HL 9: Poster 1

Time: Monday 14:30–17:00 Location: P2

HL 9.1 Mon 14:30 P2

Noncovalent Functionalization of Single Walled Carbon Nanotubes — •Pascal Bluemmel, Vitaliy Datsyuk, Antonio Setaro, and Stephanie Reich — Fachbereich Physik, Freie Universitaet, Berlin

Functionalization provides a tool to alter the electronic and dynamic properties of carbon nanotubes [1-2]. The degree of alteration depends on the type of bonding and the properties of the attached molecule. For some applications it is important to minimize the influence of the bond. Noncovalent functionalization is indicated to be a suitable way of attaching molecules to nanotubes while avoiding drastic modifications due to the bond itself [3].

We investigate pyrene and other organic molecules that are exohedrally adsorbed onto the nanotube surface via pi-pi stacking. The functionalized nanotubes are probed optically by absorption-, photoluminescence- and Raman spectroscopies.

[1] C.S. Lin et al. J. Phys. Chem. C 2007, 111(11), 4069-4073
[2] M. Müller et al. Phys. Stat. Sol. (b) 2007, 244 No. 11, 4056-4059
[3] X. Guo et al. J. Am. Chem. Soc. 2005, 127, 15045-15047

HL 9.2 Mon 14:30 P2

Temperature dependence of the conductivity of ballistic graphene — •Matthias Bräuninger[1], Markus Müller[2], and Björn Trauzettel[1] — [1]Institute for Theoretical Physics and Astrophysics, University of Würzburg, D-97074 Würzburg, Germany — [2]Department of Theoretical Physics, University of Geneva, CH-1211 Geneva, Switzerland

We investigate the temperature dependence of the conductivity in ballistic graphene using Landauer transport theory. The finite temperature only enters in the Fermi distribution functions of the reservoirs, but not in any inelastic scattering strength. Remarkably, we obtain results that are qualitatively in agreement with many features that were recently observed in transport measurements on (high mobility) suspended graphene. The conductivity at high temperature T and low density n grows linearly with T, while at low T and high n it follows $\sigma \sim \sqrt{|n|}$. In the intermediate regime the conductivity is a non-monotonic function of either T or n, exhibiting a minimum at $T = 0.693\hbar w\sqrt{|n|}$ where v is the Fermi velocity.

HL 9.3 Mon 14:30 P2

Ab initio investigations of defects in bilayer graphene — •Michael Bachmann and Christian Heiliger — I. Physikalisches Institut, Justus Liebig University Giessen, D-35392, Germany

Recent experimental observations of bilayer graphene using scanning tunnelling microscopy show scattering patterns with a 6-fold symmetry [1,2]. These cannot be explained by substitutional defects which cause scattering patterns with 3-fold symmetry. We report ab initio calculations of defects in bilayer graphene that can explain the 6-fold symmetry of the measured scattering patterns. They do not occur in single layer graphene. They occur if a defect in one layer induces changes in the electronic structure of the other layer. This work has been supported in part by the NIST-CNST/UMD-NanoCenter Cooperative Agreement.

[1] G.M. Rutter, J.N. Crain, N.P. Guisinger, T. Li, N.P. First, J.A. Stroscio, Science **317**, 219 (2007)
[2] N.P. Guisinger, G.M. Rutter, J.N. Crain, C. Heiliger, N.P. First, J.A. Stroscio, J. Vac. Sci. Technol. **26**, 932 (2008)

HL 9.4 Mon 14:30 P2

Temperature-dependent Measurements of Phonon Dynamics in Highly Oriented Pyrolytic Graphite — •Martin Scheuch[1], Konrad von Volkmann[1], Luca Perfetti[2], Tobias Kampfrath[1], Christian Frischkorn[1], and Martin Wolf[1] — [1]Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin — [2]Laboratoire des Solides Irradiés, Ecole polytechnique, 91128 Palaiseau cedex, France

We have employed THz time-domain spectroscopy in the range from 10 to 30 THz to obtain the complex dielectric function of Highly Oriented Pyrolytic Graphite (HOPG) for temperatures from 10 to 300 K. In addition to static measurements, we apply a pump pulse at 790 nm to investigate the dynamics of the energy dissipation of the photo-excited charge carriers. Our data allow us to evaluate the lifetimes of various strongly coupled high-energy phonon modes [1]. Agreement with theoretical predictions [2] is good and yields the coupling strength between these high-energy and other low-energy phonon modes. Our results are relevant to graphene and carbon nanotubes, which are closely related to graphite.

[1] T. Kampfrath et al., PRL 95, 187403 (2005) [2] N. Bonini et al., PRL 99, 176802 (2007)

HL 9.5 Mon 14:30 P2

Electron diffraction on carbon nanotubes (CNTs) — •Christian Huber, Dominik Preusche, David Kalok, Christoph Strunk, and Josef Zweck — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstraße 31, 93040 Regensburg, Germany

Depending on their specific structure, which can be described by the chiral indices, single walled carbon nanotubes (SWNT) may be either metallic or semiconducting materials. For the interpretation of measurements on spin polarized electron transport in SWNTs, contacted between magnetic leads, it is of importance to know the structure and hence the conductive properties as exactly as possible. Therefore, electron nano diffraction in a transmission electron microscope is performed on SWNTs. From these diffraction patterns, supported by high resolution images and simulations, it is possible to derive the chiral indices needed.

HL 9.6 Mon 14:30 P2

Combined optical and AFM analysis of combustion produced nano organic particles — •Antonio Setaro[1], Annalisa Bruno[2], Patrizia Minutolo[3], Andrea D'Anna[2], and Stephanie Reich[1] — [1]Fachbereich Physik, Freie Universität, Berlin — [2]Università degli studi di Napoli Federico II — [3]Istituto Ricerche Combustione-CNR Napoli

Combustion processes result in a wide range of products. Recently much attention is being devoted to the nanosized products of combustion, as their presence within the atmosphere has very profound impact not only from the climatologic point of view but also from a medical one, as many epidemiological studies outline the direct correlation between high concentration of carbonaceous nanoparticulate and deseases.
Samples from premixed laminar ethylene- air flame operating in different conditions from no-sooting to slightly sooting have been collected. Different optical techniques coupled with AFM-microscopy are here employed for getting a better insight on the chemical and morphological nature of these nanoparticulates.

HL 9.7 Mon 14:30 P2

CVD Growth of Carbon Nanotubes Using Molecular Nanoclusters as Catalyst — •Karin Goss, Akashdeep Kamra, Christian Spudat, Carola Meyer, Paul Kögerler, and Claus M. Schneider — Research Centre Jülich, Institute for Solid State Research, Electronic Properties, JARA-Jülich-Aachen Research Alliance, 52425 Jülich, Germany

Carbon nanotubes (CNTs) are known to possess superior mechanical and electronic properties that caused a lot of research in multiple fields of nanophysics. For transport measurements on CNTs and functionalized derivatives such as peapods isolated single-walled carbon nanotubes (SWNTs) are favourable. With the chemical vapour deposition (CVD) method such CNTs can be grown directly on substrates and their quality is governed by the catalyst used in the CVD procedure. Our experiments are motivated by a possible constriction of the CNT diameter distribution, which could facilitate the synthesis of peapods. Hence we investigated CNTs grown with molecular $Mo_{72}Fe_{30}$ nanoclusters as a catalyst by AFM, SEM and Raman spectroscopy. In comparison to our standard catalyst, which is composed of Fe clusters agglomerated at alumina nanoparticles, the molecular nanoclusters could enable the growth from highly defined catalyst particles. Additionally the role of the oxidation state of Mo for the growth mechanism is discussed.

HL 9.8 Mon 14:30 P2

Carbon aerogel electrodes for electrochemical double-layer capacitors based on resorcinol-formaldehyde sediments — •Mario Zeller[1], Volker Lorrmann[1], Dirk Hauschild[2], Jens Pflaum[1,2], Gudrun Reichenauer[1], and Vladimir Dyakonov[1,2] — [1]Bavarian Centre for Applied Energy Research e.V. (ZAE Bayern), D-97074 Würzburg — [2]Julius-Maximilians-University of Würzburg, Institute of Physics, Experimental Physics VI, D-97074 Würzburg

Carbon aerogels are promising candidates for electrochemical double-layer capacitors (EDLC) electrodes, because their microstructure is tuneable over a broad range. EDLC electrodes based on monolithic carbon aerogel offer an excellent electrical conductivity, however, they are very brittle.

We prepared binder electrodes based on carbon aerogel powder via pyrolysis of resorcinol-formaldehyde sediments. The influence of the respective preparation parameters, such as the concentration of the catalyst on the pore size distribution, surface and micropore properties, was evaluated by means of nitrogen sorption. Scanning electron microscopy was used to determine the size of the carbon particles.

For electrochemical investigation of the binder electrodes in different electrolytes, cyclic voltammetry (CV), and impedance spectroscopy in a three-electrode cell was performed. In addition, galvanostatic charging and discharging were investigated in a two-electrode cell, where both, the anode and cathode constituted by carbon aerogel electrodes.

The relationship between the structure and the electrochemical performance of the carbon aerogel binder systems is discussed.

HL 9.9 Mon 14:30 P2

Composite electrode of carbon aerogel and MnO_2 for electrochemical capacitors — •Christian Weber[1], Volker Lorrmann[1], Carsten Deibel[2], Jens Pflaum[1,2], Gudrun Reichenauer[1], and Vladimir Dyakonov[1,2] — [1]Bavarian Centre for Applied Energy Research e.V. (ZAE Bayern), D-97074 Würzburg — [2]Julius-Maximilians-University of Würzburg, Institute of Physics, Experimental Physics VI, D-97074 Würzburg

Electrochemical capacitors (EC) bridge the gap between conventional capacitors with high power but low energy density and batteries with high specific energy density but rather low power density. There are two types of EC: Double-layer supercapacitors, that store charges electrostatically in the electrochemical double-layer between electrolyte and high surface area electrodes of activated hard carbon. In pseudocapacitance supercapacitors the charge storage is of faradaic nature, e.g. redox processes in MnO_2. We have blended the organic precursor of a synthetic activated hard carbon (carbon aerogel) with MnO_2 particles to be used as electrode for EC. The aim is to combine the faradaic- and the double-layer capacitance of MnO_2 and carbon, to increase the achievable capacity of the electrode. The electrochemical properties of these composites were investigated with cycling voltammetry, charge/discharge cycling and impedance spectroscopy. Structural analysis was performed via nitrogen sorption, scanning electron microscopy and X-ray diffraction.

HL 9.10 Mon 14:30 P2

Transport measurements in width modulated graphene nanoribbons — •Silvia Schmidmeier, Dieter Weiss, and Jonathan Eroms — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Germany

We investigate electronic transport both in graphene and graphene nanoribbons (GNRs). The lateral confinement of the charge carriers in the quasi one-dimensional ribbons creates an energy gap near the charge neutrality point, where the gap depends on the width of the GNR. Here we are using this width dependence to create a potential modulation along the nanoribbon. To this end, the ribbon width is varied periodically, which we expect to affect the electronic transport in an interesting way. GNRs with different width, flat as well as modulated ribbons, were fabricated by electron beam lithography and plasma etching techniques. The devices are fully tunable by two graphene sidegates and a backgate. Here we present the first measurements on those GNRs. In order to verify the single-layer character we performed quantum Hall measurements and found the characteristic half-integer quantization. By examining the differential I-V characteristics of the GNRs a transport gap is clearly observed at the Dirac point. We also measured the magnetoconductance in a perpendicular magnetic field for different temperatures. At low magnetic fields weak localization is clearly visible, therefore the phase coherence length can be determined by 1D weak localization theory. Additionally it was extracted in an independent way from the amplitude of the universal conductance fluctuations.

HL 9.11 Mon 14:30 P2

Indirect exchange interaction in graphene — •Józef Barnaś[1,2], Vitalii Dugaev[3,4], Paweł Małyszek[1], and Volodya Litvinov[5] — [1]Department of Physics, Adam Mickiewicz University, 61-614 Poznań, Poland — [2]Institute of Molecular Physics, PAN, 60-179 Poznań, Poland — [3]Department of Physics, Rzeszów University of Technology, 35-959 Rzeszów, Poland — [4]Department of Physics and CFIF, Instituto Superior Técnico, 1049-001 Lisbon, Portugal — [5]Waveband/Sierra Nevada Corporation, Irvine, CA 92618, USA

We have analyzed the problem of magnetic correlations, indirect exchange interaction of magnetic impurities, and magnetic Friedel oscillations in graphene, mostly concentrating on the possible effects of spin-orbit interactions. The spin-orbit interaction produces a gap, which makes the correlation functions less long-ranged. Two kinds of spin-orbit interaction are taken into account: intrinsic spin-orbit coupling which inherently exists in graphene plane, and Rashba spin-orbit interaction due to asymmetry between bottom and top surfaces. Using the relativistic model of Dirac, we have calculated the magnetic polarization profile with Friedel oscillations effectively damped by the spin-orbit interaction. The interaction between magnetic impurities may lead to ferromagnetic ordering. The effective coupling constant is shown to depend on the location of magnetic impurities in the graphene sublattices.

HL 9.12 Mon 14:30 P2

Magnetic properties of transition metal doped Si nanocrystals and their size dependence. — •Christian Panse[1], Frank Küwen[2], Roman Leitsmann[1], and Friedhelm Bechstedt[1] — [1]Institut für Festkörpertheorie und -optik, Friedrich-Schiller-Universtität Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [2]Energieforschungszentrum Niedersachsen, Technische Universität Clausthal, Am Stollen 19, 38640 Goslar, Germany

For investigation of the magnetic and spin-related properties of nanoparticles we examine transition metal doped semiconductors. In particular Si nanocrystals (NCs) doped with Mn and Fe atoms are under investigation. We consider two different impurity positions: substitutional and interstitial sites. The optimized geometries show bond-length deviations from the ideal geometry of less than 1.5% for nearest neighbor atoms. Interestingly in the Si-rich limit interstitial impurity sites lead to the most stable bonding configurations. In addition, the existence of a so-called self-purification effect is shown for very small Si NCs.

To verify Hund's rule for the NC systems we have analysed the spin and charge distribution in these systems in detail. A strong dependence of the total magnetic moment on the energetic position of the metal d-states with respect to the Fermi level could be observed.

HL 9.13 Mon 14:30 P2

Effects of doping on the elastic properties of silicon — •Nicole Santen and Reiner Vianden — Helmholtz - Institut für Strahlen- und Kernphysik, Universität Bonn, Germany

The application of strained silicon in transistor design has led to significant progress in increasing the performance of devices. However, although the method is state of the art, many aspects in conjunction with the mechanical behaviour of strained Si layers have not yet been fully understood or even studied.

The influence of doping on the elastic properties of silicon is studied by means of the perturbed angular correlation method (PAC) using the acceptor ^{111}In as probe. This nuclear technique is well suited for studying strain on an atomic scale. After doping via ion implantation and subsequent annealing the Si samples are bent along the $\langle 110 \rangle$ crystal axis which leads to a uniaxial tensile strain.

It was found that the response of the silicon lattice to mechanical stress showed strong differences depending on the dopant species. Doping with acceptors does not change the elastic properties of silicon, whereas in n-doped silicon a significant strain relaxation is observed.

HL 9.14 Mon 14:30 P2

An x-ray Raman scattering study of the temperature–induced disproportionation in a-SiO — •Omid M. Feroughi[1], Christian Sternemann[1], Achim Hohl[2], Christoph J. Sahle[1], Heiko Conrad[1], Joe Bradley[3], Mali Balasubramanian[4], Jerry Seidler[3], and Metin Tolan[1] — [1]Fakultät Physik / DELTA, Technische Universität Dortmund, D-44221 Dortmund, Germany — [2]Institute

for Materials Science, Darmstadt University of Technology, D-64287 Darmstadt, Germany — [3]University of Washington, Department of Physics, Seattle, WA 98195 USA — [4]Argonne National Lab, 9700 Cass Avenue, Argonne, IL 60439 USA

The study of bulk amorphous silicon monoxide (a–SiO_x with $x \approx 1$) attracted great interest over the past years due to its relevance for opto– and micro–electronic applications. Native a–SiO shows a temperature–induced disproportionation in which regions of Si and SiO_2 grow by coalescence at the cost of the sub–oxides contained in the bulk material resulting in a formation of Si nanocrystals. This disproportionation is studied by means of nonresonant x–ray Raman scattering (XRS) at the Si $L_{2,3}$–edges in the temperature range between 600°C to 1200°C. XRS probes soft x–ray absorption edges using incident x–ray energies between 7 and 12 keV which yields a high bulk sensitivity. Such measurements allow a quantitative assessment of the sub–oxide contributions in native and annealed a–SiO to characterize the disproportionation process. Differently annealed a–SiO samples were also examined with x–ray diffraction which shows that bulk a–SiO is amorphous at least up to 850°C and Si nanocrystals have formed at about 950°C.

HL 9.15 Mon 14:30 P2

Phase separation and nanocrystal formation in bulk amorphous GeO — •Christoph J. Sahle[1], Christian Sternemann[1], Achim Hohl[2], Ralph Wagner[3], Dirk Lützenkirchen-Hecht[3], Alexej Herdt[3], Omid M. Feroughi[1], Heiko Conrad[1], and Metin Tolan[1] — [1]Fakultät Physik / DELTA, Technische Universität Dortmund, D-44221 Dortmund, Germany — [2]Institute for Materials Science, Darmstadt University of Technology, D-64287 Darmstadt, Germany — [3]Abteilung Physik, Bergische Universität Wuppertal, D-42097 Wuppertal, Germany

Bulk amorphous germanium monoxide (a–GeO_x with $x \approx 1$) is studied regarding the temperature–induced disproportionation, i.e phase separation of GeO_x into Ge and GeO_2, and formation of Ge nanocrystals by measurements of the Ge K–edge XANES employing fluorescence yield detection and x–ray diffraction. Germanium/oxygen systems are an interesting class of materials due to their potential as precursors for the synthesis of Ge nanocrystals in an oxide–matrix. The disproportionation of a–GeO_x was characterized in the temperature range between 160°C and 640°C. Phase separation sets in at 250°C and is almost completed at 440°C. X–ray diffraction proves the occurrence of Ge nanocrystals of several nm diameter embedded in a GeO_2 matrix for temperatures above 500°C. The findings are discussed by a structural model of a–GeO_x in which the native amorphous Ge monoxide is proposed to consist of nanoscaled regions of Ge and GeO_2 which are separated by ultra–thin sub–oxide interfaces.

