HL 50 Poster II

Time: Thursday 16:30–19:00 Room: P3

HL 50.1 Thu 16:30 P3

Pressure-Induced Insulator-Metal Transition in (CoC10H10)0.25TiSe2 — •Sergey Ovsyannikov[1,2], Vladimir Shchennikov[2], Alexander Titov[3], and Yoshiya Uwatoko[1] — [1]The Institute for Solid State Physics, The University of Tokyo, Kashiwanoha, 5-1-5, Kashiwa, Chiba 277-8581, JAPAN — [2]High-Pressure Group, Institute of Metal Physics, Urals Division of Russian Academy of Sciences, GSP-170, 18 S. Kovalevskaya Str., Yekaterinburg 620041,RUSSIA — [3]Institute of Metal Physics, Urals Division of Russian Academy of Sciences, GSP-170, 18 S. Kovalevskaya Str., Yekaterinburg 620219, RUSSIA

In the present work we (i) have synthesized the crystals of (CoC10H10)0.25-TiSe2 by intercalation of CoC10H10 into TiS2 matrix as well as (ii) have investigated their properties at extreme conditions of ultrahigh pressure up to 20 GPa at room temperature conditions. We report the high-pressure behaviours of electrical resistance, thermoelectric power, compressibility, and thermal difference along a sample. By the changes of the above properties under pressure we have established the reversible insulator-semiconductor-metal transitions. Under pressure, the compound exhibited a change of its electrical resistance by about 8 orders and two inversions of thermopower sign. We performed six subsequent cycles of pressurisation-releasing and have established both reversibility of the changes and repeatability of the results. So, this layer crystal seemed to be a new functional material for wide applications. S.V.O. acknowledges the Japanese Society of the Promotion of Science (JSPS) for the financial support. The research was supported by the Russian Foundation for Basic Research (RFBR), Gr. No. 04-02-16178.

HL 50.2 Thu 16:30 P3

ATOMISTIC STUDY OF BULK PROPERTIES AND POINT DEFECTS IN GERMANIUM — •Henning Gessner and Matthias Posselt — FZ-Rossendorf PO-Box 510119, D-01314 Dresden

Different parameterizations for the Stillinger-Weber potential and the Tersoff potential are used to determine the elastic properties and the melting point of Ge as well as the stability, the structure and the energetics of potential vacancy and self-interstitial configurations. The results are compared with literature data obtained from experiments and by tight-binding and density-functional theory calculations. Furthermore, the vacancy and self-interstitial migration is investigated for temperatures between 600 and 1200 K. The defect diffusivity, the self-diffusion coefficient per defect and the corresponding effective migration barriers are determined. These results are compared with experimental data on self-diffusion in Ge.

HL 50.3 Thu 16:30 P3

Anisotropic Zeeman splitting of shallow impurities in Si/Ge double-barrier heterostructures — •Oleksiy B. Agafonov[1], Kai-Martin Haendel[1], Ulrich Denker[2], Oliver G. Schmidt[2], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Universität Hannover, Appelstraße 2, D-30167 Hannover — [2]Max-Plank-Institut für Festkörperforschung, Heisenbergstraße 1, D-70569 Stuttgart

We report the results of our experimental investigations of the Zeeman splitting of shallow impurities in Si/Ge double-barrier heterostructures [1]. The impurities are located in a strained Ge quantum well with a thickness of four monolayers. The splitting was measured as a function of angle between the magnetic field and the sample growth direction. A strong anisotropy of the heavy-hole g-factor was observed. A complete suppression of the splitting takes place when the magnetic field is oriented perpendicular to the sample growth direction, while in the parallel field the observed splitting is maximal.

[1] K.-M. Haendel, R. Winkler, U. Denker, O. G. Schmidt and R. J. Haug (2005), cond-mat/0510322.

HL 50.4 Thu 16:30 P3

Mn-silicide nanoparticles formed inside Si using ion implantation — •Shengqiang Zhou, K. Potzger, A. Mücklich, F. Eichhorn, N. Schell, R. Grötzschel, B. Schmidt, W. Skorupa, M. Helm, and J. Fassbender — Institute for Ion Beam Physics and Materials Research at the Forschungszentrum Rossendorf, POB 510119, 01328 Dresden, Germany

300 keV Mn was implanted into p-Si with a fluence of 1*10^15/cm2, 1*10^16/cm2 and 5*10^16/cm2, respectively, at 620 K. The samples were annealed at 1070 K in N2 ambient for 5 min by rapid thermal annealing. Rutherford backscattering/channeling, transmission electron microscopy and X-ray diffraction were applied for structural characterization. Mn-silicide nanoparticles were formed with the size of 5 nm already in the as-implanted samples and grew up to around 30 nm after annealing. Moreover no significant evidence is found for Mn substituting Si sites either in as-implanted or annealed samples. The virgin samples already show a ferromagnetic like behavior, and the moment is slightly increased after implantation (1*10^16/cm2) and annealing by around 0.5 Bohr magneton per Mn. Therefore, the majority of Mn ions formed Mn-silicides, and some are diluted in Si matrix and develop into ferromagnetic coupling. These effects have to be properly considered for the design of Si-based diluted magnetic semiconductors.

[1] M. Bolduc, C. Awo-Affouda, A. Stollenwerk, M. B. Huang, F. G. Ramos, G. Agnello, and V. P. LaBella Phys. Rev. B 71, 033302 (2005).

HL 50.5 Thu 16:30 P3

Investigation of copper transport in silicon — •Mike Thieme and Jörg Weber — Technische Universität Dresden, 01062 Dresden, Germany

Copper transport was studied in p-type FZ-silicon using the DLTS-signal of the Cu-pairs to monitor the interstitial Cu concentration. Atomic copper was deposited at room temperature onto the sample surface from a diluted HF-solution containing ions of the metal. In the bulk, it was impossible to detect copper after the deposition (detection limit 10^{10} atoms/cm^3). Even a subsequent annealing up to 350 °C in helium atmosphere did not produce detectable copper traces. The scavenging of copper was studied in FZ-Si samples containing Cu-pairs. The dissociation energy of the pairs is 1.02 eV and an annealing step at 250 °C is necessary to break them up. Our investigations show that the amount of outdiffusing copper depends on the annealing gas. This opens a new way to control the interstitial copper contamination in silicon.

Acknowledgment: This work has been supported by the DFG (WE1319/15-1).

HL 50.6 Thu 16:30 P3

Acceptor passivation in silicon wafers under ambient conditions — •T.D. Vo, M. Thieme, J. Bollmann, and J. Weber — Technische Universität Dresden, 01062 Dresden, Germany

Standard p-type silicon wafers exhibit reduced conductivity at surface-near regions after storage for months under ambient conditions. The extension of this passivated layer depends on the shallow doping density. The conductivity can be reactivated by thermal treatments at moderate temperatures. Schottky barrier diodes were prepared without wet chemical treatments to avoid any additional hydrogen contamination. All samples (0.05 to 20 Ω cm, Cz- and FZ-grown) show ion drift effects during reverse bias annealing. From temperature and time dependent capacitance measurement we identify the dissociation energy of the boron complex to be 1.3 eV. Annealed samples without passivation show transient ion drift effects very similar to the initial samples. Apparently, the annealing does not cause an out diffusion of the ions. Wet chemical etching on annealed samples was performed to study the potential role of hydrogen. We discuss a possible identification of the compensating species.

HL 50.7 Thu 16:30 P3

Isolated gold impurities in surface near regions of silicon — •J. Bollmann and J. Weber — Technische Universität Dresden, 01062 Dresden, Germany

A DLTS and PL study on silicon samples doped with gold is reported. After the implantation of Au ions (particle fluence from 10^{12} to 10^{15}cm^{-2}, energy 80 keV), a thermal treatment at 950 °C (20 min) was carried out to remove the radiation damage and to diffuse in the gold atoms. The implantation makes use of ion beams of single isotope mass and a precise amount of incorporated impurities. EXAFS studies showed that under implantation conditions most of the Au atoms occupy isolated substitutional lattice sites [J. Bollmann, D. C. Meyer , J. Weber, and H.-E. Mahnke, ICDS 23]. In the samples the already known PL line at 793meV,

attributed to the neutral substitutional gold center, is identified. In contrast, the deep level centre E12 detected by DLTS does not agree with the reported energy level for the substitutional Au. The E12 defect is concentrated close to the surface.

HL 50.8 Thu 16:30 P3

Volumetric effects under pressurization and microindentation in semiconductors — •Vsevolod Shchennikov Jr[1], Sergey Ovsyannikov[2,3], Vladimir Shchennikov[2], Ivan Komarovsky[2], and Sergey Smirnov[1] — [1]Micromechanics lab., Institute of Engineering Sciences of Russian Academy of Sciences, Urals Division, GSP-207, 34 S. Komsomolskaya Str, Yekaterinburg 620219, RUSSIA — [2]High-Pressure Group, Institute of Metal Physics, Urals Division of Russian Academy of Sciences, GSP-170, 18 S. Kovalevskaya Str., Yekaterinburg 620041, RUSSIA — [3]The Institute for Solid State Physics, The University of Tokyo, Kashiwanoha, 5-1-5, Kashiwa, Chiba 277-8581, JAPAN

The results of parallel measurements of volumetric effects both under pressurization (in a region of structural transformations from 0 up to 0-20 GPa) and micro-indentation treatments in semiconductor substances are reported. For comparative characterization the single crystals of Czochralski-grown Si wafers, (i) subjected to various thermal and pressure treatments, (ii) doped with N, and (iii) irradiated with high energy particles (protons), as well as of ZnSe, and n- and p-GaAs. For the pressurization the automated was used allowing to register simultaneously several parameters of both a sample and environment. A bending has been found of the dependences of both the diamond indentor penetration depth, and contraction of sample sizes in pressure experiments, related to a drop of lattice volume at phase transitions. The model of multi-phase system has been used for analysis of the results. The work was supported by the RFBR (Gr. Ns. 04-02-16178, 04-01-00882).

HL 50.9 Thu 16:30 P3

Type-I alignment and direct fundamental gap in SiGe based heterostructures — •Michele Virgilio and Giuseppe Grosso — NEST-INFM and Dipartimento di Fisica, Universita' di Pisa, Largo Pontecorvo 3, I-56127 Pisa, Italy

We study the electronic structure of strained Si1-xGex alloys grown on (001) Si1-yGey cubic substrates. Valence and conduction band offsets at the heterointerfaces and the fundamental gap of the strained alloys are derived for all the (x,y) concentrations, adopting a first neighbors tight binding Hamiltonian description. The localized base includes sp3d5s* orbitals and spin-orbit interaction. Appropriate scaling laws for the hopping parameters are used to describe the geometrical lattice distortion induced by strain. In this way we are able to distinguish in the (x,y) plane a region characterized by robust type I alignment. Information on valence and conduction band alignment as function of alloying and strain together with suitable control of the folding mechanism along the growth direction and of the dependence of the confinement energies from the geometry, are exploited to propose a type-I SiGe quantum well. For this device electronic structure and density of states projected on each orbital and on each layer are studied by means of an iterative manipulation of the Green's function, overcoming in this way the computational difficulties related to direct diagonalization of the large period structures studied. We can therefore demonstrate that suitable choice of Ge concentrations in the substrate, spacer and active materials allows to obtain structures which are direct gap both in k- and in r space.

HL 50.10 Thu 16:30 P3

Raman spectroscopy of hydrogen molecules in germanium — •Martin Hiller, Edward Lavrov, and Jörg Weber — Technische Universität Dresden, 01062 Dresden, Germany

Single-crystal germanium wafers exposed to hydrogen and/or deuterium plasmas are studied by means of Raman scattering. The hydrogenation results in H_2 being trapped at different sites within the host lattice. Two bands at 1980 and 4155 cm^{-1} measured at room temperature are assigned to local vibrational modes of Ge–H and H_2, respectively. Polarization sensitive Raman measurements reveal that the plasma treatment results in the formation of extended planar structures called platelets, similar to the case of hydrogenated silicon. These platelets are aligned predominantly along {111} crystallographic planes and have Ge–H bonds as basic units. The signal at 4155 cm^{-1} is shown to result from molecular hydrogen trapped within these platelets. Measurements performed at a temperature of 80 K reveal two sharp Raman peaks at 3826 and 3834 cm^{-1} with an intensity ratio of 3:1, which are assigned to ortho- and para-H_2 trapped at the interstitial T site in germanium. This assignment is supported by the results of recent *ab initio* calculations. Another signal around 3930 cm^{-1} seems to be due to H_2 trapped in some other type of voids formed during the plasma treatment. The work was supported by the Deutsche Forschungsgemeinschaft (WE 1319/14).

HL 50.11 Thu 16:30 P3

Composition of Ge(Si) islands in the growth of Ge on Si(111) by x-ray spectromicroscopy — •S. Heun[1], F. Ratto[2], F. Rosei[2], A. Locatelli[3], S. Cherifi[3], S. Fontana[3], P.-D. Szkutnik[4], A. Sgarlata[4], M. De Crescenzi[4], and N. Motta[5] — [1]Laboratorio Nazionale TASC INFM-CNR, 34012 Trieste, Italy — [2]INRS-EMT, Universite du Quebec, J3X 1S2 Varennes (Quebec) Canada — [3]Sincrotrone Trieste, 34012 Trieste, Italy — [4]Dipartimento di Fisica, Universita di Roma II, 00133 Roma, Italy — [5]Dipartimento di Fisica, Universita di Roma TRE, 00100 Roma, Italy

The stoichiometry of Ge/Si islands grown on Si(111) substrates at temperatures ranging from 460 to 560 °C was investigated by x-ray photoemission electron microscopy (XPEEM). By developing a specific analytical framework, quantitative information on the surface Ge/Si stoichiometry was extracted from laterally resolved XPEEM Si 2p and Ge 3d spectra, exploiting the chemical sensitivity of the technique [1]. Our data show the existence of a correlation between the base area of the self-assembled islands and their average surface Si content: the larger the lateral dimensions of the 3D structures, the higher their relative Si concentration. The deposition temperature determines the characteristics of this relation, pointing to the thermal activation of kinetic diffusion processes.

[1] F. Ratto, F. Rosei, A. Locatelli, S. Cherifi, S. Fontana, S. Heun, P.-D. Szkutnik, A. Sgarlata, M. De Crescenzi, and N. Motta, J. Appl. Phys. 97, 043516 (2005).

HL 50.12 Thu 16:30 P3

Anisotropy of the Γ-point electron effective mass in hexagonal InN — •T. Chavdarov[1], T. Hofmann[2], V. Darakchieva[3], H. Lu[4], W.J. Schaff[4], and M. Schubert[2] — [1]Institut für Experimentelle Physik II, Universität Leipzig, Leipzig, Germany — [2]CMRA, University of Nebraska-Lincoln, Lincoln, USA — [3]Department of Physics and Measurement Technology, Linköping University, Sweden — [4]Department of Electrical and Computer Engineering, Cornell University, USA

InN recently attracted much attention due to the availability of high-quality samples. Particularly the unexpected low band gap of 0.6 to 0.7 eV has triggered new experiments, vivid debates, and many reconsiderations, but still information on fundamental material parameters like the anisotropy of the Γ-point wurtzite-structure effective electron mass are lacking. Only few experimentally determined values on the isotropically averaged effective mass value of hexagonal InN exist so far. In this contribution we employ generalized magnetooptic ellipsometry in the far-infrared spectral range to determine the effective mass parallel $m^*_{e,\parallel}$ and perpendicular $m^*_{e,\perp}$ to the c axis, the free electron concentration N, and parallel $\mu^*_{e,\parallel}$ and perpendicular $\mu^*_{e,\perp}$ optical mobility parameters in thin InN layers with different N in the range between 5×10^{17} cm^{-3} to 2×10^{19} cm^{-3} without electrical contacts. The samples were grown by molecular beam epitaxy on sapphire substrates. While our isotropically averaged effective mass values are in good agreement with recently reported values, we observe a distinct anisotropy of the effective mass, with $m^*_{e,\perp} > m^*_{e,\parallel}$, which is in good agreement with recent LDA band-structure calculation results reported by Carrier and Wei, JAP **97**, 033707 (2005).

