HL 44: Poster Session I

Time: Tuesday 18:00–21:00 Location: P3

HL 44.1 Tue 18:00 P3

Antiferromagnetic semiconductor LiMnAs — Vit Novak[1], Tomas Jungwirth[1], Miroslav Cukr[1], •Stepan Svoboda[1,2], Zbynek Soban[1,3], Xavier Marti[2], Vaclav Holy[2], Petra Horodyska[2], and Petr Nemec[2] — [1]Institute of Physics AS CR, Cukrovarnicka 10, Praha, Czech Republic — [2]Charles University, Ke Karlovu 5, Praha, Czech Republic — [3]Czech Technical University, Technicka 2, Praha, Czech Republic

LiMnAs belongs to the theoretically predicted class of I-Mn-V semiconductors with the antiferromagnetic ordering of Mn atoms. We report its first successful preparation in form of a thin film by molecular beam epitaxy. Structural properties of the material were examined in-situ by RHEED, and ex-situ by XPS and XRD, confirming the tetragonal crystal structure with its [100] direction oriented along the [110] direction of the InAs substrate. Transparency of LiMnAs in the spectral range of 870 to 1400 nm confirms the existence of an optical gap and indicates the band-gap energy above 1.4 eV. Magnetic properties measured by SQUID magnetometry show nearly compensated net magnetic moment in temperatures up to 400 K and magnetic fields up to 7 T, in a clear contrast to the ferromagnetic character of MnAs or to the paramagnetic behavior of the same amount of uncoupled Mn atoms.

HL 44.2 Tue 18:00 P3

Electric field induced transition phenomena in phase change materials — •Martin Wimmer, Gunnar Bruns, Philipp Merkelbach, Carl Schlockermann, Martin Salinga, and Matthias Wuttig — I. Physikalisches Institut (IA), RWTH Aachen University

Phase change materials have already been successfully applied in rewriteable optical media like DVD-RW and Blu-ray RW. Prototypes of electrical storage devices based on phase change memories provide key features like non-volatility and ultrafast read and write speeds. The information is stored by the distinct difference of optical or electrical properties between the amorphous and crystalline structure.

The electrical switching behaviour of GeSbTe-based phase change memory devices needs to be investigated. The phenomenon of threshold-switching, a sudden drop in resistivity in the picosecond timescale at high electric fields, is important for applications, in particular if high data transfer rates are required. To investigate very fast switching events, a high frequency optimised setup for electrical testing has been established. Time resolved measurements on the picosecond timescale during the switching process are performed, which provide detailed knowledge of the electronic switching mechanism.

HL 44.3 Tue 18:00 P3

Drift in amorphous phase change materials — •Rüdiger M. Schmidt, Gunnar Bruns, Jennifer Luckas, Carl Schlockermann, Martin Salinga, and Matthias Wuttig — I. Physikalisches Institut (IA), RWTH Aachen University

While phase change materials have been successfully applied in rewriteable data storage, they are also used for novel non-volatile electronic data storage devices. The material has the ability to be switched within nanoseconds between the two phases, which show a large optical and electrical contrast. The low resistive crystalline phase is associated with a logic zero state and the high resistive amorphous phase with a logic one state.

While the resistance of the crystalline phase does not change over time, the amorphous phase shows a resistance drift with time and temperature. This drift needs to be understood, especially in order to increase the storage density by employing multi level storage. To gain a deeper insight into the temperature and time dependant drift phenomena, a custom made setup was designed. The setup can perform measurements of sheet resistances up to 100 GΩ in a temperature range from 300 K to 625 K and has a temperature stability of 0.01 K. Our results show that drift is correlated to the activation energy and the number of bond-bending and bond-stretching constraints.

HL 44.4 Tue 18:00 P3

Black silicon with femtosecond double laser pulses — •Anna Lena Baumann[1], Thomas Gimpel[2], Kay-Michael Günther[2], Christian Lehmann[3], Augustinas Ruibys[1], Stefan Kontermann[1], and Wolfgang Schade[1,2] — [1]Fraunhofer Heinrich-Hertz-Institute, Am Stollen 19, 38640 Goslar — [2]Clausthal University of Technology, EFZN, EnergieCampus, Am Stollen 19, 38640 Goslar — [3]FU Berlin, Fachbereich für Physik, Arnimallee 14, 14195 Berlin

We investigate the influence of double femtosecond laser pulses on topology, absorption, series and shunt resistance of p-doped silicon in 500 Torr SF_6. A Michelson interferometer splits the laser pulses into pairs. The topology of p-doped silicon processed with laser pulse pairs at delay times from $\Delta t = 16$ fs to 30000 fs is different from single pulse black silicon, but similar for all delay times greater $\Delta t = 0$ fs. We process samples with 5 and 500 laser pulses per spot at delay times $\Delta t = 50$ fs and $\Delta t = 100$ fs. Optical characterization reveals the absorption characteristics in the visible and near-infrared range. We metalize the samples with an indium front and an aluminum back contact and measure series and shunt resistance. Overall absorption is greater for 500 pulse samples. In the visible range 5 pulse samples at $\Delta t = 50$ fs have slightly higher absorption. In the near-infrared both 5 and 500 pulse samples at $\Delta t = 100$ fs exhibit higher absorption values, with a difference greater 10% for the 5 pulse samples. All samples feature similar series and shunt resistance for the two delay times, while all 5 pulse samples display increased shunt resistance values.

HL 44.5 Tue 18:00 P3

Visibility of graphene on gadolinium and dysprosium oxide thin films — •I. Petrov[1], T. Toader[1], C. Bock[1], U. Kunze[1], A. Milanov[2], A. Devi[2], R. A. Fischer[2], L. Thekkekara[3], D. A. Schmidt[3], and M. Havenith[3] — [1]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum — [2]Anorganische Chemie II, Ruhr-Universität Bochum — [3]Physikalische Chemie II, Ruhr-Universität Bochum

In this work we study the visibility of monolayer graphene exfoliated on gadolinium (Gd_2O_3) and dysprosium oxide (Dy_2O_3), respectively. The rare earth oxides are deposited by thermal chemical vapour deposition on top of a highly n-doped silicon substrate. Due to the higher dielectric constant of the rare earth oxides ($\epsilon_r \approx 8-9$) compared to SiO_2 ($\epsilon_r = 3.9$), we expect an improved screening of charged impurities [1] for graphene-based devices and therefore an enhanced charge carrier mobility. In order to identify the monolayer graphene on the rare earth oxides we calculated the contrast as a function of the wavelength for different oxide thicknesses using a Fresnel-law-based model [2]. The thickness of the flakes is measured by atomic force microscopy while the contrast of the flakes for several wavelengths is determined by optical microscopy. Finally, Raman spectroscopy was performed to verify the exact thickness of the graphene flake. The calculated contrast values are in good agreement with the experimental data, proving optical microscopy is reliable identification tool for monolayer graphene.

[1] S. V. Morozov, *et al.*, Phys. Rev. Lett. **100**, 016602 (2008).
[2] P. Blake, *et al.*, Appl. Phys. Lett. **91**, 063124 (2007).

HL 44.6 Tue 18:00 P3

Ab initio study of the phase-change magnetic material — Yan Li and •Riccardo Mazzarello — RWTH Aachen, Aachen, Germany

Phase-change materials based on chalcogenide alloys are of great technological importance due to their ability to undergo reversible and fast transitions between the amorphous and crystalline phases upon heating. This property, together with the strong optical and electronic contrast between the two phases, is exploited in rewritable optical discs (CDs, DVDs, Blu-Rays discs) and prototype non-volatile memories. Up to now, very few works have addressed the properties of chalcogenide phase change materials doped with magnetic impurities. In [1] it was shown that Ge_2Sb_2Te_5 doped with Fe exhibits phase-change behavior for not too large concentrations of Fe and that both the amorphous and the crystalline phases are ferromagnetic at low enough temperatures. Moreover, the two phases were found to have different ferromagnetic properties. However, very little is known about how magnetic impurities affect the atomic-scale mechanisms of the phase transition in these systems and also about the relationship between magnetism and structural properties. To shed light on these issues, we have investigated the structural, electronic and magnetic properties of amorphous and crystalline Ge_2Sb_2Te_5 doped with magnetic impurities from first principles. Models of the amorphous phases were generated by quenching from the melt by means of ab-

initio molecular dynamics simulations. [1] W. Song, L. Shi, X. Miao and C. Chong, Adv. Mater. 20, 2394 (2008)

HL 44.7 Tue 18:00 P3

Optical Transitions in the Charged NV^--Center in Diamond — •Florian Hilser and Guido Burkard — University of Konstanz

The electronic configuration of the NV^--center in diamond is well known from spectroscopic data and the electronic states are established theoretically by linear combination of sp^3-hybridized dangling bonds forming p-like orbitals [1]. Spin-orbit interaction and strain lead to orbital symmetry-breaking and the degeneracy of the electronic states is lifted. The ordering of energy levels is determined using group theoretical considerations [2]. Furthermore the energies of the degenerate spin-triplet-states can be split by applying a magnetic field. We determine the electric dipole matrix elements for optical excitation and derive an effective Hamiltonian for optically induced spin-flip transitions.

[1] A. Lenef, S. Rand, Phys. Rev. B **53**, 13441 (1996).
[2] J. R. Maze, A. Gali, arXiv 1010.1338v1.

HL 44.8 Tue 18:00 P3

Dynamische Separation von Kohlenstoffnanoröhren — •Frieder Ostermaier, Juliane Posseckardt und Michael Mertig — TU Dresden, Professur für Physikalische Chemie, Mess- und Sensortechnik, 01062 Dresden, Germany

Einwandige Kohlenstoffnanoröhren (SWCNT) haben aufgrund ihrer besonderen elektronischen Eigenschaften großes Potenzial als Bausteine einer zukünftigen nanoskaligen Elektronik. Metallische mSWCNT sind dabei als Leiterbahnen geeignet und halbleitende scSWCNT können zur Herstellung von Feldeffekttransistoren verwendet werden. Für diese Anwendungen ist es erforderlich, SWCNT mit definierten elektronischen Eigenschaften zur Verfügung zu stellen. Bisher gibt es allerdings noch kein Herstellungsverfahren, das nur mSWCNT oder nur scSWCNT produziert. Deshalb ist eine Sortierung der SWCNT für technische Anwendungen unbedingt erforderlich. Mit bekannten Batch-Verfahren, wie der Dichtegradienten-Ultrazentrifugation, können nur geringe Mengen sortierter SWCNT hergestellt werden.

Wir haben deshalb die kontinuierliche Sortierung von SWCNT durch Dielektrophorese (DEP) in einem mikrofluidischen Kanal untersucht. Dabei wird eine quer zur Strömung gerichtete DEP-Kraft genutzt, die oberhalb einer Grenzfrequenz für mSWCNT und scSWCNT ein unterschiedliches Vorzeichen besitzt.

Zur Dispergierung der SWCNT wurde Sodiumcholat und das organische Lösungsmittel *N*-Methyl-2-pyrrolidon verwendet. Letzteres ermöglicht die Sortierung bei sehr viel kleineren Frequenzen. Zur Analyse der sortierten Dispersionen wurde UV/VIS-Spektroskopie verwendet.

HL 44.9 Tue 18:00 P3

Phonon dynamics in graphite observed with time-resolved terahertz spectroscopy — •Martin Scheuch[1,2], Konrad von Volkmann[1,3], Luca Perfetti[4], Tobias Kampfrath[2], Christian Frischkorn[1,2], and Martin Wolf[2] — [1]Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin — [2]Fritz-Haber-Institut der MPG, Faradayweg 4-6, 14195 Berlin — [3]APE GmbH Plauener Str. 163-165 Haus N, 13053 Berlin — [4]Laboratoire des Solides Irradiés, Ecole polytechnique, 91128 Palaiseau cedex, France

Time-resolved terahertz spectroscopy in the range from 10 to 30 THz is used to monitor the relaxation of highly oriented pyrolytic graphite (HOPG) that has been excited by a laser pulse (wavelength 790 nm, duration 10 fs). The measured pump-induced changes in the complex dielectric function $\Delta\varepsilon(\omega)$ show that most of the electron excess energy is transferred to few strongly coupled optical phonon modes (SCOPs) on a sub-picosecond timescale. Cooling of the hot SCOPs occurs on a picosecond time scale [1]. Temperature-dependent measurements of the SCOP lifetimes in the range from 10 to 300 K were performed to identify the decay into A_1' and E_{2g} phonons. The results are in agreement with theoretical predictions [2] and show that the A_1' mode at the K point provides the dominant relaxation channel. Additional measurements on naturally grown graphite show no differences to HOPG.

[1] T. Kampfrath *et al.*, Phys. Rev. Lett. **95**, 187403 (2005); [2] N. Bonini *et al.*, Phys. Rev. Lett. **99**, 176802 (2007)

HL 44.10 Tue 18:00 P3

Controlling exciton decay in semiconducting carbon nanotubes by surface acoustic waves — Markus Regler[1,2], Hubert J. Krenner[2], Alexander A. Green[3], Mark C. Hersam[3], Achim Wixforth[2], and •Achim Hartschuh[1] — [1]Department Chemie & CeNS, Ludwig Maximilians Universität München, Germay — [2]Department Physik, Universität Augsburg, Germany — [3]Department of Materials Science and Engineering, Northwestern University, Evanston, Illinois, USA

Single-walled carbon nanotubes (SWNTs) are quasi-1 dimensional direct-bandgap materials with unique properties making them promising candidates for a variety of technological applications including photonics, optoelectronics and sensing. The excited states of semiconducting SWNTs are formed by strongly bound luminescent excitons that can be populated either by light absorption or electrically [1]

We show that the decay dynamics of excitons in SWNTs can be controlled by surface acoustic waves (SAWs) launched in piezoelectric substrates. The photoluminescence (PL) intensity of nanotube films deposited on LiNbO3 was found to be reduced by up to 40% depending on the SAW amplitude. Time-resolved PL measurements reveal that the intensity reduction is caused by a SAW-induced decrease of the radiative exciton recombination rate that results from the electric fields associated with the SAW.

[1] P. Avouris, M. Freitag, V. Perebeinos, Nature Photon. 2, 341 (2008)

HL 44.11 Tue 18:00 P3

Magnetotransport Studies of Graphene on GaAs — •Nils Gayer, Karen Peters, Alina Tittel, Andreas Graf, Vera Paulava, Ursula Wurstbauer, and Wolfgang Hansen — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Germany

We study graphene on GaAs substrates, the preferred material for ultrafast and optical device applications. With temperature dependent magnetotransport measurements the influence of the GaAs substrates on the properties of graphene is investigated. Our substrates contain a Si-doped GaAs backgate grown by means of molecular beam epitaxy. The investigated graphene flakes were prepared by mechanical cleavage of natural graphite. Due to the very low contrast of graphene on GaAs, we established a method to enhance the visibility of graphene that facilitates the detection of graphene on this substrate using optical microscopy. For this purpose, the prepared graphene samples are spin-coated with PMMA e-beam resists of optimized layer thickness. We demonstrate that it is possible to determine the number of layers of graphene on GaAs even through the PMMA resist layer using Raman spectroscopy. We discuss our findings as well as according calculations of the contrast of graphene on GaAs as a function of the wavelength of the incident light and the PMMA layer thickness.

HL 44.12 Tue 18:00 P3

Micromechanical sensor for magnetization studies on few layer graphene — •Amadeus K. Mlynarski[1], Paul Berberich[1], Matthias Brasse[1], Karthik Sridhara[1], Benedikt Rupprecht[1], Stefanie Heydrich[2], Marc A. Wilde[1], and Dirk Grundler[1] — [1]Lehrstuhl für Physik funktionaler Schichtsysteme, Technische Universität München, Physik Department, James-Franck-Str. 1, D-85747 Garching b. München, Germany — [2]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg

Graphene is a strictly two-dimensional material exhibiting novel electronic properties due to its peculiar band structure. For graphene, magnetic edge states, a diverging magnetic susceptibility around the charge neutrality point and an unconventional de Haas - van Alphen effect have been predicted. Measuring the magnetization $M = -\partial U/\partial B$ for a temperature T→0 yields direct access to the ground state energy U of the charge carriers in graphene. Thermodynamic energy gaps in the density of states between neighboring Landau levels can be measured directly.

We intend to measure M of chemical-vapor-deposited few layer graphene (FLG) down to 300 mK and high magnetic fields up to 16 T. The FLG is characterized using magnetotransport measurements prior to the magnetization experiments. A specially designed micromechanical sensor is fabricated to allow for high sensitive magnetization measurements.

