HL 17: Poster I

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

HL 17.1 Mon 16:30 Poster D

Infrared spectroscopy on the fullerene C_{70} under pressure — •Komalavalli Thirunavukkuarasu[1], Christine.A. Kuntscher[1], Ferenc Borondics[2], Gyöngyi Klupp[2], and Katalin Kamarás[2] — [1]Experimentalphysik II, Universität Augsburg, D-86159 Augsburg, Germany — [2]Research Institute for Solid State Physics and Optics, Hungarian Academy of Sciences, P.O.Box 49, Budapest, Hungary H 1525

C_{70} is the most commonly occurring higher order fullerene next to C_{60}. Although several experimental investigations have been performed on this compound, the properties of C_{70} is not yet well understood. On cooling, C_{70} undergoes two orientational ordering transitions, one at 350 K and the other at 280 K which are accompanied by structural phase change [1]. The pressure-induced orientational ordering in C_{70} is expected around 1 GPa [2]. For a better understanding of the pressure-induced phenomena in C_{70} we carried out pressure-dependent transmittance measurements on pure C_{70} compound over a broad frequency range (400-22000 cm^{-1}) for pressures up to 10 GPa. The pressure-induced changes in the vibrational modes and the shift of the electronic absorption edge with increasing pressure are reported. *Supported by the DFG.*

[1] G. B. Vaughan et al., Chem. Phys. **178**, 599 (1993).
[2] H. Kawamura et al., J. Phys. Chem. Solids **54**, 1675 (1993).

HL 17.2 Mon 16:30 Poster D

Ionization potentials of the first members of the nanodiamond series — •Lasse Landt[1], Kathrin Klünder[1], Konstantin Lenzke[1], Trevor Willey[2], Tony van Buuren[2], Jeremy Dahl[3], Robert Carlson[3], Thomas Möller[1], and Christoph Bostedt[1] — [1]Technische Universität Berlin, Germany — [2]Lawrence Livermore National Laboratory, USA — [3]MolecularDiamond Technologies, USA

We experimentally determined the ionization potentials of small hydrogen-passivated nanodiamonds, so-called diamondoids. Diamondoids can be considered the smallest possible cage-like subunits that can be excised from diamond lattice closing the gap between large hydrocarbon molecules and nanodiamonds. Ranging in size from 0.5 to 1 nm, they can be perfectly size- and shape-selected. Ionization potentials were measured using total ion-yield spectroscopy. All data were taken from neutral, high purity samples in the gas phase yielding unprecedented comparability to theoretical predictions. The experimental ionization potentials for this new interesting class of nano-carbon materials is compared to theoretical predictions.

HL 17.3 Mon 16:30 Poster D

Fibre reinforced carbon aerogels for application as electrochemical double layer capacitors — •Henning Lorrmann[1], Volker Lorrmann[1], Ingo Riedel[1,2], Carsten Deibel[2], Gudrun Reichenauer[1], Matthias Wiener[1], and Vladimir Dyakonov[1,2] — [1]Bavarian Center for Applied Energy Research (ZAE Bayern), Functional Materials for Energy Technology, Am Hubland, D-97074 Würzburg, Germany — [2]Experimental Physics VI, Physical Institute, Julius-Maximilians University of Würzburg, Am Hubland, D-97074 Würzburg

Fibre-reinforced carbon aerogels have been prepared from resorcinol-formaldehyde (RF) for application as electrodes in electrochemical storage devices. Fibres allow ambient pressure drying without solvent exchange even for a molar ratio of resorcinol to catalyst as low as five. Accordingly, shrinkage of the precursor-aerogels during drying-process is not critical. Electrochemical properties have been investigated by means of impedance spectroscopy, cyclic voltammetry and galvanostatic charge/discharge cycles. Capacities of up to $200 F/g$ have been reached. The Ragone-plot, calculated from the impedance-data, exhibits high power densities even for high energy densities due to high specific capacitance (energy) as well as low internal resistance (power). N_2-sorption measurements reveal large micropore volumes. However, specific surface (area per mass) is relatively low compared to bulk aerogels, as fibers contain little surface. The particle size can be adjusted by variation of the resorcinol-to-catalyst-ratio, whereas the density mainly depends on the ratio of RF to the total mass.

HL 17.4 Mon 16:30 Poster D

Non-Oriented and Oriented Protein Immobilization on Diamond Surfaces — Simon Quartus Lud[1], •Philipp Sebastian Koch[1], Florian Spirkl[1], Rainer Jordan[2], Paola Bruno[3], Dieter M. Gruen[3], Jose A. Garrido[1], and Martin Stutzmann[1] — [1]Walter Schottky Institut, Technische Universität München, Am Coulombwall 3, 85748 Garching, Germany — [2]Materials Science Department, Argonne National Laboratory, Argonne, Illinois 60439, USA — [3]Chemistry Department, Technische Universität München, Lichtenbergstr. 4, 85748, Garching, Germany

Interfacial molecular assemblies play an important role for applications in all fields of biosensor design. Due to its numerous remarkable material properties, like its extreme stability, large electrochemical window and good biocompatibility, diamond is a very attractive candidate for chemical and biochemical sensing. We discuss various methods for the immobilization of proteins on a diamond substrate. More specifically, we report on random and oriented modes of binding to ultrananocrystalline diamond (UNCD) surfaces. Diamond thin films are first modified by pure chemical grafting of benzene diazonium salts with functional headgroups. AFM, XPS, electrochemical CV, and NEXAFS spectroscopy have been used to verify the direct covalent attachment of the aromatic molecules. The results confirm the presence of a very stable, homogeneous, and dense monolayer for both headgroups.

HL 17.5 Mon 16:30 Poster D

Selective growth and treatment of carbon nanotubes on various substrates — •Philipp Zeigermann, Hans Kleemann, Manuela Janietz, Mathias Steglich, and Bernd Schröter — Universität Jena, Institut für Festkörperphysik, Max-Wien-Platz 1, 07743 Jena, Deutschland

A selective growth of carbon nanotubes with particular structural and electronic properties is a prerequisite to utilize them in electronic and sensor devices.

We grow single-wall nonotubes by chemical vapour deposition (CVD) using methane as precursor gas and metallic catalyst films on various substrates like silicon, fused silica and sapphire. Scanning electron microscopy, x-ray photoelectron and raman spectroscopy demonstrate the high purity of these nanotubes. A hydrogen partial pressure can favour the growth of semiconducting nanotubes. A selective effect of hydrogen and methane has also been found in plasma and thermal treatment of nanotubes. /1/ /2/.

We investigate these effects as well as the thermal treatment in vacuum and air to develope strategies to purify, select and functionalize nanotubes as well as to check their stability.

/1/G. Zhang, et al.: Selective Etching of Metallic Carbon Nanotubes by Gas-Phase Reaction Science 314 (2006) 974-977

/2/A. Hassanien, et al.: Selective etching of metallic singlewall carbon nanotubes with hydrogen plasma Nanotechnology 16 (2005) 278-281

HL 17.6 Mon 16:30 Poster D

Morphology of graphene layers deposited on various substrates — •Ulrich Stöberl, Jonathan Eroms, Ursula Wurstbauer, Werner Wegscheider, and Dieter Weiss — Institut für Experimentelle und Angewandte Physik, Universität Regensburg

Following recent TEM studies on suspended graphene sheets, the ripple structure of graphene is believed to be an intrinsic property, influencing transport quantities, such as the minimum conductivity and the mobility of the carriers. Here, we investigate to what extent the roughness of the underlying substrate can modify the morphology of graphene layers. To this end, we have prepared single and few layer graphene samples using the mechanical exfoliation technique on standard, oxidized silicon wafers, and MBE grown GaAs and InGaAs wafers. The latter show a characteristic cross-hatched pattern with an rms roughness of about 5 nm, whereas the silicon wafers are smooth with a roughness below 1 nm. AFM investigations demonstrate that the surface of the graphene films is determined by the roughness of the underlying substrates. Furthermore this has important implications on the transport properties of the graphene film.