HL 50.13 Thu 16:30 P3

Transition energies and Stokes shift analysis for In-rich InGaN and InAlN alloys — •P. Schley[1], R. Goldhahn[1], A.T. Winzer[1], G. Gobsch[1], V. Cimalla[2], O. Ambacher[2], M. Rakel[3], C. Cobet[3], N. Esser[3], H. Lu[4], and W.J. Schaff[4] — [1]Institut f. Physik, TU Ilmenau — [2]Institut f. Mikro- und Nanotechnologien, TU Ilmenau — [3]ISAS Berlin — [4]Cornell University Ithaca

We present a comprehensive optical, electrical and structural characterization of In-rich InGaN and InAlN alloys grown on sapphire substrates with either an AlN or GaN buffer layer. The absorption and emission properties of these films were studied by spectroscopic ellipsometry in the range from 0.74 up to 9.5 eV and photoluminescence spectroscopy near the band gap, respectively. Films grown on a GaN buffer layer show a much sharper increase of the imaginary part (ε_2) of the dielectric function (DF) around the band gap and a slightly reduced Stokes shift compared to layers grown directly on AlN buffers. It is attributed to

a reduced electron concentration and improved structural quality of the films on GaN buffers. For the determination of the band gap values as a function of alloy composition, carrier induced band gap renormalization and Burstein-Moss shift are taken into account. By fitting the third derivatives of the DF up to 9.5 eV we determined for the first time the compositional dependences (bowing parameters) of the transition energies for at least four and three critical points of the band structure for InGaN and InAlN alloys, respectively.

HL 50.14 Thu 16:30 P3

Optical properties of GaMnN grown by MBE — •J. Zenneck, M. Kocan, M. Röver, D. Mai, J. Malindretos, R. G. Ulbrich, and A. Rizzi — IV. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

We successfully grew GaMnN on Si(111) with a plasma-assisted molecular beam epitaxy system. To incorporate the manganese it was necessary to lower the growth temperature from 760°C (optimized GaN growth) to 650°C and change the growth regime to nitrogen-rich. These conditions lead to mediocre crystal quality compared with pure GaN as measured by photoluminescence (PL), Raman and x-ray diffraction (XRD).

The XRD measurements reveal homogeneous material or a secondary phase ($GaMn_3N$), depending on the growth conditions. PL shows no excitonic luminescence at all, but a structured DAP-band the intensity of which decreases with increasing Mn-content. The yellow luminescence is only visible in lightly Mn-doped samples without a secondary phase. In Raman measurements so called disorder-activated modes are visible instead of a clear A1 mode in samples with higher Mn-content. We will discuss these findings with respect to the possible defects involved. Furthermore the effect of post growth annealing on the optical properties of GaMnN will be analysed.

HL 50.15 Thu 16:30 P3

Reaktive Ion Etching of c-GaN — •Marina Panfilova[1], Jörg Schörmann[1], Stefan Potthast[1], Donat Josef As[1], Ulrich Hilleringmann[2], and Klaus Lischka[1] — [1]Universität Paderborn, Fakultät für Naturwissenschaften, Department Physik, Warburger Str. 100, 33095 Paderborn — [2]Universität Paderborn, Institut für Elektrotechnik und Informationstechnik, Sensorik, Warburger Str. 100, 33095 Paderborn

Cubic III - nitride semiconductors have great potential for optoelectronic and electronic devices due to their wide direct band gaps and absence of piezoelectric polarization. Because GaN is chemically very stable, dry etching techniques must be established in order to fabricate devices. Reactive ion etching (RIE) of cubic gallium nitride (c-GaN) epitaxially grown on 3C-SiC substrate has been investigated using various chemistries based on $SiCl_4$, Ar and SF_6 plasmas. The influence of gas flow, pressure and RF - power on etch rate and surface morphology were studied. For RF - power in the range of 0.8 kW to 1.4 kW, the etch rate is found to increase with RF - power, attaining a maximum rate of 27 nm/min at 1.4 kW. The addition of an inert gas Ar is found to barely affect the etch rate. Surface morphology before and after etching is checked by atomic force microscopy. This show that the roughness of the etched surface is comparable to that of the unetched surface. The measurements by scanning electron microscopy show a slight overcut. The structural resolution of our method is in the order of 1 μm.

HL 50.16 Thu 16:30 P3

Molecular Beam Epitaxy of cubic $Al_xGa_{1-x}N$ and AlN — •Elena Tschumak, Stefan Potthast, Jörg Schörmann, Donat Josef As, and Klaus Lischka — University of Paderborn, Department of Physics, Warburger Strasse 100, D-33095 Paderborn, Germany

Cubic $Al_xGa_{1-x}N$ and AlN exhibit a huge potential in the fabrication of electronic and optoelectronic semiconductor devices. In comparison with the hexagonal phase, cubic nitrides show isotropic electrical properties due to the absence of spontaneous piezoelectric fields. In cubic AlN, which has band gap of 5.1eV, the gettered oxygen forms a deep donor level. Therefore, AlN is insulating at room temperature and can be used for electrical insulation of electronic devices on conductive substrate. $Al_xGa_{1-x}N$ with a high Al-content is also useful for the fabrication of cubic $Al_xGa_{1-x}N$/GaN Bragg reflectors yielding high reflectivity. $Al_xGa_{1-x}N$-layers with an Al-content between 0.2 and 1 were deposited on 200nm GaN-buffer on 3C-SiC (001) substrates by rf-plasma assisted MBE. The films were grown at temperatures of 750°C under stoichiometric growth conditions. Growth was in situ monitored by Reflection High-Energy Electron Diffraction (RHEED). Room temperature cathodoluminescence, High Resolution X-Ray Diffraction (HRXRD) and Energy Dispersive X-ray (EDX) measurements were performed to obtain the Al-mole fraction. Surface morphology was studied by Atomic Force Microscope. For the investigation of electrical properties of the $Al_xGa_{1-x}N$-layers, Hall effect was measured between 10-350K.

HL 50.17 Thu 16:30 P3

Growth of cubic Al_xIn_yN and cubic $Al_xGa_yIn_{1-x-y}N$ lattice-matched to GaN — •Mark Schnietz[1], Jörg Schörmann[1], Shunfeng Li[1], Jürgen Vogt[2], Jürgen W. Gerlach[3], Donat J. As[1], and Klaus Lischka[1] — [1]University of Paderborn, Department of Physics, D-33098 Paderborn, Germany — [2]Universität Leipzig, Institut für Experimentelle Physik II, Linnéstr. 5, D-04103 Leipzig,Germany — [3]Leibniz-Institut für Oberflächenmodifizierung Leipzig, Permoserstraße 15, D-04318 Leipzig, Germany

We report the first epitaxial growth of c-Al_xIn_yN/GaN and c-$Al_xGa_yIn_{1-x-y}N$/GaN heterostructures lattice-matched to c-GaN on freestanding 3C-SiC substrates by plasma-asissted molecular beam epitaxy. Cubic Al_xIn_yN alloys can be used for the realization of lattice-matched c-AlInN/GaN Bragg mirrors due to its high difference in refractive index to GaN. The c-$Al_xGa_yIn_{1-x-y}N$ alloy permits the independent control of the band gap and the lattice parameter. The ternary and quaternary films were grown at substrate temperatures of 620°C. Different alloy compositions were obtained by varying the flux of Al and Ga. The alloy composition was measured by Energy Dispersive X-ray Spectroscopy (EDS) and Rutherford Backscattering (RBS). X-ray reciprocal space map of asymmetric (-1-13) reflex were used to measure the lattice parameters and to verify the lattice match between the alloy and the c-GaN buffer layers.

HL 50.18 Thu 16:30 P3

Optical properties of InN films — •Christoph Cobet[1], Patrick Vogt[2], Munise Rakel[1,2], Rüdiger Goldhahn[3], Massimo Drago[2], Antje Vollmer[4], Wolfgang Richter[2], and Norbert Esser[1] — [1]ISAS - Institute for Analytical Sciences, Albert-Einstein-Str. 9, D-12489 Berlin — [2]Institute of Solid State Physics, TU Berlin, Hardenbergstr. 36, D-10623 Berlin — [3]Institute of Physics, TU Ilmenau, Weimarer Straße 25, D-98648 Ilmenau — [4]BESSY-GmbH, Albert-Einstein Str. 15, D-12489 Berlin

We report on measurements of the dielectric function of hexagonal InN in a broad spectral range from 0.5-12eV by means of ellipsometry. An a-plane InN(11-20) layer grown by MBE in the Cornell University was utilized to determine the ordinary and extraordinary part of the dielectric tensor. We find a huge anisotropy between both components, where specific absorption structures differ in energy position or disappear in the extraordinary component. All structures will be attributed to particular interband transitions in comparison with GaN. Our experiments indicate also a strong influence of surface contaminations, which finally effect the position of the measured band gap as well. In order to analyze the surface degradation, we performed SXPS before and after a thermal annealing of MOVPE-grown InN samples in UHV. The InN(0001) surface after transfer into UHV gives rise to clear C1s and O1s core-level contributions, the latter originating from hydroxides due to water contamination of the surface in air. Thermal annealing at 573K is sufficient to remove carbon and hydroxide components. But stable oxide contributions could not be removed.

HL 50.19 Thu 16:30 P3

Polarization properties of InGaN quantum wells grown on semipolar GaN {1-101} facets — •Martin Feneberg[1], Frank Lipski[1], Barbara Neubert[2], Peter Brückner[2], Ferdinand Scholz[2], Klaus Thonke[1], and Rolf Sauer[1] — [1]Abteilung Halbleiterphysik, Universität Ulm, 89069 Ulm — [2]Abteilung Optoelektronik, Universität Ulm, 89069 Ulm

Strong piezoelectric fields in InGaN quantum wells grown on {0001} surfaces reduce the radiative transition probability due to the quantum confined Stark effect. One possibility to enhance light output of such devices is to use nonpolar or semipolar crystal planes for quantum well growth. It is therefore desirable to gain a better understanding of the properties of quantum wells on nonpolar and semipolar facets.

We report on polarized photo- and electroluminescence emission of quantum wells grown on {1-101} side facets of selectively grown GaN stripes. The quantum wells emit light linearly polarized parallel to the <11-20> direction of the GaN crystal. This is explained by valence band

splitting due to strain. Surprisingly defect-related emission at lower energies is also linearly polarized, but perpendicular to the quantum well emission. This is most likely due to preferential defect alignment during epitaxy.

HL 50.20 Thu 16:30 P3

Optical and electrical properties of nitride-based UV LEDs — •D. Fuhrmann, T. Retzlaff, T. Litte, H. Bremers, U. Rossow, D. Dräger, and A. Hangleiter — TU Braunschweig, Inst. f. Angewandte Physik, Mendelssohnstr. 2, 38106 Braunschweig, Germany

During the last years, the efficiency of UV light emitting diodes based on AlGaN/AlGaN or GaN/AlGaN quantum well (QW) structures was strongly improved. But still, they are about one order of magnitude less efficient compared to their GaInN/GaN-based counterparts emitting in the visible spectrum. In this contribution we show our approach in order to optimize the internal quantum efficiency (IQE) of GaN/AlGaN QWs with an emission wavelength around 350nm. The samples were grown by low pressure MOVPE. The good material quality of the AlGaN buffer layer was revealed by both XRD measurements and the low temperature PL linewidth. We used temperature and excitation power dependent photoluminescence to determine the IQE. For our structures we find IQE values as high as 26% under resonant excitation. Using a nonresonant excitation with a power density of some kW/cm^2 the IQE increases even to 38%. For optimized SQW structures we find a very similar behavior concerning the IQE dependence on temperature and excitation power for both GaN/AlGaN UV-emitting structures and GaInN/GaN blue light emitters. This indicates that in both cases similar mechanisms limiting the IQE are present. A further improvement was achieved by applying an AlN buffer layer between the sapphire substrate and the AlGaN layer. Then we observed a significant improvement of the n- and p-type doping of the AlGaN layer, which will help to realize a high power UV-LED.

HL 50.21 Thu 16:30 P3

Electro- and photoluminescence investigations of nitride-based blue and green LEDs — •T. Litte, D. Fuhrmann, C. Netzel, H. Bremers, U. Rossow, and A. Hangleiter — TU Braunschweig, Inst. f. Angew. Phys., Mendelssohnstr.2, 38106 Braunschweig, Germany

In recent years very high values of 70% and 40% for the internal quantum efficiency (IQE) of GaInN/GaN based LEDs emitting in the blue and green spectral region, respectively, have been achieved. But still all devices suffer so far from a decrease of the efficiency with increasing drive current. This effect becomes even more pronounced for larger emission wavelengths λ_{peak}. In order to understand the mechanisms limiting the quantum efficiency we present here a detailed analysis of photoluminesence (PL) and electroluminesence (EL) data for blue and green emitting LEDs. The structures were grown by low pressure MOVPE and further processed into simple LEDs. The active region consisted of single and double $Ga_{1-x}In_xN$ quantum wells (QWs) with x_{In}=0.15...0.26 and d_{QW}=1.5nm...3nm and GaN barriers. We used temperature and excitation power dependent PL to determine the IQE. For both blue and green LEDs we find a good aggrement between PL and EL spectra in terms of the linewidth. We observe a very similar shift of the PL and EL peak position with increasing excitation power. As expected the wavelength shift is more pronounced for green LEDs and becomes larger for QWs with larger d_{QW} and smaller x_{In} compared to QWs emitting at the same λ_{peak} but have smaller d_{QW} and larger x_{In}. In addition we find that the drop in efficiency at higher current is smallest for LEDs that show the smallest shift of the peak position (i.e. small d_{QW}, large x_{In}).

HL 50.22 Thu 16:30 P3

UHV-cathodoluminescence investigation of metastable light emission in GaN/GaInN quantum well structures — •Martina Finke, Daniel Fuhrmann, Carsten Netzel, Heiko Bremers, Uwe Rossow, and Andreas Hangleiter — TU Braunschweig, Inst. f. Angewandte Physik, 38106 Braunschweig

In GaN/GaInN quantum well structures, the spontaneous and the piezoelectrical fields have a strong effect on the optical properties. The spontaneous field is normally shielded by charged species on the surface. Since the spontaneous field counteracts the piezoelectrical field, a blueshift in the peak-position of the luminescence and an increased intensity is expected by a removal of the deposited particles. We investigated the cathodoluminescence for various surface conditions after etching, annealing and electron beam exposition in an UHV environment. We studied several GaInN quantum well structures with different indium concentration and layer thicknesses at room and low temperatures. From time dependent measurements we find that the intensity of the luminescence of QW samples first increases rapidly and then decreases at longer times during electron beam exposure. We attribute this to a change of the spontaneous field due to electron-stimulated-desorption or due to a stimulated chemical reaction induced by the electron beam. Using systematic experiments we try to understand how the surface conditions influence the luminescence properties of QW structures via the effect of the spontaneous polarisation.

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Temperature- and electric field-dependence of photoluminescence spectra of InGaN/GaN-heterostructures — •Clemens Vierheilig[1], Harald Braun[1], Nikolaus Gmeinwieser[1], Ulrich T. Schwarz[1], Werner Wegscheider[1], Elmar Baur[2], Uwe Strauss[2], and Volker Härle[2] — [1]Naturwissenschaftliche Fakultät II - Physik, Universität Regensburg Universitätsstr. 31, 93053 Regensburg, Germany — [2]OSRAM Opto Semiconductors GmbH, Wernerwerkstr. 2, 93049 Regensburg, Germany

For further enhance the efficiency of InGaN-based LEDs, it is necessary to get a good knowledge of the processes in the active layer, in particular the impact of InGaN/GaN quantum wells and barrier structure, piezoelectric fields, and indium-fluctuation induced carrier localizations. We study the influence of these effects on carrier capture and internal efficiency. We measure field-dependent electroluminescence (EL) and photoluminescence (PL) spectra in a temperature-range between 4K and room temperature with our confocal micro-Photoluminescence setup to access a wide range of excitation densities. The radiative and nonradiative carrier-recombination rates extracted from these steady-state experiments are then compared to time-resolved measurements from a macro-PL measuring station. The results allow to draw conclusions on the mechanisms of radiative and nonradiative carrier-recombination.

HL 50.24 Thu 16:30 P3

Waveguide mode dynamics of InGaN laser diodes — •Christoph Lauterbach[1], Ulrich Schwarz[1], Alfred Lell[2], and Volker Härle[2] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg — [2]OSRAM Opto Semiconductors GmbH, Wernerwerkstr. 2, 93049 Regensburg

We use a scanning near-field microscope (SNOM) in combination with a time resolved detection scheme to measure the evolution of the near-field and far-field of InGaN laser diode (LD) waveguide modes. We observe lateral mode competition, filamentation, and beam steering. Here we compare the lateral mode dynamics for ridge waveguide LDs and oxide stripe LDs which are predominantly index and gain guided, respectively. We observe a distinct difference in the mode dynamics for ridge waveguide and oxide stripe LDs. For the former the spatio-temporal pattern resembles the mode behavior of a hard wall box defined by the edge of the ridge. For the latter the soft confinement defined by the gain guiding profile leads to a better centering of the mode and a more stable mode pattern. Filamentation affects both ridge waveguide and oxide stripe LDs in a similar manner.

HL 50.25 Thu 16:30 P3

AlGaN templates on sapphire — •Kai Otte, Tomohiro Yamaguchi, Stephan Figge, and Detlef Hommel — Universität Bremen, Otto-Hahn Allee 1, 28359 Bremen

To grow unstrained AlInN/GaN vertical cavity surface emitting laser (VCSEL) structures with high aluminium content one needs templates with a higher lattice constant than GaN. This can be reached by adding aluminium to the GaN template layer.