We thank the DFG for financial support in the SPP1459 grant no. WI3320/1-1.

HL 44.13 Tue 18:00 P3

Spin orbit mediated entanglement in graphene — •Alexander Lopez[1,2] and John Schliemann[1] — [1]Institute for Theoretical Physics, University of Regensburg, D-93040 Regensburg, Germany — [2]Centro de Fisica, Instituto Venezolano de Investigaciones Cientificas, Apartado 21874, Caracas 1020-A, Venezuela

We analyze the Spin-Orbit mediated two and three qubit entanglement production in single layer graphene. We found the striking result that, within experimentally feasible parameter values, it is possible to thermally increase the two qubit quantum concurrence, even near room temperature. We also find a cooperative effect resulting from the interplay of scattering and SO coupling. The experimental and technologically relevant implementations are further discussed.

HL 44.14 Tue 18:00 P3

Crystallographically Anisotropic Etching of Graphene — •Florian Oberhuber, Dieter Weiss, and Jonathan Eroms — Institute for Experimental and Applied Physics, University of Regensburg

We report crystallographically anisotropic carbothermal etching of graphene on SiO_2 substrates in an argon gas flow at atmospheric pressure. The samples were prepatterned with antidot lattices by electron beam lithography and reactive ion etching. The hexagonal form of the antidots obtained by the carbothermal reaction suggests the absence of armchair edges [1]. We studied the dependence of the etching rate on the number of graphene layers.

Furthermore we conducted electron transport measurements on a set of single- and bilayer samples patterned by lattices of hexagonal antidots. From temperature dependent investigation of the clearly resolved weak localization peak we deduce the phase coherence length as well as lengths for inter- and intravalley scattering.

[1] P. Nemes-Incze et al., Nano Res. **3**, 110 (2010)

HL 44.15 Tue 18:00 P3

Fabrication of top gates with ALD deposited Al_2O_3 on graphene structures — •Franz-Xaver Schrettenbrunner, Dieter Weiss, and Jonathan Eroms — Institut für Experimentelle und Angewandte Physik, Universtität Regensburg, 93040 Regensburg

We report the fabrication and transport measurements of top gated graphene devices. The insulating Al_2O_3 top gate was realized using atomic layer deposition. Usually, a seed layer (e.g. oxidized aluminum, NO_2/TMA process, etc.) has to be grown in order to achieve uniform oxide layers with low impurities. Previously, we have shown that a 100°C TMA/H_2O-process with low purge times of five seconds creates a stable top gate dielectric on graphene resulting in strong n-doping of the sample (impurity carrier density: $n_{\mathrm{ind}} = 5.2 \cdot 10^{12}\mathrm{cm}^{-2}$). Now this process was improved by growing 10nm Al_2O_3 at 100°C as a seed layer on which further material was deposited while heating the ALD reaction chamber up to 225°C. This "in-situ" annealing step forms a stable gate dielectric on our graphene structures with impurity carrier density $n_{\mathrm{ind}} = 3.6 \cdot 10^{11}\mathrm{cm}^{-2}$.

HL 44.16 Tue 18:00 P3

Paramagnetic surface-states in μc-3C-SiC as efficient acceptor in solar cells — •Andre Konopka, Siegmund Greulich-Weber, Uwe Gerstmann, Eva Rauls, and Wolf Gero Schmidt — Physics, University of Paderborn, Paderborn, Germany

Microcrystalline silicon carbide (μc-SiC) have become an attractive new class of advanced microstructured materials for heterojunction photovoltaic (PV) devices due to their wide band gap and lower absorption in the visible region while retaining their higher conductivity. We use a sol-gel process for growing μc-SiC with sizes up to several 100 μm allowing arbitrary doping. The initial material is insulating, indicating that the resulting sol-gel SiC is almost free from usually unavoidable nitrogen donors. As an analytic tool for the control of doping success we used electron paramagnetic resonance (EPR). The spectra obtained are clearly different from those known for usual shallow donors and acceptors in bulk SiC. Obviously, in microcrystals at least some of the defects seen by EPR are no longer bulk-like, but are surface-related. PV measurements support our finding that the required acceptor behavior of μc-SiC is caused by surface-related defects in combination with an appropriate position of the fermi level, which is determined by donor or acceptor doping. Based on this knowledge, the microscopic structure of the responsible defect structure at the clean surface of the microcrystallites is discussed with the help of total energy calculations in the framework of density functional theory. For possible dangling-bond related structures the elements of the electronic g-tensor are calculated and compared with the experimental values.

HL 44.17 Tue 18:00 P3

Stoichiometric defects in silicon carbide — •Guido Roma[1], Ting Liao[2], and Olga Natalia Bedoya-Martínez[1] — [1]CEA-Service de Recherches de Métallurgie Physique, Saclay, France — [2]Institute of Metal Research, Shenyang, China

Defect structures showing odd-membered rings are known features of several tetrahedral semiconductors as well as carbon nanostructures; examples of them are bond defects in crystalline and amorphous silicon, Stone-Wales defects in fullerenes and carbon nanotubes, and the core structure of partial dislocations in some tetrahedral semiconductors. We investigate, using Density Functional Theory, two types of stoichiometry-conserving defects, which we call SCD and antiSCD and which are metastable structures presenting five- and seven-membered rings, both in the cubic and in the hexagonal 4H-SiC polytypes. We also investigate the annealing properties of the two mentioned variants and find that one of them (SCD) easily disappears, turning back to a normal site, while the other (antiSCD) transforms to an antisite pair, overcoming a barrier of 0.21 eV. The very short lifetimes at ambient conditions explain why those defects have not been observed up to now, but they suggest they should be observable at very low temperature and we provide local vibrational modes to facilitate their identification.

HL 44.18 Tue 18:00 P3

Spin Noise Spectroscopy and Selection Rules in Highly Purified ^{28}Silicon — •Nils Scharnhorst[1], Georg Müller[1], Helge Riemann[2], Jens Hübner[1], and Michael Oestreich[1] — [1]Institute for Solid State Physics, Leibniz Universität Hannover, Appelstr. 2, D-30167 Hannover, Germany — [2]Institut für Kristallzüchtung, Max-Born-Str. 2, D-12489 Berlin, Germany

We present our most recent experimental setup and results in qualifying the spin-lifetime and spin-selection rules of donor-bound and free electrons in highly purified ^{28}Silicon and natural silicon. Isotopically pure ^{28}Silicon is promising very long spin-coherence times due the missing inhomogeneous spin decoherence via nuclear hyperfine-interaction. The fragile measurements on localized spins in ^{28}Silicon will be realized by spin-noise spectroscopy based upon weakly interaction off-resonant Faraday-rotation [1] while spin selective pump-probe measurements yield the spin selection rules at the Δ-band minimum in natural, slightly n-doped silicon.

[1] G. M. Müller, M. Oestreich, M. Römer, and J. Hübner, Semiconductor spin noise spectroscopy: Fundamentals, accomplishments, and challenges, Physica E **43**, 569 (2010).

HL 44.19 Tue 18:00 P3

Structural and electronic properties of silicon polymorphs — •Tobias Sander, Claudia Rödl, Kaori Seino, and Friedhelm Bechstedt — Institut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany

Currently, silicon has been assigned to 12 different high pressure phases from which two are still undetermined in their atomic geometries. Due to the occurrence of complex structures and metastable phases, a complete investigation of structural or even electronic properties has not been completed yet. The possible chance to find crystalline Si structures that may be applicable in photovoltaic devices has enforced the interest in a detailed investigation. Since it is little known about the atomic distributions, we performed ground-state calculations for three distinct exchange and correlation functionals (LDA, PBE, AM05) to obtain parameters like lattice constants, bulk moduli, or cohesive energies. Reflecting structural properties for semiconducting structures best, the AM05 functional has been used to investigate electronic properties such as band gaps, band offsets, and density of states (DOS). From that we classify four polymorphs to be semiconducting, including Si-XIII which has not been observed experimentally yet. We also investigated quasiparticle band structures within the *GW* method and compare band gap results from AM05+*GW* and HSE03+*GW* calculations. Finally, the results are completed by optical absorption spectra.

HL 44.20 Tue 18:00 P3

Investigation of the direct bandgap-emission of highly doped strained germanium layers — •Michael J. Drexler[1], Niko S. Köster[1], Kolja Kolata[1], Giovanni Isella[2], Daniel Chrastina[2], Hans von Känel[2], Hans Sigg[3], and Sangam Chatterjee[1] — [1]Faculty of Physics and Material Sciences Center, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany — [2]Dipartimento di Fisica del Politecnico di Milano, Polo di Como, via Anzani 42, I-22100 Como, Italy — [3]Labor für Micro- und Nanotechnologie, Paul Scherrer Institut, Schweiz

One of the key components of Si photonics is an all integrated laser light source emitting in the C-band at 1550 nm. A promising approach is using highly doped tensile strained germanium. Optical gain in this

material system has been shown [1]. We processed structures with several cavity lengths to investigate the edge- emitted light from the direct band-gap transitions. The system is pumped with a Q-switched laser at 1054nm with 70 ns pulses and the emitted light is spectrally resolved with a double monochromator and detected with a liquid nitrogen cooled Ge-detector.

[1] J. Liu et al, Opt. Lett. 34 (11), p. 1738-40, 2009

HL 44.21 Tue 18:00 P3

Giant dynamical Stark shift in germanium quantum wells — •Ronja Woscholski[1], Niko Steffen Köster[1], Kolja Kolata[1], Christoph Lange[1,3], Giovanni Isella[2], Daniel Chrastina[2], Hans von Känel[2], and Sangam Chatterjee[1] — [1]Faculty of Physics and Material Sciences Center, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany — [2]Dipartimento di Fisica del Politecnico di Milano, Polo di Como, via Anzani 42, I-22100 Como, Italy — [3]present address: University of Toronto, Department of Physics, 60 St. George St., Toronto ON, M5S 1A7, Canada

One of the goals in semiconductor research is to realize the necessary components for silicon photonics, like detectors, emitters, and modulators. Here, we show the potential of Ge/SiGe quantum well structures to work as optical modulators. We investigate the dynamical Stark effect by using polarization-resolved ultrafast pump and white-light probe spectroscopy. This method offers insight on both the modulation bandwidth and the switching speeds achievable in this material system. A strong blue shift of more than 150meV is found for a sample temperature of 10K, which exceeds the values typically for III-V materials. The experimental results are in good agreement with the dressed exciton model. We conclude that the ultrafast coherent dynamics are mainly governed by the direct transition; the indirect minima play only a minor role.

HL 44.22 Tue 18:00 P3

Structural modification of SHI irradiated amorphous Ge layers — •Tobias Steinbach[1], Claudia S. Schnohr[1], Leandro L. Araujo[2], Raquel Giulian[2], David J. Sprouster[2], Mark C. Ridgway[2], Daniel Severin[3], Markus Bender[3], Christina Trautmann[3], and Werner Wesch[1] — [1]Institute of Solid State Physics, Friedrich Schiller University Jena — [2]Department of Electronic Materials Engineering, Australian National University, Canberra — [3]GSI Helmholtz Centre for Heavy Ion Research GmbH

During SHI irradiation of amorphous Ge a strong volume expansion of the amorphous layer accompanied by an enhanced plastic flow process was observed. To study the effect of high electronic energy deposition ϵ_e on a-Ge layers in more detail samples were irradiated at RT and LT with Au-ions having high energies in the range of several hundred MeV. In order to quantify the swelling of the sample one half was masked to distinguish the irradiated from the unirradiated reference. We demonstrate for all used irradiation conditions that a strong swelling of the irradiated areas can be observed, which depends linearly on the ion fluence as well as on ϵ_e. XSEM revealed the transformation of the a-Ge layer into a porous structure with irregularly shaped voids thus establishing that swelling was a consequence of void formation. Moreover, an electronic energy deposition threshold has been estimated, at which the swelling, i.e. the formation of voids, begins. Furthermore, we report on the early stages of void formation in a-Ge by means of SAXS and TEM investigations, which demonstrates that voids are formed due to the imperfect resolidification of molten ion tracks.

HL 44.23 Tue 18:00 P3

Electronic structure of III-V hexagonal polytypes — •Christian Panse and Friedhelm Bechstedt — Institut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität Jena, Germany

Semiconducting nanowires (NW) are of great interest due to their potential in electronic and optoelectronic applications. With increasing success on the control over the crystal structure in the last years it became possible to grow pure layers of zinc blende (ZB/3C), wurtzite (WZ/2H) and also small segments of the hexagonal 4H polytype. As this offers a new degree of freedom for NW device design, investigations of the electronic properties of different hexagonal polytypes are needed for the design of polytypic superlattice nanowire devices.

We perform *ab-initio* calculations within the density functional theory (DFT) and discuss the results on the electronic and optical properties of III-V compounds (GaAs, InAs, InP, InSb) with respect to the different WZ/ZB stacking sequences. The bulk phases of different polytype structures (3C, 2H, 4H, 6H) are especially studied. The electronic properties are calculated versus the hexagonality of the polytypes using the LDA-1/2 method, even including spin-orbit coupling, which leads to quasiparticle band structures but with the effort of conventional DFT. We present results on effective masses, fundamental gaps, spin-orbit and crystal-field splittings and band discontinuities and how these band parameters are modified by the polytypism. Special attention is given to the impact of the cell internal structure.

HL 44.24 Tue 18:00 P3

Electronic and Optical Properties of Group-III Nitride Alloys from ab-initio Methods — •Luiz Cláudio de Carvalho, André Schleife, Abderrezak Belabbes, Cláudia Rödl, and Friedhelm Bechstedt — Institut für Festköpertheorie und -optik, Friedrich-Schiller-Universität, Max-Wien-Platz 1, 07743 Jena, Germany

Group-III mononitrides and their alloys are subject of intense investigations due their interesting electronic and optical properties. First-principles calculations based on the density functional theory, hybrid functionals, and an iterative solution of the quasiparticle equation with the exchange-correlation self-energy in GW approximation have demonstrated to give electronic structures in good agreement with spectroscopic data. Recently, a new approach called LDA-1/2, was proposed based on the concept of half occupation. Applied to excitation energies in solids one overcomes the band-gap problem and obtains reliable electronic properties with less computer-time demands. In the present work, electronic and optical properties of wurtzite group-III nitrides alloys are studied within the cluster expansion approximation. Three different cluster statistics, GQCA, SRS and MDM, are applied in order to illustrate different preparation techniques. The calculations are performed using implement atoms in the VASP code. Based on the LDA-1/2 method electronic structures, are derived optical absorption spectra including electron-hole interaction and local-field effects are computed as a function of composition by solving the Bethe-Salpeter equation. The computed spectra are analyzed and compared to available experimental data.

HL 44.25 Tue 18:00 P3

Band Parameters of (Al, Ga, In)N Polytypes from Different XC Functionals — •Luiz Cláudio de Carvalho, André Schleife, Frank Fuchs, and Friedhelm Bechstedt — Institut für Festköpertheorie und -optik, Friedrich-Schiller-Universität, Max-Wien-Platz 1, 07743 Jena, Germany

Actually a detailed knowledge of the band parameters of the group-III nitrides is necessary to interpret experimental data and understand theoretical results. The most successful theoretical approach is the Density Functional Theory (DFT), but its accuracy depends on the exchange-correlation (XC) functional. Different XC functionals yield slightly varying results for the structural and electronic properties. However, this effect is less important in comparison to the drastic changes of the electronic band structures by solving the quasiparticle (QP) equation. In this work we present and discuss the qualitative and quantitative influence of the XC functionals LDA, GGA, and AM05 induced by structural changes on the band parameters of the AlN, GaN and InN mononitrides. DFT as implemented in VASP code is used to calculate the structural and elastic properties of zinc-blende and wurtzite polytypes. The QP band structures including the XC self-energy within Hedin's GW approximation are obtained taking almost self-consistency into account using HSE03 hybrid XC functional as a starting point. The gap energies, crystal-fields splittings, momentum matrix elements, effective masses and spin-orbit coupling are computed from the QP band structures. We compare our results with experimental values reported in the literature.