HL 17.7 Mon 16:30 Poster D

Untersuchung von Graphenschichten auf Siliziumkarbid mit Hilfe der Ramanspektroskopie — •Jonas Röhrl, Martin Hundhausen, Ralf Graupner, Konstantin Emtsev, Thomas Seyller

und Lothar Ley — Technische Physik, Friedrich-Alexander Universität Erlangen-Nürnberg, Erwin-Rommel-Str. 1, 91058 Erlangen

Graphen, eine einzelne Graphitschicht, ist als 2-dimensionales elektronisches System von grundlegendem Interesse. Proben mit einer oder wenigen Graphenschichten werden gewöhnlich durch mechanische Exfolierung von Graphitkristallen (HOPG- highly oriented pyrolytic graphite) gewonnen. Im Unterschied dazu untersuchen wir hier Graphen, das sich auf SiC-(0001) Oberflächen als epitaktische Schicht beim Anlassen durch Verdampfen von Silizium bildet. Zur Charakterisierung von ein- bzw. mehrlagigen Graphenschichten eignen sich die G- und die 2D-Mode im Ramanspektrum. Wir zeigen, dass es systematische Unterschiede in den Ramanspektren von Monolage, Doppellage und mehreren Lagen gibt, die benutzt werden können, um die lokale Schichtdicke (Anzahl von Graphenlagen) mit optischen Methoden zu bestimmen. Für die Graphenmonolage finden wir im Vergleich zu freitragenden Graphenschichten eine deutliche Verschiebung der 2D- und G-Mode zu höheren Frequenzen. Da sich die erste Graphenlage im Kontakt mit dem SiC-Substrat befindet, führen wir diese Verhärtung der Phononen im Wesentlichen auf den Einfluss mechanischer Spannungen zurück, die während des Abkühlens aufgrund unterschiedlicher Ausdehnungskoeffizienten von SiC und Graphen entstehen. Wir diskutieren außerdem den Einfluss der Kohn-Anomalie.

HL 17.8 Mon 16:30 Poster D

Transport through multilayer graphene — •Thomas Lüdtke, Patrick Barthold, and Rolf J. Haug — Institut für Festkörperphysik, Leibniz Universität Hannover, D-30167 Hannover

We present transport measurements through thin films of graphite in dependence of backgate voltage and temperature.
The thin films of graphite are obtained by micromechanical cleavage of natural graphite similar to the technique described in Ref.[1]. An optical microscope is used to localize the graphite films that are deposited on a silicon substrate with 300nm SiO_2 layer. By using electron beam lithography we are able to contact the samples. Transport measurements were performed at temperatures between 1.4 K and 300 K. As we apply a backgate voltage we see a peak in the resistivity that we contribute to a field effect. In addition to transport measurements on flakes we present measurements on mesoscopically patterned devices.

[1] K. S. Novoselov et al., Proc. Natl. Acad. Sci. USA, vol. 102, p.10451 (2005)

HL 17.9 Mon 16:30 Poster D

Transport in antidot lattices in graphene layers — •Jonathan Eroms, Ulrich Stöberl, and Dieter Weiss — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg

We prepared antidot lattices in single and bilayer graphene sheets using electron beam lithography and reactive ion etching. The lattice period a was ranging between 140 nm and 200 nm. In single layer samples with a lattice period of 200 nm we find quantum Hall plateaus and Shubnikov-de Haas oscillations with the half-integer quantization that is commonly observed in single layer samples. We also find a pronounced weak localization peak in the longitudinal resistance. The mobility of the graphene flake was not sufficient to observe commensurability peaks of the antidot lattice. In samples with very narrow constrictions between the antidots, we observe a suppression of the conductance in a finite range of back gate voltage, *i.e.*, a gap develops.

HL 17.10 Mon 16:30 Poster D

THz detectors on the basis of HgTe-Quantum wells — •Fathi Gouider[1], Hartmut Buhman[2], Christoph Brüne[2], Günter Hein[3], and Georg Nachtwei[1] — [1]Institut of Applied Physics, Technical University of Braunschweig, Mendelssohnstr.2, D- 38106 Braunschweig — [2]Universität Würzburg EP III, Am Hubland, D-97074 Würzburg — [3]Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116 Braunschweig,Germany

The investigations of the THz-photoresponse (PR) of devices with HgTe QWs embedded in CdHgTe barriers are aimed at obtaining photosignals at smaller magnetic fields. The QWs have a thicknes of d_{QW} =12nm, so that the material HgTe of the QW possesses a semimetallic band structure. We found an effective mass of about $m_c = 0.026m_0$ for our samples from cyclotron resonance measurements (transmission of THz waves, Voigt configuration, Ge detector). As this cyclotron mass is by about a factor 3 smaller than the one of electrons in GaAs, the same Landau level splitting as in GaAs is reached at about 1/3 of the magnetic field. In this presentation, we present measurements of the THz photoconductivity on quantum Hall systems. HgTe/HgCdTe (MCT) heterostructures with Corbino geometry are investigated. A recipe for the preparation of metallic Corbino contacts on MCT is shown. The system is excited by the radiation of a p-Ge laser (from1.7 to 2.5 THz) and the PR is measured versus the magnetic field B . Because of the lower effective mass in MCT, the cyclotron resonance(CR) in this system appears at a relatively low magnetic field $B \approx 2$ T.

HL 17.11 Mon 16:30 Poster D

Photovoltage Induced by Microwave Radiation on AlGaAs/GaAs Hall Bars — •Tobias Krohn, Nikolai Mecking, André Wirthmann, and Detlef Heitmann — Institut für Angewandte Physik, Universität Hamburg, Jungiusstraße 11, 20355 Hamburg

We have investigated the photovoltage that was induced by irradiating microwaves on Hall bars containing a two dimensional electron system (2DES) in a AlGaAs/GaAs heterostructure. The dimensions of the Hall bars were in the 100 μm regime. The experiments were performed at fixed frequency in a sweep 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 170 GHz. We observe a rich mode spectrum with modes exhibiting positive or negative B dispersions, which we can model, respectively, by confined magnetoplasmon and edge magnetoplasmon modes. Both types of modes are governed by characteristic lengths. We find that these lengths reflect the dimensions in the close vicinity of the contacts, indicating that they are the origin of the induced photovoltage.

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

HL 17.12 Mon 16:30 Poster D

FIR and MW Spectroscopy on Carbon-Doped Two-Dimensional Hole Systems — •Kevin Rachor[1], Thomas Raab[1], Carsten Graf von Westarp[1], Detlef Heitmann[1], Andrea Stemmann[1], Christian Heyn[1], Christian Gerl[2], Werner Wegscheider[2], Dirk Reuter[3], and Andreas Wieck[3] — [1]Institut für Angewandte Physik, Uni Hamburg, 20355 Hamburg — [2]Institut für Experimentelle und Angewandte Physik, Uni Regensburg, 93040 Regensburg — [3]Ruhr-Universität Bochum, 44801 Bochum

The recent development of Carbon-doped AlGaAs heterostructures on (100) substrates permits an experimental access to two-dimensional hole systems (2DHS) with high mobilities and no anisotropy [1]. Using a microwave generator and a Fourier transform spectrometer we perform both microwave and broadband far infrared transmission experiments on such samples covering a frequency range from 50 GHz to 20.000 GHz (1.67 cm^{-1} to 600 cm^{-1}). Cyclotron resonances measured in perpendicular magnetic fields up to 14 T at 1.6 K are presented here. The effective mass m* shows a strong magnetic field dependance revealing the highly non-parabolic band structure of hole systems. Surprisingly, m* depends strongly on the temperature, too. In a certain regime of the magnetic field an additional resonance, propably an intersubband resonance is detected which is possible due to a warping of the energy contour [2]. The authors are grateful to the DFG for support through SFB 508.

[1] A. D. Wieck et al. Appl. Phys. Lett. 85, 2277 (2004).
[2] E. Bangert et al. PRL 53, 493 (1984).

HL 17.13 Mon 16:30 Poster D

Towards growth on Si: Determining the offsets of Ga(N,As,P)/GaP MQW structures by optical spectroscopy — •Christian Karcher, Bernardette Kunert, Kerstin Volz, Wolfgang Stolz, and Wolfram Heimbrodt — Dept. Physics and Material Sciences Center, Philipps-University of Marburg, Germany

Realising a monolithic optoelectronic device on Si substrate such as an efficient direct laser material would open up completely new fields of applications. The indirect compound semiconductor GaP has a lattice constant almost equal to that of Si. The novel Ga(N,As,P) direct band-gap material can be grown pseudomorphically on GaP. We study these compressively strained Ga(N,As,P)/GaP MQWs by means of both temperature- and pressuredependent modulation- and photoluminescence-spectroscopy. By applying pressure upon the samples one is able to determine the offsets of the direct Ga(N,As,P)-bandgap with regard to the indirect bandgap of the GaP-barrier. We provide this insight by comparing the modulated reflectance to the

photoluminescence of the sample. The obtained results yield additional knowledge about the band structure and in particular the offset of the quantum well, which is essential for achieving room-temperature lasing in the near future.

HL 17.14 Mon 16:30 Poster D

Influence of sulfur on the polarization degree in spin-injection light-emitting diodes with lattice-matched ZnMnSSe spin aligners — •Jens Müller, Wolfgang Löffler, Benedikt Westenfelder, Heinz Kalt, Dongzhi Hu, Daniel M. Schaadt, and Michael Hetterich — Institut für Angewandte Physik, Universität Karlsruhe (TH), 76128 Karlsruhe, Germany

We investigate the spin alignment of electrons in ZnMnSSe-based alloys and their subsequent injection into InGaAs quantum dots using spin-injection light-emitting diodes (spin-LEDs). Due to the antiferromagnetic coupling of neighbored Mn spins in ZnMn(S)Se one finds a maximum *effective* Mn concentration for $x_{\mathrm{Mn}} \sim 14\%$. However, the maximum giant Zeeman splitting occurs for $x_{\mathrm{Mn}} \sim 9\%$, apparently due to a strong increase of the effective temperature T_{eff} with manganese content. To further improve the achieved spin injection efficiency in spin-LEDs we grew ZnMnSSe aligner layers lattice-matched to GaAs. Because of poorer crystal quality in the resulting quaternary alloys, magneto-PL measurements show lower spin-polarization with increasing sulfur content. At the same time we found a dramatic increase in the intra-Mn photoluminescence at about 2.1 eV. This increase is thought to originate from localization effects of excitons that lead to Auger-like transitions within manganese atoms. The maximum circular polarization degree achieved in InGaAs quantum dot ensemble measurements of lattice-matched spin-LED structures was in the order of 70%.