We report on the growth of AlGaN templates by metal organic vapor phase epitaxy on sapphire. The 2 μm thick AlGaN layers with an aluminium mole fraction of 0.25 were grown on low temperature AlGaN nucleation layers.

High resolution x-ray diffraction and scanning electron microscopy data showing crack-free and compressively strained ($\epsilon_{xx,yy}$ = 0.3 at room temperature) templates will be presented. The templates show no compositional fluctuation in growth direction.

Reflectometry measurements during growth show no three dimensional island growth but two dimensional growth. This points to a high defect density. To reduce this effect different nucleation layers were grown.

These templates are promising for the growth of VCSEL structures. A comparison of distributed Bragg reflectors grown on AlGaN and GaN templates will be shown.

HL 50.26 Thu 16:30 P3

Electron Blocking Layers in GaN-based Laser Diodes — •Christian Meissner, Stephan Figge, Jens Dennemarck, Timo Aschenbrenner, and Detlef Hommel — Institute of Solid States Physics, University of Bremen, Otto-Hahn-Allee, D-28359 Bremen, Germany

Several InGaN multi quantum well laser diodes with different p-waveguide designs were grown in a vertical MOVPE reactor. Optical and electrical properties of these structures with AlGaN electron blocking layers will be presented.
AlGaN electron blocking layers are used in laser diodes to prevent the electron overflow to the p-doped layers. In particular the placement in the waveguide, the width and height of the electron blocking layer has an influence on the characteristics of the devices. Furthermore the electromigration of the p-dopant magnesium harms the operation of the laser diodes. Therefore, we additionally varied the onset of Mg-doping in the waveguide.
The structures were investigated by photoluminescence and electroluminescence. Both spectra indicate an operating wavelengh around 390nm. Measurements of light output power and the current-voltage characteristic show the dependence of the optical properties on the structure design.

HL 50.27 Thu 16:30 P3

Enhansed Low Stressed SiO2 Phase Creation in Nitrogen Doped Cz-Si — •Sergii Zlobin — Lashkarev Institute of Semiconductor Physics of the NASU, 41, Prospekt Nauki, 03028, Kyiv, Ukraine

This presentation deals with comparative study of oxygen structural arrangement in the Cz-Si wafers of different diameter, including those doped with nitrogen. To create oxygen precipitates two-step annealing (at 750 and 1050 oC) in argon ambient was used. Absorption band connected with stretching Si-O vibrations was measured using differential spectrometer and FTIR spectrometer. Absorbance spectra were deconvoluted into Gaussian profiles, which were analyzed in the frameworks of the Random Bonding Model to estimate contribution of different kinds of SiO4 tetrahedra rings in precipitated oxide phase lattice. It was shown that presence of soluted nitrogen promotes rapid release of the interstitial oxygen and favored creation of SiO2 phase with increased content of the less-stressed 6-fold SiO4 tetrahedra rings. This effect may be principal in providing enhanced radiation hardness and mechanical stability of the Silicon of large diameter.

HL 50.28 Thu 16:30 P3

Investigation of SnSe, $SnSe_2$ and Sn_2Se_3 alloys for electronic memory applications — •Kyungmin Chung, Daniel Wamwangi, Christoph Steimer, and Matthias Wuttig — I. Institute of Physics (IA), RWTH Aachen University, 52056 Aachen, Germany

This work reports on the temperature dependence of structural and electrical properties of SnSe, $SnSe_2$ and Sn_2Se_3 films studied in the search of new phase change alloys for electronic memory applications. Our results have shown large electrical contrast of a 6.0×10^5 and 3.9×10^6 for the $SnSe_2$ and Sn_2Se_3 alloys, respectively upon phase transition. The temperature window upon which these phase transition takes place is even lower than that of $Ge_2Sb_2Te_5$ (ΔT=20°C) for the case of the Sn_2Se_3 (ΔT=4°C) alloy. This could possibly suggest rapid switching. By comparing with $Ge_2Sb_2Te_5$ (ρ=1mΩcm) and $Ge_4Sb_1Te_5$ (ρ=3mΩcm), it can be seen that both $SnSe_2$ and Sn_2Se_3 have large resistivity values in the crystalline state of 26mΩcm and 23mΩcm, respectively. This means that $SnSe_2$ and Sn_2Se_3 alloys could possibly minimize the RESET current of PRAM devices. X-ray diffraction (XRD) investigations have attributed the large electrical contrast to structure transformation from the amorphous to crystalline phase. The activation energy against crystallization has also been determined for SnSe, $SnSe_2$ and Sn_2Se_3 alloys to 2.01 ± 0.11eV, 1.93 ± 0.07eV and 0.32 ± 0.04eV, respectively. Corresponding to the structural transitions we have determined a density change of 3.79%, 20.15% and 12.4% upon annealing by X-ray reflectometry (XRR).

HL 50.29 Thu 16:30 P3

The origin of high vacancy concentrations in chalcogenide alloys — •Daniel Lüsebrink, Wojciech Welnic, Christoph Steimer, and Matthias Wuttig — I. Insitute of Physics (IA), RWTH Aachen University, 52056 Aachen, Germany

Phase change materials that are used in rewritable CD's and DVD's show a remarkable combination of properties. They exhibit pronounced property contrast, i.e. a remarkable difference in optical properties and electronic conductivity between the amorphous and the crystalline state. This has been attributed to a considerable difference in atomic arrangement in both states. The crystalline state that is found in phase change media is a distorted rocksalt structure which is characterized by a high vacancy concentration. For example GeSb2Te4 shows a vacancy concentration of 25% at the A-site of the distorted rocksalt structure. This raises the question how structures with such high vacancy concentrations can be stabilized. To answer this question density functional theory has been employed. Calculations have been performed for both the stable crystalline state, a hexagonal atomic arrangement, as well as for metastable rocksalt structures. A reason for the surprisingly high vacancy concentration in the metastable rocksalt structure will be presented. Finally we will discuss the significance of our findings for the properties of phase change materials.

HL 50.30 Thu 16:30 P3

Indium in silicon under tensile strain — •N. Santen and R. Vianden — Helmholtz-Institut für Strahlen- und Kernphysik der Universität Bonn, Nußallee 14-16, D-53115 Bonn

In the past, donor-acceptor pairs in silicon have been studied intensively using the perturbed angular correlation method (PAC) with the acceptor ^{111}In as probe [1]. In addition it was found that the remaining unpaired indium on regular lattice sites showed a reaction on uniaxial mechanical strain, which seemed to depend on the dopant species. In order to study this phenomenon more detailed we carried out further experiments which reveal that the tension induced EFG depends on the concentration of the co-implanted donors. The results will be presented and discussed.
[1] G. Tessema, Indium-impurity pairs in semiconductors and the study of the influence of uniaxial stress on defect complexes in silicon, Dissertation Universität Bonn, 2003

HL 50.31 Thu 16:30 P3

Spatially resolved characterization of bevelled InP/InGaAs/InGaAsP structures studied by Raman spectroscopy — •Janet Leschner[1], Gert Irmer[1], Peter Krcho[2], Rudolf Srnanek[2], Stanislav Hasenoehrl[3], and Jozef Novak[3] — [1]TU Bergakademie Freiberg, Institut für Theoretische Physik, D-09596 Freiberg, Germany — [2]Microelectronic Department, Slovak University of Technology, 81219 Bratislava, Slovakia — [3]Institute of Electrical Engineering, Slovak Academy of Sciences, 84104 Bratislava, Slovakia

InP/InGaAs/InGaAsP heterojunctions have a wide application in optoelectronic devices. Structures used for photodiodes were grown by MOCVD. The bevel through this structure was prepared by chemical etching with bevel angle of about 0.00001 rad. The material composition and the strain near the interfaces due to lattice misfit are analyzed spatially resolved by micro Raman scattering of the LO-phonons. The quality of the interfaces is further characterized by measurement of the LO-phonon-plasmon coupling of photoinduced carriers.

HL 50.32 Thu 16:30 P3

Optically detected resonances in n-doped quantum wells and quantum dots — •Michael Gerbracht, A. A. Dremin, D. R. Yakovlev, and M. Bayer — Experimentelle Physik II, Universität Dortmund, D-44227 Dortmund, Germany

Optically detected resonance technique was used to study energy and spin structure of n-type doped quantum wells GaAs/(Al,Ga)As and CdTe/(Cd,Mg)Te and singly-charged (In,Ga)As/GaAs quantum dots. All samples have been fabricated by molecular beam epitaxy. The technique is based on the far-infrared laser (photon energies from 2.5 up to 20 meV) radiation effect on the electrons confined in the nanostructures. Detection is provided by means of intensity changes in photoluminescence lines of neutral and negatively charged excitons (trions). External magnetic fields up to 17 T were used to bring the system into resonance conditions. We have observed cyclotron resonances and resonances related to the internal energy structure of trion complexes. These experiments allow to study electron-exciton interaction and highlight processes of spin-dependent formation of trions.

HL 50.33 Thu 16:30 P3

Photoinduced carriers in bevelled InP structures studied by micro-Raman spectroscopy — •Geoffrey Richardson[1], Gert Irmer[1], Rudolf Srnanek[2], Stanislav Hasenoehrl[3], and Jozef Novak[3] — [1]TU Bergakademie Freiberg, Institut für Theoretische Physik, D-09596 Freiberg, Germany — [2]Microelectronic Department, Slovak University of Technology, 81219 Bratislava, Slovakia — [3]Institute of Electrical Engineering, Slovak Academy of Sciences, 84104 Bratislava, Slovakia

InP and its related alloy epilayers are of great technological interest in numerous applications such as high-speed circuits, integrated optoelectronics and high-power devices. The knowledge about near-surface properties, as well as their precise control, is becoming increasingly important, especially as the dimensions of device components continue to shrink. Raman experiments were performed on bevels of layered structures with special emphasis on the study of the generation and dynamics of photoexcited carriers. Spatially resolved measurements provide information about the local distribution of free carriers and depletion layers near the interfaces. Between the TO and LO phonon of InP a band was detected which is attributed to a highly damped mode of photoinduced holes.

HL 50.34 Thu 16:30 P3

Photoluminescence studies of GaAs quantum wells in close proximity to a GaMnAs barrier layer — •Robert Schulz, Tobias Korn, Andreas Maurer, Dieter Schuh, Werner Wegscheider, and Christian Schüller — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg

(Ga,Mn)As is a highly interesting material system for future spintronic devices, where both spin and charge of carriers are manipulated. Here, we present a study of nonmagnetic GaAs quantum wells (QW) embedded in a AlGaAs/GaAs heterostructure close to a GaMnAs barrier layer. The photoluminescence (PL) of two QWs at different distances to the GaMnAs layer is measured at low temperature. The circular polarized components of the PL are then analyzed as a function of the external magnetic field. The difference of the PL components for $\sigma^{\pm}$ shows different behaviour depending on the distance between the QW and the GaMnAs layer. The PL energy of the QW closest to the GaMnAs (distance 10 nm) shows a Brillouin function type dependence, indicating a paramagnetic behaviour of the QW. For the QW farther away (100 nm) from the GaMnAs layer, a weak quadratic dependence of the PL is observed, as expected for nonmagnetic QWs. Subsequent PL measurements after several months show that the PL signal from the QW close to the barrier layer is quenched. From these observations, we suggest that there is some Mn diffusion from the barrier layer into the closest QW during and after MBE growth.

HL 50.35 Thu 16:30 P3

Diamond zinc oxide heterojunction — •Peter Geithner, Jürgen Ristein, and Lothar Ley — Technische Physik, Universität Erlangen-Nürnberg, Germany

A favourable couple for a wide band gap heterojunction is p-type diamond and zinc oxide that is naturally n-type. With a band gap of 3.5 eV for zinc oxide this heterojunction has the potential for a UV emitting LED.

The growth habit of zinc oxide on the diamond (100) and (111) face is investigated. Zinc oxide layers are grown in three ways. Chemical vapour transport is performed in closed silica tubes in a nitrogen atmosphere containing 10% hydrogen. Deposition of textured zinc oxide films is achieved with a source temperature of 800°C and applying a linear temperature transient starting at 500°C and increasing to 700°C within 30 minutes to the sample. The resulting 5μm thick film is characterized by optical and scanning electron microscopy. Films of 1μm thickness are deposited by DC sputtering or by RF magnetron sputtering in an argon atmosphere with 25% oxygen content.

Crystal quality and impurity content in diamond and zinc oxide were investigated by cathodoluminescence (CL) spectroscopy. The CL spectra of the zinc oxide layers show sharp (<8 meV FWHM) exciton lines and a defect band centred around 2.48 eV photon energy.

HL 50.36 Thu 16:30 P3

Strongly correlated excitons in quantum wells — •Patrick Ludwig[1,2], Alexei Filinov[2], Michael Bonitz[2], and Heinrich Stolz[1] — [1]Universität Rostock, Institut für Physik, Universitätsplatz 3, 18051 Rostock, Germany — [2]Christian-Albrechts-Universität zu Kiel, ITAP, Leibnitzstrasse 15, 24098 Kiel, Germany

In this work we consider small ensembles of optically excited indirect excitons in a quantum well (QW). The spatial separation of electrons and holes and lateral exciton confinement is due to the quantum confined Stark effect produced by an external electric field of a single tip electrode. The typical trap size is of the order of several micrometers.

Using first principle Path Integral Monte Carlo simulations, we first compute the lateral confinement potential of the excitons and the effective exciton-exciton interaction potential in the presence of the electric field. These results are then used in classical thermodynamic Monte Carlo simulations to investigate systems of several tens to thousands of indirect excitions in GaAs-based QWs. By changing the field strength, the excitation intensity (exciton number) and temperature, the exciton-exciton correlations can be varied in broad ranges. We present results for the density distribution, correlation functions and the phase diagram in the density- temperature-field strength space. Our theoretical results allow us to predict the parameter range at which interesting many-particle states, including exciton crystallization should be observable in experiments.

HL 50.37 Thu 16:30 P3

Fine structure of the intersubband absorption in stepped quantum wells — •Pilar Aceituno[1], Antonio Hernández-Cabrera[1], and Fedir T. Vasko[2] — [1]Departamento de Física Básica, Universidad de La Laguna,La Laguna 38206-Tenerife, Spain — [2]Institute of Semiconductor Physics, NAS of Ukraine, Kiev, 252650, Ukraine

The relative intersubband infrared absorption (IIRA) of stepped quantum wells (SQWs) of GaAs-GaAlAs, when subjected to an intense THz irradiation, is theoretically studied. By using the matrix density formalism, together with the adiabatic and resonant approximations, we obtain analytical expressions for the IIRA. When the pump intensity is of the order of megawatts, it is found that the absorption peak splits in a set of satellites (fine structure) due to (n+1) order intersubband transitions with the contribution of (n) THz photons and one IR photon. The number of peaks depends on the width of the SQW and the THz field intensity. Moreover, it is also found a strong modification of the absorption, which consists on a noticeable broadening of the zero-field peak and a shift towards higher energy values. We have used in calculations multiple SQW structures formed by 10 decoupled SQWs because the IIRA is usually too weak to be detected in a single QW.

A. Hernández-Cabrera, P. Aceituno, and F.T. Vasko, Phys. Rev. B, **72** 045307 (2005).

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HL 50.38 Thu 16:30 P3

Ellipsometry on pentacene thin films OFETs. — •Daniel Faltermeier[1], Bruno Gompf[1], Matthias Fischer[1], Ashutosh Tripathi[2], Jens Pflaum[2], and Martin Dressel[1] — [1]1. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart — [2]3. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart

Pentacene with its high effective carrier mobility is one of the most promising organic semiconductors, and much work has been done in characterizing the electronic properties of thin pentacene films. Despite these efforts the correlation between morphology and function is still not well understood. We present a systematic approach by spectroscopic ellipsometry on highly purified pentacene thin films, evaporated on silicon wafers with thermal SiO_2 in the temperature range between 5 K and 350 K. There a temperature dependent shift of the optical spectra can be observed. The optical data are correlated with x-ray diffraction, atomic force microscopy and field effect measurements performed at room temperature at the same films. By tuning the evaporation parameters like substrate temperature and evaporation rate one can clearly correlate changes in the ellipsometric spectra, especially the influence of the mid-gap states acting effectively as charge-carrier traps, with mobilities extracted from I-V curves. We also compare the thin-film results with spectroscopic ellipsometry measurements obtained on pentacene single crystals, to learn more about the intrinsic properties of the material.

