Noncovalent Functionalization of Single Walled Carbon Nanotubes — Pascal Bleuemel, Vitaly Datsyuk, Antonio Setaro, and Stephanie Reich — Fachbereich Physik, Freie Universität 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 exotherdially adsorbed onto the nanotube surface via pi-pi stacking. The functionalized nanotubes are probed optically by absorption-, photoluminescence- and Raman spectroscopies.


Temperature dependence of the conductivity of ballistic graphene — Matthias Brauningler, Markus Müller, and Björn Trazzeitte — Institute for Theoretical Physics and Astrophysics, University of Würzburg, D-97074 Würzburg, Germany — 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 and low density 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 $T = 0.693\nu_c / |\nu|$, where $\nu$ is the Fermi velocity.

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.


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.


Electron diffraction on carbon nanotubes (CNTs) — Christian Huber, Dominik Freusche, David Kalor, Christoph Strunk, and Josef Zwick — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Universitätstraße 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.

Combined optical and AFM analysis of combustion produced nano organic particles — Antonio Setaro, Annalisa Bruno, Patrizia Minuto, Andrea D’Anna, and Stephanie Reich — 1Fachbereich Physik, Freie Universität, Berlin — 2Universität degli studi di Napoli Federico II — 3Istituto 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 diseases.

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.


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 Mo2Fe230 nanoclusters as a catalyast 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.
Carbon aerogel electrodes for electrochemical double-layer capacitors based on resorcinol-formaldehyde sediments —

**Mario Zeller**, **Volker Lorrman**, **Dirk Hauschild**, **Jens Pfeil**<sup>1,2</sup>, **Gudrun Reichenaue**<sup>1</sup>, and **Vladimir Dyakonov**<sup>1,2</sup>

<sup>1</sup>Bavarian Centre for Applied Energy Research e.V. (ZAE Bayern), D-97074 Würzburg — <sup>2</sup>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.

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**Indirect exchange interaction in graphene** —

**Jörgens Bastian**<sup>1</sup>, **Vitali Dugaev**<sup>3</sup>, **Pawel Malyszek**<sup>1</sup>, and **Volodya Litvinov**<sup>5</sup>

<sup>1</sup>Department of Physics, Adam Mickiewicz University, 61-614 Poznań, Poland — <sup>2</sup>Institute of Molecular Physics, PAN, 60-179 Poznań, Poland — <sup>3</sup>Department of Physics, Rzeszów University of Technology, 35-959 Rzeszów, Poland — <sup>4</sup>Department of Physics and CFIF, Instituto Superior Técnico, 1049-001 Lisbon, Portugal — <sup>5</sup>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.

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**Magnetic properties of transition metal doped Si nanocrystals and their size dependence.** —

**Jörgens Bastian**<sup>1</sup>, **Frank Kuehne**<sup>2</sup>, **Roman Leitsmann**<sup>1</sup>, and **Friedhelm Bechstedt**<sup>1</sup>

<sup>1</sup>Institut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany — <sup>2</sup>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.

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**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 111<sup>1</sup>In as probe. This nuclear technique is well suited for studying to strain on an atomic scale. After doping via ion implantation and subsequent annealing the Si samples are bent along the (110) 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.

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**An x-ray Raman scattering study of the temperature-induced disproportionation in a-SiO<sub>x</sub>** —

**Omid M. Feroughi**<sup>1</sup>, **Christian Steinenmann**<sup>1</sup>, **Achim Hohl**<sup>1</sup>, **Mali Balasubramaniam**<sup>4</sup>, **Heiko Conrad**<sup>3</sup>, **Joe Bradley**<sup>3</sup>, **Mali Balasubramaniam**<sup>4</sup>, **Jenri Seidler**<sup>3</sup>, and **Metin Tolan**<sup>1</sup> — 1Fakultät Physik / DELTA, Technische Universität Dortmund, D-44221 Dortmund, Germany — 2Institute
up to 850°C. X-ray diffraction which shows that bulk a–SiO₂ is amorphous at least in the as-deposited state. Differently annealed a–SiO₂ samples were also examined with nonresonant x-ray Raman scattering (XRS) in order to characterize the disproportionation into Ge and GeO₂ induced by annealing in the temperature range between 20°C and 160°C. XRS provides sensitive information on the structural state of a–SiO₂. Measurements were made at room temperature and at 77 K in order to study the effect of temperature on the paramagnetic state of a–SiO₂.

The study of bulk amorphous silicon monoxide (a–SiO₂) has attracted great interest over the past years due to its relevance for opto-electronic applications of GeO₂ in thin film solar cells and for c-Si thin film solar cells, only 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 damage induced by 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 homogeneous film of the SOD. Furthermore we analyzed 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- and p-MOSFETs were fabricated and characterized.

For temperatures above 500°C, the a–SiO₂ film is transformed into Ge and GeO₂. This transformation is proposed to consist of nanoscaled regions of Ge and GeO₂. The use of a–SiO₂ as a starting material for thin film silicon solar cells, only 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 damage induced by 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.