HL 17.15 Mon 16:30 Poster D

High Resolution Measurement of the Thermal Expansion Coefficient of Semiconductor Multilayer Lateral Nanostructures — •Björn Brüser[1], ullrich pietsch[1], souren grigorian[1], tobias panzner[1], jörg grenzer[2], and ute zeimer[3] — [1]Festkörperphysik, Universität Siegen, Walter-Flex-Str. 3, D-57068 Siegen, Germany — [2]Forschungszentrum Rossendorf e.V., P.O.Box 510119, D-013414 Dresden, Germany — [3]Ferdinand-Braun Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 24, D-12489 Berlin, Germany

We measured the thermal expansion coefficient of a vertically stacked multi-quantum-well structure buried under a thick GaAs top layer before and after lateral patterning of the GaAs top layer. After patterning the thermal expansion coefficient of the whole multi-quantum-well structure differs from that of the planar structure by about 20%. Based on calculations in terms of methods of finite elements the effect is explained by the influence of the strain field originating from the bottom edges of the etched nanostructure. Due to the long range nature of this strain field the strain release within the individual quantum wells changes as a function from the distance from the valley.

HL 17.16 Mon 16:30 Poster D

Crystallization of strongly correlated indirect excitons — •Patrick Ludwig[1,2], Alexej Filinov[1], Heinrich Stolz[2], and Michael Bonitz[1] — [1]CAU zu Kiel, ITAP, Leibnizstraße 15, D-24098 Kiel — [2]Universität Rostock, Institut für Physik, Universitätsplatz 3, D-18051 Rostock

We consider small ensembles of optically excited indirect excitons in a single quantum well. Using Path Integral Monte Carlo we compute from first principles the spatial separation of electrons and holes and the lateral quantum Stark confinement in the quantum well due to a strong electric field from a tip electrode [1]. Electrons and holes are shown to form permanent dipoles with a strong repulsion giving rise to interesting correlation and quantum effects [2,3]. By changing the field strength, tip to sample distance and excitation intensity (exciton number) and temperature we predict the parameter range where exciton crystallization is expected to be observable in experiments on ZnSe based quantum wells.

[1] P. Ludwig et al., phys. stat. sol. (b) 243, No. 10, 2363 (2006)
[2] A. Filinov et al., phys. stat. sol. (c) 3, No. 7, 2457 (2006)
[3] A. Filinov et al., J. Phys: Conf. Series 35, 197 (2006)

HL 17.17 Mon 16:30 Poster D

Epitaxially grown ZnO heterostructures for nanophotonic devices — •Marcel Ruth and Cedrik Meier — Department of Physics, Group NanoPhox, University of Duisburg-Essen, Lotharstr. 1, 47057 Duisburg

Due to its unique properties such as the large direct bandgap of 3.37eV and its high exciton binding energy, zinc oxide (ZnO) is a highly promising semiconductor for optoelectronic devices even at room temperature. By adding cadmium (Cd) or magnesium (Mg) the bandgap can be tuned between 3.0eV and 4.0eV. Above that, it is simpler to form laterally patterned devices and structures based on ZnO than on gallium nitride (GaN), e.g., by chemical etching.
For the fabrication of high-quality ZnO-based heterostructures as required for nanophotonic applications, plasma-assisted molecular beam epitaxy (MBE) is a very suitable technique. Our samples are grown in a vertical MBE system (Riber Compact 12) with double zone effusion cells and a RF-plasma source for atomic oxygen.
We present the first results of the epitaxially grown ZnO, (Zn,Mg)O and (Zn,Cd)O layers on c-plane sapphire and ZnO. The samples are characterized by morphological methods *in-situ* by reflection high energy diffraction (RHEED) and *ex-situ* methods such as atomic force microscopy (AFM), scanning electron microscopy (SEM) and x-ray diffraction (XRD). Furthermore, photoluminescence (PL) spectroscopy is used to determine their usability for nanophotonic devices like photonic crystals and microdisks.

HL 17.18 Mon 16:30 Poster D

Antilocalisation in InGaAs/InAlAs inverted 2DEGs — •Ines Hense, Ursula Wurstbauer, Dieter Schuh, and Werner Wegscheider — Universität Regensburg, Institut für Experimentelle und Angewandte Physik, 93043 Regensburg, Germany

InGaAs is one of the most studied ternary alloy systems because of its important rule in the development of electronic and optoelectronic devices. Due to a huge lattice missmatch between GaAs and InAs of about 7 % it is necessary to grow a some hundred nanometers thick buffer layer with a stepwise increasing In-concentration. In this way one creates a virtual substrate lattice-matched to InGaAs.

We present at low temperature magnetotransport experiments on 2DEGs which reside in an InAs-channel which was modulation-doped from the bottom side. One first finding was an increased magnetoconductance at low magnetic fields caused by weak antilocalisation. Following next will be an enhanced nanostructuring, e.g. to get Aharanov-Bohm rings or gate-defined quantum dots.

HL 17.19 Mon 16:30 Poster D

Structural and optical properties of ZrO_2 and Al_2O_3 thin films and Bragg reflectors grown by pulsed laser deposition — •Jan Sellmann, Chris Sturm, Rüdiger Schmidt-Grund, Helena Hilmer, Holger Hochmuth, Christian Czekalla, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Linnéstr. 5, 04103 Leipzig

Our objective is to build a threshold-less laser based on the emission from a Bose-Einstein condensate of exciton-polaritons in a semiconductor microcavity-resonator. For this purpose, high reflective mirrors with smooth boundaries are necessary. The aspired resonator structure consists of a half-wavelength ZnO cavity embedded between two ZrO_2/Al_2O_3 Bragg reflectors.

We present high-reflective ZrO_2/Al_2O_3 Bragg reflectors grown by pulsed laser deposition on c-plane sapphire and silicon substrates. For ZrO_2/Al_2O_3 Bragg reflectors with a layer pair number of 12.5, reflectivity values of 99.8% at 3.3 eV and smooth surfaces have been reached. As preceding investigations, the optical and structural properties as the refractive indices, the crystal structure, and the surface properties of the used materials have been determined and optimised. It was found that these properties depend on the substrate and the position in the Bragg reflector layer stack.

The optical and structural properties of the single layers and Bragg reflectors have been gained from spectroscopic ellipsometry in the energy range (1.0-4.5) eV, X-ray diffraction measurements, atomic force microscopy, and transmission scanning electron microscopy.

HL 17.20 Mon 16:30 Poster D

Characterization of GaSb-based heterostructures by spectroscopic investigations — •Sebastian Imhof, Christina Bückers, Björn Metzger, Angela Thränhardt, Sangam Chatterjee, and Stephan W. Koch — Fachbereich Physik und Wissenschaftliches Zentrum für Materialwissenschaften, Philipps Universität Marburg, Renthof 5, 35032 Marburg

The material system (AlGaIn)(AsSb) is suitable for laser emission at 2μm or longer wavelength, which is interesting for various applications, e.g. material processing, gas detection, medical diagnostic and laser

surgery. A wide range of material combinations is being considered for application [1-3], but there are still uncertainties with regards to their structural properties, such as band alignment, strain and general bandstructure parameters. In order to gain information on these structural properties, we investigate GaSb-based heterostructures by modulation spectroscopy using e.g. photomodulated reflection. The experimental data are compared to simulations based on a microscopic theory.

[1] M. Rattunde, J. Schmitz, G. Kaufel, M. Kelemen, J. Weber, J. Wagner, Appl. Phys. Lett. 88, 081115 (2006)
[2] C. L. Canedy, W. W. Bewley, J. R. Lindle, C. S. Kim, M. Kim, I. Vurgaftman, J. R. Meyer, J. Electron. Mater. 35, 453 (2006)
[3] E. A. Pease, L. R. Dawson, L. G. Vaughn, P. Rotella, and L. F. Lester J. Appl. Phys. 93, 3177 (2003)

HL 17.21 Mon 16:30 Poster D

Development of Photonic Sensors for Parallel Molecule Detection Based on Microresonators — •Mario Hauser, Christian Sailer, Cristian Gohn, Christian Schäfer, Wolfgang Löffler, and Heinz Kalt — Universität Karlsruhe (TH), Karlsruhe, Germany

We report on the development of versatile photonic sensors for label-free detection of proteins and DNA on the basis of semiconductor microdisks.