HL 50.39 Thu 16:30 P3

A process for screening of organic semiconductor properties based on sub micron thin film transistors — •Christian Rickert, Michael Leufgen, Georg Schmidt, and Laurens Molenkamp — Physikalisches Institut (EPIII), Universität am Hubland, 97074 Würzburg, Germany

We present a highly reproducible and fast process for the screening of electrical properties of organic thin film transistors based on various semiconducting polymers. In order to achieve a channel length of 500 nm while maintaining high throughput we have chosen a process based on all optical lithography using a thin photoresist. The transistors were fabricated in a common gate technology on silicon wafers with a 50 nm thick thermal oxide. We will present the process and results for several polymer based semiconductors. Field effect mobilities obtained in different regimes will be shown along with the influence of different contact materials. Also results on wafers with thinner oxides were carried out in order to reduce short channel effects which can occur when downscaling the transistors.

HL 50.40 Thu 16:30 P3

Investigation of electric field- and illumination intensity dependent recombination losses in polymer-fullerene bulk heterojunction solar cells — •Jörg Bösner[1], Vladimir Dyakonov[1,2], and Ingo Riedel[1] — [1]Bavarian Centre for Applied Energy Research (ZAE-Bayern e.V.), Div. Functional Materials for Energy Technology, Am Hubland, D-97074 Würzburg, Germany — [2]Experimental Physics VI, Institute of Physics, University of Würzburg, Am Hubland, 97074 Würzburg, Germany

Organic bulk heterojunction solar cells based on P3HT:PCBM composites were studied by measurements of the current-voltage characteristics (IV) and the external quantum efficiency (EQE) under variable electrical and optical bias. In EQE measurements, the simultaneous application of a white bias light results in the partial filling of traps and accounts for the presence of bimolecular recombination losses observed at higher light intensities. Spectral changes of the EQE under variable optical bias are correlated with the scaling exponents of the integral short circuit current (J_{SC}) with light intensity. At zero bias the J_{SC} in polymer-fullerene devices is primarily driven by the internal field. Hence, the mobility-lifetime product ($\mu\tau$) of majority charge carriers determines dependence of the photocurrent J_{ph} on the applied voltage. At high reverse bias, the field-dependent J_{ph} saturates and reflects the maximum J_{SC} which can be used to estimate the $\mu\tau$-product of photogenerated charge carriers. The electrical bias dependence of the EQE used to analyze the field-dependent recombination losses observed in the current-voltage characteristics under illumination.

HL 50.41 Thu 16:30 P3

Silicon Thin Films Sensitized by Phthalocyanine Dyes — •Christian Kelting[1], Ulrich Weiler[2], Thomas Mayer[2], Wolfram Jaegermann[2], Dieter Wöhrle[3], Marinus Kunst[4], and Derck Schlettwein[1] — [1]Justus-Liebig-Universität Gießen, Institut für Angewandte Physik — [2]TU Darmstadt, Fachbereich Materialforschung, Fachgebiet Oberflächenforschung — [3]Universität Bremen, Institut für Organische und Makromolekulare Chemie — [4]Hahn-Meitner-Institut, Sektion Solarenergie

A promising way to increase the light harvesting efficiency and hence the conversion efficiency of Si thin film photovoltaic cells is the utilization of the intense optical absorption of organic dye molecules in the absorber layer. Composite materials of zinc phthalocyanine (PcZn) in Si were prepared by simultaneous physical codeposition of PcZn into growing films of amorphous or microcrystalline Si from a plasma-enhanced (hot-wire) chemical deposition reaction (CVD). Thin films of PcZn (10 nm) were also prepared as model systems by physical vapour deposition on thin Si films (100-500 nm). Spectrally resolved photoconductivity measurements of pure Si films, PcZn- coated Si films and composite Si-Pc-films were used to prove the injection of charge carriers from the dye to silicon. The photoconductivity increased, in particular at the main absorption (Q-band) of the Pc. The sensitized photoconduction was obtained in the steady state under continuous illumination and the results are therefore taken as evidence for the injection of both types of charge carriers, electrons to the conduction band and holes to the valence band of Si.

HL 50.42 Thu 16:30 P3

Temperature Dependent Bias-Stress Effects on in-situ OFET Characteristics — •B. Gburek, M. Michelfeit, M. Leufgen, G. Schmidt, J. Geurts, and L.W. Molenkamp — Universität Würzburg, Physikalisches Institut (EP III), Am Hubland, D-97074 Würzburg, Germany

It is well known that applying external voltages to an organic field effect transistor (OFET) quickly results in a performance degradation. To examine this effect more closely we fabricated OFETs with dihexylquaterthiophene (DH4T) as active material by organic molecular beam deposition in UHV and characterised their electrical properties in situ. Therefore, we applied constant gate/source and/or drain/source voltages V = ± 15 V. Besides the time of their application, we also varied the sample temperature between 150 and 360 Kelvin. Upon application of a negative gate and drain bias, a clear shift of the threshold voltage towards higher negative values was observed, strongly increasing with temperature. This shift was reversible, showing nearly full relaxation after a few minutes. The relaxation was enhanced by the application of a positive gate bias. While the charge carrier mobility remained unaffected at room temperature, the simultaneous application of gate/source and drain/source voltage at elevated temperatures induced a mobility increase beyond 50 percent. This effect also showed full reversibility.

HL 50.43 Thu 16:30 P3

Scaling behaviour of sub-μm OFETs with different active-layer materials — •O. Rost, M. Leufgen, G. Schmidt, J. Geurts, and L. W. Molenkamp — Physikalisches Institut der Universität Würzburg, Am Hubland, 97074 Würzburg

The downscaling behaviour of OFETs is influenced by the crystallinity of the organic semiconductor. Therefore, we analysed different organic semiconductors with different coating methods using templates of 20 nm thin SiO_2 dielectric with metal source/drain bottom contacts. The channel length L was varied from 5μm to 100 nm. UHV deposited dihexylquaterthiophene (DH4T) resulted in a polycrystalline thin film. The mobility was beyond 0.01cm^2/Vs. A spin coated poly-triarylamine based semiconductor (amorphous) had mobility values up to 0.01cm^2/Vs. Dithiophene-tetrathiafulvalene (DT-TTF) was drop cast from solution resulting in large single crystals. Here, mobility values up to 1 cm^2/Vs were achieved. The presentation compares the scaling behaviour of the characteristic FET-parameters: mobility, threshold voltage and on/off-ratio. It also reports on the aspect of oncoming short channel effects, which in our case took place at about L = 200 nm, regardless of the material.

HL 50.44 Thu 16:30 P3

Change of the work function of a polymer substrate by electrochemical treatments: Influence on the energy level alignment — •Heiko Peisert[1,2], Andreas Petr[2], Lothar Dunsch[2], Thomas Chassé[1], and Martin Knupfer[2] — [1]University of Tübingen, IPC, Auf der Morgenstelle 8, D-72076 Tübingen, Germany — [2]Leibniz Institute for Solid State and Materials Research Dresden, D-01069 Dresden, Germany

We studied the influence of the work function change of a polymer substrate by electrochemical treatments on the energy level alignment in layered systems using core and valence level photoemission spectroscopy. As example for a technically relevant organic/organic interfaces we chose the interface between PEDOT:PSS [mixture of poly-3,4-ethylenedioxythiophene (PEDOT) and polystyrenesulfonate (PSS)] and CuPc (copper phthalocyanine). The change of the work function by about 0.75 eV affects the interface dipole whereas the barrier between HOMO (highest occupied molecular orbital) and Fermi level remains constant.

HL 50.45 Thu 16:30 P3

Solution processed single crystal organic field-effect transistors based on tetrathiafulvalene derivates — •M. Leufgen[1], O. Rost[1], G. Schmidt[1], N. S. Oxtoby[2], M. Mas-Torrent[2], N. Crivillers[2], J. Veciana[2], C. Rovira[2], J. Geurts[1], and L. W. Molenkamp[1] — [1]Universität Würzburg, Physikalisches Institut (EPIII), Am Hubland, D-97074 Würzburg, Germany — [2]Institut de Ciencia de Materials de Barcelona(CSIS), Campus UAB, 08193 Cerdanyola, Spain

Solution processed tetrathiafulvalene (TTF) derivates as active materials in organic field effect transistors (OFETs) are electrically analysed. Dithiophene- and dibenzo-tetrathiafulvalene (DT- and DB-TTF) are drop cast from solution of toluene onto lithographically structured

bottom contact FET-templates with common gate and SiO_2 dielectric. They crystallise in several micrometer size single crystals in an elongated evaporation process. A limited number of crystals hits the electrodes and thus constitutes the active channel. Here, the channel length is varied from 100 μm into the sub-micrometer regime (< 100 nm), with the use of 100 (20) nm thick SiO_2 in the first (second) case. The characteristics show the excellent properties of the materials with an on/off-ratio exceeding 10^6 and mobility values as high as 3 cm^2/Vs (in the case of DT-TTF), which is among the highest reported for solution processed crystals. The general scaling behaviour is a decrease in mobility from the 10^0 to the 10^{-1} cm^2/Vs order of magnitude, when going to sub-micrometer channel length, due to an influence of the contact resistance. The results on temperature dependant behaviour prove a thermally activated transport.

HL 50.46 Thu 16:30 P3

Topographical and electrical characterization of pentacene thin-film transistors using thiol-modified electrodes — •D.V. Pham[1], C. Bock[1], U. Kunze[1], D. Käfer[2], G. Witte[2], and Ch. Wöll[2] — [1]Lehrstuhl für Werkstoffe und und Nanoelektronik, Ruhr-Universität Bochum, D-44780 — [2]Lehrstuhl für Physikalische Chemie I, Ruhr-Universität Bochum, D-44780

We study the influence of thiol monolayers on the topography as well as on the electrical characteristics of pentacene thin film transistors. The electrodes are modified by dodecanethiol, heptanethiol and anthracenethiol, respectively. A sample with untreated Ti/Au (1 nm/25 nm) electrodes acts as reference sample. The roughness analysis of the films emphasizes the preferential growth of pentacene on the untreated gold layer. The best morphology of the organic film is achieved with electrodes treated with dodecanethiol for a channel length of 500 nm. Since alcanethiols are isolators, the injection of the charge carriers from the gold electrode into the active region is strongly reduced. Nevertheless the performance of pretreated OFETs is superior compared to the reference sample. The best results are obtained with anthracenethiol treatment. The morphology of the film is homogeneous and, due to its semiconducting behaviour, high drain currents are possible. The threshold voltage of this sample is 2 V and the ON/OFF ratio amounts to 10^6.

HL 50.47 Thu 16:30 P3

C-U INVESTIGATION OF BILAYER, IONIZED CLUSTER BEAM DEPOSITED, Al/PTCDA/CuPc/ITO ORGANIC SEMICONDUCTOR STRUCTURE — •Bruno Cvikl[1,2], Matjaž Koželj[2], and Dean Korošak[1] — [1]Chair of Applied Physics, Faculty of Civil Engineering, University of Maribor, Maribor, Slovenia — [2]Institute J. Stefan, Ljubljana, Slovenia

In this work the results of the room temperature C-U and I-U measurements of the ionized cluster beam deposited Al/PTCDA(0.8μm)/CuPc(1.2μm)/ITO organic bilayer structure, of two hole transporting materials, will be presented. Its room temperature C-U line shape, for larger reverse and forward values of bias, broadly resembles the Berleb et al. [1] of the thick Alq3 layer data. The C-U line shapes of the said structure, as a function of Alq3 thickness, are well described in terms of the newly derived expression for the differential capacitance [2]. It incorporates the bias dependent, at the cathode/organic semiconductor junction, induced net charge density and the bias independent electric dipole density existing within the organic mixture in the neighborhood of the Alq3/NPB region. However, within the interval between -1 V to + 2.5 V the C-U line shape of our sample is akin the cubic parabola that our expression for the differential capacitance fails to predict. The possible mechanisms that modulate the capacitance-voltage line shape of such an organic structure will be presented and discussed in details.

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HL 50.48 Thu 16:30 P3

Spin injection at metal/organic semiconductor interface — •Dean Korošak[1], Bruno Cvikl[1,2], and Matjaž Koželj[2] — [1]University of Maribor, Faculty of Civil Engineering, Chair for Applied Physics, Smetanova 17, 2000 Maribor Slovenia — [2]J. Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia

A theoretical investigation of a possibility of using a metal/organic semiconductor interface as a spin injector, specifically considering the role of a tunneling barrier at a metal/organic semiconductor interface serving as a spin selective mechanism. The parameters of the PCTDA electronic structure are determined from the results of the analysis of the capacitance-voltage characteristics of the ionized cluster beam deposited samples. The current spin polarization is found to critically depend on the details of the disordered interlayer the width of which and the properties can be to some extent controlled in the ionized cluster beam deposition experiment. It is shown that under the assumption of the space charge limited current through the contact the crucial parameter is the effective width of the organic layer determining the spin diffusion lenght. The structure resulting from ionized cluster beam experiment in which a thin interlayer sandwiched between the metal and organic semiconductor doped with metal clusters can be obtained is considered as a numerical example.

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HL 50.49 Thu 16:30 P3

Investigations of electron transport in a contact limited methanofullerene thin film transistor — •Elizabeth von Hauff[1], Jürgen Parisis[1], and Vladimir Dyakonov[2] — [1]Institute of Physics, Energy and Semiconductor Research Laboratory, Carl von Ossietzky University of Oldenburg, 26111 Oldenburg, Germany — [2]Experimental Physics VI, Faculty of Physics and Astronomy, University of Würzburg, 97074 Würzburg, Germany

In this study the electron transport in a methanofullerene was investigated via the thin film transistor structure. The temperature dependent source-drain current and the electron field effect mobilities in [6,6]-phenyl C_{61}-butyric acid methyl ester (PCBM) were investigated in context of a model for field effect theory in amorphous materials from the literature. An initial fit led to discrepancies between experimental and predicted data at low temperatures and gate voltages, an effect which was attributed to parasitic contact resistances between the source/drain contacts and the semiconductor. The effects of the contact resistances were then investigated. Studying the temperature and electric field activated behaviour of the contact resistance was found to aid in the understanding of charge injection in the device. A form for the contact resistance based on a diffusion limited thermionic emission current was proposed. Incorporating the proposed form of the contact resistances into the model was found to lead to much better agreement between experimental data and that predicted by the model.

HL 50.50 Thu 16:30 P3

Optical investigation of P3HT/PCBM bulk heterojunction solar cells by photoinduced absorption spectroscopy — •Stefan Voigt[1], Uladzimir Zhokhavets[1], Harald Hoppe[1], Gerhard Gobsch[1], Maher Al-Ibrahim[2], Oliver Ambacher[2], and Steffi Sensfuss[3] — [1]Institute of Physics, Ilmenau Technical University, 98684 Ilmenau, Germany — [2]Centre for Micro- and Nanotechnologies, Ilmenau Technical University, 98684 Ilmenau, Germany — [3]TITK Inst. Rudolstadt, Dept. Functional Polymer Systems, 07407 Rudolstadt, Germany

An important parameter that determines the efficiency of organic solar cells is the product of the mobility and lifetime of generated charge carriers. This product needs to be increased by an optimized choise of the materials and balanced production processes. In this work, this mobility - lifetime product of positive polarons is determined in dependence on temperature and excitation density by dynamic photoinduced absorption experiments on the accomplished devices. In addition the recombination characteristics were regarded by studying the excitation density dependence of the signal. The influence of annealing on the recombination properties is investigated, too.

HL 50.51 Thu 16:30 P3

Field Effect Mobility of the Polymer Poly(3-Hexyl Thiophene) — •Maria Hammer[1], Carsten Deibel[1], Vladimir Dyakonov[1], and Ingo Riedel[2] — [1]Experimental Physics VI, Physical Institute, University of Würzburg, 97074 Würzburg, Germany — [2]Bavarian Centre for Applied Energy Research (ZAE Bayern e.V.), Div. Functional Materials for Energy Technology, Am Hubland, 97074 Würzburg, Germany

Semiconducting polymers are interesting materials for the use in organic electronics. We investigated the field effect mobility of regio-regular and regio-random poly(3-hexyl thiophene), in dependence of temperature and charge carrier concentration. Our data will be discussed in view of re-

cently published models for charge carrier mobility in disordered organic materials, based on hopping transport of charge carriers in a gaussian density of states distribution.

HL 50.52 Thu 16:30 P3

Microresonators based on SOI for optical bio-sensory applications — •Dominic Dorfner, Felix Hofbauer, Andreas Kress, Marc Tornow, Jon Finley, and Gerhard Abstreiter — Walter Schottky Institut, Technische Universität München, Am Coulombwall 3, D-85748 Garching, Germany

We are investigating the potential to develop photonic biosensors that will combine high spatial resolution and detectivity. Our concept is based on probing the modification of the linear optical response of photonic crystal (PC) defect resonators upon surface bio-functionalization. PCs are fabricated from the biocompatible Silicon-on-insulator (SOI) materials system using electron beam lithography and reactive ion etching. They consist of a hexagonal lattice of air holes perforating the SOI membrane into which cavities are formed by single missing hole defects. Calculations demonstrate that the cavity mode frequency should be very strongly influenced by local changes of refractive index (n) on the surface of the PC. By simulating the attachment of bio-molecules to the surface, a ˜8% absolute shift of the mode frequency is predicted as n increases from ˜1.3 to ˜1.5. For a PC with lattice constant a=340nm (photonic bandgap ˜1.2 - 1.4 mu) this would correspond to delta˜30nm, easily visible even with rather low cavity Q-factors of one thousand. First optical characterizations were performed using micro-photoluminescence spectroscopy on structures infilled with PbSb nanocrystals. These measurements reveal peaks due to filtering of the QD emission through the cavity mode spectrum, with Q˜100.