HL 44.26 Tue 18:00 P3

Determination of the valence band offset at selected oxide/InN interfaces — Georg Eichapfel[1], •Marcel Himmerlich[1], Anja Eisenhardt[1], Stefan Krischok[1], Andreas Knübel[2], Thorsten Passow[2], Chunyu Wang[2], Fouad Benkhelifa[2], and Rolf Aidam[2] — [1]Institut für Physik and Institut für Mikro- und Nanotechnologien, TU Ilmenau, PF 100565, 98684 Ilmenau, Germany — [2]Fraunhofer-Institut für Angewandte Festkörperphysik, Tullastraße 72, 79108 Freiburg, Germany

The valence band offsets (VBO) at different oxide/InN(0001) interfaces are investigated for TiO_2, HfO_2, Al_2O_3 and In_2O_3 using X-ray photoelectron spectroscopy. These oxide materials might be potential candidates for the use as barrier material in InN based transistors. The precise knowledge of the band alignment at the oxide/InN interface is relevant to understand the carrier transport characteristics in

electronic devices. InN films with a thickness of 1 μm were grown by PAMBE on GaN(0001)/Al_2O_3 templates. Thin oxide films were grown on top of these InN layers, within a series of varying thickness (1-5 nm). TiO_2 and HfO_2 were deposited by plasma-assisted e-beam evaporation, while for Al_2O_3 a remote plasma ALD process was used and In_2O_3 was grown by MOCVD. Thickness dependent changes of the barrier could only be found for TiO_2 which exhibited the strongest degree of process-induced InN interface oxidation. The VBO values, which were determined by linear extrapolation of the thickness dependence, are 1.8 eV, 1.2 eV, 2.65 eV and 1.5 eV for the TiO_2/InN, HfO_2/InN, Al_2O_3/InN and In_2O_3/InN heterointerface, respectively.

HL 44.27 Tue 18:00 P3

Epitaxial growth and characterization of InN and GaN on C-face SiC($\bar{1}\bar{1}\bar{1}$)/Si(111) — •Anja Eisenhardt, Marcel Himmerlich, Pierre Lorenz, Katja Tonisch, Jörg Pezoldt, and Stefan Krischok — Institut für Mikro- und Nanotechnologien, TU Ilmenau, PF 100565, 98684 Ilmenau, Germany

We studied the epitaxial growth and characterized the surface properties of thin GaN and InN films grown by plasma-assisted molecular beam epitaxy on Si(111) substrates carbonized via rapid thermal processing (RTP). This RTP process results in a 2-3 nm thick 3C-SiC($\bar{1}\bar{1}\bar{1}$) film with C-polarity. As characterization methods for the InN and GaN layers in-situ reflection high energy electron diffraction (RHEED), photoelectron spectroscopy (UPS, XPS) and atomic force microscopy (AFM) were used. Furthermore structural properties were ex-situ determined using X-ray diffraction (XRD) measurements. The results are compared to InN(0001) and GaN(0001) grown on sapphire and SiC(0001) substrates, respectively, as well as InN(000$\bar{1}$) and GaN(000$\bar{1}$) grown on 6H-SiC(000$\bar{1}$). The electronic properties of the GaN and InN films grown on carbonized C-face SiC($\bar{1}\bar{1}\bar{1}$)/Si(111) are comparable to metal-face GaN and InN and therefore indicate metal-polarity and not the expected N-polarity. InN on C-face SiC($\bar{1}\bar{1}\bar{1}$)/Si(111) exhibits occupation of the conduction band due to the detected electron emission up to the Fermi level. The InN work function of about 4.0 eV is significantly lower compared to InN(0001)/sapphire ($\sim$ 4.6 eV) and InN(000$\bar{1}$)/6H-SiC ($\sim$ 4.8 eV) samples. All InN and GaN epitaxial films were tensily strained.

HL 44.28 Tue 18:00 P3

Ex-situ activation of magnesium acceptors in InGaN/LED-structures — •Gunnar Kusch, Martin Frentrup, Joachim Stellmach, Tim Kolbe, Tim Wernicke, Markus Pristovsek, and Michael Kneissl — Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstr. 36, 10623 Berlin, Germany

One of the main problems limiting the output power of group-III-nitride compound light emitting diodes (LEDs) and laser diodes (LD) is the p-doping of nitrides with magnesium (Mg). During metal-organic vapor phase epitaxy (MOVPE) growth of (Al)GaN:Mg magnesium acceptors are passivated by hydrogen (H). By thermal annealing under nitrogen atmosphere the Mg-H bond can be cracked, thus activating the Mg acceptor.
We have investigated ex-situ Mg-activation of the p-GaN layer and p-AlGaN electron blocking layer (EBL) in LEDs grown by MOVPE. Especially the activation of the AlGaN EBL is crucial. Simulations show, that a high doping level is required for effective electron blocking and a high injection efficency. Additionally the acceptor activation energy is expected to increase with increasing Al-content, reducing the free hole concentration in the EBL. Electroluminescence spectroscopy (EL) was performed to determine the influence of the activation on the external quantum efficiency of the LED structure. Furthermore we used CV measurements to determine the Mg-acceptor concentration.

HL 44.29 Tue 18:00 P3

Temperaturabhängigkeit des elektrischen Feldgradienten in $Al_xGa_{1-x}N$ — •Ronnie Simon[1], Sahar Hamidi[1], Patrick Kessler[1], Sérgio Miranda[2], Katharina Lorenz[2], Reiner Vianden[1] und ISOLDE Collaboration[3] — [1]Helmholtz Institut für Strahlen- und Kernphysik, Universität Bonn — [2]Instituto Tecnológico e Nuclear, 2686-953 Sacavém, Portugal — [3]CERN, Genf, Schweiz

Ternäre Verbindungen von Gruppe III-Nitriden, unter anderem das hier untersuchte $Al_xGa_{1-x}N$, finden zahlreiche Anwendungen in optoelektronischen Bauteilen wie LEDs.

In Abhängigkeit vom Al-Anteil x wurden Messungen mit der gestörten γ-γ-Winkelkorrelation (PAC) durchgeführt. Dazu wurden ^{111m}Cd(^{111}Cd), ^{117}Cd(^{117}In) und ^{111}In(^{111}Cd) als Sonden verwendet. Die bei der Implantation der Sonden entstehenden Gitterschäden wurden bei 1200K ausgeheilt. Die Auswirkungen des Al-Anteils in $Al_xGa_{1-x}N$ auf den elektrischen Feldgradienten des Gitters wurden untersucht. Dabei wurden Messungen bei Temperaturen zwischen 300K und 1000K durchgeführt.

PAC Messungen mit ^{111}In in GaN haben gezeigt, dass es zur Bildung eines Defektkomplexes aus einem substitutionellen Indiumatom und einer Stickstoffleerstelle kommt (In-V_N). In-V_N weist ein reversibles Temperaturverhalten auf und ist bis zu hohen Temperaturen stabil. Dieser Komplex ist auch in $Al_xGa_{1-x}N$ beobachtbar und zeigt eine hohe Abhängigkeit vom Al-Anteil x.

HL 44.30 Tue 18:00 P3

$In_xGa_{1-x}N$ films for use in photo-electrochemical cells — •Y.H. Wu[1,2], Philipp R. Ganz[1,2], D.Z. Hu[1,2], and Daniel M. Schaadt[1,2] — [1]Institut für Angewandte Physik, Karlsruher Institute of Technology, 76131 Karlsruhe, Germany — [2]DFG-Center for Functional Nanostructures, Karlsruher Institute of Technology, 76131 Karlsruhe, Germany

Development of renewable and clean energy is becoming interesting. Photo-electrochemical cells (PECs) are a new and promising possibility of generating hydrogen by splitting water. A PEC consists of a semiconductor electrode and a metal counter electrode and is embedded in an electrolyte or water. A possible material for the semiconductor electrode is $In_xGa_{1-x}N$, because it has an appropriate band-edge potentials, which straddles the redox potentials of water. We have characterized $In_xGa_{1-x}N$ films for use in PECs. The carrier concentrations were investigated by Hall measurement and the surface morphology by atomic force microscopy. The films were exposed to various electrolytes with different PH levels and their potential for hydrogen generation was explored.

HL 44.31 Tue 18:00 P3

Effect of nitridation on the MOVPE growth of InN on *c*-, *r*- and *a*-plane sapphire — •Sergej Solopow, Duc Dinh, Markus Pristovsek, and Michael Kneissl — TU Berlin, Institute of Solid State Physics, Hardenbergstr. 36, 10623 Berlin, Germany.

Growth of high quality InN is still challenging because of a narrow growth window and lack of suitable substrates. We report on the growth of InN on different oriented sapphire substrates, i.e. *a*-plane ($11\bar{2}0$), *c*-plane (0001), *m*-plane ($10\bar{1}0$) and *r*-plane ($10\bar{1}2$) using metalorganic vapor phase epitaxy (MOVPE).

To grow InN directly on the sapphire substrate, a nitridation process is used to improve crystallinity and optical properties. We have grown InN layers after nitridation for 2min at different temperatures from 500 °C to 1050 °C. We found that the nitridation temperature strongly affects the morphology as well as the orientation of InN layers. Atomic force microscopic (AFM) measurements on the grown samples showed smoother surfaces at higher nitridation temperatures. *c*-oriented InN was grown on *c*-plane sapphire with in-plane relationship of $[10\bar{1}0]$ || $[11\bar{2}0]_{Sapphire}$. On the *a*-plane sapphire we obtained *c*-oriented InN with in-plane relationship of $[1\bar{1}00]_{InN}$ || $[0001]_{Sapphire}$ and $[11\bar{2}0]_{InN}$ || $[1\bar{1}00]_{Sapphire}$ at nitridation temperature higher than 900 °C and additional in-plane relationship by temperatures below 900 °C. We have grown also *a*-oriended InN on *r*-plane sapphire at nitridation temperature higher than 800 °C. At nitridation temperatures below 800 °C this orientation disappears.

HL 44.32 Tue 18:00 P3

Spin Noise Spectroscopy — •Fabian Berski[1], Jens Hübner[1], Fanny Greullet[2], Georgy Astakhov[2], and Michael Oestreich[1] — [1]Institute for Solid State Physics, Leibniz Universität Hannover, Appelstr. 2, D-30167 Hannover, Germany — [2]Faculty of Physics and Astronomy, Julius-Maximilians-Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

We study the intrinsic magnetization fluctuations of the magnetic semiconductor GaMnAs at its phase transition by spin noise spectroscopy [1]. Spin noise spectroscopy avoids generating additive holes and is therefore a promising tool to unreveal unperturbed spin dynamics and has been widely applied to study spin-dynamics of non magnetic semiconductors by investigating the stochastic deviation from vanishing spin polarization at thermal equilibrium. In this contribution we explore the advancement of spin noise spectroscopy to diluted magnetic semiconductors with the aim to observe the transition from random spin fluctuations to the rise of a collective order. We examine a thin GaMnAs film deposited on a sapphire substrate. GaMnAs can easily be integrated in existing GaAs growth procedures and is consequently

an attractive candidate to engineer spintronic devices and serves as an ideal model system to study the effects of combining semiconducting and ferromagnetic properties.

[1] G. M. Müller, M. Oestreich, M. Römer, and J. Hübner, Semiconductor spin noise spectroscopy: Fundamentals, accomplishments, and challenges, Physica E 43, 569 (2010).

HL 44.33 Tue 18:00 P3

Experimental realisation of ultrafast spin noise spectroscopy — •Jan Gerrit Lonnemann, Georg Müller, Jens Hübner, and Michael Oestreich — Institute for Solid State Physics, Leibniz Universität Hannover, Appelstr. 2, D-30167 Hannover, Germany

Semiconductor spin noise spectroscopy has evolved as a powerful experimental technique to explore spin dynamics in close vicinity to thermal equilibrium [1], however, the application of a continuous wave laser limits the detectable spin frequencies to the bandwidth of the photoreceivers. Sampling the spin fluctuations with pulsed laser light allows detection of spin noise at GHz frequencies that are only limited by the inverse pulse width [2]. However this implementation is in general restricted to spin dephasing rates that are smaller than the laser repetition rate. We present the experimental relalization of a complementary technique [3] that is exclusively sensitive to spin dephasing rates that exceed the repetition rate of the laser system. This experiment will pave the way towards application of spin noise spectroscopy even at room temperature.

[1] Georg M. Müller, Michael Oestreich, Michael Römer, and Jens Hübner; Semiconductor spin noise spectroscopy: Fundamentals, accomplishments, and challenges; *Physica E*, 43(2):569 - 587, 2010.

[2] Georg M. Müller, Michael Römer, Jens Hübner, and Michael Oestreich; Gigahertz spin noise spectroscopy in n -doped bulk GaAs; *Phys. Rev. B*, 81(12):121202, Mar 2010.

[3] Sebastian Starosielec and Daniel Hägele; Ultrafast spin noise spectroscopy; *Applied Physics Letters*, 93(5):051116, 2008.

HL 44.34 Tue 18:00 P3

Photoluminescence spectra of weakly n-doped GaAs in view of spin noise spectroscopy — •Carsten Schulte[1], Jens Hübner[1], Dirk Reuter[2], Andreas Wieck[2], and Michael Oestreich[1] — [1]Institute for Solid State Physics, Leibniz Universität Hannover, Appelstr. 2, D-30167 Hannover, Germany — [2]Chair for Applied Solid State Physics, Ruhr-Universität Bochum, D-44780 Bochum, Germany

We measure the photoluminescence signal of a weakly n-doped GaAs sample ($n_D \leq 10^{14}\,\mathrm{cm}^{-3}$) in preparation of prospective spin noise spectroscopy (SNS) on non-interacting donor spins. Spin noise spectroscopy [1] is a powerful tool in semiconductor quantum optics and is capable of delivering important information on the dynamics of non-interacting spins with the long-term goal of entangled electron spin ensembles in semiconductors. The spin noise spectra provide valuable information on the dominant limitation of the spin relaxation time due to hyperfine interaction with nuclear spins. The photoluminescence and transmission spectra are used to select the sample and determining its suitability for the entanglement of spin ensembles.

[1] G. M. Müller, M. Oestreich, M. Römer, and J. Hübner, Semiconductor spin noise spectroscopy: Fundamentals, accomplishments, and challenges, Physica E 43, 569 (2010).

HL 44.35 Tue 18:00 P3

Semiconductor spin noise spectroscopy in oblique magnetic fields — •Georg Müller, Fabian Berski, Jens Hübner, and Michael Oestreich — Abteilung Nanostrukturen, Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstraße 2, D-30167 Hannover

Spin noise spectroscopy (SNS) is a powerful experimental technique to resolve equilibrium electron spin fluctuations in semiconductor systems [1]. Here, we present spin noise measurements in bulk GaAs with an arbitrary angle between magnetic field and the direction of light propagation. Usually, a magnetic field is applied in SNS in Voigt geometry, i.e., transverse to the direction of probe light propagation, to modulate the detected spin fluctuations with the Larmor frequency. This traditional experimental scheme is applied for measurements of the transverse spin dephasing time $T_2^{(*)}$. A magnetic field along the light wave vector, i.e., in Faraday geometry, introduces a splitting of the probed spin states. Correspondingly, energy relaxation accompanies the spin fluctuations and SNS with a longitudinal magnetic field is sensitive to the spin relaxation time T_1. The new experimental geometry presented in this contribution allows simultaneous detection of spin dephasing and relaxation in a single measurement. The strength of SNS in this particular experiment lies in the fact that spin dephasing and relaxation are separated in the spin noise spectrum by the Larmor frequency while these different dynamics would overlap in the time domain in corresponding measurements via pump-probe techniques.

[1] G. M. Müller *et al.*, Physica E **43**, 569 (2010).

HL 44.36 Tue 18:00 P3

Fabrication of a μ-Schottky diode using molecular beam epitaxy and ion beam lithography — •Ashish K. Rai[1], P. Szary[2], O. Petracic[2], H. Zabel[2], H.-W. Becker[3], A. Ludwig[1], D. Mantei[4], S. Gordon[4], A. Zrenner[4], D. Reuter[1], and A. D. Wieck[1] — [1]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [2]Experimentalphysik IV, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [3]Fakultät für Physik und Astronomie, Ruhr-Universität Bochum, 44780 Bochum, Germany — [4]Center for Optoelectronics and Photonics Paderborn,Uni. Paderborn, 100 33098 Paderborn, Germany

Schottky junctions of the metal-intrinsic-n-doped type are widely used to control the charge in quantum dots (QDs) underneath them by an electrical field.It is significant technological challenge to apply this concept to single QDs and requires μ-Schottky diodes with an active area of approximately 1μm x μm.In this contribution,we present a novel approach to create such μ-diodes:After growing the basic layer sequence by molecular beam epitaxy,we define a buried stripe in the n-layer by optical lithography and subsequent O ion implantation in opened stripe-like resist window.After that,a metal line oriented perpendicular to the buried stripe is defined on the surface by electron beam lithography,so that the active area of the junction is only the over-lap region of both stripes.The diode characteristic was confirmed by I-V measurements at room temperature as well as at low temperature (4.2K).It is intended to perform PLV (voltage dependent Photoluminescence of single QDs)or Electroluminescence on these structures.