The detection principle bases on the shift of the frequency of optical whispering gallery modes (WGMs) and has been proven in the case of silica spheres [1]. Each resonator will be functionalized by fixing proteins to its perimeter which can selectivley bind to well defined partners as in the case for complementary DNA sequences or antigen/antibody combinations. The evanescent field of the WGM polarizes a molecule attached to the resonator which in return shifts the mode frequency.

For detection of the modal shift of WGMs an add/drop filter scheme with integrated waveguides passing a series of microdisks at a small distance is shown. Waveguides and microdisks can be etched simultaneously with standard semiconductor technologies from a single substrate to form an integrated device. We present first results of the fabrication and the characterization of the optical resonances.

[1] S. Arnold et. al., Shift of whispering-gallery modes in microspheres by protein adsorption, Optics Lett., vol. 28, 272 (2003)

HL 17.22 Mon 16:30 Poster D

Gain measurements of violet and blue InGaN lasers using the variable stripe length method — •J. Schlegel[1], J. R. van Look[1], V. Hoffmann[2], A. Knauer[2], S. Einfeldt[2], P. Vogt[1], M. Weyers[2], and M. Kneissl[1,2] — [1]TU Berlin, Institute of Solid State Physics, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Ferdinand-Braun-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany

The development of group III-nitride based quantum wells (QWs) for blue and green laser diodes has attracted great interest in recent years. In order to realize these InGaN QW structures a significant increase of the indium content within the quantum well layer is required. However, the quantum efficiency and gain characteristics of these high indium containing QW structures is hindered by poor material quality, due to the formation of defects, compositional fluctuations and interface roughness. To optimize the growth of InGaN QWs optically pumped laser structures with varying indium content and emission wavelengths ranging between 400 and 460 nm have been characterized. These laser structures were grown by metalorganic vapor phase epitaxy (MOVPE) on (0001) sapphire substrates. The optical gain spectra were determined using the variable stripe length method (VSLM). Based on that information the layer quality and the homogeneity in the quantum well growth of different InGaN layer structures was compared. Furthermore the effect of the barrier design (i.e. GaN/InGaN as well as InGaN/InGaN) on the gain characteristics of these lasers will be investigated.

HL 17.23 Mon 16:30 Poster D

Investigations of the ability of photovoltaic solar power generators to receive RF radiation — •Markus Drapalik and Viktor Schlosser — Department of Electronic Properties of Materials, Faculty of Physics, University of Vienna, Austria

The installation of an electrical power generator of 1 MW_p operated by photovoltaic modules occupy an area of approximately 7000 m^2. Effective electrical shielding of receiving, reflecting, transmitting and emitting RF radiation of the components is very limited due to the necessity to capture as much incoming solar radiation as possible. Semiconducting pn-junctions which are the basic components of a photovoltaic power generator can act as simple RF receivers. Received electromagnetic radiation cause an increased level of electrical noise within the system which can affect the electronic components for power conditioning. Beside light intensity fluctuations RF radiation contributes to the generation and reemission of RF noise to the environment. Purpose of the present work is to investigate the ability of single solar cells and small solar modules to receive RF signals in the range of 10 Hz to 12 GHz. The amplitude modulated high frequency signal of a RF generator unit is coupled into an antenna which is placed close to the photovoltaic device. The solar power generator's output is connected in parallel to an elctrical load and to a highly sensitive two phase lock in amplifier which allows us to detect the phase resolved modulated response of multiple harmonics of the modulation frequency which is chosen in the range of 1 kHz. First results of the investigations will be presented and discussed.

HL 17.24 Mon 16:30 Poster D

Modellbasierte Optimierung von III-V Solarzellen — •Simon P. Philipps, Martin Hermle, Wolfgang Guter, Frank Dimroth und Andreas W. Bett — Fraunhofer ISE, Heidenhofstrasse 2, 79110 Freiburg

Solarzellen aus III-V Halbleitermaterialien ermöglichen hohe Wirkungsgrade, da mehrere Solarzellen mit verschiedenen Bandlücken übereinander gestapelt werden können. So kann das Sonnenspektrum effizienter genutzt werden. Die Realisierung von III-V Mehrfachsolarzellen ist aufgrund der komplexen Struktur sehr anspruchsvoll. Eine Tripelzelle beispielsweise umfasst mehr als zwanzig unterschiedliche Schichten, die sich in ihrem Verhalten gegenseitig beeinflussen und somit aufeinander abgestimmt werden müssen. Dementsprechend aufwändig ist die rein experimentelle Optimierung der Zellstrukturen. Eine effizientere Optimierung wird durch modellbasierte Analysen ermöglicht. Am Fraunhofer-Institut für Solare Energiesysteme wird dafür die Halbleitersimulationsumgebung PVObjects verwendet. Aufgrund der komplexen Schichtstrukturen werden zunächst die einzelnen Teilzellen, sowie die Tunneldioden einzeln modelliert und optimiert, um anschließend die gesamte Zellstruktur zu optimieren. In diesem Beitrag werden beispielhaft Ergebnisse von modellbasierten Optimierungen von III-V Einfachsolarzellen gezeigt, die zu einem tieferen Verständnis des Einflusses verschiedener Zellparameter auf den Wirkungsgrad geführt haben. Dies schafft eine wichtige Grundlage für die folgende Optimierung von Mehrfachsolarzellen.

HL 17.25 Mon 16:30 Poster D

Composition Dependence of Defects in CuIn1-xGaxSe2 Solar Cells — •Tobias Eisenbarth, Thomas Unold, Christian Kaufmann, Raquel Caballero, Daniel Abou-Ras, and Hans-Werner Schock — Hahn-Meitner-Institut, Glienicker Str. 100, 14109 Berlin, Germany

Chalcopyrite solar cells based on CuIn1-xGaxSe2 absorber layers so far yield the highest thin film solar cell efficiencies, with the potential to surpass the 20% efficiency mark in the near future. There are still a number of fundamental questions about the relation between the composition and the structural and electronic properties of the absorber films, in particular the relationship between the structural and electronic defects and their effect on the device performance of the solar cells. To investigate this issue further a series of CuIn1-xGaxSe2 solar cells was prepared with $0 < x < 1$, covering the full range of gallium/indium ratios using our standard three-stage co-evaporation process. The cross-section of the solar cells has been investigated in a SEM system to reveal details about the structure. On the same cells, defect spectroscopy was performed using admittance spectroscopy and drive-level capacitance profiling, to obtain an estimate of the number of deep defects present in the devices. Additionally, photoluminescence spectroscopy was applied to obtain more information about the recombination properties of the series of devices.

HL 17.26 Mon 16:30 Poster D

Deep level transient spectroscopy measurements on CuInS2-thin film solar cells — •Stephanie Malek, Martin Knipper, and Jürgen Parisi — Carl-von-Ossietzky-Universität Oldenburg, Germany

During the last decade CuInS2 was investigated for its use as absorber in thin film solar cells. Now these cells are ready for volume production. The advantages against already used materials are e. g. high absorbing capacity and cost-efficient and sustainable production. Because of the great discrepancy between predicted degree of efficiency

and the already reached degree more investigations are necessary. To get a better understanding of the electron transport and recombination in order to arise efficiency we characterize the solar cells by deep level transient spectroscopy (DLTS). This method gives information about crystal defects depending on their electric position. Transient capacity measurements in the range of 25 K and 350 K allow us to determine activation energy and concentration of electron traps.

HL 17.27 Mon 16:30 Poster D

Correlations of the structural and electrical characteristics of magnetron-sputtered ZnO:Al- and Molybdenum thin films — •Jennifer Heinemann[1], Ingo Riedel[1], Frank Hergert[2], and Jürgen Parisi[1] — [1]Energy- and Semiconductor Research Laboratory, Department of Physics, University of Oldenburg, Carl-von-Ossietzky-Strasse 9-11, D-26111 Oldenburg — [2]Johanna Solar Technology GmbH, Münstersche Straße 24, D-14772 Brandenburg an der Havel

This contribution reports on investigations of the n-ZnO:Al-front contact and Molybdenum-back electrode used in Cu(In,Ga)(S,Se)2 thin film solar cells. The transparent ZnO:Al-window contact (band gap: 3.3eV) and the Mo-electrode were both deposited by DC-Magnetron-Sputtering. By variation of the deposition parameters like Argon pressure, sputtering power, deposition rate and substrate temperature the properties of the films (e.g. grain size, textured growth, sheet conductivity) change. This requires to correlate the structural and morphological qualities with the electrical behavior. The aim of this work is to study the structural properties of the electrode materials as systematically varied by the applied process parameters and to establish their impact on the electrical film characteristics. The sheet resistance and the according conductivity of the differently prepared films were measured by four-probe current-voltage measurements. Structural and morphological properties were investigated by X-ray diffraction, force and scanning electron microscopy.