HL 50.53 Thu 16:30 P3

Anisotropic Light Emission of Quantum Dots in Photonic Crystals — •Rebecca Wagner[1], Michael Barth[2], and Frank Cichos[1] — [1]Photonics and Optical Materials, Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz — [2]Nano-Optics group, Institute of Physics, Humboldt University Berlin, Hausvogteiplatz 5-7, 10117 Berlin

Photonic crystals are periodic dielectric materials, which modify light emission by means of a photonic stop band. In weak photonic systems with low dielectric contrast, the local optical density of states is only modified in certain directions of the photonic crystal therefore giving rise to an anisotropic light propagation. We study the influence of this anisotropic light propagation on the angular emission characteristics of single quantum dots within numerical calculations and experimental investigations. The numerical calculations are based on the fractional local density of states, which describes the angular redistribution of electromagnetic modes in the photonic crystal. The fractional local density of states reveals, that even in weak photonic systems strongly directional emission of emitters may occur, especially at the short wavelength edge of the photonic stop band. This calculation is combined with imaging calculations to compare the results to experimental investigations of anisotropic light propagation using defocused fluorescence wide field imaging on single quantum dots in colloidal photonic crystals.

HL 50.54 Thu 16:30 P3

Design, fabrication and characterization of microcavity OLED structures — •Hannes Gothe, Robert Gehlhaar, Hartmut Fröb, Vadim G. Lyssenko, and Karl Leo — Institut für Angewandte Photophysik, Technische Universität Dresden, 01062 Dresden, Germany, www.iapp.de

Microcavity OLEDs exhibit a directional emission and efficiency enhancement. We report on a microcavity structure consisting of a distributed Bragg reflector (DBR) and a metal mirror. The SiO_2/TiO_2-DBR is fabricated by reactive electron-beam evaporation and covered with an electrically conductive film of indium-tin-oxide (ITO). Due to the comparably high absorption, the optical properties of the microcavity are strongly dependent on the ITO layer. By annealing and structure optimization, which reduces the electromagnetic field intensity in the ITO layer, we counteract the absorbance and decrease the optical losses within the resonator. The results of linear optical measurements are explained by transfer-matrix calculations.

HL 50.55 Thu 16:30 P3

Conventional pillar-type and novel pyramidal III-V microcavities: Fabrication and characterization — •M. Karl[1], W. Löffler[1], J. Lupaca-Schomber[1], T. Passow[1], S. Li[1], F. Perez-Willard[2], J. Hawecker[2], D. Gerthsen[2], H. Kalt[1], C. Klings-hirn[1], and M. Hetterich[1] — [1]Institut für Angewandte Physik and Center for Functional Nanostructures (CFN), Universität Karlsruhe, D-76131 Karlsruhe, Germany — [2]Laboratorium für Elektronenmikroskopie and CFN, Universität Karlsruhe, D-76128 Karlsruhe, Germany

In our contribution we discuss two different approaches to realize GaAs-based micro-cavities: In the first approach conventional pillar-type resonators with AlAs/GaAs distributed Bragg reflectors (DBRs) were fabricated from MBE-grown layer structures using focussed ion beam (FIB) milling. In(Ga)As quantum dots emitting at around 950 nm served as a broad-band light source in these cavities. To assess the optical properties of individual micro-resonators a confocal micro-photoluminescence set-up with a tunable Ti:sapphire laser for excitation was used. In particular, we investigated the dependence of the observed cavity modes on the pillar diameter.

In extension to this work we have also recently started to study the potential of a new cavity design. The latter consists of a pyramidal GaAs resonator placed on top of an AlAs/GaAs DBR. It can be fabricated by combining electron-beam lithography and wet chemical etching of structures containing an AlAs sacrificial layer. First results obtained for these resonators will be presented. In particular, it will be shown that even coupled cavities can easily be realized in this approach.

HL 50.56 Thu 16:30 P3

PAC studies with LSO scintillation crystals — •Riccardo Valentini and Reiner Vianden — Helmholtz - Institut für Strahlen- und Kernphysik der Universität Bonn, Nußallee 14-16, 53115 Bonn, Germany

The LSO (lutetium oxyorthosilicate, Lu_2SiO_5) scintillation crystal has been shown to improve the efficiency of PET apparatus considerably [1] [2]. This makes LSO interesting for Perturbed Angular Correlation (PAC) since today's solid state studies require appropriate PAC probes for specific purposes, like ^{77}Br, ^{187}W or ^{172}Lu, with more complicated energy spectra. We investigated the applicability of this new scintillator for PAC studies especially in experiments where the improvement of energy resolution as compared to BaF_2 is important without loosing time resolution. From these improvements we expect a larger effective anisotropy. Further due to the high average atomic number of LSO its photopeak efficiency is considerably high. We present here test measurements with ^{172}Lu in ZnO and a comparison with measurements on a BaF_2 setup.

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[2] C.M. Pépin et al., IEEE Trans on Nucl. Sci., 51, 2004, 789

HL 50.57 Thu 16:30 P3

Waveguide and sensor systems comprising metamaterial elements — •M. Shamonin[1], A. Radkovskaya[2], C.J. Stevens[3], G. Faulkner[3], D.J. Edwards[3], O. Sydoruk[4], O. Zhuromskyy[4], E. Shamonina[4], and L. Solymar[5] — [1]University of Applied Sciences Regensburg, D-93025 Regensburg, Germany — [2]M.V. Lomonosov Moscow State University, 119992 Moscow, Russia — [3]University of Oxford, Oxford OX1 3PJ, United Kingdom — [4]University of Osnabrück, D-49069 Osnabrück, Germany — [5]Imperial College of Science, Technology and Medicine, London SW7 2BT, United Kingdom

We shall report an experimental and theoretical study of periodic structures consisting of familiar metamaterial elements with a view to sensor applications. In the measurements one, two- and three-dimensional arrays of resonant elements are employed. The mechanism under investigation is the guiding, channelling, splitting and recombination of signals across (or along) perodic structures whose dimensionas are small relative to, or of the order of a wavelength. We shall present experimental and theoretical results on a variety of sensing systems in which the HF magnetic field plays a dominant role with potential applications in imaging, in the automotive industry and in antennas.

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HL 50.58 Thu 16:30 P3

Ground State of Electron on Short-Range Potential in Two Dimensional Structure in Magnetic Field — •Tatiana Pavlova — Moscow Engineering Physics Institute, Kashirskoe sh. 31, 115409 Moscow, Russia

The exact energy spectrum of an electron in a negative ion located in a two-dimensional structure and in a magnetic field applied perpendicular to the layer surface is derived. In our calculations we used the method of the zero-range potential derived for the three-dimensional problem (Yu.N. Demkov and G.F. Drukarev, 1965). The energy of the electron located in a short-range potential of arbitrary scattering length is obtained. The dependence of the binding energy on the magnetic field is investigated in the layer with different thickness. The diamagnetic and antidiamagnetic energy shifts from the continuous spectrum boundary are studied. In the limit of infinite layer thickness the obtained energy coincides with energy in the three-dimensional problem. The electron energy in the shallow impurity potential in a weak magnetic field agrees with the results derived previously (S.P. Andreev and T.V. Pavlova, 2005).

HL 50.59 Thu 16:30 P3

An all-Electron GW Code Based on FP-(L)APW+lo — •Ricardo I. Gomez-Abal, Xinzheng Li, and Matthias Scheffler — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin.

In recent years the GW approximation (GWA), typically applied as perturbation to DFT, has proven to be very successful describing quasiparticle excitations in semiconductors and insulators. Most of the existing codes are based on the pseudopotential (PP) method, which is well established for ground state DFT calculations. In this scheme, the self energy is computed for the valence states only. There is, however, no guarantee that "core-valence partitioning" done in this fashion is justified for the dynamical self energy, which is a highly non-linear functional of the total density. G_0W_0 results obtained with PP implentations are usually in better agreement with experiments than those reported from existing all-electron implementations. Self-consistent schemes improve the agreement of the all-electron calculations [1], but drastically worsen the PP results [2]. The reasons for this discrepancy and the necessity for self-consistency are still a matter of debate [1,2]. In order to address these questions, we are developing our own all-electron GW code. It is based on the FP-(L)APW+lo method, which currently provides the most reliable results within DFT. The code treats core, semicore and valence states on the same footing, which implies that it is applicable to a wide range of materials. In this poster we present a description of the code and the first results obtained for silicon.

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[2] K. Delaney, *et al.* Phys. Rev. Lett. **93**, 249701 (2004).

HL 50.60 Thu 16:30 P3

Ab initio calculation of electronic properties for dangling bond free nitridated silicon — •Philipp Plänitz, Alberto Martinez-Limia, Mohammed Bouhassoune, and Christian Radehaus — Institute for Electrical and Information Engineering, Technical University Chemnitz, 09107 Chemnitz, Germany

Silicon oxynitride is used by the semiconductor industry as Gate oxide for mordern MOSFETs. For a low nitrogen concentration the theoretical calculation of electronic properties is difficult due to large unit cells and amorphous structures.

Using ab initio density-functional theory the influcene of electrical inactive nitrogen in a silicon oxid matrix was investigated. We report the calculated values of the total energies, density of states, band gap and dielectric constant for different concentrations of nitrogen. By classical MC and CPMD approximate unit cells were obtained for the amorphous structures. The exact value for the band gap was calculated by means of the GW-method and the dielectric response was calculated in the framework of first order pertubation theory as implemented in the ABINIT program.

HL 50.61 Thu 16:30 P3

Time-dependent density functional theory in the non-adiabatic regime — •Günther Schwarz, Ilya V. Tokatly, and Oleg Pankratov — Chair of theoretical solid state physics - University of Erlangen-Nuremberg, Germany

The time-dependent density functional theory (TD-DFT) has proven to be an important scheme for the computation of dynamics of quantum mechanical systems. However, most of the work has been performed within the adiabatic local density approximation (ALDA) where the exchange-correlation potential v_{xc} is treated as a local function of electron density. Recent work [1,2] has shown that a non-adiabatic TD-DFT can be formulated most naturally in the co-moving Lagrangian reference frame. Within this approach the time evolution of v_{xc} is defined by a Cauchy deformation tensor as the basic variable rather than by the electron density or current. A differential equation for this tensor has to be solved in addition to the time-dependent Kohn-Sham equations. This imposes only modest computational effort over an adiabatic calculation.

We performed first tests of the dynamics of an electron gas in a single and double quantum well to demonstrate the similarities and differences of this generalized hydrodynamics approach as compared to adiabatic calculations. We aim to uncover the importance of non-adiabatic effects and thus to verify the applicability range of ALDA.

[1] I. V. Tokatly and O. Pankratov, Phys. Rev. B **37**, 201103(R) (2003).
[2] I. V. Tokatly, Phys. Rev. B **71**, 165105 (2005).

HL 50.62 Thu 16:30 P3

Spin-Dependent GW Approximation with Application to MnO — •Claudia Rödl, Patrick Hahn, Jürgen Furthmüller, and Friedhelm Bechstedt — Institut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany

Determining the electronic structure of systems containing transition metals is still a challenging task. Such systems often have a nontrivial spin ordering. In order to calculate quasiparticle band structures of magnetic materials we extend the well-known Hedin equations and subsequently the GW approximation (GWA) to systems with intrinsic spin polarization and spin-orbit coupling. In the following we restrict ourselves to collinear spin polarization which is sufficient to describe a wide range of magnetic materials. Band structure calculations for the antiferromagnetic insulator MnO using spin-density functional theory (SDFT) as well as spin-polarized GW approximation are presented. Occurring effects will be critically discussed. Furthermore, we study the consequences of including collinear spin polarization in the calculation of the optical properties of magnetic materials. The Bethe-Salpeter equations and the extension of the excitonic Hamiltonian to spin-polarized systems are considered.

HL 50.63 Thu 16:30 P3

Structural and Electronic Properties of ZnO and CdO polymorphs — •Andre Schleife, Frank Fuchs, and Friedhelm Bechstedt — Institut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany

The group-II metal oxides ZnO and CdO are both of technological and fundamental interest. In recent years this led to a variety of proposed and realized applications, mainly in the field of optoelectronics. However, on the theoretical side comparably little is known about their properties. Here we present results on the structural and electronic properties of various ZnO and CdO polymorphs in zincblende, wurtzite and rocksalt structure. We discuss the energetic stability, lattice parameters and bandstructures. The calculations are performed in the framework of generalized-gradient corrected density functional theory (DFT-GGA). The projector augmented plane wave (PAW) method is used to model the electron-ion interaction.

HL 50.64 Thu 16:30 P3

Energy spectrum of strongly correlated electrons and indirect excitons in quantum dots — •Karsten Balzer, Christoph Nölle, Michael Bonitz, and Alexei Filinov — Christian-Albrechts-Universität Kiel, Institut für Theoretische Physik und Astrophysik, Leibnizstr. 15, 24098 Kiel, Germany

In the limit of strong correlations finite electron and exciton systems in quantum dots show Fermi liquid behavior and Wigner crystallization. Wigner crystals of electrons [1] and excitons [2] are predicted to occur in semiconductor quantum dots or in quantum wells with an external electrostatic confinement. Path integral Monte Carlo (PIMC) simulations have allowed to compute the density matrix from first principles [1,2]. However, they cannot directly yield the energy spectrum and wave functions which give access to the optical and transport properties.

Here we develop an analytical approach to the many-particle wave function and energy spectrum of electrons and indirect excitons in the strong-coupling limit which is based on an expansion in terms of col-

lective eigenmodes [3]. Exact solutions are obtained for small particle numbers by direct diagonalization. For larger systems, a new method is introduced which allows one to reconstruct the energy spectrum and wave function from first principle PIMC results for the density distribution.

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HL 50.65 Thu 16:30 P3

CYLINDRIC RESONATORS WITH COAXIAL BRAGG-REFLECTORS — •R. Schmidt-Grund[1], T. Gühne[2], H. Hochmut[1], B. Rheinländer[1], A. Rahm[1], V. Gottschalch[2], J. Lenzner[1], and M. Grundmann[1] — [1]Uni Leipzig, Inst. für Exp. Physik II — [2]Uni Leipzig, Fak. für Chemie und Mineralogie

Lateral confinement for cylindrical micro-resonator light emitters improves the ratio of the number of the axial resonant modes to the number of the spontaneous emitting lateral modes. We have observed resonator behaviour of cylindrical micro-structures, whose surfaces were coated with coaxial MgO/ZrO_2 and a-Si/SiO_x Bragg-reflectors (BR).

Glass rods with circularly shaped basal planes ($\oslash$=5μ...100μm) and ZnO wires with hexagonally shaped basal planes ($\oslash$=0.8μm...10μm) were used as cavity material. The optical properties were investigated using a micro-reflectometer (μR), spatially resolved spectroscopic ellipsometry, and cathodoluminescence (CL) measurements. The Bragg-stopband (SB) of the BR deposited on the free standing ZnO-wires was found to be uniform for all hexagonal lateral facets. In contrast, the SB of the BR deposited on the horizontally mounted glass rods varies with the azimuthal position on surface. The μR measurements were performed perpendicular to the axis of the ZnO wires. In the wavelength range of the SB spectral structures due to multiple-reflection induced interferences of the ZnO cavity are visible. This indicates resonator behaviour of the coated ZnO-wires. CL measurements confirm these results.

Calculations of the electromagnetic field distribution within the cylindrically layered structures will be presented.

HL 50.66 Thu 16:30 P3

FIR spectroscopy of single quantum dots fabricated by AFM — •Steffen Groth[1], Kevin Rachor[1], Carsten Graf von Westarp[1], Can-Ming Hu[2], and Detlef Heitmann[1] — [1]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany — [2]Department of Physics and Astronomy University of Manitoba, Winnipeg, Manitoba, Canada R3T 2N2

We study charge excitations in single quantum dots fabricated on semiconductor heterostructures by *a*tomic *f*orce *m*icroscope (AFM) nanolithography. For this purpose we have established the technique of anodical oxidation to pattern a split gate directly on a GaAs/AlGaAs heterostructure with a two-dimensional electron system confined 35 nm below the sample surface. This technique enables us to prepare barriers with a geometrical thickness of less than 200 nm. The dot geometry and size (down to a few 100 nm) are both tunable by changing the applied gate voltage. We monite the tunneling conductance of the single quantum dot which oscillates as a function of the gate voltage due to the Coulomb blockade. We perform the measurement at a temperature of 250 mK using a He3 cryostat with a 10 tesla magnet connected to a far-infrared (FIR) spectrometer. We expect that under the influence of FIR radiation, the Coulomb blockade peaks will be shifted due to the charge redistribution caused by collective excitations.