HL 44.37 Tue 18:00 P3

Diffusionslängen in GaAs — •Sergej Markman, Markus K. Greff und Andreas D. Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum

Eine mögliche Charakterisierung und Optimierung der elektrischen Güte von III-V-Solarzellen für die Photovoltaik ist die Diffusionslänge der Minoritätsladungsträgern, die sowohl die Ladungsträgerbeweglichkeit als auch die Lebensdauer beinhaltet. Durch fokussierte Ionenstrahlen (FIB) können elegant laterale pn-Übergänge geschrieben werden, die oberflächennah sind. Da dann vom eingestrahlten Licht keine hoch dotierten Schichten durchquert werden müssen und so eine potenzielle Absorption entfällt, kann die Effizienz der Ladungsträgergeneration in den verarmten Bereichen zwischen p- und n-Gebiet erhöht werden.

Es sollen dann die Diffusionslängen von Elektronen bzw. Löchern in GaAs in Abhängigkeit der Dotierstoffkonzentration untersucht werden. Dazu soll, mittels eines fokussierten Ionenstrahls, Kohlenstoff in ein n-HEMT implantiert und so p-überkompensiert werden, da Kohlenstoff in GaAs einer der flachsten Akzeptoren darstellt. Komplementär dazu soll ebenfalls ein p-HEMT lokal n-dotiert werden. Die Diffusionslängen werden anschließend mittels eines OBIC-Aufbaus (eng. Optical beam induced current) gemessen. Über eine optische Abbildung der im LED-Betrieb erzeugten Infrarotstrahlung durch eine CCD-Kamera soll ebenfalls ermöglicht werden, die Diffusionslängen direkt zu beobachten.

HL 44.38 Tue 18:00 P3

Hole spin dynamics in 2D hole systems in [113]-grown GaAs/AlGaAs quantum wells at low temperatures — •Stephan Furthmeier[1], Michael Kugler[1], Tobias Korn[1], Michael Griesbeck[1], Marika Hirmer[1], Dieter Schuh[1], Werner Wegscheider[2], and Christian Schüller[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Germany — [2]Solid State Physics Laboratory, ETH Zurich, Switzerland

For the realization of scalable solid-state quantum-bit systems, spins in semiconductor quantum dots are promising candidates. This has led to studies of low-temperature hole spin dynamics in two-dimensional hole systems (2DHS) in GaAs/AlGaAs quantum wells (QW) grown in the crystallographic direction [001]. Recently, calculations and experiments have shown that the effective hole g-factor g* can have different values for a magnetic field B applied in the direction normal to the plane of the 2DHS compared to in-plane. For directions other than the high-symmetry directions [001] and [111], it is theoretically pre-

dicted that, even for a purely in-plane B, g* can depend strongly on the orientation of B with respect to the crystal axes [1].

Here, we report on our experimental findings of hole spin dynamics in [113]-grown GaAs/AlGaAs QWs at low temperatures after optical excitation. Using the all-optical time-resolved Faraday rotation technique, we observe long-lived hole spin dephasing times in our sample at a temperature of 1.2 K. A complete angle-dependent series on the direction of the in-plane B with respect to the crystal axes is planned.

[1] R. Winkler et al., Phys. Rev. Lett. 85, 4574-4577 (2000).

HL 44.39 Tue 18:00 P3

Carbon implantation in GaAs by focused ion beam and electrical activation by rapid thermal annealing — •Markus K. Greff, Arne Ludwig, Dirk Reuter, and Andreas D. Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum

Since its development at the end of the 70s, focused ion beam implantation has become a powerful tool for maskless, local implantation or sputtering with a lateral resolution about 10 nm. Because carbon is one of the shallowest acceptors in GaAs, it is desirable to create a focused carbon beam employing a suitable liquid metal ion source[1]. Also one could think about possible applications such as implantation of carbon in diamond or organic materials as well as working with carbon nanotubes or graphene.
In this contribution we would like to present first results for carbon implantation in GaAs by focused ion beam and subsequent electrical activation of implanted carbon by rapid thermal annealing.

[1] P. Mazarov, A.D. Wieck, L. Bischoff, and W. Pilz, Journal of Vacuum Science and Technology B **27**, L47 - L49 (2009).

HL 44.40 Tue 18:00 P3

Exciton-mediated lattice distortions in InAs/GaAs quantum dots — •Sebastian Tiemeyer[1], Michael Bombeck[2], Michael Paulus[1], Christian Sternemann[1], D. C. Florian Wieland[1], Oliver H. Seeck[3], Manfred Bayer[2], and Metin Tolan[1] — [1]Fakultät Physik / DELTA, TU Dortmund, D-44221 Dortmund, Germany — [2]Experimentelle Physik II, TU Dortmund, D-44221 Dortmund, Germany — [3]HASYLAB, DESY, D-22607 Hamburg, Germany

The confinement of charge carriers to length scales comparable to the de Broglie wavelength in semiconductor heterostructures such as quantum wells and quantum dots leads to a considerable modification of the density of states (DOS). In particular quantum dots represent zero-dimensional structures possessing a DOS similar to that of atoms.

Indium Arsenide (InAs) and Gallium Arsenide (GaAs) exhibit a lattice mismatch of 7% giving rise to strain fields in quantum dot heterostructures. The strain affects significantly the electronic properties of quantum dots e.g. the band structure and band gap. Previous x-ray studies have determined the strain distribution in non-excited quantum dots and the surrounding crystalline structure. The lattice distortion by optically excited carriers has been monitored up to now only indirectly by high resolution continuous wave or non-linear time-resolved optical spectroscopy. In this study we have investigated the laser-induced strain in InAs quantum dots grown on and capped with GaAs by means of anomalous x-ray diffraction at the beamlines BL9 (DELTA, TU Dortmund) and P08 (HASYLAB, DESY Hamburg).

HL 44.41 Tue 18:00 P3

MOVPE grown InAs quantum dots: Towards long wavelength emission — •Matthias Paul, Daniel Richter, Elisabeth Koroknay, Wolfgang-Michael Schulz, Marcus Eichfelder, Robert Rossbach, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, University Stuttgart, Allmandring 3, 70569 Stuttgart, Germany

In recent years, investigations on semiconductor quantum dots (QDs) have been motivated by their potential application in the field of quantum information processing. Therefore, optically or electrically addressable single quantum dots are needed on a mass production scale using metal-organic vapor-phase epitaxy (MOVPE). QD emission in the telecom wavelength bands around 1.3 μm and 1.55μm reduces optical losses in fibers to a minimum. Furthermore, low densities of QDs will allow for single-photon sources, one key device in quantum information networks. Two approaches are pursued to reach emission wavelengths of 1.3μm and 1.55μm, respectively. First, embedding InAs QDs in an InGaAs well grown on GaAs substrates the InAs QD emission is shifted to long wavelengths. Second, even longer wavelengths can be reached by growing InAs QDs on InP substrates. The influence of the growth conditions on the QD properties is investigated and optimized to achieve long wavelength emission. The optical QD properties are analyzed by photoluminescence (PL). Furthermore, the structural properties are examined.

HL 44.42 Tue 18:00 P3

Einfluss von höherer Gate-Spannung und Lichteinfluss auf die Ladespektren von InAs-Quantenpunkt-Proben mit ITO-Gates — •Patrick Labud, Arne Ludwig, Dirk Reuter und Andreas Dirk Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum

Die Ladespektroskopie an InAs-Quantenpunkten (QDs) findet ihren Anfang im Jahre 1994, als Drexler et al. [1] zum ersten Mal mittels Kapazitäts-Spannungs-Messungen (C(V)-Messungen) das gezielte Beladen von QDs mit einzelnen Elektronen nachweisen konnten. Anhand der Resultate wurde eine schalenartige Energieniveaustruktur nachgewiesen, weshalb man bei QDs auch von „künstlichen Atomen“ spricht. Durch die Herstellung von transparenten, leitfähigen ITO(Indiumzinnoxid)-Gates auf die Oberfläche von QD-Halbleiterproben kann die Ladespektroskopie um optische Untersuchungen erweitert werden. In diesem Beitrag wird der Einfluss höherer Gate-Spannungen sowie der Lichteinfluss auf die Barrierenhöhe des Schottky-Kontaktes untersucht.

[1] H. Drexler, D. Leonard, W. Hansen, J. P. Kotthaus, P. M. Petroff, *Spectroscopy of Quantum Levels in Charge-Tunable InGaAs Quantum Dots*, Phys. Rev. Lett. **73**, 2252-2255 (1994).

HL 44.43 Tue 18:00 P3

In-situ TEM mechanical testing of InAs nanowires — •Marat Mukhametshin[1], Vadim Migunov[1], Zi-An Li[1], Marina Spasova[1], Andrey Lysov[2], Werner Prost[2], Ingo Regolin[2], Franz-Josef Tegude[2], and Michael Farle[1] — [1]Fakultät für Physik and CeNIDE — [2]Fakultät für Ingenieurwissenschaften and CeNIDE University Duisburg-Essen, 47048 Duisburg, Germany

Recently, it became possible to measure the elastic properties of nanostructures by in-situ Transmission Electron Microscopy (TEM). The characteristic elastic quantities have already been implemented by several methods, such as electromechanical resonance, nanoindentation, tensile stress, bending and buckling testing [1]. In this study we used the "bending method" on InAs nanowires to obtain the bending modulus as the combination of shear and Young's modules by directly imaging the bending curvature in the TEM. The Metal Organic Chemical Vapor Deposition method was used to grow InAs nanowires on InAs (100) substrate from catalyst Au nanoparticles. Scratched and dispersed nanowires were preliminary aligned on standard TEM-grids using dielectrophoresis. A special Atomic Force Microscope in a TEM (AFM-TEM) sample holder was used to study the dependence of the mechanical properties of the nanowires on their diameter, growth direction, atomic structure and the presence of defects.

[1] Y. Zhu, C. Ke, H.D. Espinosa, Exp. Mech., 47, 7-24 (2007)

HL 44.44 Tue 18:00 P3

Homo- and heteroepitaxial GaP(100) surfaces in process gas ambients — Henning Döscher, Oliver Supplie, •Peter Kleinschmidt, Anja Dobrich, Sebastian Brückner, Christian Höhn, Antonio Müller, Claas Löbbel, and Thomas Hannappel — Helmholtz-Zentrum Berlin für Materialien und Energie, Hahn-Meitner-Platz 1, 14109 Berlin, Germany

Phosphorus based III-V semiconductors such as GaP and InP are commonly grown by metalorganic vapor phase epitaxy, where the process gas ambient has a crucial influence on the surface structure: P-rich surfaces feature hydrogen-stabilized and buckled P-dimers, a reconstruction with local p(2×2) and c(4×2) symmetries, and a flipping mechanism changing the orientation of individual dimers. A mixed dimer configuration is typical for III-rich surfaces, but only for GaP(100) in a nitrogen ambient an additional intermediate reconstruction was also observed. Heteroepitaxial growth on Si(100) introduces anti-phase disorder in GaP films, which can be observed by domains of mutually perpendicular dimer orientation on the surfaces.

HL 44.45 Tue 18:00 P3

Development of porous structures in GaSb by ion irradiation — •Tobias Steinbach, Carolin C. Jacobi, and Werner Wesch — Institute of Solid State Physics, Friedrich Schiller University Jena

Ion irradiation of GaSb causes not only defect formation but also leads

to the formation of a porous structure. To study the behaviour of this structural modification, GaSb was irradiated with 6 MeV I and two different irradiation procedures: (i) continuous irradiation of samples followed by surface profilometry analysis in air, i.e. step height measurements, and (ii) stepwise irradiation of samples with measurements of the step height in air between subsequent irradiations. Samples irradiated continuously, show a moderate increase of the step height with increasing ion fluence (up to 1.5 x 10^{14} cm^{-2}) followed by a much steeper increase for higher fluences up to a step height of 32 μm. This swelling is induced by the formation of voids, and the two different slopes can be explained by a change from isolated voids to a rod like structure (SEM investigations). For samples irradiated according to procedure (ii), the step height shows the same behaviour up to 1.5 x 10^{14} cm^{-2} but then decreases with further irradiation. The latter effect is caused by an orientation of the rod like structure perpendicular to the ion beam and occurs only if the sample was taken out of the vacuum chamber and then irradiated once more. We investigated e.g. the influence of gas, oxygen, time and pressure but the reason for the change of the behaviour of GaSb, which leads to this effect, is still an open question.

HL 44.46 Tue 18:00 P3

Lithography Optimization on HgTe — •Luis Maier, Mathias J. Mühlbauer, Bruno Krefft, Jiango Yang, Hartmut Buhmann, and Laurens W. Molenkamp — Physikalisches Institut (EP3), Universität Würzburg, 97074 Würzburg

Mercury telluride (HgTe) has become more and more important in recent years due to its topological insulator properties [1,2]. However lithographical processing is still challenging because HgTe cannot endure temperatures over 100° C and in addition mercury forms numerous alloys with various elements. Here, we present recent developments which helped to improve the fabrication of HgTe nanostructures.

Titanium (Ti) etch masks are commonly used for lithographical processes. Unfortunately, Ti reacts as well with Hg and thus influences the sample quality and the efficiency of gate electrodes. To address this problem we introduced in an additional process step a 10 nm thick SiO2 layer to separate the Ti from HgCdTe top layer. Furthermore, thermal indium bonding has been used till recently to provide ohmic contact to the buried two-dimensional electron gas in HgTe quantum well structures. This process is disadvantageous because In contact require a lot of space and the contacting depth is uncontrollable which prevents the use of back gates. A process for evaporated Gold-Germanium contacts has been developed which gives a certain control of the doping depth and additionally can be used with ultrasonic bonding which reduces the required size of the bonding pads by a factor of 3.

[1] M. König et al., Science, 318, 766, (2007)
[2] A.Roth et al., Science 325, 294 (2009)

HL 44.47 Tue 18:00 P3

Das Vorzeichen des elektrischen Feldgradienten in Halbleitern mit großer Bandlücke — •Patrick Kessler[1], Valentin Germic[1], Sergio M.C. Miranda[2], Katharina Lorenz[2], Reiner Vianden[1] und ISOLDE Collaboration[3] — [1]Helmholtz-Institut für Strahlen- und Kernphysik, Universität Bonn, Deutschland — [2]Instituto Tecnológico e Nuclear, P-2686-953 Sacavém, Portugal — [3]CERN, Genf, Schweiz

Die genaue Kenntnis des elektrischen Feldgradienten (EFG) und insbesondere dessen Vorzeichen sind Voraussetzungen für detaillierte theoretische Berechnungen von Kristalleigenschaften.

Mit der Methode der gestörten $\beta - \gamma$ Winkelkorrelation kann die Stärke und das Vorzeichen des EFG bestimmt werden. Dieser wurde mit den Sonden ^{115}Cd und ^{111}Ag in den Halbleitern AlN, GaN und ZnO gemessen. Die Isotope wurden am ISOLDE Experiment des CERN in Genf im Rahmen des Projekts IS481 hergestellt und in die Proben implantiert.

HL 44.48 Tue 18:00 P3

Effects of N and N/Li doping on ZnS epilayers grown on GaP — •Gunther Haas, Udo Römer, Stefan Lautenschläger, Sebastian Eisermann, Melanie Pinnisch, Andreas Laufer, and Bruno K. Meyer — I. Physics Institute, Justus-Liebig-University Giessen, Heinrich-Buff-Ring 16, 35392 Giessen, Germany

High quality ZnS epilayers have been grown on GaP(100) by chemical vapor deposition using metallic zinc and hydrogen sulfide as source materials. An additional ammonia flow was applied to the growth process, with the purpose of N-doping. The co-doping of N and Li was realized due to the evaporation of lithium amide. To clarify the presence of N and Li in the ZnS layers a secondary ion mass spectrometer was used. In addition to that, we analyzed the effects of the dopants on the properties of the ZnS films by investigating the films with X-ray diffraction (XRD), low temperature photoluminescence (PL) and Raman spectroscopy.