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Differently annealed a–SiO₂ samples were also examined with nonresonant x-ray Raman scattering (XRS) in order to study the influence of temperature–induced disproportionation in which regions of Si and SiO₂ grow by coalescence at the cost of the sub–oxide 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 L₂,₃–edges in the temperature range between 600°C to 1200°C. XRS provides sensitive information on the structural state of a–SiO₂. Measurements were made at room temperature and at 77 K in order to study the effect of temperature on the paramagnetic state of a–SiO₂.

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Spin noise spectroscopy in 28Si — Tammo Böntgen, Helge Riemann, Jens Hübler, and Michael Oestreich.

We employ spin noise spectroscopy [1] to examine the intrinsic spin lifetime of electrons bound to phosphorus donors in isotopically pure 28Si at low temperatures. The up to now reported spin lifetime of these electrons is 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 28Si. These transition lines scale with the isotope purity of the sample and should be according to calculations as small as 100 meV in the studied Silicon.


Optical Selection Rules in Silicon — Hauck Horn, Jens Hübler, and Michael Oestreich.

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 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 Γ₉⁺ to the lowest conduction band Γ₉⁻ at the center of the Brillouin zone is tuned to the excitation from the split-off band Γ₉⁻. To shorten the carrier lifetime to less than the spin relaxation time a biased silicon photodiode is used as sample.

H. 9.18 Mon 14:30 P2

Process conditions for doping with Spin On dopants — Sebastian Stoll, Peter Indra, Helmut Lochner, Dorota Kulaga-Egger, Torsten Sulima, and Ignaz Eisele.

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 damage induced by 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.

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Investigation of defect and phosphorus related states in very thin films of μc-Si — Konrad Klein, Martin Eberl, Benedikt Stöhl, Andre R. Stegner, Oleksandr Ashtakovsky, Friedrich Finger, Martin Stutzmann, and Martin S. Brandt.

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 thick 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 ≈ 2.3 and g ≈ 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)

Morphological properties of three dimensional Ge nanoclusters grown on SiO₃₋ₓFe(II) films — Zakir Skydov, Maria Rubeziaszkova, Christian Hoffer, Yuri Kozyrnev, Christian Tschichert, and Anton Naujovets.

Novel optoelectronic and nanoelectronic devices require smaller and smaller size of their components. This explains the interest in Ge nanostructure formation on SiO₂ matrix. A possibility of formation of such Ge nanostructures on initial amorphous SiO₂ (x<2) films is considered. Their surface was investigated using atomic-force microscopy. The height, size and distribution density of germanium nanofilms 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 stage of their formation with very low distribution density about 5 10⁶ 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 10¹¹ cm⁻². Characteristics of the formed nanostructure at the different formation stages were shown both doped (B, Sb) and undoped films. This research was supported by OAD Project UA No 2007/26.

Optical and electrical characterization of silicon nanowires etched from highly doped silicon wafers — PRATVUSH DAS KUNGO, NADINE GEYER, VADIM TALALAEV, OUSAMMA MOUTANABIR, NIKOLAI ZAKHAROV, REN BIN YANG, PETER WERNER, and ULRICH GÖTZ - 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.

MOVPE of semipolar AlGaN on m-plane sapphire — FREDTRUP S, PLOCH M, PRISTOVSEK M, and KNESSL M

MOVPE growth of AlGaN films — SAVAS O, STELLMACH C, MESSNER J, PRISTOVSEK M, and KNESSL M

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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 GaIN/GaN Quantum Well Structures with high Indium Content** — LARS HOFFMANN, HEIKO BREMMERS, HOLGER JÖNEN, DANIEL DRÄGER, UWE ROSSOW, and ANDREAS HANGLETTER — 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 degradation. Moreover, we observed high density stacking faults (BSF) 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. WIENKE, A. DAGDAR, J. BLASING, 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** — DANIS ACHARYA, KENDALL 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 polaron, gallium rich GaN (0001) surface have been investigated by using scanning tunneling microscopy and spectroscopy at 5K and 80K 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 wave functions have been directly observed. By means of bias dependent scanning tunneling microscopy studies, we have shown that these features are associated 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**


**HL 9.32 Mon 14:30 P2**

**Towards Galliumnitride nanowire field-effect transistors** — JÖRGM KINZEL, JENS EBERCKE, HUBERT KRENNER, RAFFAELA CALARCO, TOMA STOICA, and ACHIM WIXFORTH — 1.Lehrstuhl für Experimentalphysik 1, Universität Augsburg, Germany — 2Schock of Engineering and Physical Sciences, Heriot-Watt University, Edin- burgh, United Kingdom — 3Center für 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 nanoelectronics 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. We developed metal source-drain and top gate electrodes by electron-beam lithogra- phy and a lift-off technique. Samples are characterized by temperature- and bias-dependent conductivity measurements.

**HL 9.33 Mon 14:30 P2**

**Carbon doped InGaaS/InAlAs heterostructures on relaxed buffer layers** — MARIKA KUBOVA, KATHARINA SCHULZE, DIETER SCHUL, and WERNER WEGSCHEDER — Institut für Experimentelle und angewandte Physik, Universität Regensburg, D 93040 Regen- sburg, 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) for spin-valve devices. Large Rashba effect and low Schottky barrier to evaporated metals. We grow InGaAs/InAlAs/InGaAs heterostructures using 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 channels. The magnetotransport measurements on these samples at low temperatures show a change of the conduc- tivity from p-type to n-type via illumination and weak localisation at low magnetic fields.