HL 17.28 Mon 16:30 Poster D

Modelling of spectral photoluminescence yields from $Cu(In_{1-x}Ga_x)Se_2$ thin film absorber — •Sebastian Knabe, Levent Gütay, and Gottfried Heinrich Bauer — Institute of Physics, Carl von Ossietzky University Oldenburg, Germany

Photoluminescence provides means to determine different physical semiconductor properties, such as spectral absorption, defect densities and their respective energy levels, and excess carrier densities which might be expressed in terms of quasi-Fermi levels. For multilayer systems glass substrate/CIGSe-absorber/CdS-window layer we have calculated the luminescence photon flux propagating towards the detector with a 1D matrix transfer formalism. Light entrance side has been chosen through the CdS-window as well as through the glass substrate; the detector is located at the CdS-window side. For excess carrier depth profile forming the basis for the luminescence by radiative recombination we introduce a carrier generation profile dependent on absorption coefficient and photon energy, and calculate carrier densities with bulk life time/diffusion length LD, and surface recombination velocities at rear Sd and front side S0 and solve the continuity equation. We analyze the influence of LD, Sd, S0 on the spectral shape of the luminescence yield including interference effects and discuss the suitability for the extraction of the splitting of quasi-Fermi levels which in solar cell absorbers quantifies the quality of the photo excited state and limits the potential open circuit of finally processed diodes.

HL 17.29 Mon 16:30 Poster D

Local Fluctuations of Absorber Properties of $Cu(In,Ga)Se_2$ for "Real Life" Conditions by Sub-Micron Resolved PL — •Levent Gütay and Gottfried H. Bauer — Institute of Physics, University of Oldenburg, Germany

We analyze $Cu(In,Ga)Se_2$ absorber layers and solar cells in a confocal microscope setup by photoluminescence (PL) experiments. We present results on lateral inhomogeneities of the absorbers in terms of local fluctuations of the band gap and splitting of quasi-Fermi-levels which can be extracted from spectrally resolved PL (300K) scans across several tens of microns. Excitation fluxes amount to $10^2 - 10^5$ suns equivalent. We analyze the significance and the statistical distribution of the occurring fluctuations of splitting of quasi-Fermi-levels $(E_{Fn} - E_{Fp})$ which we plot in histograms, seemingly showing gaussian-like shapes. The width and shape of these distributions will be discussed, as they show substantial dependence on the excitation flux. We have extrapolated the features of the histograms from our excitation fluxes towards 1 sun equivalent in order to correct our data for absolute values $(E_{Fn} - E_{Fp})$ derived from calibrated luminescence analyses at 300 K and 1 sun equivalent on non-laterally resolved PL-studies, which provide access to the average on PL-yields $(\ln(\sum Y_{PL}))$ instead of the average of local $(E_{Fn} - E_{Fp})$ which writes $(\sum \ln(Y_{PL}))$. In our approach we strongly appeal for sufficient high spatial resolution of any experiment on polycrystalline solid matter.

HL 17.30 Mon 16:30 Poster D

Spatially resolved photoluminescence measurements on Cu(In,Ga)Se_2 absorbers and their analysis by Fourier transforms and Minkowski-operations — •Florian Heidemann, Levent Gütay, Matthias Langenmeyer, and Gottfried H. Bauer — Institute of Physics, University of Oldenburg, Germany

Thin film systems like $Cu(In,Ga)Se_2$ gain more and more importance in photovoltaics. Such multilayer structures however show significant structural and topological spatial variations which are obviously introduced by polycristallinity. With the help of spatially resolved photoluminescence measurements these variations, which are accompanied by spatial fluctuations in optoelectronic properties such as recombination rates and minority life times, can be measured. For the visualisation and quantification of measurements from $Cu(In,Ga)Se_2$ multilayer structures 2D Fourier transforms and erosion/dilatation Minkowski-operations (opening functions) are applied. These methods provide an insight in size and shape of the spatial patterns as well as into frequencies of occurrence and distribution of characteristic features. Moreover, the comparison of patterns recorded at different local positions for feature extraction with methods mentioned above allow for the proof whether data sets are statistically representative, say, scan areas are sufficiently large.

HL 17.31 Mon 16:30 Poster D

Co-Sputtering of (Zn,Mg)O buffer layers on CIGSSe thin film solar cells — •Felix Erfurth[1], Benjamin Hussmann[1], Thomas Niesen[2], Jörg Palm[2], Alexander Grimm[3], Achim Schöll[1], and Eberhard Umbach[1] — [1]Universität Würzburg, Experimentelle Physik II — [2]Avancis GmbH, München — [3]Hahn-Meitner-Institut, Berlin

To better meet the environmental requirements of thin film solar cells based on $Cu(In,Ga)(S,Se)_2$ (CIGSSe), the substitution of the CdS buffer layer by using a dry physical deposition method is of great interest. (Zn,Mg)O buffer layers deposited by rf-magnetron sputtering can result in efficiencies comparable with CdS containing solar cells. The properties of these layers depend on a multitude of parameters like sputter power, sputter pressure, and layer thickness, which therefore affect the characteristics of the entire solar cell. Of prime interest is the impact of the Mg/Zn-ratio, which in principle allows to tailor the optical band gap of the buffer layer. We are able to vary the Zn/Mg-ratio by controlling the sputter power of two separated ZnO and MgO sputter targets. By varying one specific parameter while leaving all others constant we have optimised the sputter deposition in order to achieve high efficiency solar cells. We present the influence of various parameters on cell properties like efficiency, filling factor, open circuit voltage, and short circuit current. In-situ X-Ray Photoelectron Spectroscopy measurements have been performed to investigate the direct impact of the sputter parameters on the chemical and stoichiometric properties of the buffer layer and of the absorber-buffer interface.

HL 17.32 Mon 16:30 Poster D

Correlation of grain structure and electrical properties of Cu(In,Ga)Se_2 thin-film solar cells — •Melanie Nichterwitz, Daniel Abou-Ras, Jürgen Bundesmann, Roland Scheer, and Hans-Werner Schock — Hahn-Meitner-Institut Berlin, Germany

Electron back scatter diffraction (EBSD) and electron beam-induced current (EBIC) in a scanning electron microscope are powerful tools to investigate the structural and electrical properties of polished cross sections of $Cu(In,Ga)Se_2$ thin-film solar cells. Electron beam induced current measurements allow for the analysis of the charge carrier transport with a high spatial resolution and the extraction of the minority charge carrier diffusion length. In combination with EBSD, it was possible to gain information about the influence of grain boundaries on the current collection of $Cu(In,Ga)Se_2$ thin-film solar cells. At several positions, reduced EBIC signals correlate with the positions of grain boundaries, as located by means of EBSD. These grain boundaries are identified as regions of enhanced recombination. Solar cells with various chemical compositions of the $Cu(In,Ga)Se_2$ absorbers were studied.

HL 17.33 Mon 16:30 Poster D

Lateral Inhomogeneities in $CuInS_2$-Thin Film Absorbers by Confocal Optical and Spectroscopic Analyses With μm-Lateral Resolution — •Martin Suhlmann[1], Sebastian Meier[1], Levent Gütay[1], Alexander Meeder[2], Rudolf Brüggemann[1], and Gottfried H. Bauer[1] — [1]Institute of Physics, Carl von Ossietzky University Oldenburg, F.R.Germany — [2]Sulfurcell Solartechnik G.m.b.H., Berlin

$CuInS_2$-absorbers from runs for thin film pv-module production have been analyzed by confocal spectrally resolved photoluminescence (PL) and focused spectral white light transmission. We observe in 300K-experiments substantial lateral variations in PL-yield, spectral shapes, and white light spectral transmission, potentially originating from the grainy structure, which we interpret in terms of lateral variations in element composition, defect densities and according lateral fluctuations of the splitting of quasi-Fermi levels ($E_{Fn}-E_{Fp}$). In histograms we show the distribution of fluctuations of ($E_{Fn}-E_{Fp}$) and extract half widths and higher order momenta. The comparison with CIS-absorbers of lab cells prepared under differing conditions and with data from selenide chalcopyrites, such as $Cu(In,Ga)Se_2$ show weaker fluctuation of the latter ones.

HL 17.34 Mon 16:30 Poster D

InGaAsP/InGaAs tandem solar cells for higher conversion efficiencies in multi-junction solar cells — •Ulf Seidel, Erol Sagol, Nadine Szabó, Klaus Schwarzburg, and Thomas Hannappel — Hahn-Meitner-Institut, Glienicker Str. 100, 14109 Berlin, Germany

III-V multi-junction solar cells are currently the most efficient photovoltaic devices. The present world record multi-junction solar cells (eta > 40%) contain three absorber layers: Ge, GaInAs and InGaP. Our idea is to replace the bottom Ge subcell by a more efficient InGaAsP/InGaAs tandem solar cell with low band gaps. The preparation of materials and solar cells with higher band gaps (> 1.4 eV) on the lattice constant of GaAs is already well-established, in contrast to tandem solar cells with lower band gap materials grown on InP. However, low band gaps, in particular an 1 eV absorber, are desired to raise the theoretical efficiency limit of multi junction solar cells. Here, InGaAsP/InGaAs tandem solar cells with low band gaps (1.03 eV, 0.73 eV) were grown monolithically and lattice-matched on InP(100). The serial connection of the two subcells was realized by a tunnel diode, including n-doped InGaAs and p-doped GaAsSb layers. In-house measured conversion efficiencies were much higher than the efficiency that was achieved with a single-junction Germanium subcell. The combination of the GaAs/InGaP tandem with higher band gaps and our low band gap tandem prepared on different substrates with different lattice constants can now be realized by mechanical stacking and also via splitting of the solar spectrum.