HL 44.49 Tue 18:00 P3

Group VII point defects in ZnSe — •Leonardo S. dos Santos, Eva Rauls, and Wolf Gero Schmidt — Theoretische Physik, Universität Paderborn, Germany

Chlorine is one of the best known n-dopants in ZnSe. A recent work [Yamamoto et al., Phys. Rev. Lett. **103**, 053601 (2009)] has shown that independent ZnSe quantum wells doped with fluorine can emit indistinguishable photons, with possible applications in quantum computing. We have used Density Functional Theory calculations to study Cl and F point defects in ZnSe. The use of hybrid functionals for the treatment of electron exchange and correlation leads to significant changes in the defect formation energies, when compared to the use of local functionals. Our results for Cl-doped ZnSe show that Cl atoms are found primarily in the Se-substitutional position, and that the main compensating centers are the zinc vacancy and related complexes, in qualitative agreement with earlier results.

HL 44.50 Tue 18:00 P3

Band Anticrossing in $ZnSe_xTe_{1-x}$ and ZnS_xTe_{1-x} Alloys — Tobias Bertram[1], •Christian Karcher[1], Henning Klaer[2], Sebastian Klembt[2], Carsten Kruse[2], Detlef Hommel[2], and Wolfram Heimbrodt[1] — [1]Department of Physics and Material Sciences Centre, Philipps University of Marburg, Germany — [2]Institute of Solid State Physics, University of Bremen, Germany

The goal of this research is to understand the band forming in ZnSeTe and ZnSTe semiconductors. The Band Anticrossing Model (BAC) was already succesfully applied to explain the band formation in GaNAs. One can compare the chemical properties of ZnSeTe and ZnSTe with those of GaNAs. The key difference being while the electronegativity of Nitrate is almost double that of Arsenic, Tellurium's is only slightly smaller than that of Selenium or Sulphur. Similar to GaNAs the localized Se and S states lie above the ZnTe conduction band. The BAC predicts a repulsion of the localized impurity states and the ZnTe conduction band, causing it to split into a so-called E_-- and E_+-band. The higher Se or S contents in the ZnTe host, the stronger the repulsion of the E_--band, leading to a shrinking of the bandgap energy. This behaviour can also be fitted by introducing a bowing parameter into the Virtual Crystal Approximation. ZnTe incorporated with varying contents of Se and S is characterized by various optical methods. Photoluminescence, photoreflectance and absorption spectroscopy measurements are used to fully determine both the emission and absorption characteristics of the system and by that help to gain further insight into the way the bands are formed.

HL 44.51 Tue 18:00 P3

Influence of the Mn-concentration on the magnetotransport properties of Cl-doped ZnMnSe — •Christian H. Will[1], Matthias T. Elm[1], Jörg Teubert[1], Peter J. Klar[1], and Michael Hetterich[2] — [1]1. Physikalisches Institut, Justus-Liebig-Universität, Heinrich-Buff-Ring 16, 35392 Giessen — [2]Institut für Angewandte Physik, Universität Karlsruhe, Wolfgang-Gaede-Str. 1, 76131 Karlsruhe

The incorporation of manganese ions in I_{1-x}-Mn_x-VI compounds provides a large localized magnetic moment due to their half-filled inner 3d-shell. Because manganese forms isovalent impurities, it does not affect the carrier concentration. By co-doping with Cl, the carrier concentration can therefore be tuned independently from the Mn content. In order to investigate the influence of the magnetic moment on the transport properties, ZnMnSe:Cl samples were grown by molecular beam epitaxy on undoped GaAs substrates. The samples belong to two different series. Within the first series, the amount of Cl dopants varies by a magnitude of about 10, while the Mn concentration is retained at $x \approx 6\%$. In contrast, the Mn concentration of the samples in the second series alters from 0% to 2%, while the quantity of the carrier concentration is kept constant. The magnetotransport measurements were performed in a temperature range from 1.6 K to 285 K in fields up to 10 T and the results will be discussed.

HL 44.52 Tue 18:00 P3

Tuning the Two-Dimenional Hole Gas Density in CdMnTe Quantum Wells by Near-surface Doping and Photoexcitation

— •Franziska Fricke[1], Christian Kehl[1], Georgy Astakhov[1], Jean Geurts[1], Wolfgang Ossau[1], Yuri Kusrayev[2], Kyrill Kavokin[2], Tomek Wojtowicz[3], and Grzegorz Karczewski[3] — [1]Universität Würzburg, Phys. Inst., EP3, 97074 Würzburg, Germany — [2]Ioffe Institute, RAS, 194021 St. Petersburg, Russia — [3]Institute of Physics, PAN, 02668 Warsaw, Poland

P-doped CdMnTe quantum wells are known to exhibit a trend towards ferromagnetism, induced by the two-dimensional gas of heavy holes (2DHG). One way to supply a 2DHG to the quantum well is p-type doping from surface states by tunneling through a very thin capping layer. Tuning of the 2DHG density is achieved by variation the cap layer thickness and by photogeneration of charge carriers.

We present photoluminescence (PL) and magneto-PL studies on CdMnTe/CdMgTe quantum wells using resonant quantum well excitation and above-barrier excitation. The 2DHG is characterized essentially by the intensity and spectral position of the positively charged exciton (trion X^+) with respect to the neutral exciton (X^0). We describe the observed 2DHG behaviour consistently by a model based on specific tunneling times of electrons and holes, which depend on the cap thickness and the power and photon energy of the optical excitation radiation.

HL 44.53 Tue 18:00 P3

Isostructural and heterostructural MgZnO and CdZnO alloys — •André Schleife, Claudia Rödl, and Friedhelm Bechstedt — Institut für Festkörpertheorie und -optik and European Theoretical Spectroscopy Facility, Friedrich-Schiller-Universität Jena, 07743 Jena, Germany

One important goal of materials design is to purposefully tailor the fundamental band gap. Recently, group-II oxides such as MgO, ZnO, and CdO are discussed to possibly supersede the nitrides for certain applications, e.g. in optoelectronics. Since the band gaps of the oxides cover a large spectral range from 1.8 eV (CdO) up to 7.7 eV (MgO), their alloys seem to be promising – unless the different equilibrium crystal structures of the end components (rocksalt-MgO and -CdO vs. wurtzite-ZnO) prevent their application.

By employing three different cluster statistics within a cluster-expansion approach we investigate the impact of different growth conditions on the composition of isostructural and heterostructural $Mg_xZn_{1-x}O$ and $Cd_xZn_{1-x}O$ alloys. Our total-energy calculations are based on density-functional theory using a generalized-gradient approximation for exchange and correlation.

We also compute quasiparticle energies using the HSE03+G_0W_0 approach. This allows us to derive the bowings of fundamental band gaps, which reveal a strongly nonlinear behavior. Using the solution of the Bethe-Salpeter equation for the optical polarization function we investigate the influence of the preparation conditions on the peaks related to bound excitonic states at the absorption edge.

HL 44.54 Tue 18:00 P3

Hydrothermal growth of ZnO nanorods for optoelectronic and photovoltaic applications — •Marco Braun[1], Jonas Conradt[1,2], Janos Sartor[1], Dirk Silber[1], Manuel Reinhard[3], Alexander Colsmann[3], Uli Lemmer[3], and Heinz Kalt[1,2] — [1]Karlsruher Institut für Technologie (KIT), Institut für Angewandte Physik, 76128 Karlsruhe, Germany — [2]Center for Functional Nanostructures (CFN) at KIT — [3]Lichttechnisches Institut at KIT

Incorporating low-dimensional nanostructured, wide-band gap semiconductors, such as zinc oxide (ZnO) nanorods, into optoelectronic devices is a promising approach in order to realize UV light-emitting diodes. The nanorod structure can help to improve guiding and outcoupling of light and device efficiency. We present results on the growth of ZnO nanorods on various substrates using low-temperature, hydrothermal growth. An alternative high-temperature growth method is used to produce longer ZnO nanorods, e.g. on silicon substrates. The nanostructures are characterized by scanning electron microscopy and photoluminescence spectroscopy. We also present a simple method for electrical contacting and first results of electroluminescence measurements.

HL 44.55 Tue 18:00 P3

Investigation of growth catalysts for ZnO nanopillar growth — •Manfred Madel, Ingo Tischer, Benjamin Neuschl, Tobias Meisch, Martin Feneberg, Uwe Röder, and Klaus Thonke — Institut für Quantenmaterie / Gruppe Halbleiterphysik, Universität Ulm

ZnO nanopillars were grown in hexagonal and cubic arrangements employing self-assembling polystyrene (PS) spheres to pre-pattern a-plane sapphire substrates on which gold, silver or a metal free zinc oxide seedlayer were deposited. A cubic arrangement of the PS spheres is achieved with a spin coating method. To remove the catalyst regions not protected by the PS spheres we apply wet-chemical etching. In a CVD growth process ZnO nanopillars with diameters between 200 and 500 nm and lengths up to 5 μm are grown in hexagonal and cubic arrangements. The influence of growth catalysts on growth and crystal quality is investigated and compared by cathodoluminescence, photoluminescence, energy dispersive X-ray spectroscopy and high resolution X-ray diffraction measurements.

HL 44.56 Tue 18:00 P3

vapor phase growth of ZnO single crystals — •xi zhang[1], frank herklotz[1], ellen hieckmann[1], jörg weber[1], and peer schmidt[2] — [1]Institute für Angewandte Physik, Technische Universität Dresden, 01062, Dresden, Germany — [2]Institute für Anorganische Chemie, Technische Universität Dresden, 01062, Dresden, Germany

Zinc oxide is a promising wide band gap semiconductor for future optoelectronic devices. Today ZnO bulk single crystals are grown by three different techniques: hydrothermally, from the melt and by chemical vapor transport. For our studies we employed in addition a simple and low cost vapor phase method which gives us good quality crystals and flexibility in crystal doping. The as-grown single crystals were characterized by resistivity measurements, scanning electron microscopy, electron backscatter diffraction and low temperature photoluminescence spectroscopy. The biggest crystals so far are c-axis oriented needles with maximum length of 40 mm and maximum diameter of 1 mm. The needle-shaped crystals are n-type with main donors due to Al, Ga and In impurities. The growth conditions have a strong influence on the optical properties of as-grown crystals.

This work was supported by the European Regional Development Fund and the Free State of Saxony. SAB project 14253/2423.

HL 44.57 Tue 18:00 P3

Time-resolved photoluminescence spectroscopy on ZnO based films grown by molecular beam epitaxy — •Manuel H. W. Bader, Marcel Ruth, Christina A. Fobbe, and Cedrik Meier — University of Paderborn, Experimental Physics & CeOPP, Warburger Str. 100, 33098 Paderborn

Due to its unique properties such as the large direct bandgap of 3.37 eV and its high exciton binding energy of 60 meV, zinc oxide (ZnO) is a very promising semiconductor for optoelectronic and photonic applications even at room temperature. By adding cadmium (Cd) or magnesium (Mg) the bandgap can be tuned between 2.5 eV and 4.3 eV.

Especially quantum wells and multi-quantum wells can serve as light emitting sources inside photonic devices. Therefore, thin ZnO and (Zn,Mg)O films have been grown in a plasma assisted molecular beam epitaxy system using silicon (111), sapphire (0001) and ZnO (0001) substrates. Growth conditions were systematically studied using in-situ reflection high energy electron diffraction (RHEED) and ex-situ atomic force microscopy (AFM), x-ray diffraction (XRD) and photoluminescence (PL).

Recombination dynamics and binding energies are studied using time resolved photoluminescence spectroscopy in the temperature range between T=7 K and 300 K.

HL 44.58 Tue 18:00 P3

Donor-acceptor pair recombination in ZnO — •Marko Stölzel, Alexander Müller, Stefan Müller, Gabriele Benndorf, Michael Lorenz, Holger von Wenckstern, and Marius Grundmann — Universität Leipzig, Institut für Exp. Physik II, Abteilung Halbleiterphysik, Linnéstr. 5, 04103 Leipzig

ZnO is due to its material properties an interesting semiconductor for electronic and optoelectronic applications. However, the difficulties in growing stable p-type ZnO have inhibited the commercial fabrication of devices such as LEDs. Reported acceptor activation energies are usually well above 100 meV. Therefore, only a small fraction of such acceptors would be ionized at room temperature in p-type ZnO.

In this study we report on a donor-acceptor pair (DAP) recombination at 3.325 eV at 2 K found in a nominally undoped ZnO film grown by pulsed-laser deposition on a ZnO:Al buffer layer on a-sapphire.

The sample has been investigated by temperature-dependent time-integrated and time-resolved photoluminescence (PL) as well as electrical investigations. The PL measurements show a clear shift of the DAP recombination to higher energies with increasing excitation power. The

transients exhibit a clear non-exponential behavior typical for DAP recombination and were described by the model of Thomas et al. [1] yielding the donor concentration, the Bohr radius of the donor and the pair distance. The determined donor concentration is in good agreement with that obtained from electrical measurements. From that we deduce an acceptor binding energy between 60 and 80 meV.

[1] D. G. Thomas et al. Phys. Rev. **140**, A202 (1965)

HL 44.59 Tue 18:00 P3

Thermal stability of ZnO/ZnCdO/ZnO double heterostructures — Martin Lange, •Anna Reinhardt, Christof P. Dietrich, Gabriele Benndorf, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Semiconductor Physics Group, Linnéstr. 5, D-04103 Leipzig, Germany

Band gap engineering is essential for the fabrication of efficient optoelectronic devices, which are based on heterostructures. For ZnO-based heterostructures, a material with a reduced bandgap is e.g. achieved by incorporation of Cd in ZnO.[1] As in the device fabrication, the behavior of the alloy during post-growth thermal processing is an important issue we studied the thermal stability of ZnO/ZnCdO/ZnO double heterostructures (Cd-DHS). The samples were grown by a pulsed laser deposition process on *a*-plane sapphire substrates using ZnO and CdO targets.[2] The Cd-DHS were annealed in air at temperatures from 620 °C to 970 °C to study their thermal stability.

Luminescence features of ZnO and ZnCdO where observed for the as-grown samples as well as for the annealed samples. Due to the annealing the ZnCdO-related luminescence exhibited a monotonic blue-shift with increasing annealing temperature. The underlying diffusion process, which explains the blue-shift, was investigated to determine the diffusion coefficient for the different annealing temperatures. The activation enthalpy of the diffusion coefficient was found to be between 2.1 eV and 3.5 eV, depending on the growth conditions.

[1] S. Sadofev *et al.*, Appl. Phys. Lett. **89**, 201907 (2006)
[2] M. Lange *et al.*, J. Appl. Phys. **107**, 093530 (2010)

HL 44.60 Tue 18:00 P3

Defects in ZnO thin films studied by photo-capacitance measurements — •Robert Karsthof, Matthias Schmidt, Holger v. Wenckstern, Rainer Pickenhain, and Marius Grundmann — Universtity of Leipzig, Institute for Experimental Physics II, Linnéstraße 5, D-04103 Leipzig

In zinc oxide (ZnO) extensive knowledge on localized electronic states in the vicinity of the conduction band edge exists whereas the number of reported hydrogenic acceptor states or deep levels in the midgap region is scarce. One reason is that capacitance spectroscopic methods commonly measure the thermal emission rate of trapped charge carriers. This works well for levels within 1 eV from the respective band edge at experimentally accessible temperatures and measurement times. In this study we investigated electronic states in the midgap and the vicinity of the valence band of pulsed laser deposited ZnO thin films by means of capacitance spectroscopy with additional optical excitation. The samples were thermally annealed in 700 mbar oxygen and nitrogen atmosphere as well as in vacuum at approx. 700 °C. Two states in the vicinity of the valence band have been detected of which at least one is generated by annealing the samples under low oxygen partial pressures. The photo-ionisation cross-section of the latter one was determined. A midgap level with a threshold photo-ionisation energy of approx. 1.7 eV was detected in every investigated sample. Concentration profiles of the investigated traps have been obtained from capacitance-voltage measurements conducted in the dark as well as under monochromatic excitation.

HL 44.61 Tue 18:00 P3

Back-illuminated visible-blind and wavelength selective metal-semiconductor-metal photodetectors based on MgZnO-heterostructures — •Zhipeng Zhang, Holger von Wenckstern, Jörg Lenzner, Michael Lorenz, Holger Hochmuth, and Marius Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik II, Linnéstraße 5, 04103, Leipzig

We report on the utilization of $Mg_{x_1}Zn_{1-x_1}O/Mg_{x_2}Zn_{1-x_2}O$ heterostructure having two different Mg-content ($x_1 < x_2$) enabling the construction of wavelength-selective backside-illuminated photodetectors. For that, the $Mg_{x_2}Zn_{1-x_2}O$-layer is heteroepitaxially grown by pulsed-laser deposition on a both-side polished a-plane sapphire substrate, and acts as an integrated optical passive filter blocking high energy radiation. Subsequently the $Mg_{x_1}Zn_{1-x_1}O$-layer, being the active layer of the devices is deposited. The width of bandpass of the devices is given by the bandgap difference of the two MgZnO-layers, and the center of bandpass can be shifted by using different combination of x_1 and x_2. The Schottky contacts of the interdigital metal-semiconductor-metal (MSM) structure were fabricated by reactive dc-sputtering of Pd and Pt with Pd- and Pt-capping [1], respectively.