**HL 9.34 Mon 14:30 P2**

**Magnetic and magneto-transport properties of self-assembled MLAs unclustered and -clustered GaInAs nanorods** — MATTHEW T. ELM, SHINJIROH HARA, HANS-ALBRECHT KREUG von NIDD, and PETER J. KLÄR — 1)Institute of Experimental Physics I, Justus-Liebig University Gießen, Germany — 2Research Center for In-
In semiconductor quantum dots electrons and holes are confined in all directions and their physical parameters may be controlled by changing the 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 kp-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.

Fabrication and Characterization of Cu-doped GaN —

**Philipp Ganz**1, Christoph Sürger2, and Daniel M. Schlafer

1Universität Karlsruhe, Institut für Angewandte Physik, 76131 Karlsruhe, Germany — 2Universität Karlsruhe, DFG-Center for Functional Nanostructures, 76131 Karlsruhe, Germany — 3Universität Karlsruhe, Physikalisches Institut, 76131 Karlsruhe, Germany

Semiconductor based spintronics may be implemented using InN quantum dots, which show long and temperature independent spin-life times. To inject spins into the 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 ferromagnetic order in the quantum dot system, but the occurrence of magnetism 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.

**Spin Noise Spectroscopy on Donors in GaAs** —

**Hannes Bernien**, Georg Müllner, Michael Römer, Jens Hüner, and Michael Oestreich

Institute for Solid State Physics, Gottfried Wilhelm Leibniz Universität 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. 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.

Hole Density in (Ga,Mn)As layers grown on (001), (110) and (311) GaAs Substrates —

**Michael Hirmer, Michael Mayer, Tobias Korn, Ursula Wurstbauer, Martin Utz, Stefanie Heydrich, Dieter Bucher, Werner Wiegersheimer, and Christian Schüller**

Universität Regensburg, Universitätsstraße 31, 93053 Regensburg, Germany

The dilute magnetic semiconductor (DMS) Ga1-xMnxAs 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 Tc corresponds to Tc=\alpha\mu_B^3/\epsilon_{\text{eff}} (\alpha_{ss}, eff Mn concentration, \mu: carrier density). We present a detailed study of carrier concentrations, determined by Hall measurements and Raman scattering on thin Ga1-xMnxAs 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 oxide and the Schottky contacts of about 2x10^{18}cm^{-3} to 6.6x10^{19}cm^{-3} were found with highest values for (001), in correspondence with the measured Tc values. Samples with higher Tc 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.

Annealing studies of HF implanted AlxGa1-xN —

**Thomas Geruschke1, Katharina Lorenz2, and Reiner Vianden**

1Helmholtz - Zentrum für Strahlen- und Kernphysik, Universität Bonn, Germany — 2Instituto Tecnologico e Nuclear, SACAVEM, Portugal

The annealing behaviour of 0.5 μm AlxGa1-xN on sapphire substrate after implantation of 181Hf was studied using the perturbed angular correlation (PAC) technique. Different AlxGa1-xN samples from the commercial supplier TDI Inc. were implanted with the radioisotope 181Hf 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 ≈ 0.5. To confirm the linear behaviour, additional measurements will be carried out. First results will be presented and discussed.

Control of Mn magnetic moments in GaAs quantum dots —

**Pietro Moraczewski and Daniela Pfannruche**

1Institut für Theoretische Physik, Universität Hamburg, Jungiusstraße 9, 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 kp-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.

**Fabrication and Characterization of Cu-doped GaN —**

1Philipp Ganz, Christoph Sürger, and Daniel M. Schlafer

1Universität Karlsruhe, Institut für Angewandte Physik, 76131 Karlsruhe, Germany — 2Universität Karlsruhe, DFG-Center for Functional Nanostructures, 76131 Karlsruhe, Germany — 3Universität Karlsruhe, Physikalisches Institut, 76131 Karlsruhe, Germany

Semiconductor based spintronics may be implemented using InN quantum dots, which show long and temperature independent spin-life times. To inject spins into the 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 ferromagnetic order in the quantum dot system, but the occurrence of magnetism 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.

Spin Noise Spectroscopy on Donors in GaAs —

Hannes Bernien, Georg Müllner, Michael Römer, Jens Hüner, and Michael Oestreich

Institute for Solid State Physics, Gottfried Wilhelm Leibniz Universität 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. 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.

Magnetooptics of Gd-doped GaN —

Jan Heye Buss, Jörg Rudolph, and Daniel Hägglund

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 (2.7×10^{19}cm^{-3}) on the valence and conduction band. While ferromagnetic GaMnN shows huge Kerr signals (up to 5000 γrad) [2], no difference in Kerr rotation (within the 30 γrad sensitivity of our setup) is found in comparison with an undoped GaN reference sample. These findings are in agreement with recent XMC data from Ney et al. [3] and suggest that the ferromagnetism observed in SQUID measurements is not related to the Gd-doping of GaN.


Growth of InAs quantum dots on hydrogen cleaned GaAs surfaces —

Ahish Kumar Rai, Dirk Reuter, and Andreas D. Wieck

Lehrstuhl für Angewandte Festkörperphysik Ruhr-
The quality of the cleaning process is evaluated by measuring the 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 stripping 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.