HL 9.16 Mon 14:30 P2

Spin Noise Spectroscopy in ^{28}Si — •Tammo Böntgen[1], Helge Riemann[2], Jens Hübner[1], and Michael Oestreich[1] — [1]Institute for Solid State Physics, Gottfried Wilhelm Leibniz University Hannover, Appelstr. 2, 30167 Hannover — [2]Institut für Kristallzüchtung, Max-Born-Str. 2, 12489 Berlin

We employ spin noise spectroscopy [1] to examine the intrinsic spin lifetime of electrons bound to phosphorus donors in isotopically pure ^{28}Si at low temperatures. The up to now reported spin lifetime of these electrons are already extremely long but no measurement of the intrinsic lifetime has been undertaken yet. In addition we will measure the ultra narrow exciton transition lines in ^{28}Si. These transition lines scale with the isotopical purity of the sample and should be according to calculations as small as 100 neV in the studied Silicon.
[1] M. Römer, J. Hübner, and M. Oestreich, Rev. Sci. Instrum. **78**, 103903 (2007)

HL 9.17 Mon 14:30 P2

Optical Selection Rules in Silicon — •Hauke Horn, Jens Hübner, and Michael Oestreich — Institute for Solid State Physics, Leibniz University Hannover, Appelstr. 2, 30167 Hannover, Germany

We use selective optical excitation around the direct band gap of silicon at room temperature and polarization resolved detection of the photoluminescence from the indirect band gap transition to probe the optical spin selection rules in this important semiconductor material. The degree of circular polarization from the indirect transition is monitored, while the excitation from the top most valence band Γ_8^+ to the lowest conduction band Γ_6^- at the center of the Brillouin zone is tuned to the excitation from the split-off band Γ_7^+. To shorten the carrier lifetime to less than the spin relaxation time a biased silicon photodiode is used as sample.

HL 9.18 Mon 14:30 P2

Process conditions for doping with Spin On dopants — •Sebastian Stoll, Peter Iskra, Helmut Lochner, Dorota Kulaga-Egger, Torsten Sulima, and Ignaz Eisele — Universität der Bundeswehr München, Institut für Physik, Werner-Heisenberg-Weg 39, 85577 Neubiberg

The use of spin on dopants (SOD) as a way of doping in place of ion implantation has become more important over the past years. The advantages of SOD are reduced costs and the avoidance of crystal lattice damages compared to ion implantation. SOD can be applied on the wafer by using standard photo resist equipment. The dopant produces a doped silicate film, acting as an unlimited diffusion source. By the use of a suitable diffusion process and film thickness, the sheet resistance can easily be adjusted.

First we investigated the standard procedure to apply the SOD on the wafer, known from publications. We optimized the procedure achieving a defect free and homogenous film of the SOD. Furthermore we analysed the dopant concentration and the sheet resistance after diffusion process at different temperatures. Investigations were carried out by SIMS, SEM and four-point measurements.

Finally, n- und p- MOSFETs were fabricated and characterised.

HL 9.19 Mon 14:30 P2

Investigation of defect and phosphorus related states in very thin films of μc-Si — •Konrad Klein[1], Martin Eberl[1], Benedikt Stoib[1], Andre R. Stegner[1], Oleksandr Ashtakov[2], Friedhelm Finger[2], Martin Stutzmann[1], and Martin S. Brandt[1] — [1]Walter Schottky Institut, Am Coulombwall 3, 85748 Garching — [2]Forschungszentrum Jülich, 52425 Jülich

Although very thin μc-Si films with a thickness of a few ten nanometers are used as p- and n-type layers in μc-Si thin film solar cells, only the defect and doping induced states of thick films with a thickness of several hundred nanometers have been studied systematically with Electron Spin Resonance (ESR) and Electrically Detected Magnetic Resonance (EDMR) [1,2]. Since it is known that film properties change with the thickness [3], we have investigated the paramagnetic states of 20 nm thin films of phosphorus-doped μc-Si with various doping concentrations using EDMR. The results show defect and donor related states, which are already known from thicker films, as well as two new broad paramagnetic resonances at $g \approx 2.034$ and $g \approx 1.984$. We discuss possible origins of these lines comparing the results with those obtained for phosphorus-doped crystalline silicon, silicon nanocrystals and recent results obtained with pulsed EDMR for μc-Si thin film solar cells [4]. [1] J. Mueller et al., Physical Review B, 60, 11666 (1999) [2] K. Lips et al., Solar Energy Materials and Solar Cells, 78, 513 (2003) [3] M. Tzolov et al., Journal of Applied Physics, 81, 7376 (1997) [4] J. Behrends et al., Journal of Non-Crystalline Solids, 354, 2411 (2008)

HL 9.20 Mon 14:30 P2

Morphological properties of three dimensional Ge nanoclusters grown on SiO_x (x<2) films — •Zakir Seyidov[1], Maria Rubezhanska[2], Christian Hofer[1], Yuri Kozyrev[2], Christian Teichert[1], and Anton Naumovets[3] — [1]Institute of Physics, Montanuniversitaet Leoben, Franz Josef Str. 18, A-8700 Leoben, Austria — [2]Institute of Surface Chemistry, Generala Naumova Str. 17, UA-03164 Kiev, Ukraine — [3]Institute of Physics, Prospect Nauki 46, UA-03028 Kiev, Ukraine

Novel optoelectronic and nanoelectronic devices require smaller and smaller size of their components. This explains the interest in Ge nanostructure formation in an SiO_2 matrix. A possibility of epitaxial formation of such Ge nanostructures on initial amorphous SiO_x (x<2) films is considered. Their surface was investigated using atomic-force microscopy. The height, size and distribution density of germanium nanoislands of the resultant film were determined. Ge nanoclusters were about 1-3 nm in height and 10-25 nm in the basis for the initial and intermediate stages of their formation with very low distribution density about $5\ 10^8\ cm^{-2}$. For other samples [1], Ge nanoclusters grew larger: about 20 nm in height and 30 nm in the basis. Their distribution density over the substrate surface exceeded $10^{11}\ cm^{-2}$. Characteristics of the formed nanostructure at the different formation stages were shown both doped (Sb, B) and undoped films. This research was supported by ÖAD Project UA No 2007/05.

[1]Yu.N.Kozyrev et al., Proceedings of ICTF14&RSD2008 p.76

HL 9.21 Mon 14:30 P2

Optical and electrical characterization of silicon nanowires etched from highly doped silicon wafers — •Pratyush Das Kanungo, Nadine Geyer, Vadim Talalaev, Oussama Moutanabbir, Nikolai Zakharov, Ren Bin Yang, Peter Werner, and Ulrich Gösele — Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle, Germany

Metal assisted catalytic etching of silicon nanowires (Si NWs) from silicon wafers is one of the most popular *top-down* approaches in nanotechnology. In order to use these NWs as future nano-devices, extensive investigations of the optical and electrical properties of them are required. We report on the optical and electrical characterization of Si NWs etched from highly doped (0.001 to 0.006 Ω-cm) n-type (111) Si wafers by an aqueous solution of HF and silver nitrate. Room temperature, as well as low temperature photoluminescence of the Si NWs, separated from the original silicon substrate and dispersed on a GaAs substrate, showed significant blue-shift and broadening of the silicon peak at silicon band gap as compared to the silicon substrate. Room temperature Raman spectra of the same sample showed a red shift and broadening of the principal Si-Si peak compared to the silicon substrate. Electrical measurement of individual NWs with Pt-Si contacts fabricated by electron beam lithography showed the expected electrical conductivity.

HL 9.22 Mon 14:30 P2

MOVPE of semipolar GaN on m-plane sapphire — •M. Frentrup[1], S. Ploch[1], M. Pristovsek[1] und M. Kneissl[1,2] — [1]TU Berlin, EW 6-1,Institut für Festkörperphysik, Hardenbergstr.36, 10623 Berlin, Germany — [2]Ferdinand-Braun-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str.4, 12489 Berlin, Germany

InGaN multiple quantum well (MQW) light emitting diodes on c-plane GaN suffer piezoelectric and spontaneous polarization effects. These effects lead to the well known quantum confined stark effect (QCSE), which causes a reduction of the radiative recombination efficiency. Theoretical calculations have predicted that for certain semipolar surfaces a strong reduction of the QCSE can be expected. Possible candidates for semi-polar surfaces are e.g. the $\{10\bar{1}\bar{1}\}$, $\{2\bar{1}\bar{1}2\}$ and $\{10\bar{1}\bar{3}\}$. We have investigated the growth of semi-polar GaN on $(10\bar{1}0)$ sapphire (m-plane) with metal organic vapor phase epitaxy (MOVPE). The epitaxy of nitrides on sapphire consists of three different steps - nitridation, nucleation, and buffer growth. The surface temperature for the different steps, especially for the nitridation was varied in the range between 530°C and 1100°C. We have also varied the nucleation temperature between 500°C and 700°C. The GaN growth was characterized by in-situ spectral reflectance and wafer curvature. The samples were characterized ex-situ by X-ray diffraction, AFM and photoluminescence.

HL 9.23 Mon 14:30 P2

MOVPE growth of AlGaN films — •Ö. Savaş[1], J. Stellmach[1], C. Meissner[1,2], M. Pristovsek[1], and M. Kneissl[1] — [1]TU Berlin, Institut für Festkörperphysik EW6-1, Hardenbergstr. 36, 10623 Berlin, Germany — [2]ISAS Berlin, Albert-Einstein-Str. 9, 12489 Berlin, Germany

For UV light emitting diodes (LEDs) the growth of AlGaN with high Al-content is essential. By varying the Al-content in $Al_xGa_{x-1}N$ emission energies between 3.4 and 6.2 eV can be achieved.

We have investigated the growth of AlGaN on GaN/sapphire templates by metal-organic vapour phase epitaxy (MOVPE) in a Thomas Swan vertical close coupled showerhead reactor. The influence and understanding of the strong gas phase prereactions between trimethylaluminium (TMAl) and ammonia (NH_3) are important for high quality AlGaN growth. To study these critical prereactions these effects of growth parameters like NH_3 and TMAl partial pressures, total reactor pressure and growth temperature on the Al-incorporation has been investigated. We found that the growth rate decreased with increasing temperature and the Al-content increased proportional to the square root of the TMAl partial pressure. Further investigation, in particular the effects of the gap between the showerhead (inlet for the vapours) and the substrate on the prereaction are under way.

HL 9.24 Mon 14:30 P2

Aufbau und Erprobung eines einfachen GIXRF-Messplatzes — •Stephanie Fritze, Jürgen Bläsing und Alois Krost — Institut Experimentelle Physik, Otto-von-Guericke-Universität Magdeburg, Deutschland

Die Röntgenfluoreszenzanalyse unter streifendem Einfall ist eine Methode zur Strukturanalyse, die in den letzten Jahren immer mehr an Bedeutung gewonnen hat, um Konzentrationen von Elementen und Schichtdicken von Halbleiterstrukturen zu bestimmen. Aus der Kombination eines Röntgenfluoreszenz- und eines Röntgenreflektometrie-Messplatzes wurde ein GIXRF (Grazing Incidence X-Ray Fluorescence) Messplatz aufgebaut. Mittels kontinuierlicher, semimonochromatischer und monochromatischer Anregung wurden Schichtsysteme auf der Basis von (In,Ga,Al)N auf Silizium bzw. Saphir (MQW, DBR, FET) und dünne Schichten verschiedener Metalle (Kontaktierungen) untersucht. Erste Ergebnisse der Fluoreszenzauswertung werden mit Simulationen verglichen und den Messungen der Reflektometrie und der Diffraktometrie gegenübergestellt und interpretiert.

HL 9.25 Mon 14:30 P2

Herstellung und Implantation von ^{172}Lu(^{172}Yb) in GaN und Messung bei tiefen Temperaturen — •Riccardo Valentini und Reiner Vianden — Helmholtz - Institut für Strahlen- und Kernphysik, Nußallee 14-16, 53115 Bonn

Für optoelektronische Bauteile werden Halbleiter mit großer Bandlücke verwendet, die mit Seltenen Erden dotiert sind. Um deren Verhalten nach der Implantation zu untersuchen, hat sich die Methode der γ-γ-Winkelkorrelation (PAC) bewährt. Ein geeignetes Isotop zur Untersuchung solcher Halbleiter ist ^{172}Yb.

Die Herstellung des Mutterisotops ^{172}Lu erfolgt durch Bestrahlung einer Thulium-Folie mit ^{4}He, ^{169}Tm(α,n)^{172}Lu am Bonner Isochron-Zyklotron und die Implantation in GaN am Bonner Isotopenseparator, d.h. Herstellung und Implantation finden vor Ort statt.

Es soll die Temperaturabhängigkeit der Hyperfeinfelder für ^{172}Lu(^{172}Yb) in GaN untersucht werden. Wir führen Messungen bei tiefen Temperaturen zwischen 25 K und 295 K in einem Kryostaten durch. Zu erwarten ist generell eine Zunahme der Wechselwirkungsfrequenz. Der Verlauf bei Temperaturen um 100 K konnte bisher noch nicht eindeutig geklärt werden. Die Messungen werden auf einer PAC-Anlage durchgeführt, die das Material LSO als Szintillator benutzt. Dadurch kann eine bessere Energieauflösung, eine höhere Anisotropie und eine kürzere Messzeit als mit gängigen Szintillatormaterialien erzielt werden.

HL 9.26 Mon 14:30 P2

Optical study of Rare earth ion implantation in GaN heterostructures — •JAYANTA KUMAR MISHRA, UWE ROSSOW, and ANDREAS HANGLEITER — INTITUTE OF APPLIED PHYSICS, UNIVERSITY OF BRAUNSCHWEIG,MENDELSSOHNSTRASSE 2,38106,BRAUNSCHWEIG.

Rare earth ion implanted GaN or AlGaN is a very promising material to be utilized for light emitting devices. When rare earth ions are used for that purpose, the implanted GaN shows photoluminescence in the visible range (480-650nm)[1]. We investigate the use of AlGaN/GaN/AlGaN heterostructures for the purpose of implantation. Based on the results of TRIM simulations, we choose a primary ion energy of 100 keV for Europium ion implantation.The dose and projected range are 1014cm-2 and 42 nm respectively. We have varied both the thickness of the GaN layer as well as the composition of the AlGaN cladding layers and studied the influence on Eu3+ luminescence properties.

1.J. H. Park and A.J.Steckl,APPLIED PHYSICS LETTERS 88,011111 ,2006.

HL 9.27 Mon 14:30 P2

Systematic study of *C*- and *M*-plane growth of GaN on $LiAlO_2$ by plasma assisted MBE — •Ralf Schuber[1], Yen-Liang Chen[2], Yu-Chi Hsu[2], and Daniel M. Schaadt[1] — [1]Institut für Angewandte Physik, Universität Karlsruhe (TH) and DFG Center for Functional Nanostructures, CFN, D-76128 Karlsruhe — [2]Department of Physics, National Sun Yat-Sen University, Kaohsiung, Taiwan, ROC

Group III nitrides grown along the <0001> direction show a strong quantum confined Stark effect due to the electric fields resulting from the spontaneous and piezoelectric polarization. These fields cause a reduction of the oscillator strength due to a spatial separation of electrons and holes and a decrease in the energy of the radiative transition. Epitaxial layers with non-polar surfaces such as the *M*-plane $\{1\bar{1}00\}$ are attractive due to the absence of built-in electrical fields. $LiAlO_2$ constitutes a particularly suitable substrate as its lattice mismatch to both *C*- and *M*-plane oriented GaN lies below 2%. While molecular beam epitaxy growth of *M*-plane films on $LiAlO_2$ has been well established, the growth of *C*-plane nitrides on $LiAlO_2$ is poorly understood.

To investigate the transition from *M*-plane to *C*-plane growth, we have studied the impact of various growth parameters, such as the Ga to N flux ratio, the nucleation and epi layer temperature and thickness. It was found that the crystal orientation of GaN can be adjusted by selecting appropriate growth conditions.

HL 9.28 Mon 14:30 P2

TEM Investigation of Ultrathin GaInN/GaNQuantum Well Structures with high Indium Content — •Lars Hoffmann, Heiko Bremers, Holger Jönen, Daniel Dräger, Uwe Rossow, and Andreas Hangleiter — TU Braunschweig, Institute of Applied Physics, Braunschweig, Germany

While GaN-based blue light emitting diodes exhibit exceptionally large internal quantum efficiencies (up to 80% at room temperature) their green counterparts quickly become less efficient at longer wavelength. Therefore, a green laser diode based on GaN still has to be demonstrated. Material quality and very high piezoelectric fields are the likely cause for that. While LED efficiency greatly benefits from V-shaped pits decorating threading dislocations, laser diodes require highly perfect interfaces and homogeneous quantum wells. Using Transmission Electron Microscopy (TEM) we have studied ultrathin (< 2nm) high indium content quantum well (QW) structures suitable for blue-green laser diodes. Some of the grown structures showed partial relaxation and thermal degradation. Moreover, we observed high defect densities in the low temperature grown upper waveguides. We investigate the mechanisms of relaxation and possible misfit dislocation generation in the QW structures.

HL 9.29 Mon 14:30 P2

Microscopic properties of spontaneously formed non-polar and semi-polar GaN growth domains on r-plane sapphire — •B. Bastek, J. Christen, T. Hempel, P. Veit, M. Wieneke, A. Dadgar, J. Bläsing, and A. Krost — Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany

We present a study about the microscopic optical and structural properties of spontaneously developed growth domains of non-polar GaN and semi-polar GaN on the same sapphire wafer. For optimizing the lattice match between a-plane GaN and r-plane Sapphire the growth conditions for an AlInN nucleation layer were investigated. Most of the samples exhibit layers with pure a-plane GaN of good crystallographic quality. However, on some samples a circular region of semi-polar (nearly (11-26)) GaN emerged. The thickness of the frame strongly depends on the chosen growth conditions for the nucleation layer. At the boundary the optical properties of the two growth domains drastically change. In the non-polar a-plane GaN domains the basal plane stacking fault (BSF) luminescence exceeds the excitonic luminescence by a factor of three which is specific for hetero-epitaxial non-polar GaN. In contrast the excitonic luminescence dominates the BSF emission by a factor of seven in the semi-polar region accompanied by an absolute increase of the intensity. Besides structural properties we will show *-Cathodoluminescence and TEM images of the boundary region.

