Ossietzky-Straße 9-11, D-26111 Oldenburg

This contribution reports on investigations of the charge transfer process in hybrid solar cells using II-VI semiconductor nanocrystals as acceptor material. CdSe-nanocrystals within this polymer-based-composite have the capability to increase the light absorption compared to standard fulleren-derivatives.

The charge transfer between the conjugated polymer and the nanocrystal will be characterized by Light-induced Electron Spin Resonance (LESR) spectroscopy and Optical Detection of Magnetic Resonance (ODMR). Additionally the polaronic states will be detected by Photoinduced Absorption.

These measurements will be expanded to other hybrid composites.

HL 31.67 Tue 16:30 Poster D

Development of mesoporous TiO_2-electrodes as ordered acceptor matrix for organic-inorganic bulk-heterojunction solar cells — •Jan Friedmann[1], Bettina Herbig[3], Maria Hammer[1], Andreas Sperlich[1], Moritz Liedtke[2], Ingo Riedel[1], Carsten Deibel[2], and Vladimir Dyakonov[1,2] — [1]Experimental Physics VI, Physical Institute, Julius-Maximilian University of Würzburg, Am Hubland, D-97074 Würzburg — [2]ZAE Bayern, Div. Functional Materials for Energy Technology, Am Hubland, D97074 Würzburg, Germany — [3]Fraunhofer Institut für Silicatforschung, Neunerplatz 2, D97082 Würzburg, Germany

There is a vast variety of intriguing concepts for the improvement of organic photovoltaic devices. One approach focuses on the application of mesoporous acceptor-type metal oxides (e.g., TiO_2) infiltrated by a donor-type conjugated polymer (P3HT) forming a hybrid bulk heterojunction. To establish efficient dissociation of photogenerated excitons in the polymer phase the porosity of the acceptor-template is to be optimized for twice the exciton diffusion length. We realized mesoporous TiO_2-electrodes derived from a sol-gel process using structure-directing block-copolymers and evaporation induced self assembbley technique. The structure of the mesoporous films was characterized by XRD-analysis and TEM-imaging. We experimentally verified the efficiency of this elementary via photoluminescence quenching experiments and photoinduced absorption spectroscopy to qualify the formation of long-lived excited states such as polarons, triplet excitons.

HL 31.68 Tue 16:30 Poster D

Development of Al-doped ZnO-nanocrystals for applications in advanced cell concepts of organic photovoltaics — •Daniel Rauh[1], Volker Lorrmann[1], Maria Hammer[2], Andreas Sperlich[2], Moritz Liedke[1], Carsten Deibel[2], Ingo Riedel[1], and Vladimir Dyakonov[1,2] — [1]Bavarian Centre for Applied Energy Research (ZAE Bayern), Functional Materials for Energy Technology, Am Hubland, D-97074 Würzburg — [2]Experimental Physics VI, Physical Institute, Julius-Maximilian University of Würzburg, Am Hubland, D-97074 Würzburg

We developed Al doped ZnO-nanocrystals (nc-ZnO:Al) via wet chemical synthesis. XRD-analysis, electron spin (ESR) and electron-nuclear spin double resonance (ENDOR) confirm that nc-ZnO:Al grows in Wurtzite structure and aluminium enters the crystal on site of the Zn-atom. ESR experiments on blends of P3HT and nc-ZnO:Al confirm light-induced charge separation with resonances assigned to polarons on P3HT and electrons in the nc-ZnO:Al domain. Photoinduced absorption spectroscopy was applied to rationalize infiltration of P3HT into porous nc-ZnO:Al matrix: Spectra of bilayer structures reveal coexistence of positive polarons and triplet excitons while strong polaron formation is accompanied with complete quenching of triplet excitons (TE) for infiltrated ZnO:Al-matrices. Polaron formation and quenching of TE is ascribed to the enlarged interface in the bulk heterojunction. ENDOR-measurements as well as photoluminescence studies on pure ZnO:Al confirm that sodium, incorporated during synthesis, result in deep-level acceptor states in the middle of the band gap.

HL 31.69 Tue 16:30 Poster D

Application of Al-doped ZnO-nanocrystals for novel organic–inorganic hybrid solar cells — •Stefan Geissendörfer[1], Daniel Rauh[1], Ingo Riedel[1], Carsten Deibel[2], and Vladimir Dyakonov[1,2] — [1]Bavarian Centre for Applied Energy Research (ZAE Bayern), Functional Materials for Energy Technology, Am Hubland, D-97074 Würzburg — [2]Experimental Physics VI, Physical Institute, Julius-Maximilian University of Würzburg, Am Hubland, D-97074 Würzburg

Hybrid solar cells based on polymers and metal oxides combine the advantages of organic and inorganic materials such as high absorption coefficients, efficient charge generation as well as solution-processability. Doped metal oxides are of particular interest as they are inexpensive, environmentally friendly and can be obtained in versatile shapes (dots, rods, porous films). We synthesized aluminium-doped ZnO-nanocrystals (4–7nm) to use them as electron acceptors in hybrid bulk heterojunction devices. For this, a mesoporous matrix is prepared from ZnO:Al-nanoparticle dispersions to be infiltrated by a conjugated polymer acting as electron donor. We present first realizations of hybrid ZnO:Al-poly(alkylthiophene) bulk heterojunction solar cells and discuss their photovoltaic performance in respect of modified active layer morphology and electrode materials.