[1]: H. v. Wenckstern *et al.*, Mater. Rec. Soc. Symp. Proc., **1201**, H04-02 (2010)

HL 44.62 Tue 18:00 P3

Investigation of the band structure of $Zn_xMg_{1-x}O$ alloys — •Christian Franz, Michael Czerner, Marcel Giar, Markus Heinemann, and Christian Heiliger — I. Physikalisches Institut, Justus Liebig University Giessen, D-35392, Germany

We investigate the electronic structure of $Zn_xMg_{1-x}O$ alloys as a function of composition *ab initio* by means of density functional theory. Thereby, we model the alloys by using the coherent potential approximation (CPA) [1] implemented in a Korringa-Kohn-Rostoker Green's function method. Within the CPA the band structure itself is not well defined but we can analyze the Bloch spectral functions. Out of these spectral functions we extract effective masses, the positions of band edges, and the band gap. All these quantities are discussed with respect to their dependence of composition.

[1] Soven, P.,*Coherent-Potential Model of Substitutional Disordered Alloys* , Physical Review 156,(1967)

HL 44.63 Tue 18:00 P3

Microstructuring and characterization of Cu_2O/ZnO heterostructures — •Sören Zint, Julian Benz, Achim Kronenberger, Daniel Reppin, Philipp Hering, Torsten Henning, Peter J. Klar, and Bruno K. Meyer — I. Physikalisches Institut, Justus-Liebig-Universität, Heinrich-Buff-Ring 16, 35392 Giessen

Cuprous oxide (Cu_2O) is a promising candidate for photovoltaic applications due to its direct band gap in the visible spectral range. Moreover Cu_2O is a non toxic and sustainable material. Thin Cu_2O films can be deposited on different substrates by sputtering. Since the production of n-type Cu_2O is a difficult task, ZnO can be employed for fabricating a p-n-junction. We report on the growth of lateral Cu_2O/ZnO heterostructures and current-voltage measurements of these systems. We present a model for explaining the influence of the interface cross-section distribution on the current-voltage characteristics.

HL 44.64 Tue 18:00 P3

***Ab initio* investigations of Mg diffusion in ZnMgO** — •Marcel Giar and Christian Heiliger — I. Physikalisches Institut, Justus-Liebig-Universität, D-35392 Giessen, Germany

We present *ab initio* calculations of possible diffusion paths for a single Mg atom in a ZnMgO supercell. Simple models are selected for the diffusion paths. We further estimate the energetic barrier by assuming that thermal energy at room temperature and elevated temperature suffices to activate the diffusion within the structure.

HL 44.65 Tue 18:00 P3

Preparation of donor doped ZnO_xS_{1-x} thin films — •Achim Kronenberger, Philipp Schurig, Andreas Laufer, Hauke Metelmann, Jan E. Stehr, Jan Philipps, Benedikt Kramm, Angelika Polity, Detlev M. Hofmann, and Bruno K. Meyer — I. Physikalisches Institut, Justus-Liebig-Universität Giessen, Heinrich-Buff-Ring 16, 35392 Giessen, Germany

It is well known that ZnO can easily be doped n-type which is commonly realized by incorporating group-III elements on a Zn lattice place. In contrast to that there are rather few publications reporting successful n-type doping of ZnS. The ternary material system ZnO_xS_{1-x} can be prepared without any miscibility gap by radio frequency sputtering. This offers the possibility to study the electrical activity of the shallow donor dopants over the complete composition range. In our work ZnO_xS_{1-x} thin films were deposited from a ceramic ZnS target by radio frequency sputtering on glass, sapphire and semiconductor substrates. Through reactive sputtering with oxygen gas the film composition can be adjusted to the wanted oxygen/sulphur ratio. As dopants Al, F and H were incorporated by using additional target material or reactive gas, respectively.

HL 44.66 Tue 18:00 P3

An EPR investigation of the nitrogen center in ZnO — •Jan E. Stehr, Detlev M. Hofmann, and Bruno K. Meyer — 1st Physics Institute, Justus-Liebig-University Gießen, Heinrich-Buff-Ring 16, 35392 Gießen, Germany

ZnO with the direct band gap of 3.36 eV at room-temperature is a promising material for UV light emitting devices. Therefore it is necessary to have n-type conducting ZnO as well as p-type conducting ZnO. Since ZnO is an intrinsic n-type material, p-type conductivity is the major challenge. In the last years it turned out that nitrogen is the most promising candidate.

We investigated an electron irradiated Eagle Picher ZnO bulk crystal with the method of Electron Paramagnetic Resonance (EPR). After illumination with light the well known 3-line EPR spectrum of nitrogen with I=1 in ZnO shows up [1]. We tracked the angular dependency of the 3 lines and the 6 *forbidden* EPR transitions of nitrogen. Photon-irradiation with energies higher than 2.2 eV leads to the creation of the EPR-signal and with energies of 0.7 eV it was also possible to quench it. Also the time-dependency of the EPR-signal was measured to get information on its creation- and the decay-behavior.

[1] N. Y. Garces et al., Appl. Phys. Lett. 80, 1334 (2002)

HL 44.67 Tue 18:00 P3

Electric properties of ZnO thin films before and after ion irradiation — •Florian Kuhl, Markus Piechotka, Martin Fischer, Torsten Henning, and Peter J. Klar — 1. Physikalisches Institut, Justus-Liebig-Universität, Heinrich-Buff-Ring 16, 35392 Giessen

ZnO doped with Al (AZO) is a transparent conducting oxide (TCO) and arouses interest for spacecraft applications, for example as electrode or covering layer in solar cells. In space environment this material has to resist radiation. We exposed AZO thin films to beams of Ar^+-ions to simulate the particle irradiaton in space environment.

Before and after irradiaton we characterized the surface morphology and the electrical properties of the thin films and compared them. The electrical properties, i.e. the carrier concentration and the mobility were measured in the van-der-Pauw geometry at temperatures from 1.5 K to 285 K. To investigate the surface morphology we used SEM and optical microscopy.

We found out that there are changes in electrical properties at an acceleration voltage of 500 V. With lower acceleration voltages we could not find significant changes of the electrical properties.

HL 44.68 Tue 18:00 P3

Influence of nitrogen on optical properties of zinc oxide using Raman spectroscopy — •Christian Reindl, Julian Benz, Thomas Sander, Stefan Lautenschläger, Sebastian Eisermann, Peter J. Klar, and Bruno K. Meyer — I. Physikalisches Institut, Justus-Liebig-Universität, Heinrich-Buff-Ring 16, 35392 Gießen

The wide bandgap semiconductor zinc oxide (ZnO) is an interesting material for the production of blue and UV optoelectronic devices. P-type doping remains an obstacle for fabricating devices completely based on ZnO. Since nitrogen is a promising candidate for p-type doping ZnO, thin ZnO:N layers produced by low temperature CVD using ammonia as precursor for nitrogen were investigated. We studied the influence of nitrogen on the optical properties of ZnO by Raman spectroscopy. Numerous modes related to nitrogen were found in the Raman spectra. We investigated angle dependence and the scaling of these modes with the N-concentration using green and red lasers.

HL 44.69 Tue 18:00 P3

The Role of Power-Law Correlated Disorder in the Anderson Metal-Insulator Transition — •Alexander Croy[1], Philipp Cain[2], and Michael Schreiber[2] — [1]Max-Planck-Institute for the Physics of Complex Systems, Nöthnitzer Str. 38, 01187 Dresden, Germany — [2]Institut für Physik, Technische Universität, 09107 Chemnitz, Germany

The Anderson Model of localization provides a paradigmatic description of a metal-insulator transition (MIT). A systematic variation of the effective disorder of the energy potential in a three dimensional (3D) sample leads to a change of the electronic wave function from extended to localized behavior. This MIT is characterized by a set of critical parameters,e.g., universal exponents, which depend on the type of disorder.

Here we study the case of long-ranged power-law correlated disorder. In one dimension we compare our numerical results with analytical predictions. In 3D the influence of long-range correlations on the MIT is still largely unexplored. We present numerical simulations for the density of states and the localization length for 1D and 3D systems using standard transfer matrix calculations and finite size scaling of the largest inverse Lyapunov exponent. Further we discuss the phase diagram of the MIT and the influence of the correlations on the critical exponents.

HL 44.70 Tue 18:00 P3

Disorder Induced Metal-Insulator Transition in Crystalline $Ge_1Sb_2Te_4$ — •Hanno Volker[1], Theo Siegrist[1,2], Peter Jost[1], Michael Woda[1], Philipp Merkelbach[1], Carl Schlockermann[1], and Matthias Wuttig[1] — [1]1st Institute of Physics (IA), RWTH Aachen, 52056 Aachen, Germany — [2]Department of Chemical and Biochemical Engineering, FSU, Tallahassee, FL 32310

Localization of charge carriers in crystalline solids has been the subject of numerous investigations over more than half a century. Materials showing a metal to insulator transition (MIT) without a structural change are therefore of great interest. Concepts based on electron correlation (Mott) or disorder (Anderson) are often invoked to explain such an MIT, but a clear distinction between the two mechanisms is difficult.

In this study [1] we report the observation of an MIT in crystalline $Ge_1Sb_2Te_4$ which is caused by disorder-induced localization in the 3-dimensional solid. A combination of X-ray diffraction experiments as well as optical (FT-IR) and electrical measurements reveals that the observed MIT is an intra-grain effect. The Hall carrier density barely changes during the MIT and is much higher than predicted by the Mott criterion. Therefore, the MIT is not of the Mott type, but driven by disorder.

[1] Siegrist, T. *et al.* Disorder Induced Localization in Crystalline Phase Change Materials. *Accepted for publication in Nature Mater.*

HL 44.71 Tue 18:00 P3

Statistical analysis of contact resistance between P3HT and several electrode materials on flexible substrates — •Arne Hendel, Miriam Hehn, and Veit Wagner — Jacobs University Bremen, School of Engineering and Science, Campus Ring 1, 28759 Bremen, Germany

Finite contact resistance in organic field-effect transistors is one of the major obstacles towards higher switching frequencies. In this work optimal contact materials / treatments for the organic semiconductor poly(3-hexylthiophen) (P3HT) are identified. Considered candidates are sputtered or printed Copper, Gold and Silver structures. For proper comparison the preparation of many devices (>50) and statistical analysis was found to be essential to overcome the finite sample to sample variation typically observed in organic field effect transistors (OFETs). To avoid dominating influences of adsorbates on the work functions of the different metals, ozone cleaning has been optionally applied before spin-coating the P3HT layer. The identified contact resistances were further investigated by potential mapping of the transistor channel enabled by additionally patterned sense fingers. This approach allows to determine the relative weight of source and drain contribution to the total contact resistance.

HL 44.72 Tue 18:00 P3

Contact degradation in wet-chemically produced high mobility semiconductor devices — •Mark Nikolka, Marlis Ortel, and Veit Wagner — School of Engineering and Science, Jacobs University Bremen, Campus Ring 1, 28759 Bremen, Germany

Novel wet chemical processing techniques have recently enabled to produce very high mobility devices, e.g. diodes or field-effect transistors (FETs). Yet, for high mobility devices effects start playing a role which previously could be neglected. One of these effects is contact degradation due to high current densities which eventually renders the device useless.

Therefore, a study was done on high mobility ($\mu > 1\ cm^2/Vs$) FETs made from a metal oxide-based semiconductor with gold as electrode material. The investigated devices had wide electrodes with a typical cross sectional area of 20 um x 30 nm, i.e. the electrodes were wider than the channel length of the transistor. Nevertheless these devices showed strong effects of contact degradation even after recording a single electrical device characteristic lasting less than 60 seconds. Those effects hence, could be related to high current densities present in the FET electrode finger structure. Furthermore, it was found that different types of damages occurred at the source and the drain contact, respectively. This difference cannot be explained by simple electromigration just in the elctrodes but has to be correlated to the transistor

channel as well. A corresponding, more complex model is presented which explains the experimental findings.

HL 44.73 Tue 18:00 P3

Optical spectroscopy study of c(4x2) Ge (001)-surfaces, covered with atomic Au wires — Utz Bass[1], Eugen Speiser[2], Sebastian Meyer[1], Jörg Schäfer[1], Norbert Esser[2], and •Jean Geurts[1] — [1]Universität Würzburg, Physikalisches Institut, Am Hubland, 97074 Würzburg — [2]ISAS, Albert-Einstein-Straße 9, 12489 Berlin

Novel quasi-1D systems like e.g. atomic gold chains on a c(4x2) reconstructed Ge(001)-surfaces enable the investigation of 1D-effects like the possible occurrence of the Luttinger- to Fermi liquid transition. As there is a crucial interplay of the lattice vibrations and the electrical and structural properties on such sensitive systems, phonon dynamics are in the focus of this work. The phonons were addressed by Raman spectroscopy and reveal a clear change from the Ge-oxide layer to the final surface with Au-nano wires. Thermally deoxidizing the Ge-surface under UHV leads to a distinct low-frequency vibration around 65cm-1. Its frequency range and its persistence after Gold deposition in the submonolayer range indicate that this signal is surface related. Additionally, the surface-induced anisotropy of the optical reflectance was complementary investigated by Reflectance-Anisotropy-Spectroscopy (RAS) and IR-ellipsometry.

HL 44.74 Tue 18:00 P3

Detailed analysis of hydrogen termination of MOVPE prepared Si(100) surfaces — Sebastian Brückner, Anja Dobrich, •Claas Löbbel, Peter Kleinschmidt, Henning Döscher, and Thomas Hannappel — Helmholtz-Zentrum Berlin für Materialien und Energie, Hahn-Meitner-Platz 1, 14109 Berlin, Germany

Hydrogen is usually present as carrier gas and by-product from precursors during the preparation of Si(100) in the MOVPE environment. The step structure of the silicon surface might be strongly affected by hydrogen. For a detailed analysis of hydrogen at the Si(100) surface, we applied reflectance anisotropy spectroscopy (RAS) for in situ monitoring and used various surface sensitive UHV-based techniques accessed by a contamination free MOVPE to UHV transfer system.

At Si(100), RAS measures characteristic spectra for the clean and hydrogen terminated surface, which enabled us to study H adsorption and desorption during preparation. Fourier-transform infrared (FTIR) spectroscopy in an attenuated total reflection (ATR) configuration enabled surface sensitive measurements of the silicon hydrogen bonds. Tip induced H desorption by scanning tunneling microscopy (STM) evidenced the complete H termination of the surface.

Correlation between these results led to the conclusion that the surface is hydrogen free at high temperatures of $T > 900°C$ in H_2 ambient and monohydride terminated after cool down in H_2.

HL 44.75 Tue 18:00 P3

Density-Functional Investigation of Gallium Phosphide- Silicon Interface — •Gabi Steinbach[1], Michael Schreiber[1], Sibylle Gemming[1,2], Henning Döscher[3], and Thomas Hannappel[3] — [1]Institut für Physik, Technische Universität Chemnitz, D-09107 Chemnitz, Germany — [2]Institute of Ion Beam Physics and Materials Research, HZ Dresden-Rossendorf, Postfach 51 01 19, D-01314 Dresden, Germany — [3]Helmholtz Center Berlin for Materials and Energy, Hahn-Meitner-Platz 1, D-14109 Berlin, Germany

Gallium phosphide is an established compound semiconductor in the optoelectronic industry with an indirect band gap of 2.26 eV. Used as substrate for GaAsP LEDs or active LED material itself, GaP thin films on cheaper silicon substrates promise a high application potential for LED engineering. The present study addresses the material discontinuities occuring at the boundaries of a GaP thin functional layer on a silicon substrate. Density-functional calculations have been performed with the pseudopotential plane-wave code ABINIT [1]. At the ideally flat GaP(001)|Si(001) interface both the Ga-rich and the P-rich terminations of the GaP layer are studied along with partially Si-occupied boundary layers. Substantially negative values of the work of separation for all investigated interfaces indicate the high stability and the low remanent stresses at the GaP-Si interface. Extended studies contain steps along the <110> direction with the aim to distinguish point-defects and line-defects as origin of the experimentally observed anti-phase boundaries. [1] www.abinit.org.