The goal of this work is to introduce site-selective growth of InAs quantum dots in bulk GaAs — [1] HAZEM ABBAS-FARSAKH and JÖRG NEUGEBAUER — Max-Planck-Institut für Eisenforschung GmbH, Max-Planck-Str. 1, 40235 Düsseldorf, Germany — Université Paderborn, Warburger Str. 100, 33098 Paderborn, Germany

Ternary GaAs$_{1-x}$N$_x$ and quaternary In$_x$Ga$_{1-x}$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 sub-surface 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 prevents N from getting incorporated in the sub-surface layers. These results also allow to identify the mechanism which controls the achievable enhancement in the bulk N concentration, to revise previous growth and incorporation models, and to provide a direct microscopic basis of the recently reported In-N compositional anti-correlation in In$_x$Ga$_{1-x}$As$_{1-y}$N$_y$ quantum wells [2].


We measure the electron Lande g-factor and electron spin lifetime in (110)-oriented GaAs quantum wells by time- and position-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.

Magnetism in manganese modulation-doped two-dimensional hole systems — [3] WOLFGANG KRENKER, BENEDICT RUPPRECHT, TAIJER WINDSCH, URSULA WUSTEBURGER, MARC WILDE, WERNER WEBSCHEIDEN, and MICHAEL OESTREICH — Universität Hannover, Institut für Festkörperphysik, Abteilung Nanostrukturen, Appelstr. 2, D-30167 Hannover, Germany

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 Microcanonical Cantiellever 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.

Magnetotransport and THz photoresponse of combined Hall-Corboino devices patterned on HgCdTe based wafers. — [1] FATHI GOUDEI, CHRISTOF BRUNER, JENS KOSMANN, YURI VASILEVY, MAREK BUGAN, and GEORG NACHTWEI — 1 Institut für Angewandte Physik, TU-Braunschweig, Mendelssohnstraße 2, D-38106 Braunschweig, Germany — 2 Physikalisches-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, Polyteknicheskaya 26, 194021 St. Petersburg, Russia

We present photoconduction measurements of the HgTc/HgCdTe (MCT) - Quantum Well in Hall bar, Corbino as well as combined Corbino-Hall bar geometry in the quantum-Hall- (QH) and quantum-oscillating (QO) regime. The HgCdTe 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 material system MCT is due to the small effective mass (compared with GaAs) and the smaller magnetic fields for operation of interest. For the InAs free-standing superconducting 10 T-magnet and an adjustable $\mu$-Gyro cyclotron resonance laser are operated (the laser as FIR source, wave-length range of 120 - 1800 μm).
Determination of Hall-mobilities using a maximum entropy approach

Robert Heinhold, Matthias Brandt, Holger von Wenckstern, Gisela Brühne, Holger Hochmuth, Michael Lorenz, and Markus 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.


Energy dynamics in ZnSe/ZnMnSe double-quantum-well structures

Stefan Janowski, Wolfram Heimbrodt, Swantje Horst, Alexei Cherkinov, and Sangam Chatterjee — Department of Physics and Material Sciences Center, Phillipes-University Marburg, Renthof 5, 35032 Marburg, Germany

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.

Optical and magnetic properties of MnS in low dimensions

Manuel Derr, Limei Chen, Daniela Schlup, Franz-Friedrich Neu, and Holger Hohmuth — Institut für Physik, Justus-Liebig University Gießen, Germany

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 4T1−6A1 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 be discussed in detail.

Simulation of wavepropagation in nanocrystalline powders

Daniel Schneider, Johannes Fallert, Janos Sartor, Roman J. B. Dietz, Viktor Zalamai, Claus Klingsshin, 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.

Temperature dependence of lasing modes in ZnO nanorods

Janos Sartor, Johannes Fallert, Viktor Zalamai, Florian Maier-Flag, Claus Klingsshin, 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 dependence 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.

Investigation of physical damage in artificially structured AlxZn1−xO and ZnO thin layers, respectively

Markus Piechota, Torsten Henning, Martin Eckhoff, Peter J. Klar, Bernd Szybisz, and Thomas Wassen — JLU Giessen, Germany

ZnO thin layers of about 300 nm thickness were grown by 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 H2PO4 − HAC − H2O-mixture and radio frequency ion thruster based ion beam etching, respectively, was used to transfer the pattern into the thin films. The structural properties of the wire edges were determined 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.

Nitrogen doping of RF-sputtered CuO 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 CuO 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 CuO crystalline structure.
Meyer, and Peter J. Klar — Institute of Experimental Physics I, Justus-Liebig-University Gießen, Germany

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.

Artificial structuring of Cu_{2}O by wet chemical etching —

• Julian Benz, Daniel Reppin, Sven 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 artificially structure Cu_{2}O/ZnO heterostructures to investigate the p-n junction. The results of the different etchants and different etch concentrations are discussed respectively.