HL 9.30 Mon 14:30 P2

Novel Low Temperature Surface Reconstructions of GaN(0001) Surface — Danda Acharya, •Kendal Clark, Muhammad Haider, Erdung Lu, Arthur Smith, and Saw-Wai Hla — Ohio University, Physics and Astronomy Department, Athens, Ohio 45701, USA.

Low temperature electronic and structural properties of a nitrogen polar, gallium rich GaN (0001) surface have been investigated by using scanning tunneling microscopy and spectroscopy at 5 K and 80 K substrate temperatures. Deviating from the known room temperature surface reconstructions, we find novel low temperature surface structures having a rhombohedral lattice with a 12 * 12 gallium atomic periodicity. From the tunneling spectroscopy data, two of the surface states of GaN (0001) originated from the overlap of gallium adatom wavefunctions have been directly observed. By means of bias dependent scanning tunneling microscope imaging, we show that these novel surface structures are contributed from the predicted surface state bands, B1 and B2. This work is supported by the National Science Foundation NSF-PIRE grant, OISE 0730257, and the United States Department of Energy, DE-FG02-02ER46012 grant.

HL 9.31 Mon 14:30 P2

Lumineszenzuntersuchungen an ,,photonic band gap“ GaN-LED Strukturen auf SOI-Substrat — •A. Franke[1], J. Krimmling[1], T. Hempel[1], J. Christen[1], A. Dadgar[1,2], A. Krost[1,2], K.X. Lin[3], S.L. Teo[3] und S. Tripathy[3] — [1]Institut für Experimentelle Physik, Otto-von-Guericke-Universität Magdeburg — [2]AZZURRO-Semiconductor AG, Magdeburg — [3]Institute of Material Research and Engineering, IMRE, Singapore

Zur Erhöhung der Auskoppeleffizienz von GaN-LEDs wurde unter Verwendung von trockenchemischen Ätzmethoden ein photonischer Kristall hergestellt. Die LEDs wurden mittels MOVPE auf einem 6” SOI-Substrat gewachsen. Als aktives Medium dient ein InGaN/GaN Muliquantumwell (MQW). Zur Oberflächenstrukturierung wurde die Probe unter Verwendung von plasmagestütztem Trockenätzen und ICP-Sputtern in zylindrische Mesas von etwa 230 μm Querschnitt unterteilt. Hierauf wurden entlang des Durchmessers auf einem ca. 50 μm breiten Streifen Nanokegel mit einem Querschnitt von etwa 300 nm strukturiert. Integrale Mikro-Photolumineszenzspektren (μ-PL), lateral über die Mesen gemittelt, zeigen eine dominante MQW-Emission bei 560,6 nm, moduliert durch starke Fabry-Perot-Interferenzen sowie bandkantennahe GaN-Lumineszenz bei 354,5 nm. μ-PL mappings zeigen am Ort der Nanostrukturierung eine starke Erhöhung der Intensität der GaN Lumineszenz sowie eine Rotverschiebung der Emissionswellenlänge um etwa 3 nm. Im Kontrast dazu ist die Intensität der MQW-Emission lateral konstant, jedoch wird hier eine starke Blauverschiebung um 6 nm im Bereich der Nanokegel beobachtet.

HL 9.32 Mon 14:30 P2

Towards Galliumnitride nanowire field-effect transistors — •Jörg Kinzel[1], Jens Ebbecke[2], Hubert Krenner[1], Raffaela Calarco[3], Toma Stoica[3], and Achim Wixforth[1,4] — [1]Lehrstuhl für Experimentalphysik 1, Universität Augsburg, Germany — [2]School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, United Kingdom — [3]Institute of Bio- and Nanosystems (IBN-1), Research Centre Jülich GmbH, Germany, and JARA- Fundamentals of Future Information Technology — [4]Center for NanoScience, Ludwig-Maximilians-Universität, München, Germany

Group III-nitride nanowires (NWs) have drawn particular interest over the past years owing their potential for wide-spread applications in nano-electronics and optoelectronics at ambient temperatures. We report on recent progress on the realization of field effect transistors using doped GaN nanowires grown by molecular beam epitaxy[1]. We define metal source-drain and top gate electrodes by electron-beam lithography and a lift-off technique. Samples are characterized by temperature- and bias-dependent conductivity measurements.

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HL 9.33 Mon 14:30 P2

Carbon doped InGaAs/InAlAs heterostructures on relaxed buffer layers — •Marika Kubová, Katharina Schulze, Dieter Schuh, and Werner Wegscheider — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D 93040 Regensburg, Germany

The InAlAs/InGaAs heterostructures with high In content are promising candidates for spintronic applications such as spin-valve mesoscopic devices due to their large Landé g-factor (around 15 in InAs), large Rashba effect and low Schottky barrier to evaporated metals. We grow InGaAs/InAlAs/InAs heterostructures using a step-graded metamorphic buffer layer on GaAs (001) substrates via molecular beam epitaxy. In order to obtain 2DEGs or 2DHGs, these structures have been grown either undoped [1] or remote doped with Si [2] and Mn [3]. Here we present results on carbon doped InGaAs/InAlAs heterostructures with embedded InAs channel. The magnetotransport measurements on these samples at low temperatures show a change of the conductivity from p-type to n-type via illumination and weak localisation at low magnetic fields.

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HL 9.34 Mon 14:30 P2

Magnetic and magneto-transport properties of self-assembled MnAs-nanoclusters on undoped GaInAs-surfaces. — •Matthias T. Elm[1], Shinjiroh Hara[2], Hans-Albrecht Krug von Nidda[3], and Peter J. Klar[1] — [1]Institute of Experimental Physics I, Justus-Liebig University Gießen, Germany — [2]Research Center for In-

tegrated Quantum Electronics, Hokkaido University, Sapporo, Japan — [3]Experimentalphysik V, University of Augsburg, Germany

Self-assembled MnAs nanoclusters were grown on undoped GaInAs/InP (111)B-substrate by MOVPE. The MnAs nanoclusters were randomly distributed on the samples. The c-axis of all clusters is orientated perpendicular to the growth direction. The lateral size and height of typical nanoclusters are 100 and 47 nm, respectively. The density of the nanoclusters varies from 2.8×10^{8} to 6.6×10^{8} cm^{-2} due to different growth conditions. The growth of the MnAs nanoclusters leads to a p-type conductivity of the samples with carrier concentrations of about $2\times10^{18}cm^{-3}$ at room temperature. The magnetic properties were probed by ESR measurements in order to determine the magnetic anisotropy of the clusters. The samples were also investigated by angle-dependent magneto-transport measurements in the temperature range from 20 to 280 K in external magnetic fields up to 10 T. The differences in the temperature-dependent behavior, in the magneto-resistance as well as the influence of the ferromagnetic clusters on the transport will be discussed.

HL 9.35 Mon 14:30 P2

Hole Density in (Ga,Mn)As layers grown on (001), (110) and (311) GaAs Substrates — •Michael Hirmer, Michael Mayr, Tobias Korn, Ursula Wurstbauer, Martin Utz, Stefanie Heydrich, Dieter Schuh, Werner Wegscheider, and Christian Schüller — Universität Regensburg, Universitätsstraße 31, 93053 Regensburg, Germany

The dilute magnetic semiconductor (DMS) $Ga_{1-x}Mn_xAs$ is a very promising candidate for building spintronic devices, due to theoretically predicted room temperature ferromagnetism. Since the ferromagnetism of this Zener-like DMS is hole-mediated, the ferromagnetic transition temperature T_C corresponds to $T_C \alpha x_{eff} p^{1/3}$ (x_{eff}: effective Mn concentration, p: carrier density). We present a detailed study of carrier concentrations, determined by Hall measurements and Raman scattering on thin $Ga_{1-x}Mn_xAs$ films. The films were grown on (001), (311) and (110) semi-insulating GaAs substrates with layer thicknesses ranging from 5 to 300 nm and Mn contents of 6% using low temperature molecular beam epitaxy. Hole concentrations in the range of 10^{20} cm^{-3} were found with highest values for (001), in correspondence with the measured T_C values. Samples with higher T_C show a contribution of side jump to AHE, only. Measurements before and after annealing suggest that the AHE is not caused by scattering processes, only, consist with theoretically predicted intrinsic contributions. Therefore, we used Raman scattering intensity analysis of the uncoupled LO and the coupled plasmon LO phonon mode to determine p, independent of transport measurements, before and after annealing.

HL 9.36 Mon 14:30 P2

Annealing studies of Hf implanted $Al_xGa_{1-x}N$ — •Thomas Geruschke[1], Katharina Lorenz[2], and Reiner Vianden[1] — [1]Helmholtz - Institut für Strahlen- und Kernphysik, Universität Bonn, Germany — [2]Instituto Tecnologico e Nuclear, SACAVEM, Portugal

The annealing behaviour of 0.5 μm $Al_xGa_{1-x}N$ on sapphire substrate after implantation of ^{181}Hf was studied using the perturbed angular correlation (PAC) technique. Different $Al_xGa_{1-x}N$ samples from the commercial supplier TDI Inc. were implanted with the radioisotope ^{181}Hf at the Bonn Isotope Separator. Subsequently the samples were annealed in a rapid thermal annealing apparatus at 1273 K in nitrogen atmosphere. The strength of the electrical field gradient at the probe site varies almost linear with the concentration x of aluminum in the ternary compound, whereas the uniformity of this hyperfine interaction has its minimum at $x \approx 0.5$. To confirm the linear behaviour, additional measurements will be carried out. First results will be presented and discussed.

HL 9.37 Mon 14:30 P2

Control of Mn magnetic moments in GaAs quantum dots — •Peter Moraczewski and Daniela Pfannkuche — I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstraße9, 20355 Hamburg

In semiconductor quantum dots electrons and holes are confined in all three spatial directions. Their eigenstates can be tailored by the used materials, the size and the shape of the dot and also by applied electric and magnetic fields. When we dope the quantum dot with atoms carrying a large magnetic moment, like Mn, they will interact with the electrons or holes via the Coulomb and Exchange interaction. We can now expect to manipulate the alignment of the Mn-spins by changing the states of electrons or holes. In III-V semiconductors such as GaAs the Mn atom is an acceptor, so holes will be the main charge carriers. We calculate the eigenstates of several holes in a quantum dot by k*p-theory-, under the influence of a magnetic field and with many-body interaction. Then we examine the interplay between the hole states and the magnetic moments of one or two manganese impurities.

HL 9.38 Mon 14:30 P2

Fabrication and Characterization of Cu-Doped GaN — •Philipp Ganz[1,2], Christoph Sürgers[2,3], and Daniel M. Schaadt[1,2] — [1]Universität Karlsruhe, Institut für Angewandte Physik, 76131 Karlsruhe, Germany — [2]Universität Karlsruhe, DFG-Center for Functional Nanostructures, 76131 Karlsruhe, Germany — [3]Universität Karlsruhe, Physikalisches Institut, 76131 Karlsruhe, Germany

Semiconductor based spintronics may be implemented using InN quantum dots, which show long and temperature in-dependent spin-life times. To inject spins electrically into these quantum dots, a spin alignment layer which yields high spin-polarizations at room temperature is essential for realistic applications. A possible material for a nitride based spin aligner is Cu-doped GaN. Theoretical predictions show the possibility of ferromagnetism and high spin-polarization for certain Cu arrangements. Initial experimental results have already indicated ferromagnetism. However, the origin of the ferromagnetism is still under debate. Additionally, the influence of defects on the ferromagnetism in Cu doped nitrides is still unclear. We have used density functional theory to verify previous theoretical predictions and to investigate the effects of various parameters on the ferromagnetic nature of the material. Additionally, we have investigated the growth of Cu-doped GaN by molecular beam epitaxy and the influence of growth parameters, such as the metal to nitrogen flux ratio, Cu to Ga flux ratio and growth temperature, on the magnetic properties.

HL 9.39 Mon 14:30 P2

Spin Noise Spectroscopy on Donors in GaAs — •Hannes Bernien, Georg Müller, Michael Römer, Jens Hübner, and Michael Oestreich — Institute for Solid State Physics, Gottfried Wilhelm Leibniz University Hannover, Appelstr. 2, 30167 Hannover, Germany

In recent experiments spin noise spectroscopy (SNS) has proven to be a very sensitive technique to study electron spin dynamics in semiconductors at thermal equilibrium[1]. Here we present SNS-measurements on donor bound electrons in very low doped bulk GaAs. In this environment the donors do not interact with each other and form artificial atoms. We discuss the detection of single donor bound electron spins, which should have extremely long spin relaxation times compared to ensemble spin relaxation times. In further experiments the electron bound to the donor will be used to probe and study the local nuclear magnetic field at the donor site.

[1] M. Römer. J. Hübner, and M. Oestreich, Rev. Sci. Instrum. **78**, 103903 (2007)

HL 9.40 Mon 14:30 P2

Magnetooptics of Gd-doped GaN — •Jan Heye Buss, Jörg Rudolph, and Daniel Hägele — AG Spektroskopie der kondensierten Materie, Ruhr Universität Bochum, Germany

SQUID measurements of Gd-doped GaN showed Curie-temperatures up to 700 K [1]. GaN:Gd is therefore discussed as a potential electron spin aligner for room temperature spintronics. We perform room temperature magneto-optical Kerr effect (MOKE) measurements at the band edge to directly probe the effect of Gd-doping ($2.7\times10^{19}cm^{-3}$) on the valence and conduction band. While ferromagnetic GaMnAs shows huge Kerr signals (up to 5000 μrad) [2], no difference in Kerr rotation (within the 30 μrad sensitivity of our setup) is found in comparison with an undoped GaN reference sample. These findings are in agreement with recent XMCD data from Ney et. al. [3] and suggest that the ferromagnetism observed in SQUID measurements is not related to the GaN host matrix.

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[3] A. Ney et al., Phys. Rev. B. **77**, 233308 (2008).

HL 9.41 Mon 14:30 P2

Growth of InAs quantum dots on hydrogen cleaned GaAs surfaces — •Ahish Kumar Rai, Dirk Reuter, and Andreas D. Wieck — Lehrstuhl für Angewandte Festkörperphysik Ruhr-

Universität Bochum Universitätsstraße 150, Gebäude NB,D-44780 Bochum,Germany

The goal of this work is to introduce site-selective growth of InAs quantum dots on ex-situ patterned GaAs layers. A key step in this process is the cleaning on the surface after patterning. We will report on cleaning by atomic hydrogen. The surface was as exposed to air and chemicals like photo resist. After striping and cleaning, InAs quantum dots have been grown followed by a GaAs cap layer. The quality of the cleaning process is evaluated by measuring the quantum dot photo luminescence, which is very sensitive to surface contaminations. We will discuss the influence of various parameters e.g. the substrate temperature during cleaning.

HL 9.42 Mon 14:30 P2

The role of surface kinetics in achieving high non-equilibrium N concentrations in bulk GaAs — •Hazem Abu-Farsakh[1,2] and Jörg Neugebauer[1,2] — [1]Max-Planck-Institut für Eisenforschung GmbH, Max-Planck-Str. 1, 40237 Düsseldorf, Germany — [2]Universität Paderborn, Warburger Str. 100, 33098 Paderborn, Germany

Ternary $GaAs_{1-x}N_x$ and quaternary $In_xGa_{1-x}As_{1-y}N_y$ alloys have attracted a considerable interest for applications including infrared laser diodes and photovoltaic solar cells. Despite the very low equilibrium solubility of N in bulk GaAs, N concentrations up to few percents can be achieved in MBE growth experiments. *Ab-initio* calculations indicate that N incorporation in the subsurface layer is thermodynamically most favorable, which can be utilized to achieve high concentrations by employing surface kinetics [1]. To explore possible roles for surface engineering we have calculated the kinetic barriers for various mechanisms and reaction paths of N at the GaAs(001) surface. Based on our results we propose a trapping mechanism that effectively prohibits N from getting incorporated in the subsurface layers. These results also allow (*i*) to identify the mechanism which controls the achievable enhancement in the bulk N concentration, (*ii*) to revise previous growth and incorporation models, and (*iii*) to provide a direct microscopic basis of the recently reported In-N compositional anti-correlation in $In_xGa_{1-x}As_{1-y}N_y$ quantum wells [2].

[1] H. Abu-Farsakh and J. Neugebauer, Phys. Rev. B (submitted).
[2] M. Albrecht, H. Abu-Farsakh *et al.*, Phys. Rev. Lett. **99**, 206103 (2007).

HL 9.43 Mon 14:30 P2

Anisotropy of electron Lande g-factor in (110) GaAs quantum wells — •Sergej Kunz[1], Stefan Oertel[1], Jens Hübner[1], Dieter Schuh[2], Werner Wegscheider[2], and Michael Oestreich[1] — [1]Universität Hannover, Institut für Festkörperphysik, Abteilung Nanostrukturen, Appelstr. 2, D-30167 Hannover — [2]Universität Regensburg, Institut für Experimentelle und Angewandte Physik, D-93040 Regensburg

We measure the electron Lande g-factor and electron spin lifetime in (110)-oriented GaAs quantum wells by time- and polarization resolved photoluminescence spectroscopy. The electron Lande g-factor shows an anisotropy on the in plane magnetic field direction and this anisotropy is investigated in detail for different quantum well widths. Furthermore, the electron spin dynamics is determined in dependence on quantum well widths and spin orientation.

HL 9.44 Mon 14:30 P2

Magnetism in manganese modulation-doped two-dimensional hole systems — •Wolfgang Krenner[1,4], Benedikt Rupprecht[1], Tjark Windisch[1], Ursula Wurstbauer[2,3], Marc Wilde[1], Werner Wegscheider[2], and Dirk Grundler[1] — [1]Physik Department E10, TU München, James-Franck Str. 1, 85748 Garching — [2]Institut für Angewandte und Experimentelle Physik II, Universität Regensburg, Universitätsstr. 31, 93040 Regensburg — [3]Current address: Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg — [4]Current address: Physik Department E20, TU München

Diluted magnetic semiconductors on the one hand and two-dimensional carrier systems with strong spin-orbit-coupling on the other hand have been of increasing interest over the past few years. Here we present magnetization measurements on a Mn-modulation doped InGaAs/InAs quantum well at 400 mK in external magnetic fields of up to 15 T. For the measurements a Micromechanical Cantilever Magnetometer (MCM) mounted on a rotational stage was employed. This allows the variation of the tilt angle between the sample magnetization and the external magnetic field.
The measurements show a fourfold anisotropy and a hysteretic behavior of the magnetization around B=0. This may be associated with the coupling of the free holes to the magnetic moments of the Mn dopants. An oscillatory behavior that was observed in high magnetic fields could be interpreted as the de Haas-van Alphen effect of the free holes.
We thank the DFG for funding via project GR1640/3 in SPP 1285.