HL 17.35 Mon 16:30 Poster D

Properties of the crystal lattice and electronic structure of metastable III(N,V) semiconductors — •Martin Güngerich[1], Gerhard Weiser[1], Wolfram Heimbrodt[1], Oleg Rubel[1], Peter J. Klar[2], Paul Harmer[3], Mark P. Jackson[3], and Matthew P. Halsall[3] — [1]Fachbereich Physik und WZMW, Philipps-Universität, 35032 Marburg, Germany — [2]I. Physikalisches Institut, Justus-Liebig-Universität, 35392 Gießen, Germany — [3]Department of Electronic and Electrical Engineering, University of Manchester, Manchester M60 1QD, United Kingdom

The incorporation of nitrogen on group-V lattice sites in III-V semiconductors like GaP, GaAs and GaSb leads to substantial changes of the vibrational spectrum and the electronic structure compared to the host crystals. Our work gives an overview of the interesting physical properties of such metastable compounds with N concentrations up to a few percent. We show that local vibrational modes (LVMs) of the N atoms are a common feature in these alloys. The pressure-dependent frequency shifts of the LVMs are used to investigate the micro-mechanical properties of the N-Ga bonds. It is shown that the electronic structure in both Ga(N,P) and Ga(N,As) is governed by an interplay between the spatial distribution of the N impurities themselves and the coupling of their localized states to the host conduction bands. Correlations between different local N environments and the respective changes of the global electronic structure are studied on hydrogenated ternary Ga(N,As)/Ga(N,P) as well as on quaternary (Al,Ga)(N,As) crystals which exhibit disorder on the nearest-neighbour shells of the N atoms.

HL 17.36 Mon 16:30 Poster D

Homo- and heteroepitaxial growth behavior of upright InAs nanowires on InAs and GaAs substrates — •Jens Bauer[1], Volker Gottschalch[1], Hendrik Paetzelt[1], Gerald Wagner[2], and Ulrich Pietsch[3] — [1]Institut für Anorganische Chemie, Universität Leipzig, Johannesallee 29, D-04103 Leipzig — [2]Institut für Kristallographie und Mineralogie, Universität Leipzig, Linnestr. 5, D-04103 Leipzig — [3]Festkörperphysik, Universität Siegen, D-57068 Siegen

Semiconductor nanowires (NW) acquire recently attraction because of promising new application fields in electronics and optoelectronic. We applied the vapor-liquid-solid mechanism with gold seeds in combination with low-pressure metal-organic vapor phase epitaxy (LP-MOVPE) to achieve replicable InAs NW growth with high growth rates. Since the initial alloying of the gold seeds with the substrate material plays a deciding role for the inceptive NW growth, InAs free standing nanowires were grown on GaAs(111)B substrate as well as on InAs/GaAs(111)B quasi-substrate. The influence of the MOVPE parameters will be discussed with respect to NW morphology and real-structure. A special focus will be set on the heteroepitaxial InAs NW growth on GaAs substrates. Gracing-incidence x-ray studies and transmission electron microscopy investigations revealed the existence of a thin $Ga_xIn_{1-x}As$ graduated alloy layer with embedded crystalline gold alloy particles at the NW substrate interface. The effect of droplet composition on the VLS growth will be presented in a thermodynamic model.

HL 17.37 Mon 16:30 Poster D

Selective-area growth of III-V nanowires — •Hendrik Paetzelt[1], Volker Gottschalch[1], Jens Bauer[1], and Gerald Wagner[2] — [1]Institut für Anorganische Chemie, Universität Leipzig — [2]Institut für Mineralogie, Kristallographie und Materialwissenschaft, Universität Leipzig

We present a catalyst-free approach for the growth of III-V semiconductor nanowires which is of interest to build ordered arrays of nanowires without the vapor-liquid-solid mechanism. The nanowires were grown from circular openings of a SiN_x mask on GaAs (111)B substrate using the selective-area metal-organic vapor phase epitaxy. The opening were defined by electron-beam lithography and wet chemical etching of the SiN_x-layer which was deposited using plasma enhanced chemical vapor deposition. We investigated the growth conditions (III/V-ratio, temperature, pressure, mask-openings, ...) for GaAs-, InAs- and InGaAs-nanowires. At optimized conditions extremely uniform arrays of semiconductor nanowires with diameters down to 50 nm were realized. The nanowires with a growth direction in [111]B direction showed a hexagonal cross-section and (110) facet sidewalls. The nanowires were characterized with cathodo-luminesenz and transmission electron microscopy.

HL 17.38 Mon 16:30 Poster D

Switching the Charge of a Single Mn-Dopant in InAs with the STM in Experiment and Model — •Felix Marczinowski, Focko Meier, Jens Wiebe, and Roland Wiesendanger — Institut für Angewande Physik, Universität Hamburg

We performed low-temperature scanning tunneling microscopy and -spectroscopy on Mn-doped InAs. We looked at (110) surfaces prepared by in-situ cleavage of InAs samples with Mn doping densities of $1*10^{17}cm^{-3}$ and $1*10^{19}cm^{-3}$. We find rings of increased differential conductance surrounding each Mn dopant with bias-voltage dependent diameter. When the ring crosses the acceptor, the well known anisotropic shape of the bound-hole wave function [1] appears in topographs. We take the rings as evidence for a charge-change of the acceptors caused by the tip-induced potential. A very simple Tersoff-Hamann based model, integrating the voltage dependent tip-induced quantum dot and the decharging, was used to accurately reproduce our observations. Our understanding allows interpreting the observed ring shapes as equipotential lines of the tip-induced quantum dot and the ring intensity as a direct measure for the screened Coulomb potential of the charged acceptor.

[1] Marczinowski, F.; Wiebe, J.; Tang, J.-M.; Flatté, M. E.; Meier, F.; Morgenstern, M. & Wiesendanger, R. ,Phys. Rev. Lett. 99, 157202 (2007)

HL 17.39 Mon 16:30 Poster D

Photoluminescence and ultrafast spectroscopy on diffusion barriers between GaAs quantum wells and GaMnAs layer — •R. Schulz, A. Wagner, T. Korn, U. Wurstbauer, D. Schuh, W. Wegscheider, and C. Schüller — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Ger-

many

GaMnAs is a highly interesting material system for future spintronic devices. We present a study of nonmagnetic GaAs quantum wells (QW) embedded in AlGaAs barriers, close to a ferromagnetic GaMnAs layer. The samples were grown on semi-insulating GaAs(001) and contain two QWs, where one QW is close (between 3 and 10 nm) to the GaMnAs layer and the other one is farther away (120 nm), and serves as a reference. We studied the influence of different types and widths of the barrier material (AlGaAs layer and a short-period AlAs/GaAs superlattice) as well as post-growth annealing. The photoluminescence (PL) of the upper quantum wells shows a significant broadening and quenching depending on barrier width. Additionally, time-resolved Faraday rotation (TRFR) reveals that the spin lifetime in the upper QW is up to 50 times longer than that in the lower QW. We attribute these observations to backdiffusion of Mn into the QW during and after growth. Both, the PL and the TRFR, are highly sensitive to small quantities (below 0.05 %) of Mn and allow us to study the efficiency of barrier layers in suppressing Mn diffusion.

We acknowledge support by the DFG via project SCHU1171/1 and SFB 689 TP B4.

HL 17.40 Mon 16:30 Poster D

Test and characterisation of a self-built III-V molecular beam epitaxy system — •Kirill Trunov, Dirk Reuter, and Andreas D. Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätsstr. 150, D-44780 Bochum

A self-built three-chamber III-V molecular beam epitaxy (MBE) system with some non-conventional, low-cost technical and software solutions, such as ball bearing free cell- and window-shutter mechanisms is discussed. The first Si-doped $Al_{1-x}Ga_xAs$/GaAs(100) heterostructures grown by this MBE system exhibit a Hall mobility exceeding 2.0×10^6 cm^2/Vs at 4.2 K after illumination with the corresponding carrier density of about 5.0×10^{11} cm^{-2}. As further example for the performance of the system, first results for the growth of GaAs on Ge(100) substrate are discussed. Financial support from DFG GRK384 is gratefully acknowledged.