Anisotropy of the dielectric function of ZnO including exciton-polariton formation obtained from ellipsometry —

• Munsee Cobert\(^1\), Ronny Krist\(^2\), Markus Wagner\(^1\), Axel Hoffmann\(^2\), Christoph Werner\(^2\), Christoph Cobert\(^2\), Norbert Essen\(^2\), and Christian Thomsen\(^2\) — Institut für Festkörperphysik, TU Berlin, 10623 Berlin — SIAS- 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 excitation absorptions containing a significant formation of polaritons and the related exciton-phonon-complexes. The scattering near \(\omega = 0\) with the longitudinal optical phonon shows up in a replication of the three-peak structure every 72 meV but might be arranged in different angles with respect to the temperature gradient.

Temperature dependent incorporation and thermal stability of hydrogen in zinc oxide layers — Marc K. Dietrich, Achim Kronenberg, Andreas Laufer, Sebastian Zöller, Angela Pof Fill, 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 these 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.

Photoluminescence properties of ZnS single crystals and CVD thin films — Melanie Pinnisch, Joachim Saß, Oliver Graau, Stefan Lautenschläger, Markus Wagner, Jan-Hendrik Kurz, Axel Hoffmann, and Bernhard Meyer — I. Physikalisches Institut, Justus-Liebig-Universität Gießen, Heinrich-Buff-Ring 16, 35392 Gießen, Germany — 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 the theoretical effective-mass approximations, we try to assign the measured emissions to specific crystal defects. Finally we compare the results to photoluminescence data from ZnS CDV thin films grown on GaP- or Si-substrates.
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.

Electronic and Optical Properties of Lithium doped ZnO Nanocrystals — Markus R. Wagner1, Ronny Kirste1, Christian Rauch1, Gordon Callsen1, Munise Cobert1, Wolfgang Gehlich2, Enno Mal Guth3-1, Michael Lehnmann3, Sebastian Polzack1, Yilmaz Aksu3, and Matthias Dr uess3 — 1Institut für Festkörperphysik, TU Berlin; 2Optisches Institut, TU Berlin; 3Fachbereich Chemie, Universität Konstanz; 4Institut für Chemie, TU Berlin.

Lithium doped ZnO nanoparticles were grown using a novel organometallic precursor system, where the resulting material is organized 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 crystallize in the wurtzite structure, with a well defined lattice constant. 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 in the absence of Fe impurities was 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.

Catalytic growth of ZnO nanowires via chemical vapor deposition — Sebastian Eremann, Stefan Lautenschlager, Torsten Henning, and Bruno K. Meyer — 1Physicalisches 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 epitaxial ZnO nanowires were grown with controllable diameter. The nanowires 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.

Structure and optical properties of ZnO nanocrystals embedded in amorphous SiO2 — Gillian Mayer1, Mikhail Fomin2, Ulrich Rudiger1, Reinhard Schneider3, Dagmar Gertschen1, Nils Jansen1, and Rudolf Bratschitsch1 — 1Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany; 2Laboratorium für Elektronenmikroskopie, Universität Karlsruhe, 76128 Karlsruhe, Germany; 3Fachbereich 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 SiO2/ZnO/SiO2 layer stack on Si(100) and Al2O3(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 SiO2 matrix. High resolution TEM shows a well-defined hexagonal close packed wurzite 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 SiO2 matrix is corroborated by energy-filtered TEM. Measurements of the optical transmittance confirm the results obtained by TEM.

Optical characterization of epitaxially grown Zn1-xMg xO/ZnO quantum wells — Thomas Sanders1, Peter J. Klar1, Martin Eckhoff2, and Thomas Wassn1 — 1Friedrich-Schiller-Universität Jena, 07743 Jena, Germany; 2W Cameroon Munich, Germany.

The Zn1-xMgO/ZnO quantum well 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 photoluminescence measurements were performed 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.

Acceptor centres in Ga2O3 — Jan Stehr1, Andreas Lauffer1, Detlev M. Hofmann1, Bruno K. Meyer1, Daniel Röhlens2, and Wolfzag Gehlich2 — 1Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany; 2WISI Munich, Germany.

The Zn1-xMg2O3/ZnO quantum well 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 photoluminescence measurements were performed 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.
and Manfred Martin — "I. Physikalisches Institut, Justus-Liebig-
Universität, Heinrich-Buff-Ring 16, D-35392 Giessen — 2Institut für
Physikalische Chemie, RWTH Aachen, Landoltweg 2, D-52074
Ga2O3 is a wide band gap semiconductor (Eg0 = 4.9 eV) with poten-
tial applications as a TCO material (Transparent Conducting Oxide).
The n-type conductivity of the undoped material is caused by the pres-
cence of vacancies which act as shallow donors. The oxygen va-
cancies can be introduced by heat treatments in reducing atmospheres
such as ammonia. Information on the nature of the acceptors in this
material is unknown. We investigated a set of Ga2O3 powder samples by electron param-
agnetic 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 impu-
sities. 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 Ga4+ and Cu2+ or As6+. The g-values g1 =
2.33 and g2 = 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 nitriding time. The intensity of
signal B is not correlated which can be taken as evidence that it is of
an extrinsic origin.