HL 9.45 Mon 14:30 P2

MBE growth of GaAs/GaMnAs core-shell nanowires — •Andreas Rudolph[1], Marcello Soda[1], Matthias Kiessling[1], Benedikt Bauer[1], Dieter Schuh[1], Tomasz Wojtowicz[2], Werner Wegscheider[1], and Elisabeth Reiger[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany — [2]Institute of Physics, PAS, Al. Lotników 32/46, 02-668 Warszawa, Poland

We investigate the growth conditions of core-shell nanowires consisting of a GaAs core and a magnetic GaMnAs shell. The diluted magnetic semiconductor GaMnAs is of great interest for spintronics applications as it allows a high degree of spin injection into GaAs. However, as the typical growth temperature of GaMnAs is very low it is not compatible with typical growth conditions for axial growth of nanowires. The GaAs core NW is grown on GaAs(111)B substrates using the gold catalyst technique. To gain control over the position and the diameter of the nanowire we recently started nanostructuring the Au film by electron beam lithography. In a second step the GaMnAs is grown on the <110> facets of the GaAs nanowire using typical growth parameters of the 2D growth on GaAs(110). We study the influence of various growth parameters, e.g. the substrate temperature, the flux ratio Ga/As4... on the GaMnAs shell growth. The nanowires are characterized by SEM, TEM and SQUID.

HL 9.46 Mon 14:30 P2

Magnetotransport and THz photoresponse of combined Hall-Corbino- devices patterned on HgCdTe based wafers. — •Fathi Gouider[1], Christof Brüne[3], Jens Könemann[2], Yuri Vasilyev[4], Marek Bugar[5], and Georg Nachtwei[1] — [1]Institut für Angewandte Physik, TU-Braunschweig, Mendelssohnstraße 2, D-38106 Braunschweig, Germany — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116 Braunschweig, Germany — [3]Fakultät für Physik und Astronomie, Julius-Maximilians-Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany — [4]A.F. Ioffe Physical Technical Institute, Polytekhnicheskaya 26, 194021 St. Petersburg, Russia — [5]Institute of Physics, Charles University in Prague, Ke Karlovn 5, 121 16 Prague2 , Czech Republic

Quantum- Hall- (QH) - systems are discussed as promising THz detectors. In this presentation we present photoconduction measurements of the HgTe/HgCdTe- (MCT) - Quantum well in Hall bar, Corbino as well as combined Corbino- Hall bar geometry in the quantum-Hall- (QH) - regime accomplished. FIR photoconduction measurements of the MCT samples are done to supply a contribution for the basic research of the photoconduction at QH-systems and in addition to contribute to the development of a sensitive as well as spectrally adjustable QH detectors. The materiel system MCT is due to the small effective mass (compared with GaAs) and the smaller magnetic fields for operation of interest. For the measurements a superconducting 10 T-magnet and an adjustable *p*-Ge cyclotron resonance laser are operated (the laser as FIR source, wave-length range of 120 - 180μ m).

HL 9.47 Mon 14:30 P2

Ortsaufgelöste Photostromuntersuchungen an Zinkoxid Schottky-Kontakten — •Zhipeng Zhang, Christian Czekalla, Matthias Schmidt, Alexander Lajn, Holger Hochmuth, Holger von Wenckstern und Marius Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik II, Linnéstr. 5, 04103, Leipzig, Germany

Wir präsentieren ortsaufgelöste Light Beam Induced Current (LBIC)-Untersuchungen an gesputterten Schottky-Kontakten auf heteroepitaktischen Zinkoxid (ZnO)-Dünnschichten. Für die LBIC-Messungen wurde ein HeCd-Laser (325 nm) verwendet. Als Kontaktmaterialien wurden Silber (Ag), Gold (Au), Palladium (Pd) und Platin (Pt) verwendet, welche sowohl in Argon- (nicht reaktiv) als auch in Sauerstoffatomosphäre (reaktiv) auf die Probenoberfläche gesputtert wurden. Die LBIC-Scans der reaktiv gesputterten Kontakte zeigten eine deutlich höhere laterale Homogenität als die der nicht reaktiv gesputterten. Durch Aufbringen einer zusätzlichen nicht reaktiv gesputterten Deckschicht (capping) konnte die Homogenität weiter

erhöht werden. Weiterhin wurden an Pd-Schottky-Kontakten verschiedene Kombinationen aus Kontaktmetall- und Capping-Schichtdicken, abgeschieden unter verschiedenen Sputterbedingungen, untersucht. Die Kontakte wurden mittels Strom-Spannungs- sowie Kapazitäts-Spannungsmessungen bezüglich ihrer elektrischen Eigenschaften charakterisiert.

HL 9.48 Mon 14:30 P2

Determination of Hall-mobilities using a maximum entropy approach — •Robert Heinhold, Matthias Brandt, Holger von Wenckstern, Gisela Biehne, Holger Hochmuth, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Semiconductor Physics Group, Institut für Experimentelle Physik II, Leipzig, Germany

Hall measurements are one of the most commonly used techniques to characterize semiconductors. Such measurements are integral measurements and do, therefore, require homogeneous samples. Nevertheless, it is possible to differentiate layers with different mobilities by performing variable field Hall effect measurements. In this work we employ an iterative algorithm for a multi-carrier characterization using the maximum entropy principle (MEP) [1]. The main concept is to consider the mobility spectrum in the form of a probability distribution which we use to define the information entropy. Maximizing this entropy leads us to the most probable spectrum of carrier mobilities and their relative contribution to the total conductivity. We applied the MEP method to analyze the data measured on various semiconductor single-crystals and multi-heterostructures.

[1] S. Kiatgamolchai et al.: Phys. Rev. E **66**, 036705 (2002).

HL 9.49 Mon 14:30 P2

Energy dynamics in ZnSe/ZnMnSe double-quantum-well structures — •Stephanie Jankowski, Wolfram Heimbrodt, Swantje Horst, Alexej Chernikov, and Sangam Chatterjee — Department of Physics and Material Sciences Center, Phillipps-University Marburg, Renthof 5, 35032 Marburg

Asymmetric ZnSe/ZnMnSe double-quantum-well (DQW) structures with different barrier width have been grown between dilute magnetic ZnMnSe cladding layers on a (100) GaAs substrate with a ZnSe buffer. The DQWs have been studied by cw and time resolved spectroscopy in external magnetic fields up to 7 Tesla. The ZnSe quantum wells are under tensile strain in these DQW structures yielding the light-hole exciton states to be the energetically lowest lying states. This is the main difference to earlier papers, where tunnelling of carriers and excitons have been studied in DQW structures with heavy hole excitons being the lowest lying states. In the magnetic field we were able to change the barrier height, to split the states of the wells due to the Giant-Zeeman-effect of the ZnMnSe barriers and to manipulate the radiationless energy transfer processes between the 3d-internal transitions and the excitonic states. As a result of the sophisticated interaction of these mechanisms a unique excitation energy dynamics was found and will be discussed in detail.

HL 9.50 Mon 14:30 P2

Optical and magnetic properties of MnS in low dimensions — •Manuel Demper[1], Limei Chen[1], Christine Bradford[2], Hans-Albrecht Krug von Nidda[3], Kevin A. Prior[2], Alois Loidl[3], and Wolfram Heimbrodt[1] — [1]Departement of Physics and Material Science Center, Philipps University, Marburg — [2]School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh — [3]Center for Electronic Correlation and Magnetism, University Augsburg

The continuously decrease of magnetic structures sooner or later reaches fundamental boundaries. Hence, it is essential to understand the magnetic interactions in low dimensions. Therefore we investigated the transition from 3D-2D on a series of MBE grown zinc blende MnS-layers with various thicknesses between 1ML and 8.6nm by using photoluminescence and SQUID techniques. The PL spectra of these antiferromagnetic MBE-layers exhibit a strong yellow emission band, which belongs to the internal d-d transition of the manganese ions. This $^4T_1 \rightarrow {}^6A_1$ transition offers an optical access to the magnetic properties of MnS. Thus, the temperature dependence of the yellow emission bands shows a significant red-shift at low temperatures caused by the energy relaxation of the Mn d-states at the para- to antiferromagnetic phase transition. Surprisingly, there is no clear indication for a reduced Néel-temperature down to one monolayer. These optical results are confirmed by SQUID measurements. Besides the antiferromagnetic phase transition, the thinnest MnS films additionally exhibit a clear ferromagnetic phase below 150K. The unique behaviour will discussed in detail.

HL 9.51 Mon 14:30 P2

Simulation of wavepropagation in nanocrystalline powders — •Daniel Schneider, Johannes Fallert, Janos Sartor, Roman J. B. Dietz, Viktor Zalamai, Claus Klingshirn, and Heinz Kalt — Institut für Angewandte Physik, Universität Karlsruhe (TH), Germany

In strongly scattering and optically amplifying materials, random lasing can be observed at sufficient high excitation powers. Apart from pure signal amplification in such a laser spectrally sharp and spatially localized modes can be observed due to backscattering and interference. In this contribution we show simulations of the localized random lasing modes which are based on a finite difference time domain method. This way the propagation of electromagnetic waves in randomly aligned nano particles can be calculated. The simulation parameters are fitted to actual experiments on ZnO nanoparticles in order to compare the results of the simulations with experimental data.

HL 9.52 Mon 14:30 P2

Temperature dependance of lasing modes in ZnO nanorods — •Janos Sartor, Johannes Fallert, Victor Zalamai, Florian Maier-Flaig, Claus Klingshirn, and Heinz Kalt — Institut für Angewandte Physik, Universität Karlsruhe(TH), Germany

ZnO can be grown in the form of nanorods which form a natural cavity for nanoscaled lasers. In this work the temperature dependance of stimulated emission from nanorods under quasi-stationary excitation has been investigated. Collection by a microscope objective allows to analyze the photoluminescence from single nanorods. Stable multimode lasing can be observed after optical pumping of the ZnO nanorods. Though the lasing threshold increases with higher temperatures, the individual laser modes can be traced up to room temperature. A spectral red-shifting of the modes which is observed at higher temperatures is attributed to the narrowing of the bandgap with increasing temperature and an additional band gap renormalization due to high carrier concentrations.

HL 9.53 Mon 14:30 P2

Investigation of physical damage in artificially structured $Al_xZn_{1-x}O$ and ZnO thin layers, respectively — •Markus Piechotka[1], Torsten Henning[1], Martin Eickhoff[1], Peter J. Klar[1], Bernd Szyszka[2], and Thomas Wassner[3] — [1]JLU Giessen, Germany — [2]IST Braunschweig, Germany — [3]WSI Munich, Germany

The $Al_xZn_{1-x}O$ films were grown by magnetron RF-sputtering whereas the ZnO films were grown epitaxially using plasma assisted MBE. The layers were artificially structured into arrays of similar wires using photolithography followed by an etching step. The wire diameters were varied between 4 and 1000 μm. Chemical wet etching using a $H_3PO_4 - HAc - H_2O$-mixture and radio frequency ion thruster based ion beam etching, respectively, is used to transfer the pattern into the thin films. The structural properties of the wire edges were analyzed by atomic force microscopy. The influence of the etching induced damage as well as surface effects due to varying surface-to-bulk-ratio on the electronic properties were studied by resistance measurements in the temperature range from 2 to 300 K and in magnetic fields between 0 and 10 T.

HL 9.54 Mon 14:30 P2

Nitrogen doping of RF-sputtered Cu_xO samples investigated by Raman spectroscopy — •David Hartung, Swen Graubner, Bruno K. Meyer, and Peter J. Klar — Institute of Experimental Physics I, Justus-Liebig University Gießen, Germany

A series of Cu_xO layers of about 300 nm thickness was grown by RF-sputtering on glass-substrates. Nitrogen gas was used for doping in the sputter process. For the different samples the nitrogen flow varied between 0.2 and 4 sccm. In order to determine the influence of nitrogen on the structural properties, the samples were investigated by Raman spectroscopy. For excitation of the samples three different laser-wavelengths were used, a HeNe- (633 nm), a frequency-doubled Nd:YAG- (532 nm) and a HeCd-laser (325 nm). The resulting Raman spectra shed light on the question whether and how the nitrogen is incorporated and its influence on the Cu_xO crystalline structure.

HL 9.55 Mon 14:30 P2

Thermoelectric measurements on artificially structured ZnO/ZnS bars — •Gert Homm, Torsten Henning, Bruno K.

Meyer, and Peter J. Klar — Institute of Experimental Physics I, Justus-Liebig-University Gießen, Gemany

ZnO layers of about 700 nm thickness were grown by RF Sputtering on glass substrates. The layers are n-type with electron concentrations of about 10^{21} cm^{-3}. Arrays of the as grown samples were artificially structured by photolithography. The patterns consist of regular arrays of bars with different spacings and bar width. The bars can be arranged in different angles with respect to the temperature gradient applied in the measurement. The patterns were transferred by wet-chemical etching. In a second sputter process a thin layer (500 nm) of ZnS was grown on the structured array to achieve the ZnO/ZnS bar structure. The Seebeck coefficient is measured in the temperature range from 50 to 300 K. The influence of the artificial structuring and the orientation of the wires with respect to the temperature gradient on the Seebeck coefficient is discussed.

HL 9.56 Mon 14:30 P2

Artifical structuring of Cu_2O by wet chemical etching — •Julian Benz, Daniel Reppin, Swen Graubner, Torsten Henning, and Peter J. Klar — Institute of Experimental Physics I, Justus-Liebig University Gießen, Germany

Cuprous oxide layers of about 350 nm were artificially structured by means of photolithography and wet chemical etching. We used patterns of different sizes and investigated different etchants. To determine the etch rates and the aspect ratio we used atomic force microscopy. Wet chemical etching was employed to artificial structurize Cu_2O/ZnO heterostructures to investigate the p-n-junction. The results of the different etchants and different etch concentrations are discussed respectively.

HL 9.57 Mon 14:30 P2

Anisotropy of the dielectric function of ZnO including exciton-polariton formation obtained from ellipsometry — •Munise Cobet[1], Ronny Kirste[1], Markus Wagner[1], Axel Hoffmann[1], Christoph Werner[2], Christoph Cobet[2], Norbert Esser[2], and Christian Thomsen[1] — [1]Institut für Festkörperphysik, TU Berlin, 10623 Berlin — [2]ISAS- Institute for Analytical Sciences, 12489 Berlin

The complex dielectric tensor of ZnO is obtained by analysis of ellipsometric data for photon energies of 2.5-32 eV. The comparison to ab-initio calculations performed including many-body effects shows a good agreement for both independent components. A strong anisotropy mainly above 10 eV could be verified by our results. At the band gap ZnO shows free exciton absorptions containing a significant formation of polaritons and the related exciton-phonon-complexes. The scattering near k=0 with the longitudinal optical phonon shows up in a replication of the three-peak structure every 72meV but might be mixed with higher excitations (n=2,3,.). A possible reversal in the two upper valence bands due to a negative spin-orbit-splitting is considered as a consequence of the near resonance between the Zn3d-level and the O2p-orbital (p-d-repulsion). Vice versa, strain as a structural treatment could affect the d-level or lead to changes in the crystal-field interaction. Raman and XRD revealed even in homoepitaxial grown samples the existence of strain. At energies 9.5-16 eV transitions including the 3d-level and at higher energies O2s-core-level occur. The loss function shows prominent peaks at the plasmon frequencies $\hbar\omega_p$.

HL 9.58 Mon 14:30 P2

Growth and characterization of ZnO nanostructures for hybrid solar cells — •Florian Maier-Flaig[1], Johannes Fallert[1], Janos Sartor[1], Jonas Conradt[1], Manuel Reinhard[2], Alexander Colsmann[2], Uli Lemmer[2], Daniel Weissenberger[3], Dagmar Gerthsen[3], Claus Klingshirn[1], and Heinz Kalt[1] — [1]Institut für Angewandte Physik, Universität Karlsruhe (TH), Germany — [2]Lichttechnisches Institut, Universität Karlsruhe (TH), Germany — [3]Laboratorium für Elektronenmikroskopie, Universität Karlsruhe (TH), Germany

Among the multitude of prospects of ZnO-nanostructures, recently their integration in hybrid solar cells has attracted a large interest. In this contribution we show our results in growth of ZnO-nanostructures used for solar cells. The underling vapour-liquid-solid (VLS) growth has been optimized to achieve a high density of thin nanowires with a suitable length. First, we point out the influence of different conducting substrates on the manner of growth. For the realization of efficient solar cells a high conductivity through these nanowires and the connected substrate is of crucial importance. Therefore additional doping has successfully been introduced in the wires by the simple choice of the conducting substrate, shown via photoluminescence measurements. Finally we present first results of dye-sensitized hybrid solar cells based on ZnO-nanostructures.

HL 9.59 Mon 14:30 P2

Influence of Mn on the impurity-band transport in Cl-doped (Zn,Mn)Se — •Jörg Teubert[1], Peter J. Klar[1], and Michael Hetterich[2] — [1]I.Physikalisches Institut JLU-Giessen — [2]Institut für Angewandte Physik, Universität Karlsruhe

The hopping mechanism of conduction in ordinary, non-magnetic semiconductors has been studied extensively, but little is known about the influence of magnetic interactions in this regime. In II_{1-x}-Mn_x-VI compounds, Mn^{2+}-ions are incorporated isovalently on group II lattice sites. The half filled d-shells of Mn ions give rise to local magnetic moments (total spin $S = 5/2$). At a concentration of $x \approx 6\%$, the hydrogen-like wavefunction of a shallow donor overlaps with several hundred localized spins giving rise to s-d exchange interaction. We present magnetotransport properties of n-doped $Zn_{0.94}Mn_{0.06}Se$:Cl crystals with Cl doping concentrations both below and above the metal-insulator transition. The modifications of the impurity band transport induced by magnetic interactions will be studied and the interpretations given by present theories will be discussed.