HL 44.76 Tue 18:00 P3

Raman study of band-bending at ZnSe/GaAs(001) interfaces — Utz Bass, Alex Frey, Suddhasatta Mahapatra, Claus Schumacher, Karl Brunner, and •Jean Geurts — Universität Würzburg, Physikalisches Institut, Experimentelle Physik III, Am Hubland, 97074 Würzburg

At heterovalent interfaces thermodynamically induced intermixing of the constituent materials with different numbers of valence electrons usually causes large variations in band offsets and local doping density, depending on the spatial arrangement of atoms at the interface. We varied the interface stoichiometry of n-doped ZnSe / GaAs (001) heterostructures by the predeposition of different amounts of Zn or Se on n-GaAs prior to n-ZnSe layer growth by MBE. The induced changes in band bending were optically analysed by Raman spectroscopy from coupled Plasmon-LO-Phonon modes and by Far-Infrared reflectance spectroscopy for calibration. We detect a depletion layer of about 50 nm at the heterointerface, which partially shifts from the GaAs into the ZnSe with Se predeposition. Together with data from electrical transport across the interface and capacitance-voltage profiling, our results are explained consistently by a 550 mV potential barrier in the conduction band at a Zn-rich n-ZnSe / n-GaAs interface, which is tuned down to about 70 mV by increasing Se predeposition. In addition, PL signatures for excitation above and below the ZnSe band gap are presented.

HL 44.77 Tue 18:00 P3

Electro-forming – the initial step to resistance switching in vacancy-doped metal-$SrTiO_3$-metal structures — •Florian Hanzig, Juliane Seibt, Ralph Strohmeyer, Hartmut Stöcker, Barbara Abendroth, and Dirk C. Meyer — TU Bergakademie Freiberg, Institut für Experimentelle Physik, Leipziger Straße 23, 09596 Freiberg

Strontium titanate is a widely-used model oxide for solids which crystallize in the perovskite-type of structure. With its large bandgap energy, high dielectric constant and its mixed ionic and electronic conductivity, $SrTiO_3$ is a candidate material for future metal-insulator-metal (MIM) structures in resistive switching memory cells. Here, strontium titanate single crystals doped with oxygen vacancies induced by high temperature vacuum annealing were used. The essential step to enable resistive switching is the electro-forming of the structures by dedicated current-voltage programs. Therefore, the longtime current behaviour of such MIM stacks was investigated. A degradation of the electrical resistance led to a minimum resistivity after a characteristic forming time. During continued formation the resistivity increases up to a failure of the system. A model related to oxygen vacancy diffusion and the introduction of novel structural phases near the surface is proposed.

HL 44.78 Tue 18:00 P3

Investigation of morphological changes of $SrTiO_3$ surfaces induced by annealing and ion bombardment — •Ralph Strohmeyer, Juliane Seibt, Florian Hanzig, Tina Nestler, Mandy Koitzsch, Hartmut Stöcker, Barbara Abendroth, and Dirk C. Meyer — TU Bergakademie Freiberg, Institut für Experimentelle Physik, Leipziger Straße 23, 09596 Freiberg

Strontium titanate is a promising oxide semiconductor in which oxygen vacancies act as intrinsic donors. In order to produce n-doped layers, several approaches to modify the crystal surface are possible. Different methods of vacuum annealing and ion implantation are commonly used. Here, we use atomic force microscopy to study $SrTiO_3$ single crystal surfaces that were modified according to these known methods to investigate whether the surface structure is changed during the process and if the electrical properties correlate with these changes. Based on the morphology of the untreated surface, which shows a terrace structure with step heights equal to the dimensions of the cubic $SrTiO_3$ unit cell, the exposure to heat leads to a formation of 'bubble-like' structures and possibly even local melting and recrystallization. The kind of restructuring strongly depends on temperature and exposure time. The implantation of different ions (i.e. of Ar, O and H) is found to have a comparatively weaker impact on the surface morphology.

HL 44.79 Tue 18:00 P3

Strontium titanate surface and bulk modifications due to vacuum annealing — •Juliane Seibt, Florian Hanzig, Ralph Strohmeyer, Hartmut Stöcker, Barbara Abendroth, and Dirk C. Meyer — TU Bergakademie Freiberg, Institut für Experimentelle Physik, Leipziger Straße 23, 09596 Freiberg

Vacuum annealing is a widely used method to increase the electric

conductivity of $SrTiO_3$ single crystals. The induced oxygen vacancies act as intrinsic donors and lead to n-type conductivity. Apart from the changed electric properties, however, also structural modifications arise from this treatment. Here, we try to summarize all such changes originating from the in-vacuum heat-treatment. Used characterization methods include atomic force microscopy, transmission electron microscopy, X-ray diffraction, ellipsometry, infrared and photoluminescence spectroscopy. Beside the expected variation of bulk properties, especially surface modifications could be detected. The intrinsic number of near-surface dislocations in the samples was reduced by vacuum annealing but the surface roughness increased due to a self-organized restructuring process. Furthermore, the photoluminescence spectra revealed dependencies on exposure time and surrounding atmosphere. The influence of adsorbed or intrinsic surface layers on the observed behaviour will be discussed.

HL 44.80 Tue 18:00 P3

Cubic-tetragonal phase transition at elevated temperatures and resistivity hysteresis of surface vacuum annealed $SrTiO_3$ — •Tina Nestler[1], Kay Potzger[2], Hartmut Stöcker[1], Barbara Abendroth[1], Ralf Strohmeyer[1], Robert Zierer[1], and Dirk C. Meyer[1] — [1]TU Bergakademie Freiberg, Institut für Experimentelle Physik, 09596 Freiberg, Germany — [2]Forschungszentrum Dresden-Rossendorf e.V., Institut für Ionenstrahlphysik und Materialforschung, Bautzner Landstraße 128, 01328 Dresden, Germany

Electrical properties of $SrTiO_3$ single crystal samples treated by an anisotropic surface annealing technique under reducing conditions have been investigated in the temperature range of 35 K–300 K. Optical and atomic force microscopy shows that annealing gives rise to the formation of colored dendritic structures and polycrystallization. Hall and resistivity measurements show metallic behavior due to oxygen vacancy doping. Additionally, the temperature dependent resistivities indicate the cubic-tetragonal phase transition, which has not been reported to our knowledge before. Furthermore, the transition occurred up to 53 K above the known bulk transition temperature T_C at 105 K with a hysteresis up to a temperature of 220 K. Both phenomena possibly arise from dislocations and associated strains introduced by surface annealing that are assumed to lower the free energy of the tetragonal phase and simultaneously pin tetragonal domains. Thus, microregions of the tetragonal phase persist above T_C causing the hysteresis in resistivity up to ∼3 %. This possibly provides new chances for future oxide based non-volatile data storage devices.

HL 44.81 Tue 18:00 P3

Valence Change of $SrTiO_3$ in a DC Electric Field due to Oxygen Redistribution — •Hartmut Stöcker[1], Tilmann Leisegang[2], Matthias Zschornak[1], Juliane Seibt[1], Florian Hanzig[1], and Dirk C. Meyer[1] — [1]TU Bergakademie Freiberg, Institut für Experimentelle Physik, Leipziger Str. 23, 09596 Freiberg — [2]Forschungszentrum Dresden-Rossendorf, Bautzner Landstr. 400, 01328 Dresden

Strontium titanate is an oxidic semiconductor and crystallizes in the perovskite-type of structure, however, several methods have been shown to induce distortions of this perfect cubic lattice. One of the key parameters is the oxygen stoichiometry that on the one hand acts as doping and has great influence on the electric conductivity but on the other hand also couples to the crystal structure. Since oxygen ions and vacancies are electrically charged, external electric fields make it possible to redistribute oxygen and to study accompanying structural modifications. Therefore, $SrTiO_3$ (001) wafers have been investigated *in situ* by fluorescence X-ray absorption near edge structure (XANES) analysis in grazing incidence geometry. The XANES spectra show a clear shift of the Ti-K absorption edge energy depending on the polarity of the applied static electric field. The shift can be attributed to a change of the Ti valence state due to diffusion of oxygen in the near-surface region. No shift was observed for the Sr-K absorption edge energy. A controlled switching of the Ti valance may give rise to a variety of interesting applications.

HL 44.82 Tue 18:00 P3

Electrical and Optical Characterisation of ta-C/Silicon MASS Diodes — •Julian Alexander Amani, Marc Brötzmann, Ulrich Vetter, and Hans Hofsäss — Georg-August-Universität Göttingen, II. Physikalisches Institut, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

The metal - amorphous semiconductor - semiconductor (MASS) system metal/ta-C/silicon forms heterojunctions, which exhibit a pronounced rectifying behaviour, low saturation current and low parasitic currents. The conduction in this system is well described by a serial arrangement of an ideal Schottky diode and a Frenkel-Poole resistance which is dominant at forward bias [1,2].

In this work ta-C based MASS diodes were produced via mass separated ion beam deposition of carbon on p-type silicon substrates. To facilitate photoconductivity measurements of the heterostructures ITO was used as gate contact.

We present electrical characterizations of those structures with I-V and C-V measurements. Time and wavelength resolved photoconductivity measurements were performed in order to find the energetic distribution of defect states in the ta-C band gap.

[1] M. Brötzmann et al., JAP 106, 063704 (2009)
[2] M. Brötzmann et al., PSS C 7, 256 (2009)

HL 44.83 Tue 18:00 P3

The study of Landé g-factor and effective mass of electrons in GaAs/AlGaAs quantum wells — •feng liu[1], alexander schwan[1], gregor bartsch[1], dmitri yakovlev[1], k biermann[2], r hey[2], p.v. antos[2], and manfred bayer[1] — [1]Experimental Physics 2, TU Dortmund University, D-44221 Dortmund, Germany — [2]Paul-Drude-Institute für Festkörperelektronik, 10117 Berlin, Germany

The Landé g-factor is a quantity which characterizes energy levels of electrons in magnetic field. The g-factor is important because the behavior of electron spins can be manipulated by controlling the electron g-factor. In our work, the influence of the spin-orbital splitting in the conduction band in GaAs quantum wells (QWs) on electron g-factor was studied. The g-factor of free electrons in GaAs/AlGaAs QWs with and without spin-orbit splitting in the conduction band was measured using time-resolved Kerr rotation technique and compared. It was found that the spin-orbit splitting of the conduction band only slightly influence the electron g-factor. Additionally, the effective mass of free electrons is also measured using optically detected cyclotron resonance technique and internal transitions of trions were observed.

HL 44.84 Tue 18:00 P3

Reducing the dislocation density of GaAs on Si(001) using InAs quantum dots — •Martin Etter, Michael Wiesner, Wolfgang-Michael Schulz, Robert Rossbach, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und funktionelle Grenzflächen, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany

In order to integrate optoelectronics with standard Si microelectronics, several attempts were made to grow GaAs on Si by using buffer layers of Ge/GeSi/Si or graded GaAsP or InGaP layers or the use of strained-layer superlattices consisting of InGaAs, GaAsP or AlGaAs layers to overcome the large lattice mismatch and the different thermal expansion coefficient. A novel approach is the implementation of InAs quantum dots, which have the ability to suppress the dislocations which propagate to the GaAs surface due to their high strain field. In our work we characterize GaAs/Si-samples including different numbers of InAs quantum dot layers with a maximum GaAs layer thickness of 1 μm. Characterization is done by X-ray diffraction measurements, scanning electron microscopy (SEM), atomic force microscopy, respectively photoluminescence spectroscopy were perfomed to characterize the GaAs layers. Thereby SEM pictures show clearly the improvement of the GaAs surface compared to the other approaches. Furthermore, the influence on the quality of optoelectronic structures is shown.

HL 44.85 Tue 18:00 P3

Device Simulation of ZnO/Cu_2O Heterojunction Solar Cells — •Philipp Hering and Bruno. K. Meyer — 1. phys. Inst., Justus-Liebig-Universität, Heinrich-Buff-Ring 16, 35392 Giessen, Germany

Cuprous oxide thin films constitute despite the relatively large band gap (2.17 eV) a very promising absorber material for sustainable low cost photovoltaic application due to the high absorption coefficient and great abundance. A model was developed to describe the illuminated operation of the heterojunction zinc oxide forms with cuprous oxide, taking full account of interface recombination. Numerical analysis was performed, providing insight into the impact of the conduction band discontinuity, interface states and doping on power conversion efficiency

HL 44.86 Tue 18:00 P3

Determination of the band offset for the heterostructure

ZnO/Cu_2O and ZnS/Cu_2O via X-Ray Photoelectron Spektroscopy (XPS) — •Benedikt Kramm, Andreas Laufer, Achim Kronenberger, Swen Graubner, Daniel Reppin, Alba Seibert, Philipp Schurig, Angelika Polity, and Bruno K. Meyer — 1. Physikalisches Institut, Justus-Liebig-Universität, Heinrich-Buff-Ring 16, 35392 Gießen, Germany

ZnO and Cu_2O are direct band-gap semiconductors. Both are promising materials for electronic devices like diodes, transistors or solar cells. Important is, that ZnO and Cu_2O contain only non toxic und sustainable elements. Due to a band-gap energy of 2.1 eV for Cu_2O a high absorption in the visible light spectrum could be obtained which is suitable for solar cells. We produced a heterojunction of intrinsic p-type Cu_2O and hydrogen doped n-type ZnO or ZnS on sapphire using sputter deposition. Investigating the energy band structure of the thin film heterojunction ZnO/Cu_2O via XPS yield to be a type II alignment with a valence-band offset between $2.4-2.7$ eV. Furthermore the band offset between ZnS and Cu_2O, using ZnS as a buffer-layer for the heterostructure $ZnO/ZnS/Cu_2O$, was explored. For the band offset structure of the whole system the band offset values for ZnS/ZnO, determined by Persson [1], have been used.

[1] Perrson et al. Strong Valance-Band Offset Bowing of $ZnO_{1-x}S_x$ Enhances p-Type Nitrogen Doping of ZnO-like Alloys, *Phys. Rev. Lett.*, Okt 2006, **97**(14):146403

HL 44.87 Tue 18:00 P3

Photoluminescence studies of top-down $Zn_{1-x}Mg_xO/ZnO$ quantum square samples with different dimensions — •Martin Fischer[1], Markus Piechotka[1], Torsten Henning[1], Alexej Chernikov[3], Bernhard Laumer[2], Sangam Chatterjee[3], Peter J. Klar[1], Martin Eickhoff[1], and Bruno K. Meyer[1] — [1]I. Physikalisches Institut, Justus-Liebig-Universität Gießen, Heinrich-Buff-Ring 16, 35392 Gießen — [2]Walter-Schottky-Institut, Technische Universität München, Am Coulombwall 3, 85748 Garching — [3]Fachbereich Physik, Philipps-Universität Marburg, Renthof 5, 35032 Marburg

Quantum square structures with lateral lengths from 100 nm to 4 μm were prepared from PAMBE-grown $Zn_{1-x}Mg_xO/ZnO$ single quantum well samples with 10 nm well width and a Mg content of 0.16 by using electron beam lithography followed by ion-beam etching. Low temperature photoluminescence spectroscopy studies were done on groups of several squares. We also investigated single squares in time-dependent photoluminescence spectroscopy. We report the influence of strain relaxation in quantum squares of different dimensions on the excitonic transitions. The lateral dimension of the quantum squares allows one to exclude additional lateral quantum confinement effects in the samples.

HL 44.88 Tue 18:00 P3

Spectroscopic ellipsometry for process control in PLD growth — •Jan Lorbeer, Tammo Böntgen, Jan Zippel, Rüdiger Schmidt-Grund, Michael Lorenz, and Marius Grundmann — Universtät Leipzig, Institut für Experimentelle Physik II, Linnéstr. 5

We present detailed measurements of the surface condition of typical substrates and the dynamics of growth processes in heterostuctures. Process control is a vital part of modern thin film synthesis. We have used in situ spectroscopic ellipsomety (SE) to gain inside into the growth process of several oxidic compounds. Surface quality plays an important role for epitaxial growth as it determines the possible relations between the substrate and the epilayer. Thus in situ control of the surface condition is of importance. This is especially true when special growth conditions lead to surface reconstruction or the formation of oxide layers. We have investigated the surface of severals typical substrates (e.g. Si, GaAs, ZnO). Si and GaAs both exhibit the growth of an oxide layer when exposed to high oxygen partial pressure during heating. When heated under vacuum conditions on the other hand the a reduction of the Si oxide layer thickness was observed. ZnO is also prone to oxygen loss in low pressure conditions, leading to a reduction of the ZnO surface. We observed a change of the surface of single crystal ZnO substrates when heated in vacuum conditions. These results are compared to RHEED measurement of the same sample. This work was supported by Deutsche Forschungsgemeinschaft in the framework of Sonderforschungsbereich 762 "Functionality of Oxidic Interfaces".