Monday

HL 9.70 Mon 14:30 P2
High Resolution RBS on High-k Dielectrics — 1Mark Vrieluf, 2Rainer Grotzschuhl, 1Christian Nieeleubi, 1Frans
Munnik, and 1Stepfen Teichert — 1Institute of Ion Beam Physics
and Materials Research, FZD, Bautzner Landstraße 128, 01314 Dres-
den, Germany — 2Qimonda Dresden GmbH & Co. OHG, Koenigs-
bruecker Strasse 180, D-01099 Dresden, Germany
The further development of microelectronic circuits requires the usage of
high-k dielectrics. In order to characterize the charging and discharging of materials
properties on the relevant length scale. In particular it is important to
analyse the depth dependent element distribution or elemental com-
position 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 us-
ing 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 distribu-
tion 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 — 1Jorg Teubert, 2Peter J. Klar, and
Wolfram Heimbödt — 1Physikalisches Institut JLU-Giessen — 2Philips-Universität Marburg
By incorporating magnetic impurities into semiconductors, one im-
mediately 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 activa-
tion 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 elec-
tric resistivity near the MIT. InSb:Ge shows the commonly observed
behavior whereas InSb:Mn exhibits a strong enhancement of the resis-
tivity 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 — 1Martin Emmrich, Philipfph 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 multifrac-
tal 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 — 1Oliver Böhm, Philipfph 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 en-
ergy 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
shorter 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 par-
ticularity of these networks is, that the average path length is much
shorter as in regular networks. It is not obvious whether an LD tran-
sition 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 — 1Jochen
Otzmann, Helmut Lochner, Peter Iskra, Dorothea Kulaga-Egger,
Torsten Selma, and Ignaz Eisele — Universität der Bundeswehr
München, Institut für Physik, Werner-Heisenberg-Weg 39, 85577 Neub-
berg
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 leak-
age currents or interface traps for example. We investigate improved cleaning procedures to decrease or remove organic and inorganic contaminations on wafer surfaces, like carbon impuri-
ties and the native or chemical oxide on silicon substrates. There-
fore several different process plans were defined. P-in-n diodes were
fabricated in an Applied Materials Centura Cluster Tool with epitax-
ial 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 an-
alyzed. With the help of L-V measurements the p-in 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 —
1Karsten Sperlich, 2Patrick Ludewig, Alexei Filinov, 3Michael
Bonitz, 4Heinrich Stolz, 5Detlef Hommel, and 6Arne Gust
1Department of Physics, University of Rostock, Germany —
2Department of Physics, Christian-Albrechts-University of Kiel, Ger-
many — 3Institute of Solid State Physics, University of Bremen, Ger-
many
Microwave Spectroscopy of Confined and Edge Magnetoplasmons in 2D Electron Stripes — Tobias Krohn, Niko- lail Mecking, Matthias Wiemann, Uwe Kunze, Johannes Kunze, Christian Heyn, and Detlef Heitmann. Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg — 2Lehrstuhl für Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, 4780 Bochum — 3Lehrstuhl für Integrierte Systeme, Ruhr-Universität Bochum, 4780 Bochum

We have investigated the photovoltage that was induced by irradiating microwaves on typically 30 × 60 μm² stripes containing a two-dimensional electron system (2DES) in a modulation-doped Al-GaAs/AlAs heterostructure. The stripes 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 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.

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 up to 14 T. We have investigated the photovoltage that was induced by irradiating microwaves on typically 30 × 60 μm² stripes containing a two-dimensional electron system (2DES) in a modulation-doped Al-GaAs/AlAs heterostructure. The stripes 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 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.

In combination with GaN based doped magnetic semiconductors GaN/AlN resonant tunneling diodes are potential candidates for spin injectors/detectors. Furthermore 2DEG heterostructures consisting of GaN and thin AlN on MOCVD GaN templates to achieve good crystalline quality and smooth GaN/AlN interfaces. Both are necessary to obtain highly efficient RDTs 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-consistently Schrödinger-Poisson solver.
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 some 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.

Polymer field effect transistor with contact modification by organic molecules — Carsten Deibel

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.

Transfer mechanisms between emitter molecules for OLED applications — Frank Stienkemeier

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 output and reduce driving voltage to 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 probably on the total concentrations and therefore the distance between the molecules involved.

Deposition of PTCDA on an Ultra Thin Optical Fibre

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. Here, we present ab initio studies for the aromatic core and lead to quenching of luminescence.

Influence of F8BT/P3HT blend composition on organic field-effect transistors — Eva Johanna Feldmeier, Christian Melzer, and Heinz von Seggern

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.

Influence of F8BT/P3HT blend composition on organic field-effect transistors — Eva Johanna Feldmeier, Christian Melzer, and Heinz von Seggern

Transfer mechanisms between emitter molecules for OLED applications — Frank Stienkemeier

Measurements of absorption, fluorescence and lifetimes of C14MePCTCDI in different solvents and crystalline phases — Frank Friedrichski, Harald Graaf, and Christian von Borczyskowski

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. Here, we present ab initio studies for the aromatic core 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, 7, 10-tetra-chloro-N, N'-dimethyl-perylene-tetracarboxylic-bisimide (C14MePCTCDI). 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.
Photoluminescence Detected Magnetic Resonance (PLDMR) studies on oxygen doped P3HT — HANNES KRAUS, ANDREAS SPERLICH, CARSTEN DEIBEL, and VLADIMIR DYAKONOV
1Experimental Physics VI, Physical Institute, Julius-Maximilians-University of Würzburg, D-97074 Würzburg — 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: photoluminescence detected magnetic resonance (PLDMR). With PLDMR, the sample’s spin state can be identified by measuring the photoluminescence change due to resonant microwave irradiation. By comparing the data obtained with ESR, PL and PLDMR on P3HT, before and after oxygen exposure, a more complete picture of oxygen-P3HT interaction can be achieved.