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HL 50.67 Thu 16:30 P3

Coherence properties of the resonance fluorescence from GaAs Quantum Wells — •Gerolf Burau, Birger Seifert, and Heinrich Stolz — Institut für Physik, Universität Rostock, 18051 Rostock

We study the spectral coherence properties of the resonance fluorescence from excitons in GaAs quantum wells under coherent resonant excitation. The distinction between the coherent and the incoherent component of the radiation emitted from excitons is experimentally challenging. Therefore a new setup for spectral speckle analysis has been developed for precise measurement of the secondary emission intensity distribution. We considerably improved the quality of the quantitative analyzed speckle distribution due to the improved optical imaging and the higher spectral resolution. A single frequency laser with 4 neV (1 Mhz) bandwidth was used for excitation.

HL 50.68 Thu 16:30 P3

Optical beam indal npn-structure junction devicesuced current measurements at planar two-dimension — •C. Werner, D. Reuter, and A.D. Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum

By overcompensating a p-doped $GaAs/In_{0.19}Ga_{0.81}As/Al_{0.33}Ga_{0.67}As$ pseudomorphic heterostructure we have fabricated two-dimensional npn-junction devices. The molecular beam epitaxy grown base material has a hole density of 7×10^{11} cm^{-2} and the mobility of the holes is 200 cm^2/Vs at room temperature.

By implanting silicon ions we locally overcompensate the heterostructure, as described in [1, 2], and obtain n-doped areas. The implantation consists of two rectangles with a non-implanted area in between. We expect the resulting photocurrent to be linearly dependent on the position of a light spot for this type of sample. Therefore we made OBIC-measurements (optical beam induced current) by scanning a modulated focused laser beam (635 nm) across the sample perpendicular to the junctions and measuring the voltage drop over a resistance connected to the device by a lock-in amplifier.

This project is gratefully acknowledged by the Evangelische Studienwerk "Haus Villigst" within the "Promotionsschwerpunkt Wechselwirkungen".

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[2] D. Reuter, C. Werner, A. D. Wieck and S. Petrosyan, Appl. Phys. Let. 86 (2005) 162110.

HL 50.69 Thu 16:30 P3

Resonant Raman scattering in Cu_2O — •Jan Brandt[1], Dietmar Fröhlich[1], Christian Sandfort[1], Manfred Bayer[1], and Heinrich Stolz[2] — [1]Institut für Physik, Universität Dortmund, D-44221 Dortmund, — [2]Fachbereich Physik, Universität Rostock, D-18051 Rostock

We present results on exciton phonon polariton scattering in Cu_2O. We study by high resolution spectroscopy (ΔE< 10neV) resonant Raman scattering on the yellow 1S orthoexciton for optical phonons of different symmetry (Γ_3^-, Γ_4^-, Γ_5^-). The Γ_4^- phonon of 19meV is optically active and has thus to be considered as a polariton with TO and LO components split by 0.3meV. For forward Raman scattering the polariton character of the TO components has to be taken into account. We present the Raman selection rules for quadrupole excitation of the threefold Γ_5^+ exciton. The splitting in up to three components by k-dependent exchange interaction is also taken into account[1].

[1] Dasbach et al. PRB 70, 045206 (2004)

HL 50.70 Thu 16:30 P3

Calculation of optical mode energies and field distributions in micron-sized semiconductor ring resonators — •Ch. Strelow, T. Kipp, and D. Heitmann — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Germany

We calculate the mode structure and field distributions of micrometer-sized semiconductor ring resonators with very thin walls and compare it to experimental spectra.

Using polar coordinates and a radial stepwise arrangement of refractive index we get an exact solution of Maxwell's equation by matching Bessel functions at the boundaries. The mode energies and their field distributions sensitively depend on the thickness of the wall, its refractive index and radius. We compare these exact results to a simplified model of a planar dielectric wave guide applying periodic boundary conditions. The theoretical results show a very good agreement to experiments on a novel kind of microcavity, namely a InGaAs/GaAs microtube ring resonator, which we prepared using the self-rolling mechanism of strained bilayers. We acknowledge financial support by the Deutsche Forschungsgemeinschaft via SFB 508.

HL 50.71 Thu 16:30 P3

Transport investigation on ZnO Nanowires — •T. Lüdtke[1], J. M. Becker[1], R. J. Haug[1], B. Postels[2], M. Kreye[2], and A. Waag[2] — [1]Institut für Festkörperphysik, Universität Hannover, D-30167 Hannover — [2]TU-Braunschweig, D-38106 Braunschweig

We report on fabrication and transport measurements on ZnO nanowires. The nanowires are grown vertically onto a highly doped SiO_2 substrate and have a diameter of 50nm - 200nm and a length up

to $2\mu m$. We use a method to contact this array of nanowires vertically. The sample is completely coated with an insulating polyimid whereas the tips of some wires are uncovered in several etching steps. Gold pads of a few tenth μm are located above the uncovered tips to connect the wires to leads.

The sample is measured inside a He^4 cryostat allowing temperatures down to 1.5 K and magnetic fields up to 15T. I-V characteristics shows an asymmetric diode like behaviour and the current rises while increasing the temperature. By illuminating the sample the conductivity is increasing by a factor of 2. Further temperature dependent measurements have been performed to analyze possible piezoelectric effects of the ZnO.

HL 50.72 Thu 16:30 P3

Self-Assembly of Nitride Nanowires grown by MBE — •Ratan Debnath[1], Ralph Meijers[1], Thomas Richter[1], Toma Stoica[1,2], Raffaella Calarco[1], Michel Marso[1], and Hans Lüth[1] — [1]Institute of Thin Films and Interfaces (ISG1) and CNI - Centre of Nanoelectronic Systems for Information Technology, Research Center Jülich,52425 Jülich, Germany — [2]INCDFM, Magurele, POB Mg7, Bucharest,Romania

Among different types of nanostructures, semiconductor nanowires and nanotubes are extremely interesting as building blocks for nanoelectronics, due to their suitability for fabricating both nanoscale devices and interconnects. Although there have been a lot of investigations on these semiconductor nanowires, fundamental physical properties are still unclear. The growth mechanism and especially the nucleation of the wires, which is very important for producing ordered arrays of nanowires is not understood in detail. The self-assembled growth of GaN, InN as well as $In_xGa_{1-x}N$ nanowires on Si(111) substrates by molecular beam epitaxy (MBE) was investigated by means of several characterization methods. Scanning electron microscopy (SEM) images showed the influence of growth parameters on column shape and density whereas, optical methods (photo- (PL) and cathodoluminescence (CL)) provided the information about the quality of the grown wires. It was even possible to get spatially-resolved information by combining SEM and CL. By introducing doping materials (Si and Mg) in the nanowires, column morphology can be changed considerably, depending on the concentration of the dopants.

HL 50.73 Thu 16:30 P3

Structural and electronic properties of morphological transformed InAs quantum dots — •Andreas Schramm, Jan Schaefer, Fabian Wilde, Tobias Kipp, Stephan Schulz, Christian Heyn, and Wolfgang Hansen — Institut für Angewandte Physik, Jungiusstraße 11C, 20355 Hamburg

We study the structural and electronic properties of morphological transformed InAs-quantum dots embedded in Schottky diodes using atomic force microscopy (AFM), photoluminescence (PL), capacitance (CV) and deep level transient spectroscopy (DLTS). The samples were grown on (001) GaAs in a solid-source MBE system. We find that we can control the shape of the dots by an annealing step after growth of an AlAs cap layer. Both AFM data as well as the electronic properties show that the dots size increases with the AlAs cap layer thickness. Furthermore, we observe a strong lateral shape anisotropy in quantum dots grown beneath AlAs cap layers. The influence on the electronic properties like threshold voltages and energies as well as number of observed DLTS-maxima will be briefly discussed.

HL 50.74 Thu 16:30 P3

Constant capacitance deep level transient spectroscopy on InAs quantum Dots — •Jan Schaefer, Andreas Schramm, Stephan Schulz, Christian Heyn, and Wolfgang Hansen — Institut für Angewandte Physik, Jungiusstraße 11 20355 Hamburg

The thermionic emission of charge carriers from self-assembled quantum dots embedded in Schottky diodes is found to strongly depend on the electric field at the location of the quantum dots. So far, the emission rates have been studied with transient capacitance spectroscopy. However, in such measurements (conventional deep level transient capacitance spectroscopy, DLTS) the electric field does not remain constant while the transient is recorded. It is thus very desirable to have a method at hand, that allows to probe the carrier emission at constant field condition. Here we report about the implementation of such a method: The so-called constant capacitance deep level transient spectroscopy (CC-DLTS). We present first CC-DLTS measurements on InAs quantum dots and compare the results obtained with this and the conventional DLTS method.

HL 50.75 Thu 16:30 P3

Deposition and epitaxial overgrowth of colloidal nanocrystals on ZnSe surfaces — •Dirk Mügge[1], Christof Arens[1], Detlef Schikora[1], Klaus Lischka[1], Oliver Schöps[2], Ulrike Woggon[2], and Mikhail V. Artemyev[3] — [1]Dep. Physik, Universität Paderborn, Warburger Str. 100, 33098 Paderborn, Germany — [2]FB Physik, Universität Dortmund, Otto-Hahn-Str. 4, 44227 Dortmund, Germany — [3]Institute for Physico-Chemical Problems of Belarussian State University, Minsk, Belarus

The incorporation of colloidal Nanocrystals (NCs) in an epitaxial grown ZnSe Matrix is an alternative production technology of Quantum Dot (QD) structures adverse to the self organized Stranski Krastanow (SK) QD growth. The advantages of such hybrid epitaxial-colloidal structures are the production of QD layer with variable QD densities (theoretically from 10^0 cm^{-2} to 10^{14} cm^{-2}) and the possible incorporation of different colloidal NCs into the same QD layer (e.g. different materials, size, shape). The NCs are kept in Pyridine and transmission measurements allow the determination of the absolute NC density in the carrier solvent. We will present optical and structural properties of core(shell) CdSe(ZnS) NCs with different NC densities on epitaxial grown ZnSe surfaces treated by standart deposition technologies (e.g. spin coating, dip coating) and investigations of optical and structural properties of integrated NCs in an epitaxial grown ZnSe Matrix.

HL 50.76 Thu 16:30 P3

Constant capacitance deep level transient spectroscopy on InAs quantum Dots — •Jan Schaefer, Andreas Schramm, Stephan Schulz, Christian Heyn, and Wolfgang Hansen — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstraße 11, D-20355 Hamburg, Germany

The thermionic emission of charge carriers from self-assembled quantum dots embedded in Schottky diodes is found to strongly depend on the electric field at the location of the quantum dots. So far, the emission rates have been studied with transient capacitance spectroscopy. However, in such measurements (conventional deep level transient capacitance spectroscopy, DLTS) the electric field does not remain constant while the transient is recorded. It is thus very desirable to have a method at hand, that allows to probe the carrier emission at constant field condition. Here we report about the implementation of such a method: The so-called constant capacitance deep level transient spectroscopy (CC-DLTS). We present first CC-DLTS measurements on InAs quantum dots and compare the results obtained with this and the conventional DLTS method.

HL 50.77 Thu 16:30 P3

Raman study of CdSe core/shell nanorods — •N. Tschirner[1], M. Machon[1], U. Woggon[2], M.V. Artemyev[3], and C. Thomsen[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Germany — [2]Fachbereich Physik der Universität Dortmund, Germany — [3]Minsk State University, Belarus

CdSe nanorods were studied using Raman spectroscopy. The spectra reveal an LO peak which is shifted from the bulk Raman frequency by $\approx 3\,cm^{-1}$. The linewidth and lineshape are also affected. We discuss our results on nanorods without and with ZnSe shells of different sizes.

HL 50.78 Thu 16:30 P3

Modeling the growth of quantum dot stacks via kinetic Monte Carlo simulations — •Roland Kunert and Eckehard Schöll — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin

We study the heteroepitaxial growth of self-assembled quantum dot stacks, grown in the Stranski-Krastanov growth mode, using kinetic Monte Carlo simulations.

The focus of our investigations is the effect of the three-dimensional anisotropic strain field induced by the lattice mismatch, which is computed self-consistently in the framework of elasticity theory. With this approach we can explain the seemingly contradictory predictions about the positions of anticorrelated stacks of quantum dots in theory[1] and experiment[2].

Using a hybrid method, we simulate the growth of the quantum dot arrays, taking into account the strain field generated by the layers beneath.

[1] V. Holý, G. Springholz, M. Pinczolits, and G. Bauer, Phys. Rev. Lett. **83**, 356 (1999).

[2] X.-D. Wang, N. Liu, C. K. Shih, S. Govindaraju, and A. L. Holmes, Jr., Appl. Phys. Lett. **85**, 1356 (2004).

HL 50.79 Thu 16:30 P3

Positioning of self-assembled InAs quantum dots by focused ion beam implantation — •Minisha Mehta, Alexander Melnikov, Dirk Reuter, and Andreas D. Wieck — Lehrstuhl für Angewandte Festkörperphysik,Ruhr-Universtät Bochum, Universitätstraße 150, D-44780 Bochum,Germany

Self-assembled quantum dots (QDs) have attracted great interest in the last years for realization of novel nanoelectronic devices based on single quantum dots. For such devices, well controlled positioning of the InAs QDs is necessary.

We have studied a selective positioning method for self-organized InAs quantum dots (QDs) on patterned GaAs substrate by a combination of in-situ focused ion beam implantation (FIB) and self-organized molecular beam epitaxy (MBE) technology. We have proposed square lattice of nanoholes by FIB-implantation of Ga and In ions respectively. These arrays were overgrown with InAs to induced preferred QD formation at the hole positions. The shape and position of the QDs were investigated by scanning electron and atomic force microscopy. We studied the influence of the ion dose, an in-situ thermal treatment and the In amount deposited. By optimizing these parameters, we could achieve a minimum of approximately 7 QDs per hole without having QDs in the unpatterned areas.

Financial support from the DFG GRK384 and the BMBF contract BM451 NanoQuit is gratefully acknowledged.

HL 50.80 Thu 16:30 P3

Top-down fabrication of GaAs/AlAs nanocolumns with lateral dimensions in the sub-100nm range — •Jakob Wensorra[1], Mihail Ion Lepsa[1], Klaus Michael Indlekofer[1], Arno Förster[2], and Hans Lüth[1] — [1]Institut für Schichten and Grenzflächen (ISG1) und Center of Nanoelectronic Systems for Information Technology (CNI), Forschungszentrum Jülich GmbH, 52425 Jülich — [2]Fachhochschule Aachen, Abteilung Jülich, Physikalische Technik, Ginsterweg 1, 52428 Jülich

We report on a top-down fabrication technique for vertical GaAs nanocolumns with embedded AlAs barriers.

Layer stacks with double barrier resonant tunneling structures have been grown by MBE. Precise plasma etching of nanocolumns with lateral dimensions down to the sub-100nm range was achieved by using electron beam lithography and high resolution Hydrogen Silsesquioxan (HSQ) negative resist as the mask material. HSQ is also employed to planarize and physically isolate the devices. A novel non-alloyed ohmic contact based on a very thin low-temperature-grown GaAs (LT-GaAs) top layer is used for contacting the nanostructures.

HL 50.81 Thu 16:30 P3

Synthesis and characterization of CdS nanowires — •Jens Böttcher, Marko Burghard, and Klaus Kern — Max-Planck-Institut für Festkörperforschung, Stuttgart

Cadmium sulphide (CdS) nanowires with an average diameter of 30 nm and lenghts of up to 10 μm have been synthesized via a novel solvothermal method that uses a single-source precursor and ethylenediamine as coordinating solvent. Investigations by X-ray powder diffraction (XRD), scanning electron microscopy (SEM), transmission microscopy (HRTEM), thermal gravimetric analysis (TGA), and photoluminescence (PL) studies indicate that the described synthesis approach yields pure, structurally uniform, and single crystalline nanowires. Furthermore, spatially resolved photoconductivity measurements were used to determine the mechanism of photocarrier transport in individual CdS nanowires.