HL 9.60 Mon 14:30 P2

Temperature dependent incorporation and thermal stability of hydrogen in zinc oxide layers — •Marc K. Dietrich, Achim Kronenberger, Andreas Laufer, Sebastian Zöller, Angelika Polity, and Bruno K. Meyer — I. Physikalisches Institut Justus Liebig Universität Gießen, Germany

Hydrogen-doped zinc oxide films (ZnO:H) were deposited on c-axis sapphire by radio frequency magnetron sputtering. An argon-hydrogen gas mixture was used as sputtering gas. At first we investigated the influence of substrate temperature on the incorporation of hydrogen. Hydrogen-doped zinc oxide films deposited at room temperature had a carrier density of about 10^{20} cm^{-3}. Hydrogen diffusion has been observed by annealing those films at high temperatures in a nitrogen atmosphere. In the experiments the annealing temperature as well as the annealing time has been varied.

The hydrogen incorporation in the zinc oxide film was verified by secondary ion mass spectrometry. X-ray diffraction measurements showed that the lattice spacing of c-axis in zinc oxide increased at higher hydrogen concentrations.

HL 9.61 Mon 14:30 P2

Photoluminescence properties of ZnS single crystals and CVD thin films — •Melanie Pinnisch[1], Joachim Sann[1], Oliver Graw[1], Stefan Lautenschläger[1], Markus Wagner[2], Jan-Hindrik Schulze[2], Axel Hoffmann[2], and Bruno K. Meyer[1] — [1]I. Physikalisches Institut, Justus-Liebig-Universität Gießen, Heinrich-Buff-Ring 16, 35392 Gießen, Germany — [2]Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin,, Germany

ZnS with its large bandgap of 3.6 eV at room temperature is a promising candidate for optoelectronic applications in the blue and near UV. However, the fundamentals of the material have not been investigated properly. Neither acceptor nor donor bound exciton recombinations have been properly identified so far. In this work we report on low temperature and time resolved photoluminescence properties of ZnS single crystals grown by seeded vapour transport. By comparing the recombination energies of the PL-spectra with theoretical effective-mass-approximation-values we try to assign the luminescences to specific crystal defects. Finally we compare the results to photoluminescence data from ZnS CDV thin films grown on GaP- or Si-substrates.

HL 9.62 Mon 14:30 P2

Critical thickness of ZnMnSe spin aligner layers on GaAs — •B. Westenfelder, R. Dörlich, P. Asshoff, D. Z. Hu, D. M. Schaadt, H. Kalt, and M. Hetterich — Institut für Angewandte Physik, Universität Karlsruhe (TH), and DFG Center for Functional Nanostructures, CFN, D-76128 Karlsruhe

The diluted magnetic semiconductor ZnMnSe proved to be an efficient spin aligner in quantum dot spin-injection light-emitting diodes, where polarization degrees close to 100% were demonstrated. Since the minimization of spin scattering is crucial for high-fidelity spin-injection, the spin aligner should have a high epitaxial quality. Within this context,

the critical thickness of the ZnMnSe layer is of importance - beyond the critical thickness, misfit dislocations are produced and strain relaxation occurs. To determine the critical thickness of ZnMnSe with different Mn concentrations, we grew suitable epilayers on GaAs(001) and analyzed them by x-ray diffraction techniques. As expected, we observed that the critical thickness of ZnMnSe is reduced when Mn is incorporated. The results obtained will be presented and compared with different theoretical models.

HL 9.63 Mon 14:30 P2

Electronic and Optical Properties of Lithium doped ZnO Nanocrystals — •Markus R. Wagner[1], Ronny Kirste[1], Christian Rauch[1], Gordon Callsen[1], Munise Cobet[1], Wolfgang Gehlhoff[1], Enno Malguth[1,2], Michael Lehmann[3], Sebastian Polarz[4], Yilmaz Aksu[5], and Matthias Driess[5] — [1]Institut für Festkörperphysik, TU Berlin — [2]Georgia Institute of Technology, Atlanta — [3]Optisches Institut, TU Berlin — [4]Fachbereich Chemie, Universität Konstanz — [5]Institut für Chemie, TU Berlin

Lithium doped ZnO nanoparticles were grown using a novel organometallic precursor system, where the resulting material is preorganized on a molecular stage with Li concentration varied between 0.1% and 12%. XRD patterns and high resolution TEM images demonstrate that the ZnO crystals are of similar size (70-80nm) and solely crystallise in the wurtzite structure, with no other phases present. The successful incorporation of Li on the Zn lattice site is clearly proven by EPR measurements. It is shown that the Li doping leads to the introduction of lithium related acceptor states which consequently result in a strong lowering of the Fermi level. EPR and PL further show the additional introduction of Fe impurities. The lowering of the Fermi level is proven by the disappearance of the shallow donor EPR signal without optical excitation and by evident presence of Fe3+. The band-edge PL spectra are dominated by the bound exciton emission and a strong surface bound exciton line at 3.31eV. In addition, a DAP luminescence is observed and confirmed by time resolved PL. The binding energy of this acceptor state, introduced by Li doping, is calculated to 150meV.

HL 9.64 Mon 14:30 P2

Raman Spectroscopy on Lithium Doped ZnO Nanocrystals — •Ronny Kirste[1], Yilmaz Aksu[2], Markus R. Wagner[1], Surajit Jana[2], Gordon Callsen[1], Matthias Driess[2], and Axel Hoffmann[1] — [1]TU Berlin, Institute of Solid State Physics, Berlin — [2]TU Berlin, Institute of Chemistry: Metalorganics and Inorganic Materials, Berlin

ZnO still receives much attention due to its possible application for field emission displays, high frequency electronic devices, short wavelength lasers or light emitting diodes. But there is still a lack of knowledge in terms of p-doping of ZnO. Over the past years, Lithium revealed to be a good candidate for shallow acceptors. So far ZnO:Li has been investigated by many methods in different groups. However, there is only little knowledge about the influence of Li doping to the vibrational properties of ZnO. Recently Yadav et al. (JAP 104, 053507) reported about low energy Raman modes below 200 1/cm and a high energy mode around 1090 1/cm. They attributed them to zone boundary phonons and a resonant second order mode, respectively. In this contribution a detailed analysis of these Raman modes in ZnO:Li nanocrystals with different Li incorporation will be presented. We will show that these modes already appear at very low Li concentrations. According to the 1090 1/cm line, a dependence of the intensity on the Li incorporation can be seen. Furthermore excitation dependant Raman measurements will be presented. To complete our investigations photoluminescence measurements have been performed. Thereby no dependency between exciton energy and Li incorporation can be seen.

HL 9.65 Mon 14:30 P2

Dry Etching of ZnO using an Inductively Coupled Plasma: Role of plasma chemistry — •Minisha Mehta[1], Marcel Ruth[1], Karoline Piegdon[1], David Krix[2], Hermann Nienhaus[2], and Cedrik Meier[1] — [1]Experimental Physics, University of Paderborn, Warburger Str.100, 33098 Paderborn, Germany — [2]Experimental Phyics, University of Duisburg-Essen, Lotharstr.1, 47057 Duisburg,Germany

ZnO has gained much interest due to its potential applications in optoelectronic and electronic devices. In order to achieve the small dimensions required for such devices, the development of plasma etching instead of wet chemical etching is imperative. Dry etching processes for ZnO using an inductively coupled plasma (ICP) based on $SiCl_4$ and CH_4 plasma chemistry have been investigated. The influence of plasma chemistry, base pressure, radio frequency (rf) table power and ICP power on etch characteristics have been studied. The etch rate, etch profile and surface morphology of etched samples were characterized by surface profilometer, scanning electron microscopy and atomic force microscopy, respectively. It was found that CH_4-based chemistry showed a higher etch rate than the $SiCl_4$ based chemistry, presumably due to the formation of highly volatile metal organic zinc compound. Moreover, Auger electron spectroscopy (AES) and X-ray photon spectroscopy (XPS) have been performed and analyzed to examine the surface stoichiometry of etched ZnO using both plasma chemistries. Furthermore, based on UV-photoluminescence study, the effect of dry etching on the optical properties of ZnO will also be outlined.

HL 9.66 Mon 14:30 P2

Catalytic growth of ZnO nanowires via chemical vapor deposition — •Sebastian Eisermann, Stefan Lautenschläger, Torsten Henning, and Bruno K. Meyer — 1. Physikalisches Institut, Justus-Liebig-Universität Gießen, Heinrich-Buff-Ring 16, 35392 Gießen

Zinc oxide nanowires were synthesized on silicon via a catalytically activated vapor-liquid-solid process governed by chemical vapor deposition. On the silicon substrates, square two dimensional arrays of equally spaced gold nanodots with diameters of approximately 100 nm were structured via electron beam lithography and acted as catalysts. The structural properties of the nanowires were investigated via X-ray diffraction (XRD) and scanning electron microscope (SEM) measurements. Raman measurements were performed to examine the lattice dynamics. The optical characteristics were checked with photoluminescence (PL) and cathodoluminescence (CL) analysis.

HL 9.67 Mon 14:30 P2

Structure and optical properties of ZnO nanocrystals embedded in amorphous SiO_2 — •Gillian Mayer[1], Mikail Fonin[1], Ulrich Rüdiger[1], Reinhard Schneider[2], Dagmar Gerthsen[2], Nils Janssen[3], and Rudolf Bratschitsch[3] — [1]Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany — [2]Laboratorium für Elektronenmikroskopie, Universität Karlsruhe, 76128 Karlsruhe, Germany — [3]Fachbereich Physik, Universität Konstanz and Center for Applied Photonics, 78457 Konstanz, Germany

Zinc oxide (ZnO) is a wide gap semiconductor with a broad range of optoelectronic applications due to its direct band gap and high exciton binding energy. ZnO quantum dots have attracted attention since their spins might be used as qubits in quantum information technology.

In this study, ZnO nanocrystals (NCs) were grown by radio-frequency magnetron sputtering as a $SiO_2/ZnO/SiO_2$ layer stack on Si(100) and Al_2O_3(0001) substrates with an intermediate in situ annealing step. Structural properties were investigated by transmission electron microscopy (TEM), which reveals a uniform dispersion of ZnO NCs with sizes up to 16 nm in the amorphous SiO_2 matrix. High resolution TEM shows a well-defined hexagonal close packed wurtzite structure for individual NCs with lattice parameters close to those of bulk ZnO. Statistics of the NC sizes lead to a grain size of 5 ± 2 nm for more than 70 % of the NCs. The chemical separation of the ZnO NCs from the surrounding SiO_2 matrix is corroborated by energy-filtered TEM. Measurements of the optical transmittance confirm the results obtained by TEM.

HL 9.68 Mon 14:30 P2

Optical characterization of epitaxially grown $Zn_{1-x}Mg_xO$/ZnO quantum wells — •Thomas Sander[1], Peter J. Klar[1], Martin Eickhoff[1], and Thomas Wassner[2] — [1]JLU Giessen, Germany — [2]WSI Munich, Germany

The $Zn_{1-x}Mg_xO$/ZnO quantum wells and $Zn_{1-x}Mg_xO$ epitaxial layers were grown by molecular beam epitaxy on sapphire as well as on ZnO substrates. The photo-modulated reflectivity of the samples was measured at room temperature using a HeCd laser (325 nm) for modulation. The phonon spectra were investigated by Raman spectroscopy using different excitation wavelengths of 633 nm, 532 nm and 325 nm, respectively. The optical transitions in the photo-modulated spectra will be assigned and discussed in terms of the band structure. The changes of the Raman spectra of the epitaxial layers as a function of x will be analysed.

HL 9.69 Mon 14:30 P2

Acceptor centres in Ga_2O_3 — •Jan Stehr[1], Andreas Laufer[1], Detlev M. Hofmann[1], Bruno K. Meyer[1], Daniel Röhrens[2],

and Manfred Martin[2] — [1]I. Physikalisches Institut, Justus-Liebig-Universität, Heinrich-Buff-Ring 16, D- 35392 Giessen — [2]Institut für Physikalische Chemie, RWTH Aachen, Landoltweg 2, D- 52074

Ga_2O_3 is a wide band gap semiconductor ($E_{gap} = 4.9$ eV) with potential applications as a TCO material (Transparent Conducting Oxide). The n-type conductivity of the undoped material is caused by the presence of oxygen vacancies which act as shallow donors. The oxygen vacancies can be introduced by heat treatments in reducing atmospheres such as ammonia. Information on the nature of the acceptors in this material is rare.

We investigated a set of Ga_2O_3 powder samples by electron paramagnetic resonance (EPR) which were annealed in ammonia at 780 °C for 5, 18, 30 and 120 minutes. We observe 3 centres. Signal A at g = 4.3 is prominent in all samples and is attributed to residual Fe impurities. Signal B, consists of a set of two groups with 4 lines of equal intensities. The spectrum is explained by a state with S = 1/2 and I = 3/2. Possible candidates are Ga^{4+}, Cu^{2+} or As^0. The g-values $g_\perp$ = 2.33 and $g_{||}$ = 2.04 are typical for an acceptor centre. Signal C is the oxygen vacancy shallow donor at g = 1.96, as expected the intensity of this signal is increasing with the nitridation time. The intensity of signal B is not correlated which can be taken as evidence that it is of an extrinsic origin.

HL 9.70 Mon 14:30 P2

High Resolution RBS on High-k Dielectrics — •Maik Vieluf[1,2], Rainer Grötzschel[1], Christian Neelmeijer[1], Frans Munnik[1], and Steffen Teichert[1,2] — [1]Institute of Ion Beam Physics and Materials Research, FZD, Bautzner Landstraße 128, 01314 Dresden, Germany — [2]Qimonda Dresden GmbH & Co. OHG, Koenigsbruecker Strasse 180, D-01099 Dresden, Germany

The further development of microelectronic circuits requires the usage of new materials and, consequently, the characterization of materials properties on the relevant length scale. In particular it is important to analyse the depth dependent element distribution or elemental composition on interfaces of new ultrathin layer stacks with subnanometer depth resolution. A well-established complementary method is High Resolution Rutherford Backscattering Spectrometry (HRRBS). This technique is based on binary elastic nuclear scattering with well known cross sections and the inelastic energy losses of incident ions. The high energy resolution, necessary for high depth resolution, is achieved using a Browne Buechner type magnetic spectrometer with a position sensitive detector (PSD) at the 3 MeV Tandetron accelerator of the FZD. We present recent results of the investigation of the initial stage of layer growth if ZrOx and HfOx on native SiOx or TiN. The shape of the high resolution energy spectra provides knowledge about interfaces between different layers. Furthermore, the elemental areal density is also an important parameter to obtain information about atomic layer growth. For this reason, the depth dependent charge state distribution of such ultrathin layers close to the surface is investigated and discussed.

HL 9.71 Mon 14:30 P2

Influence of magnetic dopants on the metal-insulator transition in semiconductors — •Jörg Teubert[1], Peter J. Klar[1], and Wolfram Heimbrodt[2] — [1]I.Physikalisches Institut JLU-Giessen — [2]Philipps-Universität Marburg

By incorporating magnetic impurities into semiconductors, one immediately enters interesting intermediate areas between the fields of magnetism and semiconductor physics. In III-Mn-V compounds the magnetic impurity Mn serves both as the source of a large localized magnetic moment and as the source of a loosely bound hole due to its acceptor character. We will compare the transport behavior of InSb:Mn (magnetic) with InSb:Ge (non-magnetic). Both Mn and Ge form shallow acceptor levels in InSb with identical acceptor activation energies. Thus, the MIT occurs at the same critical impurity concentration and the two systems are directly comparable. However, InSb:Mn and InSb:Ge samples reveal distinct differences in their electric resistivity near the MIT. InSb:Ge shows the commonly observed behavior whereas InSb:Mn exhibits a strong enhancement of the resistivity below 10 K and pronounced negative magnetoresistance effects at 1.6 K. Both effects increase by applying hydrostatic pressure. A qualitative model explaining the observed effects based on spin effects will be presented.

HL 9.72 Mon 14:30 P2

Multifractal Analysis for the Anderson Model and in Small World Networks — •Martin Emmrich, Philipp Cain, and Michael Schreiber — Institut für Physik, Technische Universität, D-09107 Chemnitz

We study the influence of long-range links on the critical behavior of the Anderson model of localization (AML) by means of multifractal analysis of the electronic wave functions. In three dimensions it is known that the wave functions of the AML exhibit a localization-delocalization transition which can be driven by disorder strength. For the discrete AML on a three-dimensional cubic lattice the disorder is considered as an uncorrelated variation of the on-site potential and each site is connected to its six neighbor sites. We extend the AML by modifying the links between sites similar to a small-world network (SWN) where the six links of each site can connect to any other site in the system independent of the distance between the sites. This transformation between network topologies is implemented gradually by replacing links with a given probability, which allows us to trace the critical behavior starting from the AML to the new SWN case. We find that already a small number of SWN links leads to an increase of the critical disorder of the localization-delocalization transition.

HL 9.73 Mon 14:30 P2

Energy Level Statistics for the Anderson Model and in Small World Networks — •Oliver Böhm, Philipp Cain, and Michael Schreiber — Institut für Physik, Technische Universität, D-09107 Chemnitz

The Anderson model of localization (AML) describes the behavior of a single electron in a disordered solid. In three dimensions this model shows a localization-delocalization (LD) transition of the electronic wave function. For our investigation we evaluate the statistics of energy level spacings which allows us to characterize the LD transition and to distinguish between localized and delocalized behavior. First, we study the discrete AML on a three-dimensional cubic lattice where disorder is described by a variation of the on-site potential and each site is connected to its six neighbor sites. Then we extend the AML by modifying the links between sites similar to a small-world network (SWN) where the six links of each site can connect to any other site in the system independent of the distance between the sites. The particularity of these networks is, that the average path length is much shorter as in regular networks. It is not obvious whether an LD transition can be observed. Since we transform links to SWN links with a given probability we can trace the critical behavior starting from the known case of AML. We show that an increase of the critical disorder results already from a small percentage of SWN links.

HL 9.74 Mon 14:30 P2

Optimized cleaning procedures for silicon wafers — •Jochen Otzmann, Helmut Lochner, Peter Iskra, Dorota Kulaga-Egger, Torsten Sulima, and Ignaz Eisele — Universität der Bundeswehr München, Institut für Physik, Werner-Heisenberg-Weg 39, 85577 Neubiberg

The usage of improved cleaning methods is an increasingly important issue for the fabrication of nanoscale semiconductor devices. Even smallest impurities can lead to a total loss of the device, due to leakage currents or interface traps for example.