Modification of the injection properties in small molecule thin film transistors — FLORIAN WORNER, PETER NILL, and JENS FRIESE
1Experimental Physics I, Julius-Maximilians-University of Würzburg, 97074 Würzburg — 2Inst. for Appl. Physics, University Tübingen, 72076 Tübingen — 3Bavarian 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.

Temperature-dependent bias stress effects in organic thin film transistors — NICOLE KILLAT, INGO HORSELMANN, SUSANNE SCHEINERT, and GERHARD GORSCH — TU Ilmenau, 98684 Ilmenau, PF 100565, Germany
An investigation of the stability of organic thin-film transistors (OTFTs) was carried out by bias stress measurements. OTFTs with bottom- and top-source/drain-contacts (W/L=1000/30) were fabricated with 30nm SiO2 as gate dielectric and the polypyrrole 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 principal tendencies are not affected.

Exciton binding energy in conjugated polymers — DANIEL MACK, JULIEN GORENPLOT, 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 optimization 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 radiative 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].


Switching of drain potential in organic field effect transistor — INGO HORSELMANN 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 Si3N4 layer grown by chemical vapor deposition (CVD). As active semiconductor material poly(3-hexylthiophene) P3HT was used. A Mo gate electrode was deposited on the 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 depletes 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 × 10^{13} 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.

Packaging of Planar Organic Molecules: Interplay of van der Waals and Electrostatic Interaction — MIRA EL HELOU, DANIEL KAEPER, CHRISTIAN GEIMEL, and GREGOR WITTE – Physikalische Chemie I, Ruhr-Universität Bochum, D-44780 Bochum, Germany — 3Anorganische 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-to-edge herringbone packing, both oxygen containing species adopt an almost coplanar stacking. Quantum chemical calculations reveal discernible charge localization on the oxygen atoms which in turn cause an electrostatic O...O interaction and hence favour a planar stacking. On the other hand, the large mobility of the aromatic system 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].


Deviations from the Einstein relation in organic semiconductors — VERA STYHR, CARSTEN DEIBEL, and VLADIMIR DYAKONOV
1Experimental Physics VI, Physical Institute, Julius-Maximilians-University of Würzburg, D-97074 Würzburg — 2Functional 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-

Monday
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.

Observation of single quantum dots in GaAs/AlAs micropillar cavities — Philipp Burger, Matthias Karl, Dongzhi Hu, Daniel M. Scharadt, Heinz Kalt, and Michael Hetterich — Institut für Angewandte Physik und 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. InGaAs 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 conventional micro-photoluminescence setup 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.

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

\[ H = -\sum_{\Gamma} (a_\Gamma^+ a_{\Gamma+1} + a_{\Gamma+1}^+ a_\Gamma) + \frac{\Omega}{2} \sigma_\Gamma + V (\sigma_\Gamma^-) + a_\Gamma^+ \sigma_\Gamma^+, \]

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


SOURCES AS AN EXTENSION OF THE FOURIER MODAL METHOD — Martin Klock, Zdenko Kröpfel, Sabine Essiambre, Andreas Schneider, and Kurt Busch — Institut für Theoretische Festkörperphysik, Universität Karlsruhe — Karlsruhe School of Optics & Photonics (KSO) — 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 a line source in an infinite dielectric cylinder. Furthermore, we demonstrate the method’s potential for applications related to the design of structures, plasmonic enhanced light emitting diodes.

Modelling of metamaterials using a coupled dipole approach — Jens Küchenmeister, Sabine Essiambre, Lasha Tskeshelashvili, and Kurt Busch — Institut für Theoretische Festkörperphysik, Universität Karlsruhe — Karlsruhe School of Optics & Photonics (KSO), Universität Karlsruhe — DFG Centrum für Funktionselle 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 significant 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 design studies. We apply this model to certain (chiral) multi-layer structures.

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.


Modification of emission of internal emitters in Photonic Crystals — Rebecca Wagner, Sven Zimmermann, and Frank Cichos — Molecular Nanophotonics Group, University of Leipzig, Germany.
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(2) 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.

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

Vertical-external-cavity surface-emitting lasers (VECSELS) have attracted a wide range of applications in biophotonics, telecommunication, or projectors and spectroscopy. Here, VECSELS overcome the disadvantages of common high-power edge-emitting semiconductor lasers which often suffer from 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 TEM00 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 Al0.55Ga0.45InP barriers on an Al0.5Ga0.5As/AiAs distributed Bragg reflector for an operation wavelength of around 660 nm. With simulations based on a transfer-matrix method we produced a resonant 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.

Mode characteristics of red VCSEL with oxide-confined aperture — Susanne Weidendorf, 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 (VCSELs) 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 (<1 mA) 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.