HL 50.82 Thu 16:30 P3

Optical properties and structure of CdP4 nanoclusters in zeolite Na-X and fabricated by laser ablation — •Oleg Yeshchenko — Physics Department, National Taras Shevchenko Kyiv University, 2 Akademik Glushkov prosp., 03022 Kyiv, Ukraine

CdP4 nanoclusters were fabricated by incorporation into the pores of zeolite Na-X and by deposition of the clusters onto a quartz substrate using laser ablation-evaporation technique. Absorption and photoluminescence (PL) spectra of CdP4 nanoclusters in zeolite were measured at the temperatures of 4.2, 77 and 293 K. Both absorption and PL spectra consist of two blue shifted bands. We performed DFT calculations to determine the most stable clusters configuration in the size region up to size of the zeolite Na-X supercage. The bands observed in absorption and PL spectra were attributed to emission of (CdP4)3 and (CdP4)4 clusters with binding energies of 3.78 eV and 4.37 eV per atom respectively. The Raman spectrum of CdP4 clusters in zeolite proved the fact of creation of (CdP4)3 and (CdP4)4 clusters in zeolite pores. The PL spectrum of CdP4 clusters produced by laser ablation consists of single band that was attributed to emission of (CdP4)4 cluster.

HL 50.83 Thu 16:30 P3

Excitons and band behavior in ultrasmall nanoclusters. — •Anton Grygoriev and Vladimir Litovchenko — V. Lashkarev Institute of Semiconductor Physics NASU 45 Prospect Nauki, Kyiv 03028, Ukraine

We present experimental and theoretically investigation of nanosized effects: transformation of the energetic structure of quantum dots in oxide matrix. Calculations were performed taking into account the electron-hole Coulomb interactions, expanded interface area, leakage of electronic density from quantum dot, increasing the effective mass and experimental values of barrier high. The interactions of electrons and holes are strongly enhanced in ultrasmall *quasiopen* quantum dots because of decreasing effective permittivity, which lead to very stable exciton (at T room). Dependences of exciton binding energy, work function (electron affinity), effective mass and energy of optical transfers from quantum dot diameter have been obtained. The achieved results demonstrate notably difference to the parameters achieved from well-established idealized case (sharp and infinite barriers) to the ultrasmall (˜1-3 nm) dots. Comparison cluster calculations with revised effective mass approximation prove correctness developed approach up to 1 nm. Using of renewed by us effective media approximation allows us to predict some principal new physical effects, such as negative electron affinity (electrons localization outside the dot), which can be useful for electron photo and field emission applications

HL 50.84 Thu 16:30 P3

Coherence time of single photons from laterally coupled InGaAs/GaAs quantum dot molecules — •Serkan Ates[1], Sven M. Ulrich[1], Mohamed Benyoucef[2], Armando Rastelli[2], Lijuan Wang[2], Oliver G. Schmidt[2], and Peter Michler[1] — [1]5. Physikalisches Institut,Universität Stuttgart, Pfaffenwaldring 57 D - 70550 Stuttgart — [2]Max-Planck-Institut für Festkörperforschung Heisenbergstr. D-70569 Stuttgart

In this work, we report detailed investigations on the coherence length of single photons from laterally coupled InGaAs/GaAs quantum dots. The lateral coupled QDs were grown on GaAs substrates by a unique combination of molecular beam epitaxy and in-situ layer precise etching [1]. The samples were cooled to 4 K and optically pumped by a continuous-wave Ti:sapphire laser at a pump wavelength of 800 nm. Our measurements were performed using a Michelson interferometer combined with a micro-photoluminescence (μ-PL) setup and a Hanbury Brown and Twiss setup. The visibility of the interferometer setup was over 90 % with the Ti:sapphire laser. We have observed excitonic and biexcitonic transitions and the visibility curve of the transitions showed a Gaussian behavior. We get the coherence length of transitions in the range of 30 - 40 ps, corresponding to a linewidth of approx. 40 μeV by using the Gaussian fitting. These results indicate that decoherence processes are present even at low temperatures. [1] R. Songmuang, S. Kiravittaya, and O. G. Schmidt, APL 82,2892 (2003)

HL 50.85 Thu 16:30 P3

Theory of Optical Dephasing in Semiconductor Quantum Dots — •Carsten Weber, Matthias Hirtschulz, and Andreas Knorr — Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

Within a density matrix approach, the nonlinear quantum kinetic dynamics of semiconductor quantum dots is investigated. We consider different dephasing mechanisms, e.g. electron-phonon interaction and the interaction with the underlying wetting layer, in order to describe in a realistic manner the damping mechanisms. Non-Markovian dynamics as well as scattering processes lead to a damping of the Rabi oscillations, which can be compared to single-quantum dot experiments.

HL 50.86 Thu 16:30 P3

The role of non-equilibrium phonons for the optically induced dynamics in quantum dots — •Annette Krügel, Vollrath Martin Axt, and Tilmann Kuhn — Institut für Festkörpertheorie, Westfälische Wilhelms-Universität, 48149 Münster, Deutschland

For GaAs type quantum dots it has been shown that pure dephasing due to the coupling to longitudinal acoustic (LA) phonons gives a major contribution to the initial dephasing on picosecond time scales. For high density excitation also the phonon system is driven out of its equilibrium state and coherent phonon amplitudes and non-equilibrium phonon coherences and occupations act back on the carrier system. We study the exciton dynamics in a quantum dot coupled to LA-phonons. The carriers are excited by Gaussian laser pulses of arbitrary duration. For the electron-phonon interaction we concentrate on pure dephasing processes described by the independent boson model. Numerical results are obtained by using a correlation expansion within the density matrix formalism. We account for all single and double assisted density matrices as well as for the coherent phonon amplitudes and non-equilibrium phonon occupations and correlations. A pronounced influence of these non-equilibrium phonons on the carrier dynamics is observed. We find that especially for low temperatures and longer pulses of several picoseconds non-equilibrium phonons play an important role and cannot be neglected.

HL 50.87 Thu 16:30 P3

Multiphonon Raman scattering of spherical PbSe quantum dots — •J. T. Devreese[1,2], S. N. Klimin[1,3], V. M. Fomin[1,2,3], and F. W. Wise[4] — [1]TFVS, Universiteit Antwerpen, B-2610 Antwerpen, Belgium — [2]Department of Semiconductor Physics, TU Eindhoven, NL-5600 MB Eindhoven, The Netherlands — [3]State University of Moldova, Kishinev, Republic of Moldova — [4]Department of Applied Physics, Cornell University, Ithaca, New York 14853, USA

Multi-phonon resonant Raman scattering in spherical PbSe quantum dots is investigated using a non-adiabatic approach. The optical phonons in quantum dots are treated within the multimode dielectric continuum model, taking into account both the electrostatic and mechanical boundary conditions for the relative ionic displacement. The exciton-phonon interaction is considered for all phonon modes specific for these quantum dots. Our multimode dielectric continuum model, which includes, as a substantial ingredient, the realistic dispersion of optical phonons, adequately describes the optical-phonon spectra of spherical PbSe quantum dots. The non-adiabaticity leads to a substantial enhancement of the relative intensities of multi-phonon peaks with respect to the intensity of the one-phonon peak. The peak positions and intensities of the calculated Raman scattering spectra for spherical PbSe quantum dots are in good agreement with recent experimental results on the Raman scattering in oleic-acid-capped colloidal PbSe nanocrystals.

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HL 50.88 Thu 16:30 P3

Single electron quantum dot in a spatially periodic magnetic field — •Daniel Buchholz[1] and Peter Schmelcher[1,2] — [1]Theoretische Chemie, Institut für Physikalische Chemie, Universität Heidelberg, Im Neuenheimer Feld 229, 69120 Heidelberg, Germany — [2]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg, Germany

A general overview of the electronic properties of a harmonically confined single electron quantum dot inside a spatially periodic magnetic field is presented. The energy spectrum, magnetization, probability density and current density are calculated for varying parameters (i.e. amplitude, wavelength and phase) of the periodic magnetic field. For wavelengths comparable to the oscillator length of the dot, we observe a rich spectral behavior. Avoided and exact level crossings dominate the spectrum and ground state degeneracies occur for particular values of the field. The probability and current densities are very sensitive with respect to the phase of the magnetic field. Differently to the dot inside a homogeneous magnetic field, the magnetization, as a function of the field amplitude, has a minimum, depending on the phase and wavelength of the field. For wavelengths being small compared to the oscillator length, the impact of the field on the lowest eigenenergies is almost zero, thus the obtained spectrum is approximately that of a pure harmonic oscillator. The eigenfunctions take up a spatial dependent phase yielding a non-vanishing probability current.

HL 50.89 Thu 16:30 P3

Single photon emission from CdSe/ZnSe quantum dots — •Christian Peitzmeyer, Steffen Michaelis deVasconcellos, Patrick Ester, Christof Arens, Dirk Mügge, Artur Zrenner, Detlef Schikora, and Klaus Lischka — Universität Paderborn, Department Physik, Warburger Strasse 100, D-33095 Paderborn

We have studied the correlation of the photon emission from a single selfassembled CdSe/ZnSe Stranski-Krastanow quantum dot under cw excitation from a blue-emitting laser diode. The quantum dot surface density was 10^{10} to 10^{11} cm^{-2}. Spectra were taken on mesa structures at T = 4.2K, which contain only a small number of dots. The emission of the CdSe dots was measured by a micro-photoluminescence setup, using a LN_2-cooled CCD camera. In the single dot emission antibunching is observed. Therefore a single CdSe dot can be used for the generation of single photons on demand. Stranski-Krastanow-grown quantum dots as used within this work have advantages in comparison to other emitters in the green spectral range, because photobleaching, blinking and spectral diffusion do not occur.

HL 50.90 Thu 16:30 P3

Energy transfer processes in ensembles of CdSe quantum dots of different sizes — •M. Rohe[1], M. Grau[1], P.J. Klar[1], W. Heimbrodt[1], M. Yosef[2], and S. Schlecht[2] — [1]Dept. Physics and WZMW, Philipps-University of Marburg, Germany — [2]Institute of Chemistry and Biochemistry, FU Berlin, Germany

Bimodal random ensembles of CdSe quantum dots containing two distinct sizes (e.g. 3 nm and 9 nm) and mixed different ratios were studied by cw and time-resolved photoluminescence (PL) techniques. Due to different quantum confinement situations in the two subsystems of dots, the corresponding PL spectra show two spectrally resolved bands of which the high-energy band corresponds to the 3 nm dots whereas the low-energy band corresponds to the 9 nm dots. A coupling between the two subsystems of dots is revealed by time-resolved PL where the decay time of the 9 nm dots is significantly increased in the presence of 3 nm dots compared to an ensemble of solely 9 nm dots. This demonstrates that, in addition to energy transfer processes within each of the two subsystems, an energy transfer takes place from the 3 nm dots to the 9 nm dots. We study these energy transfer processes in dependence on the mixing ratios.

HL 50.91 Thu 16:30 P3

Influence of an in-plane electric field on the photoluminescence of single InGaAs/GaAs quantum dots — •Moritz Vogel[1], Sven M. Ulrich[1], Lijuan Wang[2], Armando Rastelli[2], Oliver G. Schmidt[2], and Peter Michler[1] — [1]Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, 70569 Stuttgart, Germany

We present a systematic investigation of the quantum confined Stark effect in (In,Ga)As/GaAs quantum dots. For this purpose lateral static electric fields have been applied via lithographically defined Schottky contact structures on top of our low-density sample structures. The quantum dots were cooled to 4 K and optically pumped using a cw or a mode-locked Ti:Sapphire laser with a repetition rate of 76 MHz and a pulse width of 2 ps tuned to 800 nm. We adopt the technique of scanning Fabry-Perot interferometry to perform high-resolution spectroscopy on the biexcitonic (XX) and excitonic (X) radiative transitions. From studies on numerous quantum dots we typically observe narrow emission lines with a full width at half maximum as low as 13 *eV which is significantly below the resolution limit provided by conventional single-stage spectrometers. Within a small bias range a strong nonlinear dependence of the emission energy due to the quantum-confined Stark effect has been observed which allows for a stable and reversible control of the emission energy. In conjuction with field-dependent measurements, the polarization properties of the emission will also be discussed.

HL 50.92 Thu 16:30 P3

Observation of Multi-exciton Transitions in Individual Quantum Dot Molecules — •Emily Clark[1], Hubert J. Krenner[1], Toshihira Nakaoka[1,2], Matthias Sabathil[1], Max Bichler[1], Yasuhiko Arakawa[2], Gerhard Abstreiter[1], and Jonathan J. Finley[1] — [1]Walter Schottky Institut and Physik Department, Technische Universität München, Germany — [2]University of Tokyo, 4-6-1, Komaba, Meguro-ku, Tokyo, 153-8505, Japan

We present investigations of single, charged and multi-exciton states in individual quantum dot molecules (QDMs). The samples investigated

consist of pairs of self assembled, vertically stacked InGaAs-GaAs QDs embedded in an n-type Schottky photodiode. This device geometry enables us to control the coupling between excitonic states in the upper and lower dots via the electric field. Previously, we demonstrated an anticrossing of spatially direct (e,h in the same dot) and indirect (e,h in different dots) excitons with an average coupling energy of 2E=1.6±0.3meV. By comparing these findings with realistic calculations of the single exciton spectrum, we confirm that the observed anticrossing is due to hybridization of the electron component of the exciton wavefunction. New emission peaks emerge at higher excitation levels, the intensity of which increases quadratically on the excitation intensity, identifying them as biexcitons in the QDM. Both spatially direct (two excitons in upper dot) and separated (single exciton in upper and lower dot) biexcitons are identified. Comparison between quasi resonant and non-resonant excitation, separates between charged and neutral excitons.

HL 50.93 Thu 16:30 P3

Lateral and vertical electric field applied to Self-Assembled QDs — •V. Stavarache[1], D. Reuter[1], A. D. Wieck[1], R. Oulton[2], and M. Bayer[2] — [1]Lehrsthul für Angewandte Festkörperphysik, Ruhr Universität Bochum, Universitätstrasse 150, D-44780, Bochum — [2]Experimentele Physik II, Otto-Hann Strasse 4, D-44221 Dortmund

The effect of an in-plane (lateral) and a vertical electric field on self-assembled InAs -quantum dots (QDs) by photoluminescence (PL) and time-resolved spectroscopy will be presented. For this purpose, we have fabricated a double p-i-n device with application of an electric field in the lateral and vertical directions. Combining techniques such as, electron beam lithography (EBL), focus ion beam implantation (FIB), and standard optical lithography we are able to define small p-i-n structures, which allow us the realization of fields higher than $\sim 10^5 V m^{-1}$. By applying an external electric field, a redshift of the wavelength emission is expected due to the Stark effect, as well as an increase in the radiative lifetime of the exciton accompanied by a decrease in the PL intensity.

HL 50.94 Thu 16:30 P3

Highly resonant Raman spectroscopy of InAs quantum dots — •Tim Köppen, Thomas Brocke, Tobias Kipp, Andreas Schramm, Christian Heyn, and Detlef Heitmann — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung der Universität Hamburg, Jungiusstraße 11, 20355 Hamburg, Germany

We investigate the electronic properties of InAs quantum dots grown with Indium flush technique [1] using resonant inelastic light scattering. These quantum dots allow for highly resonant excitation with near-infrared laser light near the E_0 gap. Photoluminescence measurements show this gap to be at approximately 1.2 eV. In previous Raman experiments on InAs quantum dots grown without flush technique we used the $E_0 + \Delta$ gap ($\sim$1.65 eV) for resonant excitation [2]. With technical improvements and the stronger resonance we get an increase in the electronic Raman signal of a factor of $\sim$250. We now observe signatures of single quantum dots in our spectra.

This project is supported by the Deutsche Forschungsgemeinschaft via SFB 508 "Quantenmaterialien".

[1] S. Fafard et al., *Phys. Rev. B* **59**, 15368
[2] T. Brocke et al., *Phys. Rev. Lett.* **91**, 257401

HL 50.95 Thu 16:30 P3

Engineering the multi-exciton spectra in wurtzite InN/GaN quantum dots — •Norman Baer, Stefan Schulz, Stefan Schumacher, Paul Gartner, Gerd Czycholl, and Frank Jahnke — Institute for Theoretical Physics, University of Bremen

The emission spectra of nitride based quantum dots (QDs) differ dramatically from those known from other III-V material systems. We use an atomistic description of the single-particle properties in InN/GaN QDs and combine them with a microscopic calculation of the Coulomb interaction effects. Details of a tight-binding (TB) study that fully incorporates the underlying wurtzite lattice structure and the induced electrostatic fields are presented. In the TB-model we use a sp^3 basis set and calculate the internal fields via the solution of the Poisson equation. From the resulting TB-wave functions Coulomb- and dipole matrix elements are evaluated and enter the Full Configuration Interaction calculations. The effects of Coulomb correlations on the optical properties of the nitride system are investigated. In particular we study in detail the influence of the QD geometry and the effect of the strong built-in fields on the emission spectra. The dependency of the ground state symmetry as a function of the QD size and the resulting changes in the optical spectra are discussed, which allow to tailor the emission spectra.