HL 17.41 Mon 16:30 Poster D

High mobility GaN based 2DEG heterostructures by MBE — •D. Broxtermann, M. Sivis, A. Bedoya Pinto, J. Malindretos, and A. Rizzi — IV. Physikalisches Institut and Virtual Institute of Spin Electronics (VISel), Georg-August Universität Göttingen, D-37077 Göttingen, Germany

In order to realize spin electronic devices using GaN diluted magnetic semiconductors as spin injectors or detectors, well-matched GaN-based semiconductor heterostructures for spin control are required. The $Al_xGa_{1-x}N/In_yGa_{1-y}N$ heterostrucutures for $x, y = 0...0.2$ are considered here. In our work we first optimize the MBE process of AlGaN/GaN heterostructures on MOCVD GaN templates. Thereby the GaN flux as well as the pretreatment of the substrates have been found to be crucial for good crystal quality. To obtain state of the art high mobility structures, we vary the AlGaN barrier width, the GaN cap layer thickness as well as the Al composition. The electrical properties are analyzed by magneto transport experiments and corresponding calculations of a self-consisting Schrödinger-Poisson solver.

HL 17.42 Mon 16:30 Poster D

Manganese implanted GaAs films — •Danilo Bürger[1], Heidemarie Schmidt[1], Qingyu Xu[1], Andreas Kolitsch[1], Stephan Winnerl[1], Harald Schneider[1], Shengqiang Zhou[1], Kay Potzger[1], Manfred Helm[1], Gisela Biehne[2], and Volker Gottschalch[3] — [1]Forschungszentrum Dresden-Rossendorf e.V., Institut für Ionenstrahlphysik und Materialforschung — [2]Universität Leipzig, Institut für Experimentelle Physik II — [3]Universität Leipzig, Arbeitskreis Halbleiterchemie

Electron spin preservation has been proven in unmagnetic GaAs over several μm by time-resolved luminescence measurements [1]. The synthesis of Mn-alloyed GaAs has introduced a controllable spin degree of freedom in the GaAs device technology. Approx. 1 μm thick n-type (Si) and p-type (Zn) GaAs films have been grown on highly conducting n- and p-GaAs substrates by metalorganic chemical vapour deposition. For magnetotransport measurements reference samples have been grown on insulating substrates. Mn^+ ion beam implantation with 300/150 keV at 200°C yielded a boxlike Mn-implantation profile of the 250 nm thick GaAs surface layer with a nominal implantation dose dependent Mn content of 1 and 6 at%. Rapid thermal annealing has been performed at 650°C for 10 s. Magnetic properties have been investigated by means of SQUID-magnetometry. The relation between concentration of free charge carriers, defect formation and magnetoresistance effects in manganese implanted GaAs will be discussed with respect to theoretically predicted double-exchange mechanisms.

[1] D. Hägele et al., Appl. Phys. Lett. 73, 1580 (1998)

HL 17.43 Mon 16:30 Poster D

Post growth annealing behaviour and carrier concentration of $Ga_{1-x}Mn_xAs$ grown on (001), (311) and (110) GaAs substrates — •Michael Hirmer, Ursula Wustbauer, Dieter Schuh, and Werner Wegscheider — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Germany

We present a detailed study of post-growth annealing experiments of thin $Ga_{1-x}Mn_xAs$ films grown by low temperature molecular beam epitaxy. The films were grown on (001), (311) and (110) semi-insulating GaAs substrates with layer thickness ranging from 5 to 300nm. Since the ferromagnetism of this Zener-like diluted magnetic semiconductor is hole-mediated, the ferromagnetic transition temperature T_C can be increased corresponding to $T_C \propto x_{eff}p^{1/3}$ (x_{eff}: effective Mn concentration, p: carrier density) by post growth annealing. This reduces the Mn-interstitial lattice defects, which act as double donors and couple antiferromagnetically with substitutional Mn, thereby suppressing the ferromagnetism. As a result, we have increased T_C by annealing at about 200°C in air to 167K. To improve the process, we monitored the resistance in situ and identified negative annealing-effects, which were more distinctive with higher As:Ga ratio during growth. The out-diffusion of Mn_I is strongly dependent on growth direction, annealing temperature and the passivation process on the surface. To estimate the Mn_I content and get the enhancement of carrier concentration (p), we calculated p from high magnetic field Hall measurements before and after annealing. The changes in the measurements suggest that the anomalous Hall-effect is not only caused by scattering processes.

HL 17.44 Mon 16:30 Poster D

Growth of InN and InGaN/InN heterostructures for electronic device applications — •Joerg Hisek[1], Heiko Bremers[2], Uwe Rossow[2], Jochen Aderhold[3], Juergen Graul[1], and Andreas Hangleiter[2] — [1]LFI, Leibniz Universitaet Hannover, Schneiderberg 32, 30167 Hannover — [2]IAP, TU Braunschweig, Mendelsohnstr. 2, 38106 Braunschweig — [3]Fraunhofer Wilhelm-Klauditz-Institut, Bienroder Weg 54E, 38108 Braunschweig

As a low-bandgap material, InN has a rather low electron effective mass and may therefore be expected to exhibit quite large electron mobility, making it potentially useful as a channel material for HEMTs or bipolar devices. Due to the difficulties in epitaxial growth of InN and the strong surface electron accumulation, carrier densities found InN layers are still quite large. We have grown InN as well as InGaN/InN heterostructures using RF-MOMBE. On c-plane sapphire 500-1000 nm thick InN layers were grown at about 500° C. InGaN/InN structures were realized by adding a thin InGaN cap layer with up to 10% Ga. By AFM we find a well developed step structure with indications for step bunching with step heights of twice the c-lattice constant. HRXRD show good quality InN with rocking widths as low as 400 arcsec for (0002) and (10-15) reflections. Inclusions of metallic Indium are below 0.2%. Hall-effect data result in electron densities in the high 1018 cm-3 and electron mobility up to 800 cm2/Vs. Preliminary measurements on InGaN/InN structures indicate somewhat higher electron densities at similar mobility. Further investigations are underway to reveal a possible 2D behaviour at the InGaN/InN interface.

HL 17.45 Mon 16:30 Poster D

Influences of growth conditions on surface properties of MBE grown InN films — •Anja Eisenhardt, Marcel Himmerlich, Juergen A. Schaefer, and Stefan Krischok — Institut für Physik and Institut für Mikro- und Nanotechnologien, TU Ilmenau, P.O. Box 100565, 98684 Ilmenau, Germany

We present a study of the InN surface properties investigated in a UHV system (base pressure $< 2\times10^{-10}$ mbar) consisting of a surface analytics chamber directly connected to a molecular beam epitaxy (MBE) chamber. Thin InN films were grown on GaN/Al_2O_3(0001) as well as on GaN/SiC(0001) templates by plasma assisted MBE. The growth was monitored using reflection high energy electron diffraction (RHEED). The dependence of the surface properties (e.g. morphology, stoichiometry and surface electronic structure) on growth conditions was studied using atomic force microscopy as well as X-ray and ultraviolet photo-

electron spectroscopy. For stoichiometric and nitrogen rich conditions, the InN grows in the Stranski-Krastanov mode and 3D transmission spots are observed in the RHEED pattern, while a streaky RHEED pattern induced by residual indium on the surface is found for In rich conditions. Depending on In-flux and template 2×2, 2×1, $\sqrt{3} \times \sqrt{3}$ surface reconstructions were observed. Differences in the core level as well as valence band spectra will be presented and discussed. For nitrogen rich conditions, insertion of excess nitrogen takes place, whereas a shift of all occupied states by 0.3 eV towards E_F was observed after indium rich growth.

HL 17.46 Mon 16:30 Poster D

Temperature and doping dependent photon-recycling in GaInP-GaInAs double heterostructures — •Raymond Hoheisel, Wolfgang Guter, Simon Philipps, Frank Dimroth, and Andreas Bett — Fraunhofer Institut für Solare Energiesysteme, Heidenhofstrasse 2, 79110 Freiburg

The effect of photon recycling in GaInP-GaInAs heterostructures as a function of doping concentration, GaInAs layer thickness, temperature and total excitation intensity is presented. The radiative recombination process is investigated by an activated germanium substrate on which the GaInP-GaInAs heterostructures are grown. The photon recycling signal is measured by the Ge photodiode via spectral response from the upper layers. The experimental data show that the internal quantum efficiency of radiative recombination increases significantly with decreasing temperature. The influence of temperature dependent nonradiative recombination centers affecting the Shockley-Read-Hall (SRH) lifetime and the photon recycling signal is discussed.