HL 44.89 Tue 18:00 P3

Combinatorial growth of ZnO resonators — •Helena Hilmer[1], Tom Michalsky[1], Chris Sturm[1], Rüdiger Schmidt-Grund[1], Jesús Zúñiga-Pérez[2], Renate Fechner[3], Frank Frost[3], and Marius Grundmann[1] — [1]Universität Leipzig, Inst. für Exp. Physik II, Linnéstr. 5, 04103 Leipzig — [2]CRHEA, Rue Bernard Grégory, 06560 Valbonne, France — [3]IOM e.V., Permoserstr. 15, 04318 Leipzig

We report on the growth of planar microresonators, which consist of two all-oxide Bragg reflectors surrounding either a MgZnO/ZnO quantum well (QW) structure or a ZnO bulk cavity as active medium. For the growth of such resonators, there is a competition between a high-quality photonic structure and a homogeneous electronic system. In order to improve both simultaneously we use a combination of different preparation techniques as pulsed laser deposition (PLD), molecular beam epitaxy (MBE) and ion beam smoothing (IBS).

ZnO bulk cavities, grown intentionally rough, yield good electronic properties. By applying IBS on these structures we have improved the photonic properties. Clearly, two polariton branches can be seen, which are related to the A-/B- (coupling strength $V_{A,B} \cong 15\,\mathrm{meV}$) and the C-exciton ($V_C \cong 60\,\mathrm{meV}$) at $T = 10\,\mathrm{K}$, indicating both, high photonic and electronic quality.

For the QW-cavity, we have found an influence of the resonator on the QW-exciton lifetime, i.e. resonator is in the weak coupling regime. For the enhancement of the oscillator strength, multiple QW-cavities have been grown by a combination of PLD and MBE showing smooth layers together with good electronic properties.

HL 44.90 Tue 18:00 P3

Cavity-photon mode dispersion in 1D confined optically anisotropic microresonators — •Chris Sturm, Helena Hilmer, Rüdiger Schmidt-Grund, and Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Linnéstraße 5, 04103 Leipzig

Microresonators with an anisotropic cavity medium, e.g. GaN and ZnO, became more important in the last years. These structures allow the realization of devices operating in the UV spectral range (e.g. blue LEDs) and the observation of a strong exciton-photon coupling at room temperature and above. For a precise description and understanding of the coupled particles the properties of the involved photons (especially their dispersion) have to be known.

Here we present an approach to the calculation of the cavity-photon dispersion which takes into account the optical anisotropy of the cavity medium as well as the number of layer pairs of the Bragg reflectors which are used as mirrors for the microresonator. Thereby we found, that even for a uniaxial c-plane oriented cavity with a birefringence of 3% (similar to that of ZnO), the influence of the anisotropy on the TE-TM splitting is in the same order of magnitude as the splitting itself. Therefore the anisotropy of the cavity medium cannot be neglected. Furthermore, we applied this model to a ZnO-based microresonator which yields good agreement with the experimentally observed dispersion of the cavity-photon mode.

HL 44.91 Tue 18:00 P3

Electrical and structural properties of the $ZnO/BaTiO_3$ interface — •Peter Schwinkendorf, Kerstin Brachwitz, Tammo Böntgen, Jan Zippel, Holger Hochmuth, Michael Lorenz, and Marius Grundmann — Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik II, Universität Leipzig

Semiconductor/ferroelectric heterostructures are important for the realisation of new microelectronic applications such as the ferroelectric field-effect transistor[1]. To develop corresponding technologies up to commercial relevance there are several problems left to be solved. In particular, the interface semiconductor/ferroelectric seems to be the major key to further progress.

$ZnO/BaTiO_3$(BTO) heterostructures were grown by pulsed laser deposition on $SrRuO_3$(SRO) covered $SrTiO_3$(100) substrates. X-Ray diffraction measurements revealed the orientation of the SRO layer to be (100) and that of BTO to be (001), respectively. The surface morphology of the particular layers was studied by atomic force microscopy. The interfaces are smooth exhibiting RMS values of about 1 nm. For electrical measurements ohmic top Au-contacts were fabricated by dc-sputtering. The conducting SRO layer ($\varrho = 3.3\times10^{-6}\,\Omega$m) serves as ohmic back-contact. Due to this design the structures are considered to be of MIS type. Current-voltage measurements indicate charging effects at the ZnO/BTO interface. To further investigate these charging effects, capacitance-voltage- and admittance-spectroscopy were performed.

[1] M. Brandt *et al.*, J. Vac. Sci. Technol. B, Vol. 27, 1789 (2009)

HL 44.92 Tue 18:00 P3

Growth induced structural defects in $BaTiO_3$3-ZnO-heterostructures — •Christian Kranert, Tammo Böntgen, Rüdiger Schmidt-Grund, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Semiconductor Physics Group, Institut für Experimentelle Physik II, Leipzig, Germany

The coupling of the switchable and non-switchable polarization of ferroelectric ($BaTiO_3$) and pyroelectric (ZnO) materials, respectively, in heterostructures results in new physical effects which can be used for modulators, sensors and memories. Their fabrication requires epitaxial growth processes. We present investigations on the crystal structure of $BaTiO_3$-ZnO-heterostructures grown by pulsed laser depostion using X-Ray diffraction and Raman spectroscopy. The latter was carried out with an excitation wavelength of 325 nm in the absorption regime allowing to study the Raman spectra of ultra-thin (< 10 nm) $BaTiO_3$ layers.

We show that the orientiation of $BaTiO_3$ grown on ZnO can be switched between (001) and (111) by variation of the growth parameters for a certain range of the layer thickness. Especially the (111)-oriented $BaTiO_3$ layers exhibit the assembly of a hexagonal impurity phase. Different rotation domains were observed in the top layer ($BaTiO_3$ on ZnO or vice versa) in agreement with a recent group-theoretical treatment [1].

[1] M. Grundmann et al., Phys. Rev. Lett. **105**, 146102 (2010)

HL 44.93 Tue 18:00 P3

Plasma-oxidation of Ge(100)-surfaces characterized by MIES, UPS and XPS — •Lienhard Wegewitz[1], Sebastian Dahle[1], Oliver Höfft[2], Wolfgang Viöl[3], Frank Endres[2], and Wolfgang Maus-Friedrichs[1] — [1]Institut für Energieforschung und Physikalische Technologien, Technische Universität Clausthal, Leibnizstr. 4, 38678 Clausthal-Zellerfeld, Germany — [2]Institut für Mechanische Verfahrenstechnik, Technische Universität Clausthal, Arnold-Sommerfeld-Str. 6, 38678 Clausthal-Zellerfeld, Germany — [3]HAWK Göttingen, Fakultät Naturwissenschaften und Technik, Von-Ossietzky-Str. 99, 37085 Göttingen, Germany

Cleaning and passivation of Germanium surfaces is of tremendous technological interest. Germanium has various applications, for example in complementary metal-oxide-semiconductor elements. It turned out to be difficult to prepare contamination free Germanium surfaces by methods of wet chemistry. Several attempts have been made preparing such surfaces by different plasma treatments. We report cleaning and passivation of Ge(100)-surfaces by dielectric barrier discharge plasma at ambient temperature in oxygen and in air studied by Metastable Induced Electron Spectroscopy (MIES) and Photoelectron Spectroscopy (UPS(He I) and XPS). The plasma treatment is carried out in a special high-vacuum chamber which operates up to ambient pressure and is directly connected to the ultra-high vacuum chamber including the analysis equipment. In summary the air plasma treatment as well as the oxygen plasma treatment result in contamination free GeO_2 covered surfaces.

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Soft landing Indium ion beams produced by a variable energy focused ion beam system — •Yu-Ying Hu, Dirk Reuter, and Andreas D. Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany

A focused ion beam (FIB) system under conventional operation employs 30 keV ions for micro-fabrication. In this work, the landing energy of ions can be tuned by applying positive voltages on the substrate, i.e. employing a retarding mode: the substrate potential decelerates the 30 keV ions, generating ions with various landing energies given by the difference between the accelerating and the decelerating voltage. The decelerating voltage to be operated on the GaAs substrate is at maximum 30 kV, i.e. soft landing is possible. In this study, we employ ion beams with very low landing energies of a few tens to few hundreds of eV which yields implantation depths in the range of only a few nm according to simulations. An Indium liquid metal ion source is produced for this experiment. The ion-induced damage is reduced due to low landing energy, which is observed through secondary electron images after ion sputtering. Above 29.76 kV decelerating voltage, no ion sputtering trace can be seen on the substrate. The adaptive objective lens voltage has to be reduced to focus the soft landing ion beam. Nevertheless, the diameter of the low energy beam is several μm, i.e., roughly 30 times larger as without a retarding voltage.

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Copper oxide films prepared by rf sputter deposition — •Ekachai Chongsereecharoen, Achim Kronenberger, Angelika Polity, and Bruno K. Meyer — I. Physikalisches Institut, Justus-Liebig-Universität Giessen, Heinrich-Buff-Ring 16, 35392 Giessen, Germany

Cuprite (Cu_2O) and tenorite (CuO) are two well known phases of copper oxide. A metastable copper oxide, paramelaconite (Cu_4O_3), is another phase of copper oxide which has been rarely studied. CuO is p-type semiconductor which has many application such as solar cells, sensors and lithium ion Batteries. In this study CuO and Cu_4O_3 films were prepared on glass substrates by reactive rf sputter deposition. The structural properties were characterized by x-ray diffraction. The results show that with varying deposition conditions (sputtering power and oxygen flow rate), the formation of CuO and Cu_4O_3 phase is controllable. The optical and electrical properties of the sputtered films were investigated by optical spectroscopy and Hall effect measurement respectively. The properties of the films depend on the phase of the prepared films and deposition conditions.

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Quantification of Impurities in Cu2O — •Hauke Metelmann[1], Andreas Laufer[1], Daniel Reppin[1], Swen Graubner[1], Angelika Polity[1], Bruno K. Meyer[1], Sebastian Geburt[2], and Carsten Ronning[2] — [1]I. Physikalisches Institut, Justus-Liebig-Universität Giessen, Heinrich-Buff-Ring 16, 35392 Giessen, Germany — [2]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany

Cuprous oxide (Cu2O) has suitable properties for thin film solar cell applications. One powerful method to investigate concentrations of impurities is secondary ion mass spectrometry (SIMS). This method stands out due the fact that the chemical identity can be directly determine without considerations of ionisation state or binding energy. The quantification of SIMS data requires the usage of so called relative sensitivity factors (RSFs) which are dependent on the analysed material. While some materials like Si, GaAs, InP or ZnO already have established RSF tables there has been no such reference for Cu2O yet. In the presented work the RSF table for Cu2O has been determined for sputtered Cu2O thin films by using implantation standards. The RSFs of the elements follow systematic trends according to their ionisation potential and their electron affinity so that the RSF value for unmeasured elements can be interpolated or extrapolated by a set of determined RSFs. Finally, these RSFs have been used to investigate impurities in various Cu2O layers.

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Strukturelle und elektrische Eigenschaften von PLD-gezüchteten Zinkferrit-Dünnfilmen — •Katja Mexner, Matthias Brandt, Kerstin Brachwitz, Holger Hochmuth, Michael Lorenz und Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Linnéstrasse 5, 04103 Leipzig

Zinkferrit ($ZnFe_2O_4$) ist ein Material, mit einer Curie-Temperatur $T_C > 300$ K, das durch seine elektrischen und magnetischen Eigenschaften in der Spintronik Anwendungen finden kann. Mittels gepulster Laserabscheidung wurden von stöchiometrischen Targets Zinkferrit-Dünnfilme ($d \approx 200$ nm) auf (001)-orientierten $SrTiO_3$- und MgO-Substraten hergestellt. Die jeweiligen Gitterfehlpassungen betragen $\Delta a_{SrTiO_3} = 7,5\%$ und $\Delta a_{MgO} = 0,2\%$. Durch Röntgenbeugungsmessungen konnte (001)-orientiertes, epitaktisches Wachstum auf den verwendeten Substraten festgestellt werden. Es zeigte sich, dass die strukturellen und elektrischen Eigenschaften der Dünnfilme deutlich von der Substrattemperatur und weniger vom Sauerstoffpartialdruck während der Abscheidung abhängen. Mit steigender Temperatur sinken das Zn/Fe-Verhältnis und die out-of-plane-Gitterkonstante, die 2Θ–ω-Röntgenreflexe werden schärfer und der spezifische Widerstand nimmt zu. Temperaturabhängige Messungen des spezifischen Widerstandes zeigen einen thermisch aktivierten Leitungsmechanismus in den $ZnFe_2O_4$-Dünnfilmen. Es wurden Aktivierungsenergien von 50 bis 90 meV bestimmt. Magnetfeldabhängige Messungen des Hallwiderstandes bis 2 T zeigen den Einfluss des anomalen Hall-Effekts für $B < 0,5$ T.

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Electrical and structural properties of Zn-Co-O thin films — •Friedrich Schein, Holger Hochmuth, Holger von Wenckstern, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut fürExperimentelle Physik II, Linnéstr. 5, 04103 Leipzig

Considering that virtually all transparent oxide semiconductors (TOSs) are n-type it is of great interest to investigate p-type TOSs. A promising class of such materials are the zinc spinels ZnM_2O_4 (M = Co, Rh, Ir) [1]. They can be fabricated near and at room temperature; for $ZnRh_2O_4$ [2] and $ZnCo_2O_4$ [3] indications for stable p-type conductivity even in amorphous form were reported.

We present structural and electrical properties of zinc-cobalt-oxide thin films grown by pulsed laser deposition. The fabrication parameters like oxygen partial pressure and temperature are optimized in terms of electrical conductivity σ and surface quality. Zn-Co-O thin films deposited at low temperature ($\approx 200°$ C) are polycrystalline and exhibit σ up to 18 S/cm whereas room temperature fabrication reveals X-ray-amorphous films having $\sigma = 6$ S/cm. Smooth surfaces with rms-roughness less than 0.5 nm have been measured with atomic force microscopy. The presentation includes a discussion of Hall effect measurements indicating p-type conductivity for certain growth conditions. Heterostructures using ZnO as n-type TOS are also shown.

[1] Dekkers *et al.*, Appl. Phys. Lett. **90**, 021903 (2007)
[2] Narushima *et al.*, Adv. Mater. **15**, 1409 (2003)
[3] Kim *et al.*, J. Appl. Phys. **107**, 103538 (2010)

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Sputtering of ZnO by a modified Radio-Frequency Ion Thruster (RIT) as Ion-Beam-Sputter-Source — •Martin Becker, Angelika Polity, Davar Feili, and Bruno K. Meyer — I. Physikalisches Institut, Justus-Liebig-Universität Giessen, Heinrich-Buff-Ring 16, 35392 Giessen, Germany

Radio-Frequency-Ion-Thrusters, as designed for propulsion systems (ion extraction and grid system), are also qualified for thin film deposition and surface etching, because they can be used with different gases (inert and reactive) and extraction voltages.

ZnO thin films were deposited on float glass using a 4 inch ceramic ZnO target. The deposition temperature was varied using a heated substrate holder, as well as additional oxygen flow was provided to control the stoichiometry of the films. First investigations on this thin films will be presented.

HL 44.100 Tue 18:00 P3

Electronic structure of ZrS_xSe_{2-x} by density functional theory — •Ailakbar Ghafari[1], Arash Bouchani[2], Mohamed Moustafa[1], Christoph Janowitz[1], Helmut Dwelk[1], and Recardo Manzke[1] — [1]Institut für Physik, Humboldt-Universität zu Berlin, Newtonstr. 15, D-12489 Berlin, Germany — [2]Physics Department, Islamic Azad University, Kermanshah Branch, Iran

The electronic properties of the ZrS_xSe_{2-x} (x varies between zero and two) semiconductors have been calculated by density functional theory (using the Wien2K code) employing the full potential Hamiltonian within the Generalized Gradient Approximation (GGA) method. The results obtained for the end members of the series, i.e. ZrS_2 and $ZrSe_2$ reveal that the valence band maximum and conduction band minimum are located at Γ and between Γ and K respectively which is in agreement with our photoemission experimental data. Trends in the electronic structure for the whole substitution series are discussed.