HL 50.96 Thu 16:30 P3

Size dependence of quantum confinement effects in HgTe nanocrystals determined by spectroscopic ellipsometry — •Veronika Rinnerbauer[1], Maksym Kovalenko[2], Ventsislav Lavchiev[1], Wolfgang Heiss[2], and Kurt Hingerl[1] — [1]Christian Doppler Labor für oberflächenoptische Methoden, Universität Linz, 4040 Linz, Austria — [2]Institut für Halbleiter- und Festkörperphysik, Universität Linz, 4040 Linz, Austria

We have explored the optical properties of HgTe nanocrystals which were prepared from a colloidal solution. These nanocrystals show strong luminescence in the near infrared (λ=1550 nm), which makes them an interesting material for the telecommunication area. The emission wavelength can efficiently be tuned by controlling the size of the nanocrystals.

We report spectroscopic ellipsometry measurements, which show clearly an energy shift of the critical points in the dielectric function of these HgTe nanocrystals when compared to the HgTe bulk properties. This shift δ of the E1 and E1+ Δ1 transitions to higher energies is caused by the quantization effect due to the small size of the crystals. The exact peak energies of the transitions were fitted with line-shape models for critical points (CP). We observe not only a shift of the oscillator energies, but also the inhomogeneous broadening of the peaks due to the size distribution of the nanocrystals. The size dependence of the energy shift was studied for samples with nanocrystals of different sizes (3-10 nm). It can be seen that the energy of the CPs shifts from near bulk level for the biggest nanocrystals to higher energies with decreasing size.

HL 50.97 Thu 16:30 P3

Lateral Features of Cu(InGa)Se_2-Heterodiodes by Submicron Resolved Simultaneous Luminescence and Light Beam Induced Currents — •Levent Gütay, Tim Jürgens, and Gottfried Heinrich Bauer — Institute of Physics, Carl von Ossietzky University Oldenburg, F.R.G.

Polycrystalline Cu(InGa)Se_2-absorbers and hetero-diodes show lateral variations in optoelectronic magnitudes like luminescence yield (pl) and short circuit current density (j_{sc}) in the few micrometer range (3-8 μm) whereas structural features such as grain sizes lie in the 1μm-scale or even below. From the dependence of pl-yield and j_{sc} on temperature of regimes with high and with low signals we estimate activation energies for non-radiative optical transitions and for minority transport and relate these numbers to potential fluctuations for which we got evidence from the dependence of spectrally resolved pl versus exitation level. Variations of the lateral extension of j_{sc}-patterns will be discussed in terms of the influence of a circuitry model of non illuminated diodes in the neighborhood of an illuminated junction.

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Computer modelling of gettering under conditions of rapid thermal processing — •Carsten Rudolf[1], Michael Seibt[1], and Vitaly Kveder[2] — [1]IV. Physikalisches Institut der Universität Göttingen, Friedrich-Hund-Platz 1, D-37077 Goettingen — [2]Institute of Solid State Physics RAS, Chernogolovka, 142432 Moscow reg., Russia

We modelled phosphorous-diffusion-gettering of iron in monocrystalline p-Si under the conditions of a 2-step rapid thermal processing by using our gettering simulator software tool. The applied thermal treatment consists of a preceding step at 1100°C and a subsequent step at 800°C. The step at higher temperature enables dissolution of precipitates whereas the actual gettering takes place during the step at lower temperature.

Results of two sets of simulations are presented: 1) time at 800°C is varied while the time at 1100°C is kept constant. 2) times at both temperatures are varied in such a way that a constant sheet resistance is yielded.

Gettering after dissolution step of appropriate duration reduces the total amount of metal in the bulk of the wafer significantly compared to gettering without prior dissolution step. For RTP at constant sheet resistance gettering is limited by incomplete dissolution of precipitates for too short times at 1100°C and by incomplete outdiffusion of the mobile Fe species for too short times at 800°C.

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Study of bulk defects in $CuIn_{1-x}Ga_xSe_2$ based solar cells — •Verena Mertens[1], Jürgen Parisi[1], Robert Kniese[2], Marc Köntges[3], and Rolf Reineke-Koch[3] — [1]University of Oldenburg , Institute of Physics, Energy and Semiconductor Research Laboratory, 26111 Oldenburg — [2]Center for Solar Energy and Hydrogen Research (ZSW), Heßbrühlstr. 21c, 70565 Stuttgart — [3]Institut für Solarenergieforschung Hameln/Emmerthal (ISFH), Am Ohrberg 1, 31860 Emmerthal

$CuIn_{1-x}Ga_xSe_2$ based solar cells with different molar gallium to gallium plus indium ratio (GGI) are investigated concerning the bulk defects of the absorber material using admittance spectroscopy (AS) and deep level transient spectroscopy (DLTS). The study aims to clarify why in devices with GGI larger than 0.3 the open circuit voltage does not increase linearly with the band gap of the material as it does in those with gallium poor absorber layers. We find that in samples with mixed absorber composition, i.e. those containing both indium and gallium, the same bulk defects are detected. The devices with $CuInSe_2$ and $CuGaSe_2$ absorbers show some additional trap signals. As no principle difference in defect spectra of gallium poor and gallium rich samples is found, we conclude that the bulk defects of the absorber material do not play an important role concerning the "open circuit voltage problem" of the gallium rich devices.

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Lattice parameters of CuAu- and chalcopyrite-phase of epitaxial CuInS2 on silicon substrates — •Janko Cieslak[1], Thomas Hahn[1], Jürgen Kräusslich[2], Heiner Metzner[1], Jens Eberhardt[1], Mario Gossla[1], Udo Reislöhner[1], and Wolfgang Witthuhn[1] — [1]Institut für Festkörperphysik, Friedrich Schiller Universität Jena, Max-Wien-Platz 1, 07743 Jena — [2]Institut für Optik und Quantenelektronik, Friedrich Schiller Universität Jena, Max-Wien-Platz 1, 07743 Jena

Epitaxial thin films of CuInS2 (CIS) were grown on Si(111) and Si(100) substrates using molecular beam epitaxy from elemental sources. Their lattice parameters were measured by means of x-ray diffraction at the European Synchrotron Radiation Facility in Grenoble in reflection as well as transmission geometry, respectively. The epitaxial films show a coexistence of the CuAu- and the chalcopyrite-phase with different lattice constants and tetragonal distortions. The volume fractions of both phases were determined. The lattice parameters for both substrate orientations are compared with values of single crystals and discrepancies and their implications for CIS thin film growth are discussed.

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Hillock formation in epitaxial Cu(In,Ga)S2 thin films — •Thomas Hahn, Janko Cieslak, Jens Eberhardt, Mario Gossla, Heinrich Metzner, Udo Reislöhner, Kristian Schulz, and Wolfgang Witthuhn — Friedrich-Schiller-Universität Jena, Institut für Festkörperphysik, Max-Wien-Platz 1, 07743 Jena, Germany

Epitaxial thin films of the ternary chalcopyrite semiconductor Cu(In,Ga)S2 are grown epitaxially on Si substrates by molecular beam epitaxy from elemental sources. The samples are analyzed according to their morphological and structural properties utilizing electron diffraction, Rutherford backscattering spectroscopy, and atomic force microscopy. A strong tendency for the formation of hillocks, achieving heights of nearly a magnitude larger as compared to the underlying film thickness, is observed. The influences of deposition parameters and metastabilities during film growth on the occurence of these hillocks are investigated. The possibility of hillock formation being due to internal stresses during film growth is discussed.

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2. A comparative photoluminescence study on CuInS2 absorber layers for solar cell applications from a rapid thermal process and from RF reactive sputtering — •Tobias Enzenhofer, Thomas Unold, Klaus Ellmer, and Hans-Werner Schock — Hahn-Meitner-Institut, Glienicker Strasse 100, 14109 Berlin

This contribution reports detailed temperature and intensity dependent photoluminescence measurements on CuInS2 thin films deposited by RF reactive sputtering and from a rapid thermal process and relates several commonalities and differences in the defect structure of the films prepared by the two different techniques. First, we compare the various luminescence transitions in absorber layers from reactive sputtering and from a rapid thermal process. Second, we propose a model concerning the role of the deep level luminescence emission which occurs in the high temperature region in both types of absorber layers at about 1.15eV but vanishes for sputtered Cu-rich absorbers at about T<140K. Third, we correlate the properties and quality of photovoltaic devices with the investigation of the deep level in CuInS2 thin films.

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SILAR conditioning of TiO_2 / In(OH)_xS_y / PbS(O) structures — •Ilona Oja[1], Sergej Gavrilov[2], Bianca Lim[3], Abdelhak Belaidi[3], Larissa Dloczik[3], Martha Ch. Lux-Steiner[3], and Thomas Dittrich[3] — [1]Tallinn University of Technology, Department of Materials Science, Ehitajate tee 5, Tallinn 19086, Estonia — [2]Moscow Institute of Electron Technology, 124498 Moscow, Russia — [3]Hahn-Meitner-Institute, Glienicker Str. 100, D-14109 Berlin, Germany

In(OH)_xS_y and PbS(O) films and ultra-thin inter-layers were deposited by SILAR (successive ion layer adsorption reaction, this is a wet chemical deposition technique in aqueous solution) and TiO_2 / In(OH)_xS_y / PbS(O) / PEDOT:PSS solar cell structures were prepared to investigate photoelectrical properties of the layers. Investigations were carried out by spectral surface photovoltage in the Kelvin-probe and capacitor arrangements, current-voltage and quantum efficiency analysis. The band gap of In(OH)_xS_y was tuned between 2.6 and 1.9 eV by changing the annealing temperature of In(OH)_xS_y in air between 50 and 350°C. The open circuit voltage of the solar cell structures correlated well with the band gap and the work function of the In(OH)_xS_y. Surprisingly, excess charge carriers generated in the PbS(O) layer do not contribute significantly to the short circuit current. The interface between the In(OH)_xS_y and the PbS(O) layers has been modified by introducing ultra-thin layers which are important for high open circuit potentials.

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III-V materials for multi-junction solar cells on the lattice constant of InP — •Ulf Seidel, H.-J. Schimper, U. Bloeck, K. Schwarzburg, F. Willig, and T. Hannappel — Hahn-Meitner-Institut, Glienicker Str. 100, 14109 Berlin

At present, the world record solar cell is a monolithic triple junction cell epitaxially grown on the lattice constant of GaAs or rather Ge. Considering the thermodynamic limit of the theoretical efficiencies of multijunction cells with more than two band gaps there is a need of an appropriate material with a band gap in the range of 1eV.
For that, different III-V compound semiconductors were tested for application in multi-junction solar cells based on the lattice constant of InP, in particular InGaAs, GaAsSb (E_{gap} = 0.75eV) and InGaAsP, InAlGaAs (E_{gap} around 1.0eV). Solar cells consisting of these materials were grown via metalorganic vapor phase epitaxy (MOVPE) using the alternative precursors TBAs, TBP and TESb. An InP n/p cell was prepared as a reference and showed that highest internal quantum efficiencies were achieved using these nongaseous less toxic precursors. Single n/p cells with different absorber materials and nearly the same band gaps (0.75eV and 1.0eV) were compared to each other concerning short-circuit current, open-circuit voltage, FF, and quantum efficiency. Accordingly, a monolithic tandem solar cell was designed employing these sub cells for its application in a four or five junction cell as the low band gap part. Our tandem cell consists of an InGaAs bottom cell (Egap = 0.75eV) and an around 1eV InGaAsP sub cell. Connecting these two sub cells a new tunnel junction was produced including n-InGaAs and p-GaAsSb.

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The Prospects of Development of Photoelectric Convertors by Using Solar Energy in Georgia — •Ia Trapaidze, Rafiel Chikovani, Tengiz Mkheidze, and Gela Goderdzishvili — Georgian Technical University, Dep. of Physics,Tbilisi, Georgia

Georgia together with use of traditional energy resources attaches a very large importance of using renewable energy sources. The location of Georgia, the annual duration of solar radiation in the majority of areas ranges from 250 to 280 days, approximately 1900-2200 hours in a year. The prospects of development of solar photoenergetic devices in Georgia are analyzed. It is noted that the photoelectric method of conversion of the solar energy based on semiconductor materials is especially promising. It would be expedient to realize the production and application of solar photoelectric convertors in Georgia by stages in the scope of a complex research, technical and industrial program for 10-12 years. We have ve studied photoelectric converters on the base silicon, also GaAlAs. After research we observed that convertor obtained on the base of semi-

conductive compound of GaAlAs is more effective (2-2.5 times), than converter with silicon.

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Memory effects in MOS-structures containing nanoclusters — •M. Allardt[1], R. Pietzsch[1], J. Bollmann[1], J. Weber[1], and V. Beyer[2] — [1]Technische Universität Dresden, 01062 Dresden, Germany — [2]Forschungszentrum Rossendorf, 01314 Dresden, Germany

Memory devices based on embedded silicon nanoclusters are prepared by implantation of Si ions into SiO_2 and subsequent annealing [K. H. Heinig, T. Müller, B. Schmidt, M. Strobel, and W. Möller, Appl. Phys. A 77, 17 (2003)]. The charge retention of the metal-oxide-semiconductor (MOS) structures is investigated by capacitance–voltage (CV) measurements. The devices exhibit almost ideal MOS-CV-behavior indicating a low density of interface states. Positive and negative charges can be stored depending on the applied voltage. The programming voltages generate a memory window which seems to be suitable for future device applications. We compare these results to electrical properties of alternative SONOS-memory devices.

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Calculation of the direct tunneling current in a Metal-Oxide-Semiconductor structure with one-side open boundary — •Ebrahim Nadimi — Technische Universität Chemnitz, Fakultät für Elektrotechnik und Informationstechnik, Reichenhainer Straße 70, D-09126 Chemnitz, Deutschland

The leakage current through the oxide of an n-channel Metal-Oxide-Semiconductor (MOS) structure with one-side-open boundary is numerically computed by applying an one-dimensional Schrödinger-Poisson self-consistent solver. By embedding the n-channel MOS in a well, which prevents the penetration of particles into the metallic gate, the potential profile, the bounded energy levels and spatial distributions of electrons in the quantized levels are calculated in the inversion regime. Penetration of electrons into the metallic gate with open boundary results in a broadening of the discrete bound states at the interface of the substrate with the oxide, transforming the bounded energy levels to the quasi- bound states. Starting from the continuity equation, a qualitative formula for the current in terms of the electrons* lifetime in the quasi-bound states is derived. Based on the determination of the energy level width by means of wave functions, we suggest a method to compute the lifetime, and subsequently, the tunnelling current across the potential barrier. The tunnelling current is computed for a MOS structure with Silicon oxide and Silicon nitride gate oxides. The computation results are compared against results obtained experimentally for similar structures, yielding an excellent agreement.

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Realization of logic circuits with in-plane gate transistors written using focused-ion-beam implantation — •M. Draghici, D. Reuter, and A. D. Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätsstr. 150, 44780 Bochum

In-plane gate (IPG) transistors realized by writing insulating lines with focused ion beam (FIB) implantation technique [1] are promising devices for logic devices due to the fact that this technique requires no alignment between gate, source and drain. Considering this aspect, the fabrication of IPG transistors is a very reliable single step process. The drawback of this method consists in impossibility to realize complementary device structures on the same sample because only one carrier type is available depending on the heterostructure doping. In order to overcome this problem, we use FIB implantation doping to fabricate n- and p-type channel IPG transistors by implantation of Si and Be, respectively [2].

We present here the realization of logic devices based on IPG transistors realized by insulating lines (negative writing) or overcompensation doping by FIB implantation (positive writing). Different geometries and implantation doses will be studied and analyzed especially for the circuits realized by positive writing.

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Optical response of Ag-induced reconstructions on vicinal Si(111) — •Sandhya Chandola[1], J Jacob[1], K Fleischer[1], P Vogt[2], W Richter[2], and J McGilp[1] — [1]Physics Department, University of Dublin, Trinity College, Dublin 2, Ireland — [2]Technische Universität Berlin, Institut für Festkörperphysik, Sekr. PN 6-1, Hardenbergstr. 36, D-10623 Berlin, Germany

The optical response of the Si(111)-3x1-Ag surface has been studied for the first time with reflectance anisotropy spectroscopy (RAS). A single domain surface was obtained by depositing < 1 ML of Ag onto a vicinal Si(111) substrate at 870 K. A significant optical anisotropy develops around 2.2 eV which is related to the formation of the 3x1 structure. This surface was then used as a template to grow one-dimensional (1D) arrays of Ag nanodots, and also 3D Ag islands, by depositing 0.5 ML, and higher, coverages of Ag at room temperature. RAS of these structures showed a different response in the 2.2 eV region, with a broadened and reduced anisotropy. By extending the RA spectra into the infra-red region (0.5-1.5 eV), substantial differences between the structures were observed below 1 eV, which may be linked to a difference in the metallic character of the nanodots and islands.