HL 17.47 Mon 16:30 Poster D

Minimierung von seriellen Widerstandsverlusten in Solarzellen mit Hilfe von SPICE-Netzwerksimulation — •Marc Steiner, Simon Philipps, Martin Hermle, Frank Dimroth und Andreas Bett — Fraunhofer ISE, Heidenhofstrasse 2, 79110 Freiburg, Deutschland

Der photovoltaisch generierte Strom einer Solarzelle wird über eine kammartige Struktur metallischer Finger eingesammelt. Der Wirkungsgrad von Solarzellen hängt unter konzentriertem Sonnenlicht wesentlich von der Geometrie dieser Kontakte auf der Vorderseite der Solarzelle ab. Bei einer Konzentration von 500 Sonnen entstehen Stromdichten von etwa 15A/cm2. Deshalb ist es wichtig die Geometrie und Verteilung der Metallfinger in Bezug auf die ohmschen Widerstandsverluste zu optimieren ohne dabei zuviel aktive Fläche abzuschatten. Die Solarzelle wurde mit Hilfe des Zweidiodenmodells und einer Netzwerksimulation der SPICE-Familie zur digitalen Berechnung elektrischer Schaltkreise modelliert. Die Simulation wurde anhand gemessener Materialparameter (Dunkelströme, spez. Widerstände) parametrisiert und die Ergebnisse wurden mit Messdaten von speziell hierfür hergestellten Testzellen validiert. Der Verlauf der wichtigsten Solarzellenkenngrößen wie Wirkungsgrad und Füllfaktor gegenüber der Konzentration wurde durch das Modell gut wiedergegeben. Physikalische Effekte wie der nicht passivierte Solarzellenrand wurden durch zusätzliche Randdioden reproduziert, um auch die optimale Solarzellengröße ermitteln zu können. Die Methodik der Netzwerksimulation, sowie ein Vergleich von experimentellen und gerechneten Daten, werden vorgestellt.

HL 17.48 Mon 16:30 Poster D

Doping Concentration Measurement by Spatially Resolved Spin Noise Spectroscopy — •Michael Römer, Jens Hübner, and Michael Oestreich — Institute for Solid State Physics, Gottfried Wilhelm Leibniz University of Hannover, Appelstr. 2, 30167 Hannover, Germany

We introduce spin noise spectroscopy as an optical method to spatially resolve the impurity concentration in n-doped, direct gap semiconductors [1, 2]. The technique is contact free and allows for a lateral resolution of about one micrometer and a depth resolution better than 50 micrometers.

We demonstrate the depth resolution in a proof of concept experiment using a 700 μm n-doped GaAs stack with two different doping concentrations. The spin noise spectrum is measured by below band-gap Faraday-rotation at low temperatures with a high frequency spectrum analysis technique. Additionally, measurements at higher temperatures and further optimizations of the detection setup will be discussed.

[1] M. Oestreich, M. Römer, R. Haug, and D. Hägele, "Spin Noise Spectroscopy in GaAs", Phys. Rev. Lett. **95**, 216603 (2005). [2] M. Römer, J. Hübner and M. Oestreich "Spin Noise Spectroscopy in Semiconductors", Rev. Sci. Instrum. **78**, 103903 (2007).

HL 17.49 Mon 16:30 Poster D

Optical investigation of doped and undoped AlN layers — •Günther M. Prinz[1], Ingo Tischer[1], Martin Schirra[1], Martin Feneberg[1], Sarad B. Thapa[2], Ferdinand Scholz[2], Yoshitaka Taniyasu[3], Makoto Kasu[3], Rolf Sauer[1], and Klaus Thonke[1] — [1]Institut für Halbleiterphysik, Universität Ulm, D-89069 Ulm — [2]Institut für Optoelektronik, Universität Ulm, D-89069 Ulm — [3]NTT Basic Research Laboritories, NTT Corporation, 3-1 Morinosato-Wakamiya, Atsugi, 243-0198, Japan

Aluminum nitride (AlN) represents the upper end of the technologically interesting ternary alloy system AlGaN with an ultra-wide direct band gap of approximately 6.1 eV at liquid helium temperature. Here doped and undoped AlN layers on sapphire and SiC were investigated by means of cathodoluminescence and Raman spectroscopy. All layers show intense near-band edge luminescence at approx. 6eV. This luminescence shifts down as a function of the Si doping concentration but is independent for growth on the two different substrates or for different growth temperatures. Concomitantly, the E_2^{high}-Raman mode shifts to lower wave numbers, indicating tensile strain in the doped AlN layers. Correlating these results quantitatively we show that the near-band edge luminescence shift is exclusively due to tensile strain and is not a result of a reduced band gap through high doping concentrations as suggested in literature.

HL 17.50 Mon 16:30 Poster D

High temperature electron spin relaxation in bulk GaAs — •Stefan Oertel, Jens Hübner, and Michael Oestreich — Universität Hannover, Institut für Festkörperphysik, Abteilung Nanostrukturen, Appelstr. 2, 30167 Hannover

The electron spin relaxation in weakly n-doped bulk GaAs in the temperature range from 300K to 450K is determined by time and polarization resolved photoluminiscence spectroscopy with a synchroscan streakcamera. The spin relaxation is dominated by the D'yakonov-Perel' relaxation mechanism in this temperature regime, leading to spin relaxation times between 60 and 10 ps. The influence of faster electron momentum scattering becomes explicitly apparent by examining the dependency of the spin relaxation time on the excitation density. The density dependency is studied by directly mapping the spatial density profile of the photoluminiscence on the streakcamera.

HL 17.51 Mon 16:30 Poster D

Optical gain in Ga(NAsP) quantum wells using the variable stripe-length method — •Daniel Franzbach, Christoph Lange, Michael Schwalm, Sangam Chatterjee, Bernadette Kunert, Kerstin Volz, Wolfgang Stolz, and Wolfgang Rühle — Faculty of Physics and Materials Sciences Center, Philipps-Universität Marburg

A series of Ga(NAsP) quantum well samples grown by MOVPE on a GaP substrate with varying concentrations of N and As is measured using the variable stripe-length method.

A Nd:YAG laser is used for excitation. The beam is widened to 4cm, clipped to a rectangular shape and focussed onto the sample. A cylindrical lens allows for exciting a stripe-shaped region, whose length is controlled with two slit apertures. Amplified spontaneous emission is collected from the facet of the sample. By varying the length of the stripe, the gain can be determined.

Both the absorptive regime and spectral regions with optical gain are covered. Different excitation conditions are studied, and gain up to 20/cm is observed. The dependence of the gain maximum on the material composition is determined.

HL 17.52 Mon 16:30 Poster D

Temporal evolution of gain and carrier dynamics of (GaIn)As/(GaIn)(NAs) heterostructures — •Niko Köster[1], Christoph Lange[1], Sangam Chatterjee[1], Angela Thränhardt[1], Bernadette Kunert[1], Kerstin Volz[1], Wolfgang Stolz[1], Stephan Koch[1], Wolfgang Rühle[1], Galina Khitrova[2], Hyatt Gibbs[2], and Lutz Geelhaar[3] — [1]Faculty of Physics and Materials Sciences Center, Philipps-Universität Marburg — [2]College of Optical Sciences, The University of Arizona, 1630 E University Blvd, Tucson, Arizona 85721 USA — [3]Infineon Technologies, München, Germany

We present gain measurements of III-V semiconductor samples, both highly temporarily and spectrally resolved. The pump-probe Ti:Sapphire amplifier-driven setup features high excitation densities,

a temporal resolution of below 200fs and a white-light supercontinuum probe. The latter, in combination with a spectrometer with a (GaIn)As photo-diode array, allows for the spectral resolution within one experimental run. The experimental spectra are compared with calculations based on a microscopic theory, which requires no free fit parameters. The good agreement underlines the predictive capability of the theory. Gain up to gL = 0.002 for (GaIn)As and gL = 0.003 for (GaIn)(NAs) per quantum well is observed, as well as numerous effects related to carrier dynamics such as feeding and hot carrier relaxation.

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Einfluss der Schichtdicke von GaMnAs auf die Curietemperatur und die Magnetotransporteigenschaften — •Matthias Schmidt, Florian Adler, Andrea Stemmann, Christian Heyn und Wolfgang Hansen — für Angewandte Physik und Zentrum für Mikrostruktuforschung, Hamburg, Deutschland

Wir untersuchen die Curietemperatur und Transporteigenschaften von GaMnAs-Schichten. Spezielles Augenmerk liegt hier auf dem Einfluss der Schichtdicke, welche über zwei Methoden variiert wird. Erstens wurden Schichten unterschiedlicher Dicke mittels Molekularstrahlepitaxie gewachsen. Da die Wachstumsbedingungen einen starken Einfluss auf die Probeneigenschaften bezüglich Transport und Curietemperatur haben, sind alle Proben unter gleichen Wachstumsbedingungen entstanden. Die zweite Methode zur Variation der Schichtdicke besteht im nachträglichen Dünnen durch Ätzen. Dazu wird mit Hilfe einer Ätzlösung aus Wasser, Phosphorsäure und Wasserstoffperoxyd bei der Probe mit der dicksten GaMnAs-Schicht die Schichtdicke reduziert. Wir finden unterschiedliches Verhalten von GaMnAs-Proben vergleichbarer Schichtdicken, die entweder MBE gewachsen oder nachträglich verdünnt wurden.