Spin Injection in GaAs by Cleaved-Edge-Overgrowth — Arne Ludwig1, Carsten Goedde2, Sani Noor3, Hasim Hakim4, Stephan Hoveln5, Mingyuan Li1, Dirk Reuter1, Andreas D. Wiencek1, Ulrich Köhler5, and Martin Hoffmans3

1Lehrstuhl für Angewandte Festkörperphysik — 2Experimentalphysik IV - AG Oberflächenphysik — 3Lehrstuhl für Photonik und Tera- hertztechnologie, 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 layer. In this report, we discuss the preparation of the different contact configurations and first results from Electro luminescence measurements.

Magnetic Anisotropy and Anisotropic Magneto resistance of (Ga,Mn)As — Lukas Drescher, Joachim Daubler, Michael Glunk, Christoph Rapp, Wladimir Schoch, Rolf Sauер, 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), (332), and (110) plane at various field strengths. It turned out that the resistivity parameters are significantly dependent 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.

Measurement of long spin lifetimes, spin diffusion and spin drift in n-doped GaAs — Andreas Maurer, Roland Völki, Andreas Einwanger, Tobias Kern, Marcusz Ciorca, Dieter Schuh, Dieter Weiss, Werner Wegscheider, and Christian Schuller — 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. Two 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 integral at half maximum of the signal is proportional to 1/τ.

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.

Investigation of the de Haas-van Alphen effect in an asymmetric InGaAs/InP quantum well — Benedikt Rupprecht1, Tjak Windisch2, Marc A. Wilde2, Thomas Schrapers2, Christian Hey2, and Dirk Grundler1 — Lehrstuhl für Physik funktionaler Schichtsysteme, Technische Universität München, Physik Department, James-Franck-Str. 1, D-85747 Garching — 2Institute of Bio- and Nano systems (IBN-1) and Centre of Nanoelectronic Systems for Information Technology (CNI), Research Centre Jülich, D-52425 Jülich

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 Bext= 1 T, allowing the detection of the 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 Daubler,
Daniela Donhauser, Michael Glunk, Vladimir Schoch, Stephan Schweiger,
Rolf Sauer, and Wolfgang Lügger — 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 ~ 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 employ-
ing a single-domain model. In order to analyze the break-down of the
single-domain model, we now study in detail magnetization re-
versal by preparing 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 ex-
ternal 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 moment-
um is transferred between the up and down spin electrons. This damp-
ing 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 char-
acterizes the spin Coulomb drag for a 2DEG in presence of Rashba
spin-orbit coupling and disorder. Our calculations are in the frame-
work of a kinetic equation for the density matrix in spin space, captur-
ing 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. Neumayer1, A. Vogl1, U. Wurstbauer2, M. Utz1, W. Wegscheider1, and D. Weiss3 — 1Universität Regensburg — 2Universität Hamburg
In ferromagnetic (Ga,Mn)As the conductivity σ decreases with de-
creasing temperature below 10 K. Preliminary experiments have shown that
enhanced electron-electron interaction (EEl) [1] is the origin of this
decrease. We present results from 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(EF) by Einstein’s rela-
tion: σ = e²N(EF).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 cross-over regime
from quasi 2D to 1D, to get knowledge about the diffusion constant and
the effective density of states. The measured values of N(EF) 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.


HL 9.118 Mon 14:30 P2
Coulomb blockade dominates transport across lateral (001)-
(Ga,Mn)As nanocostricions — •MARKUS SCHLAPP1, TERESA LEHM1ER1, STEFAN GEISSLER1, DANIUS KUDEIKIS2, RASHID GAREEV3, JANUSZ SADOWSK2, WERNER WEGSCHERIDERS, and DIETER WEISS3 — 1Universität Regensburg — 2Max-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 resis-
tance 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 mi-
oscopic 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 de-
pendence 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

HL 9.119 Mon 14:30 P2
Investigation of Quantum Hall arrays for resistance standards — •JENS KÖNEMANN, GÜNTER HEIN, HeINER SCHUMACHER, RALF KIRZ, and HANS WERNER SCHUMACHER — Physikalisch-Technische
Bundesanstalt, Bundesallee 100, D-38116 Braunschweig
Today’s quantum resistance standards are generally implemented us-
ing the integer Quantum Hall effect at filling factor ν = 2 correponding
to a quantized resistance value of RQ = 12.9 kΩ. Arranging several
Hall bars in series or in parallel promises extending the range of quan-
tized resistance values between 100 Ω and 1 MΩ, whilst maintaining
low uncertainties within the order of some parts in 10⁸. In this work,
we test the feasibility of such a resistance standard based on Quantum
Hall arrays by interconnecting Hall bars with standard bonding techni-
que. Additionally, we have realized a serial array of ten Hall bars with
liathographically 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 GEBERDING1, LINA BOCHKORN1, AN-
NELENE F. DETHLEFSEN1, WERNER WEGSCHERIDERS1, and ROLF J.
HAUC1 — 1Institut für Festkörperphysik, Leibniz Universität Hannover — 2Centre for Atom Optics and Ultrafast Spectroscopy, Fac-
ulty of Engineering and Industrial Science, Swinburne University of
Technology — 3Institut für Experimentelle und Angewandte Physik,
Universität Regensburg
We study the fractional Quantum-Hall effect in high mobility twodi-
dimensional 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 per-
pendicular 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.