We investigate improved cleaning procedures to decrease or remove organic and inorganic contaminations on wafer surfaces, like carbon impurities and the native or chemical oxide on silicon substrates. Therefore several different process plans were defined. P-i-n diodes were fabricated in an Applied Materials Centura Cluster Tool with epitaxial growth. The substrate was an n+Silicon 100 wafer. After several cleaning processes, all wafers got the same intrinsic layer and a p+Si top coating. To get the results the wafers were structured and analyzed. With the help of I-V measurements the p-i-n diodes were evaluated and secondary ion mass spectrometries (SIMS) affirm the results.

New results led us to further optimized processing parameters. We will present suggestions on potential improvements and results from our successful experiments

HL 9.75 Mon 14:30 P2

Electric field-induced exciton localization in quantum wells — •Karsten Sperlich[1], Patrick Ludwig[2], Alexei Filinov[2], Michael Bonitz[2], Heinrich Stolz[1], Detlef Hommel[3], and Arne Gust[3] — [1]Department of Physics, University of Rostock, Germany — [2]Department of Physics, Christian-Albrechts University of Kiel, Germany — [3]Institute of Solid State Phyics, University of Bremen, Germany

We report on first spectrally and spatially high resolved measurements of a recently suggested flexible electrostatic confinement for excitons in a single quantum well [1], which is created by a fine tip electrode due to the quantum-con*ned Stark effect. For this strongly correlated system we present finite-temperature quantum Monte-Carlo results and discuss the specific trap parameters at which prominent many-particle effects, including the Wigner crystal phase of spatially indirect excitons, are expected to be accessable [2].

[1] Ludwig et al., phys. stat. sol. (b) 243, No. 10, 2363 (2006)
[2] Sperlich et al., phys. stat. sol. (c) 2008

HL 9.76 Mon 14:30 P2

Microwave Spectroscopy of Confined and Edge Magnetoplasmons in 2D Electron Stripes — •Tobias Krohn[1], Nikolai Mecking[1], Matthias Wiemann[2], Ulrich Kunze[2], Johannes Kunze[3], Christian Heyn[1], and Detlef Heitmann[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg — [2]Lehrstuhl für Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, 44780 Bochum — [3]Lehrstuhl für Integrierte Systeme, Ruhr-Universität Bochum, 44780 Bochum

We have investigated the photovoltage that was induced by irradiating microwaves on typically 30 x 60 μm^2 stripes containing a two-dimensional electron system (2DES) in a modulation-doped AlGaAs/GaAs heterostructure. The experiments were performed in sweeps of a magnetic field B that was applied perpendicularly with respect to the 2DES. The temperature was 4.2 K.

Our set up allows us to investigate a wide frequency range from 9 GHz to 325 GHz. We use special frequency modulation techniques to reduce impedance matching effects in the microwave setup. We observe a rich mode spectrum with modes exhibiting positive or negative B dispersions, which we can model, respectively, by confined magnetoplasmon and edge magnetoplasmon modes. Both types of modes are governed by characteristic lengths. We find that these lengths reflect the stripe's dimensions.

We gratefully acknowledge support through SFB 508 and BMBF 01BM461.

HL 9.77 Mon 14:30 P2

FIR and Microwaves Spectroscopy on Two-Dimensional Hole Systems in Mn doped InAs Quantum Wells — •C. G.v.Westarp, N. Mecking, W. Hansen, D. Heitmann, and U. Wurstbauer — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg

We have investigated hole systems in InAs quantum wells sandwiched in between InGaAs and InAlAs layers. One serie of our samples was modulation doped in the AlGaAs by δ carbon doping and by manganese co-doping, another series was doped with manganese. We have performed microwave and FIR transmission spectroscopy, covering the range of 60 GHz to 9000 GHz (300 cm^{-1}) at low temperatures (1.6 K) and perpendicular magnetic fields up to 14 T.

We observe a well pronounced cyclotron resonance with a non-parabolic effective mass with typical values of 0.1 m_e at high magnetic fields. On some samples additional resonances are found with exhibit an anticrossing with the cyclotron resonance.

We gratefully acknowledge support through SFB 508.

HL 9.78 Mon 14:30 P2

Transport properties of magnetic-codoped two-dimensional hole system — •Stefan Knott, Ursula Wurstbauer, and Wolfgang Hansen — Institut für Angewandte Physik, Universität Hamburg, 20355 Hamburg

The interaction of localized magnetic moments with a two dimensional hole system (2DHS) is studied with low-temperature magnetotransport measurements on molecular beam epitaxially grown InAs or InAlGaAs quantum-well structures that are C-modulation and Mn co-doped. Measurements in magnetic fields applied perpendicular to the 2DHS reveal the typical transport behaviour of a two-dimensional charge carrier system indicated by Shubnikov-de Haas oscillations and quantum-Hall plateaus. Investigations at milli-Kelvin temperatures show a metal-insulator transition in the low field region. The fully spin-polarized quantum Hall state at filling factor $\nu = 1$ is very pronounced, i.e. over a field range of more than 4 T the longitudinal resistance vanishes and the Hall resistance is constant. Surprisingly, the $\nu = 2$ state seems to be fully suppressed whereas the $\nu = 3$ state is clearly resolved by an indistinct structure in the Hall resistance and a minimum in the longitudinal resistance. Transport measurements in tilted magnetic fields are carried out to resolve the nature of the observed quantum-Hall states.

HL 9.79 Mon 14:30 P2

Magnetotransport on evenly curved graphene and thin graphite — •Karen Peters, Ursula Wurstbauer, Stefan Mendach, and Wolfgang Hansen — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg

We study evenly curved conventional and massless dirac fermions in graphite and graphene with transport measurements. To experimentally realise evenly curved graphene and thin graphite sheets with metal contacts for transport experiments we use semiconductor-graphene metal hybrid microscrolls with rolled-in sheets of thin graphite. The specific semiconductor substrates are grown on semi-insulating (001) GaAs by means of molecular beam epitaxy and include a degenerate doped back-electrode to tune the position of the Fermi energy via field effect. Further the established method of preparation, electrical and morphological characterisation of graphene layers on SiO2 is transferred to graphite deposited on GaAs substrates. Graphene on GaAs is characterized by scanning electron microscopy (SEM) and patterned with optical as well as electron beam lithography or by local oxidation with an AFM tip. Transport will be studied as function of the carrier type and density adjusted by the gate electrode and of a magnetic field which perpendicular component is sinusoidally modulated along the perimeter of the microscroll. In first experiments we use thin graphite in two-terminal geometry for optimisation of the fabrication process.

HL 9.80 Mon 14:30 P2

PLD-growth of ZnO-based planar and cylindrical microresonators — •Helena Hilmer, Chris Sturm, Rüdiger Schmidt-Grund, Jesús Zúñiga-Pérez, Jan Sellmann, Annekatrin Hinkel, Christian Czekalla, Jörg Lenzner, Gregor Zimmermann, Holger Hochmuth, Michael Lorenz, Bernd Rheinländer, and Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Linnéstr. 5, 04103 Leipzig

We have grown planar and cylindrical microresonators by means of pulsed laser deposition containing as active medium a half wavelength ZnO-cavity and free-standing ZnO-nanopillars with diameters of $(50-500)$ nm and $(5-10)\,\mu$m in length, respectively. These cavities are embedded between two all-oxide Bragg reflectors (BR) respective coated with coaxial BR made of quarter-wave stacks of yttria stabilised zirconia (YSZ) and Al_2O_3. Atomic force microscopy and scanning transmission electron microscopy show very smooth interfaces for the planar BR (average roughness $R_a = 1$ nm). For the cylindrical BR we have reached excellent quality of lateral and longitudinal homogeneous layers around the ZnO-nanopillars.
Photoluminescence spectroscopy (PL) and reflectivity (R) measurements have revealed the planar resonator to be in the strong coupling regime up to 410 K with a maximum Rabi splitting of the polariton branches of about 90 meV (PL) and 95 meV (R) at 10 K. Room-temperature spatially resolved PL and R spectra of the coated nanopillars show structures related to exciton-polariton branches in photonic wires.

HL 9.81 Mon 14:30 P2

GaN-based heterostructures for future spin electronic applications — •D. Broxtermann, C. Zube, A. Bedoya Pinto, J. Malindretos, and A. Rizzi — IV. Physikalisches Institut, Georg-August Universität Göttingen, D-37077 Göttingen, Germany

In combination with GaN based diluted magnetic semiconductors GaN/AlN resonant tunneling diodes are potential candidates for spin injectors/detectors. Furthermore 2DEG heterostructures consisting of the same materials could be utilized as diffusion channels in future spintronic applications. In this work we first optimize the MBE growth of GaN and thin AlN on MOCVD GaN templates to achieve good crystal quality and smooth GaN/AlN interfaces. Both are necessary to obtain highly efficient RTDs as well as high electron mobility 2DEGs. Effects of growth parameters on electrical properties are analyzed by magneto transport measurements and compared to calculations of a self-consisted Schrödinger-Poisson solver.

HL 9.82 Mon 14:30 P2

Spin-transitions in semiconductor quantum rings — •Benjamin Baxevanis and Daniela Pfannkuche — 1. Institut für Theoretische Physik, Universität Hamburg, Jungiusstraße 9, D-20355

Hamburg, Germany

The path integral Monte Carlo (PIMC) method is a numerically exact method to investigate properties of quantum systems in thermal equilibrium which are not in the range of other numerical methods. The main advantage of PIMC is its ability to treat strongly correlated electron systems at finite temperature. Usual approaches preserve only S_z symmetry and result in thermal averages of states with different S^2 quantum numbers. In order to avoid this spin contamination problem we extend the PIMC method to study magnetic transitions in a semiconductor quantum ring: using Young diagrams we explicitly construct eigenstates of the S^2 operator. In our model of a quantum ring diameter, width and elliptical deformation can be tuned. At a given electron number the ground state exhibits spin-transitions depending on the ring geometry.

HL 9.83 Mon 14:30 P2

Polymer field effect transistor with contact modification by organic molecules — •Rebecca Winter[1], Maria S. Hammer[1], Carsten Deibel[1], and Jens Pflaum[1,2] — [1]Julius-Maximilians-University of Würzburg, Institute of Physics, Experimental Physics VI, D-97074 Würzburg — [2]Bavarian Centre for Applied Energy Research e.V. (ZAE Bayern), D-97074 Würzburg

In recent years organic electronics processed from solution received a lot of attention due to their low cost potential. The performance of field effect transistors (FET) influenced the quality of electronic curcuits. In order to get high on/off ratios and low threshold voltages the organic FET has to be optimized. The output current is strongly affected by injection of charge carriers at the contacts. Here we discuss the limitation of the performance of the organic FETs due to this contact/channel interface. Therefore we examine the influence of a monolayer of organic molecules on the Au- contacts before spincoating rr-poly-3-hexyl-thiophene(rr-P3HT) on the contact resistance and the threshold voltage. From our presented data we will conclude on changes of the respective work functions with and without functionalization. By temperature dependent measurements we are able to discriminate between tunnelling assisted injection processes and those based on thermally activation.

HL 9.84 Mon 14:30 P2

Deposition of PTCDA on an Ultra Thin Optical Fibre from a Helium Nanodroplet Beam — •Tobias Knoblauch, Matthieu Dvorak, Oliver Bünermann, and Frank Stienkemeier — Physikalisches Institut, Universität Freiburg, 79104 Freiburg

Helium nanodroplet isolation (HENDI) spectroscopy is a powerful technique to analyse the electronic structure of molecules. Because of the very low temperature of the droplets (0.4 K) and their superfluid property, helium nanodroplets provide a cold and weakly interacting matrix. Furthermore, it can be used to form peculiar complexes of molecules inside the droplets. The high spectral resolution of this technique allows disentangling the contributions of different complex sizes.

Vibronic spectra of PTCDA isolated in helium droplets have been extensively studied in our group [1]. To link our results with film spectroscopy we extended our molecular beam apparatus in order to deposit molecules and complexes formed in the droplets on an ultra thin optical fibre. Light passing through the optical fibre exhibits a pronounced evanescent field that interferes with the deposited material on its surface and allows high sensitive transient absorption spectroscopy [2]. We will present the status and first results of this setup.

[1] M. Wewer and F. Stienkemeier, J. Chem. Phys. 120, 1239 (2004)

[2] F. Warken, E. Vetsch, D. Meschede, M. Sokolowski and A. Rauschenbeutel, Optics Express 15, 11952 (2007)

HL 9.85 Mon 14:30 P2

Influence of F8BT/P3HT blend composition on organic field-effect transistors — •Eva Johanna Feldmeier, Christian Melzer, and Heinz von Seggern — Electronic Materials Department, Institute of Materials Science, TU Darmstadt, Petersenstraße 23 , 64287 Darmstadt, Germany

The ambipolar poly(9,9-di-n-octylfluorene-alt-benzothiadiazole) (F8BT) and p-type regioregular poly(3-hexylthiophene) (P3HT) are well known in the field of photovoltaic cells, where they act as electron acceptor and electron donor, respectively. Here ambipolar top-gate organic field-effect transistors from different blends of F8BT and P3HT with Au source and drain contacts are analysed with respect to charge-carrier transport properties in dependence of the blend composition. The change in transistor performance will be investigated on basis of the respective transfer characteristics and of the device parameters extracted from the saturation regimes. The evolution of the extracted field-effect mobilities and threshold voltages of both charge carrier species will be discussed considering the injection and transport properties of the individual materials as well as the energetics of the investigated blend.

HL 9.86 Mon 14:30 P2

Transfer mechanisms between emitter molecules for OLED applications — •Frank Steinbacher[1,2], Chien-Shu Chiu[3,2], Ralf Krause[2], Arvid Hunze[2], and Albrecht Winnacker[1] — [1]Department of Materials Science VI, University of Erlangen-Nuremberg, Germany — [2]Siemens AG, CT MM 1, Günther-Scharowsky-Str. 1, 91058 Erlangen, Germany — [3]Department of Electrical Engineering & Information Technology, Technical University of Braunschweig, Germany

Within the last few years white organic light emitting diodes based on small molecules have shown the potential to have a promising future in the field of lighting technology. Nevertheless there is still room for improvement of the overall efficiency and lifetime of white OLEDs. A deeper understanding of the energy transfer mechanisms between different matrix and emitter molecules used in the OLED stack concept can help to optimize the layout and reduce driving voltage thus increasing the power efficiency and color stability of the device. To simplify the complex interactions within a complete white OLED we start out with a basic model system only containing the molecules of interest. This enables us to predict the fundamental concepts causing the behavior of more intricate systems. Using photoluminescence, excitation spectra and time-resolved photoluminescence we investigated the exciton transfer between different dyes for a variety of emitter systems. Our results indicate a dependence of exciton transfer probability on the total concentrations and therefore the distance between the molecules involved.

HL 9.87 Mon 14:30 P2

Structural and electronic properties of melanin-like materials — •Falk Tandetzky, Frank Ortmann, Karsten Hannewald, and Friedhelm Bechstedt — IFTO & ETSF, Friedrich-Schiller-Universität Jena, Jena, Germany

The macromolecule melanin which is primarily known as a pigment has also attracted recent interest as a possible high-tech functional material with potential electronic applications. However, the complexity of its structure as well as the relationship to its electronic properties is still not fully understood [1]. Here, we present ab initio studies for the structural, energetic, and electronic properties of various molecular building blocks (monomers, dimers, and tetrameric rings) of eumelanin. The band structure of one-dimensional stacks composed of such units are calculated and consequences for the charge transport along the stacks are discussed.

HL 9.88 Mon 14:30 P2

Measurements of absorption, fluorescence and lifetimes of Cl4MePTCDI in different solvents and crystalline phases — •Frank Friedriszik, Harald Graaf, and Christian von Borczyskowski — Center of Nanostructured Materials and Analysis, TU Chemnitz, 09107 Chemnitz, Germany

Perylene dye molecules are well know organic semiconductors with n-type behaviour. Most of the small perylene derivates consist of planar aromatic system, which leads to high molecular order in the solid state accompanied with strong intermolecular interactions. These chromophore couplings cause high electron mobility within the stack and lead to quenching of luminescence.

By chemical substitution in the bay position with chlorine a twist of the aromatic core can be found, which drastically lowers the molecular interactions. We show the changes in the photo-physical properties in solution and in the solid state using our model substance 1, 6, 7, 10-tetra-chloro-N, N'-dimethyl-perylene-tetracarboxylic-bisimide (Cl4MePTCDI). Directly after preparation an amorphous state is detected , which shows slow ordering under ambient conditions. The rate of this self-organization process depends on the temperature and is characterized by intermolecular interaction causing changes in optical absorption and luminescence. Lifetime measurements of the excited states in the crystalline and amorphous phase complete our investigations.

HL 9.89 Mon 14:30 P2

Photoluminescence Detected Magnetic Resonance (PLDMR) studies on oxygen doped P3HT — •Hannes Kraus[1], Andreas Sperlich[1], Carsten Deibel[1], and Vladimir Dyakonov[1,2] — [1]Experimental Physics VI, Physical Institute, Julius-Maximilians-University of Würzburg, D-97074 Würzburg — [2]ZAE Bayern, Div. Functional Materials for Energy Technology, D-97074 Würzburg

Poly(3-hexylthiophene) (P3HT) is one of the most promising semiconducting polymers for applications in organic optoelectronics and solar cells. To improve the overall stability of polymer devices, the intrinsic stability of P3HT has to be further investigated. The excited states in P3HT subjected to oxygen were studied with optical (PL excited by 532nm) and spin-sensitive (X-band electron spin resonance, ESR) techniques, and furthermore with a combination of these: photoluminescense detected magnetic resonance (PLDMR). With PLDMR, the sample's spin state can be identified by measuring the photoluminescense change due to resonant microwave irradiation. By comparing the data obtained with ESR, PL and PLDMR on P3HT, before and after oxygen exposition, a more complete picture of oxygen-P3HT interaction can be achieved.

HL 9.90 Mon 14:30 P2

Modification of the injection properties in small molecule thin film transistors — •Florian Wörner[1], Peter Nill[2], and Jens Pflaum[1,3] — [1]Experimental Physics VI, Julius-Maximilians University Würzburg, 97074 Würzburg — [2]Inst.for Appl. Physics, University Tübingen, 72076 Tübingen — [3]Bavarian Center for Applied Energy Research e.V. (ZAE Bayern)

Over the past, the electronic characteristics of thin film transistors based on small molecules have continuously improved making their implementation in all-organic devices close to the market. Still, one of the bottlenecks is the injection of charge carriers into the conduction channel, hampered by charge transfer and the formation of dipoles at the metal-organic interface. In our contribution we discuss a possible strategy to overcome this limitation by use of metal contacts coated with monolayers of small molecules, namely oxides of the organic semiconductor pentacene. We demonstrate that this functionalization leads to a significant improvement of the transistor performance in terms of the contact resistance and the threshold voltage. Temperature dependent transport studies enable us to analyze the underlying microscopic mechanisms determining the injection behavior and to discriminate between a tunneling and a thermally assisted injection process. Finally, we discuss the applicability of our approach to molecular materials preferentially showing an n-type semiconducting behavior.

HL 9.91 Mon 14:30 P2

Temperature-dependent bias stress effects in organic thin-film transistors — •Nicole Killat, Ingo Hörselmann, Susanne Scheinert, and Gerhard Gobsch — TU Ilmenau, 98684 Ilmenau, PF 100565, Germany

An investigation of the stability of organic thin-film transistors (OTFT) was carried out by bias stress measurements. OTFTs with bottom- and top- source/drain-contacts (W/L=1000/30) were fabricated with 30nm SiO_2 as gate dielectric and the polythiophene P3HT or the polyvinylene TPD(4M)-MEH-PPV as active layer. The transfer characteristics after each stress sequence as well as the time-dependent drain-current at constant gate bias were measured in the linear regime at a constant temperature between 240K and 340K and in nitrogen atmosphere. For both polymers a negative gate bias caused a negative threshold voltage shift during stress time, which increased with higher temperatures. In contrast to P3HT, PPV showed no complete reversibility of the negative threshold voltage shift after applying a positive gate bias, which is not affected by heating. However, the positive threshold voltage shift of a top-contacted transistor with P3HT, caused by a positive gate bias, increased significantly with higher temperatures. Measurements in air enforced the bias stress effect in the PPV-OTFT. In P3HT the acceptor-like doping by oxygen amplified the positive threshold voltage shift during positive bias stress and was hardly compensated by negative bias stress. As a conclusion, the bias stress effect in OTFTs increases with higher temperatures, but principle tendencies are not affected.

HL 9.92 Mon 14:30 P2

Exciton binding energy in conjugated polymers — •Daniel Mack, Julien Gorenflot, Carsten Carsten, and Vladimir Dyakonov — Experimental Physics VI, Julius-Maximilians-University of Würzburg, , D 97074 Würzburg

One important parameter governing the efficiency of organic donor:acceptor solar cells is the open-circuit voltage. The relative energy levels of donor and acceptor are a trade-off between efficient charge transfer, i.e., exciton dissociation, and large open-circuit voltage. A deeper understanding of the exciton binding energy and factors influencing it are therefore important in view of an optimisation of the performance of organic solar cells. We studied the exciton binding energy in the conjugated polymer poly(3-hexylthiophene) by field-dependent photoluminescence (PL) quenching. A laser generates singlet excitons within the polymer matrix; an electric field is then applied in order to dissociate these excited states into electron*hole pairs. The field-induced separation of the excitons, corresponding to a reduction of ratiative recombination, is investigated by monitoring a decrease of the PL signal. Our experimental results are discussed and compared with calculations after the models of Arkhipov [1] and Emilianova [2].

[1] V. I. Arkhipov, H. Bässler, M. Deussen und E. O. Göbel, Field-induced exciton breaking in conjugated polymers. Phys. Rev. B, 52 (1995) 4932. [2] E. V. Emelianova, M. van der Auweraer, and H. Bässler, Hopping approach towards exciton dissociation in conjugated polymers. J. Chem. Phys. 128 (2008) 224709.

HL 9.93 Mon 14:30 P2

Switching of drain potential in organic field effect transistor — •Ingo Hörselmann and Susanne Scheinert — TU Ilmenau

An organic field effect transistor (OFET) with source/drain electrodes self-aligned to bottom gate contact was prepared, resulting in a low overlap capacitance C_{GD} of 10pF for a channel width to length ratio of 8000. The gate insulator is a 200nm Si_3N_4 layer grown by chemical vapor deposition (CVD). As active semiconductor material poly(3-hexylthiophene) (P3HT) was used to produce a p-channel transistor. The drain and gate potential was switched with square-wave pulses and the transient response of the source and drain currents was recorded to investigate the transient behavior. Switching the drain potential between 0 and -10V with a ramptime of 50μs at constant gate-source voltage, which deplets the semiconductor layer, the measured transient source current is 5 orders higher then the expected displacement current originating from the geometry capacitance between source and drain. Numerical 2D simulation affirmed this tendency in case of acceptor-like bulk trap densities of about $5 \times 10^{17}\mathrm{cm}^{-3}$. The simulated decay behavior for switching the drain potential from -10 to 0V showed a strong dependency on the energy of the trap level, which is supported by an observed current decay during the measurements.

HL 9.94 Mon 14:30 P2

Packing of Planar Organic Molecules: Interplay of van der Waals and Electrostatic Interaction — •Mira El Helou[1,2], Daniel Käfer[2], Christian Gemel[3], and Gregor Witte[1,2] — [1]Molekulare Festkörperphysik, Philipps-Universität Marburg, D-35037 Marburg, Germany — [2]Physikalische Chemie I, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [3]Anorganische Chemie II, Ruhr-Universität Bochum, D-44780 Bochum, Germany

The molecular packing and thermal stability of pentacene and its two oxo-derivatives (6,13-pentacenedione and 5,7,12,14-pentacenetetrone) in their crystalline phase have been analyzed and compared with quantum chemical calculations of the electronic structure of the molecular entities. While pentacene reveals a face-on-edge herringbone packing, both oxygen containing species adopt an almost coplanar stacking. Quantum chemical calculations reveal discernible charge localization at the oxygen atoms which in turn causes an electrostatic O-π-interaction and hence favours a planar stacking. On the other hand, the polarizability of the conjugated systems of both oxo-species is reduced and their intermolecular distance is enlarged, due to the bulky oxygen atoms, both leading to a lower van-der Waals interaction and thus explains the decreased thermal stability of the studied oxidized entities. The present study emphasizes the importance of the balance of electrostatic and van-der Waals interactions [1].

[1] D. Käfer, M. El Helou, Ch. Gemel, Gregor Witte Crystals Growth and Design 8, No.8, 3053 (2008).

HL 9.95 Mon 14:30 P2

Deviations from the Einstein relation in organic semiconductors — •Vera Stehr[1], Carsten Deibel[1], and Vladimir Dyakonov[1,2] — [1]Experimental Physics VI, Physical Institute, Julius-Maximilians-University of Würzburg, D-97074 Würzburg — [2]Functional Materials for Energy Technology, Bavarian Centre for Applied Energy Research (ZAE Bayern), D-97074 Würzburg

During the last years, increasing attention is drawn to organic semi-

conductors, since they capture more and more fields of application (e. g. light emitting diodes, organic photovoltaics). It is known that the Einstein relation, which states that the ratio of the diffusion to the mobility equals the thermal voltage, does not hold for organic semiconductors with a gaussian density of states distribution. Deviations were observed in the case of high energetic disorder and low temperatures. We studied these deviations by means of Monte Carlo simulations, paying particular attention to the so far mostly neglected electric field. We discuss the relevance of our findings to the physical description of organic devices.

HL 9.96 Mon 14:30 P2

Observation of single quantum dots in GaAs/AlAs micropillar cavities — •Philipp Burger, Matthias Karl, Dongzhi Hu, Daniel M. Schaadt, Heinz Kalt, and Michael Hetterich — Institut für Angewandte Physik and DFG Center for Functional Nanostructures (CFN), Universität Karlsruhe (TH), 76128 Karlsruhe, Germany

In our contribution we present the fabrication steps of micropillar cavities and their optical properties. The layer structure consisting of a GaAs-based lambda-cavity sandwiched between two GaAs/AlAs distributed Bragg reflectors is grown by molecular-beam epitaxy. In(Ga)As quantum dots, emitting at around 950 nm, are embedded as optically active medium in the middle of the cavity. The pillars are milled out of this structure with a focused ion-beam. A confocal micro-photoluminescence set-up allows to measure optical cavity modes as well as single quantum dots in the pillars when using low excitation intensity. This enables us to observe a (thermal) shift of the single quantum dot peaks relative to the cavity mode. In addition, we increased the numerical aperture of the set-up (originally 0.4) with a solid immersion lens up to 0.8. Thus we are able to detect the fundamental mode of pillars with very small diameters. Furthermore, the collection efficiency increases substantially.

HL 9.97 Mon 14:30 P2

Few-Photon-Quantum Transport Through a Photonic-Crystal Waveguide With A Two-Level System — •Paolo Longo[1], Kurt Busch[1,2], and Peter Schmitteckert[2] — [1]Institut für Theoretische Festkörperphysik, Universität Karlsruhe (TH) — [2]Institut für Nanotechnologie, Forschungszentrum Karlsruhe

Quantum optics in photonic crystals is a very fascinating field of research. Recent work [1] shows that scattering of a two-photon state with a two-level impurity is qualitatively different from single-particle physics which effectively enables the possibility to induce interactions between photons.

Exact numerical studies of the interaction of a multi-photon, multimoded, quantized light field with a single two-level impurity are presented. The time evolution of photonic wave-packets, observables and correlation functions can be calculated by using a discrete finite-lattice version of a generalized Dicke-Hamiltonian.

For first considerations the Hamiltonian is reformulated as a tight-binding model,

$$H = -t \sum_{i=1}^{M-1} (a_{i+1}^\dagger a_i + a_i^\dagger a_{i+1}) + \frac{\Omega}{2}\sigma_z + V(a_l^\dagger \sigma^- + a_l \sigma^+),$$

with which we evolute photonic quantum states in time in order to calculate scattering properties of single- und multi-photon states.

[1] J. T. Shen and S. Fan, Phys. Rev. Lett. 98, 153003 (2007).

HL 9.98 Mon 14:30 P2

Untersuchungen von Metamaterialien aus Split-Ring-Resonatoren bei Millimeterwellen — •Andreas Schneider, Sebastian Engelbrecht, Alexey Shuvaev und Andrei Pimenov — Experimentelle Physik 4, Universitaet Wuerzburg, Am Hubland D-97074 Wuerzburg

In dieser Arbeit wurden Millimeterwellen-Eigenschaften von Metamaterialien bestehend aus Split-Ring-Resonatoren (SRR) in einem Frequenzbereich von ca. 60 GHz bis 260 GHz untersucht. Split-Ring-Resonatoren sind wegen ihrer ungewöhnlichen Eigenschaften, wie Magnetismus, Bianisotropie oder negativer Brechung besonders interessant. Konventionelle Methoden des Elektromagnetismus eignen sich nicht zur Charakterisierung der SRR, da sie zusätzlich zur ihrer dielektrischen Funktion (ϵ) und ihrer Permeabilität (μ) einen Kreuzterm, den sog. Bianisotropie-Term (ξ), besitzen. Die daraus resultierenden Zusatzeffekte können nicht vernachlässigt werden und erfordern spezielle Verfahren zur Bestimmung der elektromagnetischen Eigenschaften. Für die Millimeterwellen Experimente wurden die SRR mit einem Standardverfahren der Photolitographie auf Textolitplatinen hergestellt. Zur Charakterisierung der Split-Ring-Resonatoren wurden Transmissionsspektren und ihre zugehörigen Phasen für sechs verschiedene Anregungsgeometrien der Ringe gemessen. Mittels einer Transfermatrixmethode wurden komplexe Transmissionsfunktionen berechnet. Die komplexen Größen ϵ, μ und ξ wurden direkt aus den Transmissions- und Phasenwerten in der Nähe der Resonanzfrequenz bestimmt.

HL 9.99 Mon 14:30 P2

Sources as an Extension of the Fourier Modal Method — •Christian Klock[1], Thomas Zebrowski[1,2,3], Sabine Essig[1,2,3], and Kurt Busch[1,2,3] — [1]Institut für Theoretische Festkörperphysik, Universität Karlsruhe — [2]Karlsruhe School of Optics & Photonics (KSOP) — [3]DFG Center for Functional Nanostructures (CFN)

The Fourier Modal Method (FMM) enables the study of electromagnetic field distribution in structures with periodicity in the lateral plane. A nonlinear conformal coordinate mapping realizes absorbing boundaries and also allows us to treat aperiodic, finite-sized structures. Commonly, the method is used to simulate a system's response to an incoming wave.

Our poster illustrates how to extend the method to include the emission from line sources in 2D and point sources in 3D. We present comparisons of numerical and analytical field distributions for the case of an emitter in an infinite dielectric cylinder. Furthermore, we demonstrate the method's potential for applications related to the designs of structured, plasmonic enhanced light emitting diodes.

HL 9.100 Mon 14:30 P2

Modelling of metamaterials using a coupled dipole approach — •Jens Küchenmeister[1], Sabine Essig[1,2,3], Lasha Tkeshelashvili[1,3], and Kurt Busch[1,2,3] — [1]Institut für Theoretische Festkörperphysik, Universität Karlsruhe — [2]Karlsruhe School of Optics & Photonics (KSOP), Universität Karlsruhe — [3]DFG Centrum für Funktionelle Nanostrukturen (CFN), Universität Karlsruhe

Controlling the properties of metamaterials using different sizes and shapes of the basic building blocks, i.e. metallic nanostructures allows for a far-reaching control of the effective material properties. Fully numerical approaches via, e.g., the Fourier Modal method (FMM) or the Finite Element Method that directly solve Maxwell's equations require siginificant computational resources and are usually not suitable for design studies.

We present a coupled-dipole approach to metamaterials which allows for efficient parameter studies. The model contains few free parameters that are determined by comparison with exact numerics via FMM for simple systems such as periodic arrays of metallic rods. More complex structures can be systematically constructed, thus providing physical insights and allowing for rapid designs studies. We apply this approach to certain (chiral) multi-layer structures.

HL 9.101 Mon 14:30 P2

Transmission line circuit analysis of split-ring resonator metamaterials — •Liwei Fu, Heinz Schweizer, and Harald Giessen — 4th Physics Institute, University of Stuttgart, 70550 Stuttgart, Germany

Split-ring resonators (SRRs) are well studied due to their application potentials for superlenses, cloaking devices, perfect absorbers, and magnetic levitation. There are different interpretations about the dependence of their resonance frequency on structure parameters using LC circuit models. However, these models can not explain the blue-shift of the resonance frequency with the metal thickness [1]. In this report, we show that by distinguishing between series impedance and shunt admittance and by fitting the numerical results using transmission line circuit models [2,3], we can quantitatively derive the dependence of the circuit parameters on the SRR structure parameters. Novel thickness dependent interpretations will be given. Clear physical insight in SRR-based metamaterials is obtained.

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HL 9.102 Mon 14:30 P2

Modification of emission of internal emitters in Photonic Crystals — •Rebecca Wagner, Sven Zimmermann, and Frank Cichos — Molecular Nanophotonics Group, University of Leipzig,

Linnéstraße 5, 04103 Leipzig

In a photonic crystal the dielectric constant varies spatially on the length scale of optical wavelengths which leads to the formation of a photonic band structure. In weak dielectric systems there exist no complete gaps but stop bands for certain directions. This results in a spectral and angular redistribution of the emission of internal emitters.

We use dye beads that are homogeneously distributed within a 3D crystal in a low concentration to locally probe the band structure. The emitters are detected by defocused imaging microscopy. The diffraction patterns show a three-fold symmetry that is connected to the local structure of the crystal. The intensity I(z) of single beads in depth z inside a PC follows the usual Lambert-Beer-law for emission wavelengths outside the band gap. For beads emitting in the band gap there is a modification of the law. The enhanced attenuation is caused by a stop band that inhibits emission into direction of the detection.

HL 9.103 Mon 14:30 P2

Wet chemical grown ZnO nanowires for use in polymer-hybrid-LEDs — •Jan-Peter Richters, Apurba Dev, and Tobias Voss — Institute of Solid State Physics, University of Bremen, P.O. Box 330440, D-28334 Bremen

Due to their large surface-to-volume ratio and the photon confinement, ZnO nanowires are good candidates for applications in nanoscaled sensor technology and optoelectronics in the blue-UV spectral region. Especially low-temperature grown ZnO nanowires are very promising candidates for the production of environmentally friendly and cost-efficient solar cells and light emitting diodes. The difficulties in p-type doping of ZnO have led to a huge variety of approaches to replace the missing p-type component by e.g. ionic liquids or p-type conductive polymers.

We report on wet-chemically grown ZnO nanowire arrays grown on various substrates with very good homogeneity for areas as large as 1.5×1.5 cm^2. The typical dimensions of the nanowires are about 100 nm in diameter and 2 μm in length. The crystalline structure is investigated by using TEM measurements. Photoluminescence measurements (4K up to room-temperature) show clear excitonic features which indicate an overall good optical quality with low visible deep-level luminescence. We processed ZnO nanowire / PEDOT:PSS compound structures that act as light emitting diodes and report a high rectification ratio of about 10^5 and current densities up to 50 mA/mm^2.

HL 9.104 Mon 14:30 P2

Energy Dynamics in Polymer-Coated Quantum Dots with Integrated Dye Molecules — •Tobias Niebling, Ali Zulqurnain, Feng Zhang, Wolfram Heimbrodt, and Wolfgang J. Parak — Department of Physics and Material Sciences Center, Philipps University Marburg, Germany

Semiconductor nano-particles have emerged as promising candidates for the basis of sensors in bioanalytics and markers for biolabeling. Inorganic CdSe quantum dots are coated with amphiphilic polymers in order to transfer them to aqueous solutions. Additionally, it is possible to embed ATTO-dye molecules in the polymer shell. The spectral overlap between the emission of the nano-particles and the absorption of the dye molecules can be modified by choosing different sizes of the quantum dots. Continuous-wave measurements as well as time-resolved photoluminescence measurements show that the emission properties of the quantum dot-dye molecule system are dominated by energy transfer processes. The presence of the quantum dots decelerates the decay of the dye emission, due to (i) re-absorption of photons emitted by the nano-particles and (ii) non-radiative energy transfer. The latter becomes more important the smaller the distance between the nano-particles and the dye molecules and the larger the spectral overlap between quantum dot emission and dye absorption. The measurements can be described within a model that accounts for the interplay of the excitation dynamics of the quantum dot and the dye molecules with respect to the different transfer processes.

HL 9.105 Mon 14:30 P2

MBE growth and characterisation of Heusler Alloy Ni_2MnIn on (001) InAs — •Sascha Bohse, Andriy Zolotaryov, Andreas Volland, Christian Heyn, and Wolfgang Hansen — Universität Hamburg, Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, D-20355 Hamburg, Germany

We study the morphological, structural, and magnetic properties of thin Ni_2MnIn Heusler films grown on (001) InAs by molecular beam epitaxy (MBE) at temperatures between 80 °C and 360 °C. The structural properties of the films with thicknesses of 20, 60, and 100 nm are studied with atomic force microscopy (AFM), X-ray reflectivity measurements (XRR), and transmission electron microscopy (TEM). For magnetization measurements SQUID magnetometry has been used. Furthermore a composition analysis of TEM crossections is provided with energy dispersive X-ray spectroscopy (EDX). The TEM investigations reveal the formation of an intermixed layer on the film/substrate interface by diffusion of As from the substrate into the Heusler deposit. The intermixing process is accompanied by a B2 to $L2_1$ phase transition between 250 °C - 300 °C and a fast morphological degradation of the Heusler films at temperatures higher than 300 °C. The Ni_2MnIn films grown within the 250 °C - 300 °C temperature window are found to be single-crystalline with best morphological and structural quality. Interestingly, films in $L2_1$ phase are found to have a (110) surface orientation in contrast to the InAs (001) substrate crystal.

HL 9.106 Mon 14:30 P2

Electron Dynamics in Light Emitting Quantum-Dot Heterostructures with Momentum Resolved Carrier-Phonon Scattering — •Janik Wolters[1], Matthias–René Dachner[1], Ulrike Woggon[2], Andreas Knorr[1], and Marten Richter[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin — [2]Institut für Optik und Atomare Physik, Technische Universität Berlin

We present a microscopic theory of the light emission dynamics of an electrically pumped quantum dot emitter below laser threshold. The structure consists of a bulk semiconductor and Stranski-Krastanov grown InGaAs/GaAs quantum dot layers, operating at room temperature. Transport through the structure is driven by scattering with longitudinal-optical phonons, including nonequilibrium phonons.
It appears that even though the phonon distribution remains thermal, there is a substantial carrier heating in the quantum wells.

HL 9.107 Mon 14:30 P2

Microscopic model for the Switch-on Dynamics of Quantum-Dot VCSELs — •Jeong Eun Kim, Ermin Malic, Marten Richter, and Andreas Knorr — Institut für Theoretische Physik, Technische Universität Berlin*Hardenbergstr. 36, 10623 Berlin, Germany

Quantum dots (QDs) as active medium in vertical-cavity surface-emitting lasers (VCSELs) promise improved device performance [1]. We present a microscopically motivated calculation of the switch-on dynamics of an electrically pumped QD-VCSEL. The electric field propagation and the dynamics of the QD and WL charge carrier densities are calculated using spatially one-dimensional Maxwell-Bloch equations. For a detailed understanding, microscopically calculated Coulomb scattering processes [2] and a model for spontaneous emission [3] are incorporated into the Maxwell-Bloch equations. The equations are numerically solved by finite-difference time-domain (FDTD) method to investigate the temporal quantum electrodynamics. After the switch-on of the laser on a ns time scale, relaxation oscillations result from an interplay of carrier filling, induced emission, and absorption processes.

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HL 9.108 Mon 14:30 P2

Pulse propagation in Quantum Dot Semiconductor Optical Amplifiers — •Niels Majer, Miriam Wegert, Ermin Malic, Kathy Lüdge, and Eckehard Schöll — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin

We investigate pulse propagation in quantum dot semiconductor optical amplifiers (QD SOA) using travelling wave equations for the electric field amplitude on the basis of Maxwell's equations coupled with Semiconductor Bloch equations. The model includes microscopically calculated Coulomb scattering rates in the dynamic equations for the carrier populations of the quantum dots, and a phenomenological dephasing time.

Simulations of the spatiotemporal dynamics of the system using ultrashort (150 fs FWHM) input pulses reveal the following intensity-dependent effects: As the pulse travels along the SOA, it is deformed and may even develop a two-peak structure (pulse-breakup).

HL 9.109 Mon 14:30 P2

Fabrication and characterization of red AlGaInP-VECSEL — •Thomas Schwarzbäck, Marcus Eichfelder, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funkionelle Grenzflächen, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany

Vertical-external-cavity surface-emitting lasers (VECSELs) have attracted a wide range of applications in biophotonics, television or projectors and spectroscopy. Here VECSELs overcome the disadvantages of common high-power edge-emitting semiconductor lasers which often suffer under insufficient beam quality and catastrophic optical mirror damage. With usage of external cavities and optical pumping VECSELs achieve high continuous-wave output power and near-diffraction-limited beam quality with a TEM_{00} Gaussian beam profile.

We present a fully operating VECSEL system based on a multi-quantum-well structure of the chip with compressively-strained GaInP quantum wells within $Al_{0.55}GaInP$ barriers on an $Al_{0.50}GaAs/AlAs$ distributed Bragg reflector for an operation wavelength of around 660 nm. With simulations based on a transfer-matrix method we produced a resonant periodic gain design of the chip-cavity. The laser system is actively cooled by thermo-electric cooling and key parameters of this laser system were investigated intensively.

After optimization of the VECSEL structure and set-up a future prospective could be frequency-doubling to enter the UV spectral range.

HL 9.110 Mon 14:30 P2

Mode characteristics of red VCSEL with oxide-confined aperture — •Susanne Weidenfeld, Michael Wiesner, Marcus Eichfelder, Robert Rossbach, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany

For optical data transmission over short distances polymer optical fibers (POF) are the preferred low cost medium due to their relatively high mechanical flexibility and the large core diameter. Red vertical-cavity surface-emitting lasers (VCSEL) target one absorption minimum of the POF at around 650 nm and exhibit circular beam profile and low divergence angle for an easy coupling of light into the fiber.

Our AlGaInP-based devices are grown by metal-organic vapor-phase epitaxy (MOVPE). They have low threshold current (<1mA) and an optical output power up to 4 mW. For practical application a stable single transverse mode especially the fundamental mode and a stable polarization of the emission is desirable owing to higher coupling-efficiency in optical fibers.

In the current work we investigate the beam-profile depending on different parameters. The transverse mode profile is analyzed regarding aperture and mesa size. Also the influence of operation current and temperature on the mode shape is investigated. Measurements of the divergence angle and the polarization of the modes are presented.

HL 9.111 Mon 14:30 P2

Spin Injection in GaAs by Cleaved-Edge-Overgrowth — •Arne Ludwig[1], Carsten Godde[2], Sani Noor[2], Hasmik Harutyunyan[2], Stephan Hövel[3], Mingyuan Li[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]Lehstuhl für Photonik und Terahertztechnologie, all Ruhr-Universität 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 and first results from Electroluminescence measurements.

HL 9.112 Mon 14:30 P2

Magnetic Anisotropy and Anisotropic Magnetoresistance of (Ga,Mn)As Layers on (113)A GaAs — •Daniela Donhauser, Lukas Dreher, Joachim Däubler, Michael Glunk, Christoph Rapp, Wladimir Schoch, Rolf Sauer, and Wolfgang Limmer — Institut für Halbleiterphysik, Universität Ulm, 89069 Ulm, Germany

We study the magnetic anisotropy and the anisotropic magnetoresistance of compressively strained (Ga,Mn)As films with various Mn concentrations, grown on (113)A-oriented GaAs substrates. High-resolution x-ray diffraction (HRXRD) studies reveal a monoclinic symmetry of the distorted (113)A layers in agreement with an explicit calculation of the strain tensor. Based on this result, general expressions for the resistivity tensor and the free energy of single-crystalline ferromagnets are derived from a series expansion with respect to the magnetization orientation, including terms up to the fourth order. With these expressions we are able to model the measured angular dependences of our magnetotransport data with the assumption of a single ferromagnetic domain model. In order to quantitatively derive the resistivity and anisotropy parameters the longitudinal and transverse resistivities are experimentally studied for magnetic fields rotated within the (113), $(33\bar{2})$, and $(\bar{1}10)$ plane at various field strengths. It turned out that some of the resistivity parameters significantly depend on the strength of the external magnetic field. Furthermore we found that the layers exhibit a uniaxial anisotropy along the [001] crystallographic axis, which can be theoretically explained based on the explicit form of the strain tensor.

HL 9.113 Mon 14:30 P2

Measurement of long spin lifetimes, spin diffusion and spin drift in n-doped GaAs — Andreas Maurer, •Roland Völkl, Andreas Einwanger, Tobias Korn, Mariusz Ciorga, Dieter Schuh, Dieter Weiss, Werner Wegscheider, and Christian Schüller — Universität Regensburg

On the road to spintronic devices it is crucial to develop materials with long spin lifetimes and to determine spin drift/diffusion lengths in these materials. The usual methods for measuring spin lifetimes are time resolved Kerr/Faraday rotation experiments, but this well established technique reaches its limits if the spin lifetime exceeds 10 ns.

Here, we report on Hanle-MOKE-measurements that show spin lifetimes far above 10 ns and mapping of spin drift and spin diffusion on the 50 μm scale. In the Spin-Hanle experiment[1], spins are injected with a circularly polarized CW-Laser and the net spin polarisation perpendicular to the sample plane is measured by detecting the Kerr rotation of a linearly polarized laser. By applying an external magnetic field the spins start to precess and the spin polarisation is reduced. This effect is stronger when the spin lifetime τ is longer. In both cases the width at half maximum of the signal is proportional to $1/\tau$

By focussing the two beams through an optical microscope and scanning the pump beam with a motorized mirror we can measure spin diffusion, and by applying electrical fields spin drift.

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HL 9.114 Mon 14:30 P2

Investigation of the de Haas-van Alphen effect in an asymmetric InGaAs/InP quantum well — •Benedikt Rupprecht[1], Tjark Windisch[1], Marc A. Wilde[1], Thomas Schäpers[2], Christian Heyn[3], and Dirk Grundler[1] — [1]Lehrstuhl für Physik funktionaler Schichtsysteme, Technische Universität München, Physik Department, James-Franck-Str. 1, D-85747 Garching — [2]Institute of Bio- and Nanosystems (IBN-1) and Centre of Nanoelectronic Systems for Information Technology (CNI), Research Centre Jülich, D-52425 Jülich — [3]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Jungiusstrasse 11, D-20355 Hamburg

We report on magnetization measurements on a two-dimensional electron system (2DES) in an asymmetric InGaAs/InP quantum well using a micromechanical cantilever magnetometer. The magnetometer has a noise level of about 10^{-14} J/T at $B_{ext} = 1$ T, allowing the detection of de Haas-van Alphen oscillations of the 2DES at 300 mK. The magnetization is a thermodynamic quantity that at low temperature directly reflects the ground state energy of the system. From the data we can directly extract material parameters such as the g-factor and the effective mass m^* as well as information about the spin-orbit coupling. Magnetotransport measurements on similar 2DES revealed

a clear beating pattern in the Shubnikov-de Haas oscillations due to the Rashba spin-orbit coupling. We present the measurement setup as well as the results of the magnetization measurements focusing on bandstructure parameters and the spin-orbit interaction.
We acknowledge support through GR1640/3 in SPP1285.

HL 9.115 Mon 14:30 P2

Magnetotransport in (Ga,Mn)As on the Verge of the Single Domain Model — •Christoph Rapp, Lukas Dreher, Joachim Daeubler, Daniela Donhauser, Michael Glunk, Wladimir Schoch, Stephan Schwaiger, Rolf Sauer, and Wolfgang Limmer — Institut für Halbleiterphysik, Universität Ulm, 89069 Ulm

We investigate the limits of the single-domain model in (Ga,Mn)As by performing detailed angle- and field-dependent magnetotransport measurements in samples with differing magnetic anisotropies. For this purpose, a series of (Ga,Mn)As layers with Mn concentrations of $\sim 5\%$ was grown by low-temperature molecular-beam epitaxy on relaxed (In,Ga)As/GaAs templates with different In-concentrations, realizing different strain conditions from compressive to tensile. In past investigations we have elucidated the strain dependence of the magnetic anisotropy and of the anisotropic magnetoresistance employing a single-domain model. In order to analyze the break-down of the single-domain model, we now study in detail magnetization reversal processes by sweeping an external magnetic field along selected axes. The magnetic-field sweeps are compared with a series of angle-dependent magnetotransport measurements, carried out at weak external magnetic fields.

HL 9.116 Mon 14:30 P2

Spin Coulomb drag in presence of spin-orbit coupling and disorder — •Matthias Lüffe — Institut für Theoretische Physik, Freie Universität Berlin

It is experimentally established (Weber *et al.*, 2005) that electron-electron interactions lead to a decay of spin currents because momentum is transferred between the *up* and *down* spin electrons. This damping of the relative motion of the two spin species is commonly termed *spin Coulomb drag* (D'Amico and Vignale, 2000). The phenomenon has been subject of several theoretical investigations based on both Boltzmann equations (Flensberg, Jensen and Mortensen, 2001) and diagrammatic linear response calculations (Tse and Das Sarma, 2007). We aim at computing the trans-resistivity as the quantity that characterizes the spin Coulomb drag for a 2DEG in presence of Rashba spin-orbit coupling and disorder. Our calculations are in the framework of a kinetic equation for the density matrix in spin space, capturing spin precession and spin coherent scattering from both impurities and electrons. This ensures the validity also in a regime where the D'yakonov-Perel spin relaxation is important.

HL 9.117 Mon 14:30 P2

Electrical measurement of the effective density of states in (Ga,Mn)As — •D. Neumaier[1], A. Vogl[1], U. Wurstbauer[2], M. Utz[1], W. Wegscheider[1], and D. Weiss[1] — [1]Universität Regensburg — [2]Universität Hamburg

In ferromagnetic (Ga,Mn)As the conductivity σ decreases with decreasing temperature below 10 K. Preliminary experiments have shown that enhanced electron-electron interaction (EEI) [1] is the origin of this conductivity decrease [2]. The size of the conductivity correction due to EEI is depending on the diffusion constant D. Hence a detailed analysis of the conductivity correction provides experimental access to the diffusion constant. The diffusion constant is connected to the effective density of states at Fermi's energy $N(E_F)$ by Einstein's relation: $\sigma = e^2 N(E_F) D$. For (Ga,Mn)As it is still an open issue whether Fermi's energy is in the valence band or in a detached impurity band [3]. Here we present measurements of the conductivity correction in quasi 1D and quasi 3D (Ga,Mn)As, as well as in the crossover regime from quasi 2D to 1D, to get knowledge about the diffusion constant and the effective density of states. The measured values of $N(E_F)$ will be compared with recent theoretical calculations [4]. The good agreement shows, that the transport in (Ga,Mn)As can be described well within the picture, that Fermi's energy is in the valence band.

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HL 9.118 Mon 14:30 P2

Coulomb blockade dominates transport across lateral (001)-(Ga,Mn)As nanoconstrictions — •Markus Schlapps[1], Teresa Lermer[1], Stefan Geissler[1], Daniel Neumaier[1], Rashid Gareev[1], Janusz Sadowski[2], Werner Wegscheider[1], and Dieter Weiss[1] — [1]Universität Regensburg — [2]Max-Lab, Lund University, Sweden

Narrow constrictions in GaMnAs films display large magnetoresistance (MR) effects [1-6]. Explanations of these effects involve the formation of a tunneling barrier [1,2]. A pronounced dependence of the resistance on the magnetization direction was ascribed to the tunneling anisotropic MR [2] and, more recently, to a metal-insulator transition [4,5]. On the other hand, experiments on a narrow GaMnAs channel revealed a Coulomb blockade anisotropic MR effect[6]. Hence the microscopic origin of the huge MR effects is still under discussion. Here we present experiments on single-constricted GaMnAs wires. Based on measurements of the resistances' bias voltage and temperature dependence down to millikelvin temperatures we compare the models currently used. We show that the large MR jumps of up to several thousand percent are solely connected to the magnetization alignment in the constriction and that the transport mechanism is dominated by Coulomb blockade. Using additional side-gates the device acts as a single electron transistor. [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) [5] K. Pappert et al. , Nature Physics 3, 573 - 578 (2007) [6] J. Wunderlich et al. , PRL 97, 077201 (2006)

HL 9.119 Mon 14:30 P2

Investigation of Quantum Hall arrays for resistance standards — •Jens Könemann, Günter Hein, Bernhard Schumacher, Klaus Pierz, and Hans Werner Schumacher — Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116 Braunschweig

Today's quantum resistance standards are generally implemented using the integer Quantum Hall effect at filling factor $i = 2$ corresponding to a quantized resistance value of $R_Q = 12.9$ kΩ. Arranging several Hall bars in series or in parallel promises extending the range of quantized resistance values between 100 Ω and 1 MΩ, whilst maintaining low uncertainties within the order of some parts in 10^9. In this work, we test the feasibility of such a resistance standard based on Quantum Hall arrays by interconnecting Hall bars with standard bonding technique. Additionally, we have realized a serial array of ten Hall bars with lithographically defined connections on chip. First high-precision measurements of such a device are presented on our poster.

HL 9.120 Mon 14:30 P2

Gap measurements at filling factors 1/3 and 2/5 in the FQHE regime — •Oliver Gerberding[1], Lina Bockhorn[1], Annelene F. Dethlefsen[1,2], Werner Wegscheider[3], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover — [2]Centre for Atom Optics and Ultrafast Spectroscopy, Faculty of Engineering and Industrial Science, Swinburne University of Technology — [3]Institut für Experimentelle und Angewandte Physik, Universität Regensburg

We study the fractional Quantum-Hall effect in high mobility twodimensional electron systems (2DES). The Hall geometries are created by photolithography on a GaAs/GaAlAs heterostructure containing a 2DES.

The activation gaps of the fractional Quantum-Hall state at constant filling factors 1/3 and 2/5 have been measured as a function of a perpendicular magnetic field B. The mobility and the density of electrons are manipulated by using a topgate. For a given density of electrons we study the Shubnikov-de Haas oscillations for different temperatures to extract the activation energies.

For several filling factors we find an astonishing linear dependence for small magnetic fields and a cross over to square root dependence for high magnetic fields.