HL 27: II-VI semiconductors

Time: Wednesday 14:15–17:30 Location: H13

HL 27.1 Wed 14:15 H13

Neue ungewöhnliche Diffusionsprofile in II-VI Halbleitern — •Jörg Kronenberg[1], Frank Wagner[1], Herbert Wolf[1], Thomas Wichert[1] und ISOLDE Collaboration[2] — [1]Technische Physik, Universität des Saarlandes, 66041 Saarbrücken — [2]CERN, CH-1211 Genf 23, Schweiz

Nach Implantation von ^{111}Ag und ^{67}Cu in die Halbleiter CdTe und CdZnTe und Diffusion unter Cd-Druck werden symmetrische Profilformen beobachtet, die in der Mitte des Kristalls eine hohe und in den bis 250 μm tiefen Randzonen eine niedrige Ag bzw. Cu Konzentration zeigen [1]. Diese unterscheiden sich von gewöhnlichen Diffusionsprofilen, die sich in einer monotonen Abnahme des Konzentrationsprofils äußern. In den hier vorgestellten Experimenten wurde untersucht, ob ähnliche Diffusionsprofile auch mit anderen Dotieratomen in II-VI Halbleitern beobachtet werden können. Hierfür wurden in CdTe, CdZnTe und CdS ^{24}Na, ^{43}K, ^{56}Mn, ^{65}Ni und ^{59}Fe mit einer Energie von 60 keV in 500 μm bis 800 μm dicke CdTe, CdS oder CdZnTe Einkristalle implantiert und diese zwischen 750 K und 900 K getempert. Ähnliche Effekte wie für Ag oder Cu in CdTe konnten für ^{24}Na in CdTe und CdS sowie für ^{65}Ni in CdZnTe beobachtet werden. Für ^{43}K, ^{56}Mn und ^{59}Fe dagegen konnten in keinem der drei untersuchten Materialien solche Profile gefunden werden.

Gefördert durch das BMBF, Projekte 05KK1TSB/7 und CZE 3/002.

[1] H.Wolf *et al.*, Phys. Rev. Lett. 94 (2005) 125901.

HL 27.2 Wed 14:30 H13

Characterization of $Mg_xZn_{1-x}O$-layers grown by plasma assisted molecular beam epitaxy — •Thomas Andreas Wassner, Bernhard Laumer, Stefan Maier, Martin Stutzmann, and Martin Eickhoff — Walter Schottky Institut, Technische Universität München, Am Coulombwall 3, 85748 Garching, Germany

$Mg_xZn_{1-x}O$ layers have been grown epitaxially on (0001)- and (11-20)-sapphire by plasma assisted molecular beam epitaxy. Structural analysis was carried out by high resolution X-ray diffraction to extract the lattice parameters as well as the density of edge- and screw dislocations as a function of the Mg content. The impact of Mg incorporation on the optical properties was investigated by temperature-dependent photoluminescence spectroscopy and photothermal deflection spectroscopy. The corresponding electronic properties were investigated by Hall measurements. Furthermore, the influence of the growth parameters (e.g. the substrate temperature) on the resulting Mg content in the layers will be addressed.

HL 27.3 Wed 14:45 H13

Conductivity measurements on ZnO/YBaCuO — •Nilotpal Ghosh[1], Heidemarie Schmidt[1], Qingyu Xu[1], Lars Hartmann[1], Holger Hochmuth[1], Michael Lorenz[1], Gerald Wagner[2], and Marius Grundmann[1] — [1]Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik II, Linnéstr. 5, 04103 Leipzig, Germany — [2]Institut für Mineralogie, Kristallographie und Materialwissenschaft, Linnéstr. 5,04103 Leipzig, Germany

200 nm magnetic ZnO films were grown on $Y_1B_2Cu_3O_7$(YBCO) films on sapphire by pulsed laser deposition for future Andreev Reflection (AR) study and to compare with previous spin polarization results [1]. Initial critical current density of 6×10^6 A/cm^2 of YBCO at 77K [2] slightly reduced after growth of granular ZnO film and critical temperature was above 77K. Four-point transport measurements across ZnO/YBCO junction (area $\gg 1$ mm^2) resulted in nonlinear I-V characteristics in 5-150 K. Noisy conductivity fluctuations noticed at lower T at 0 bias were probably due to large junction area lying in Maxwell range (where $d \gg l$, d = contact radius, l = mean free path). Fitting of conductivity data after Blonder-Tinkham-Klapwijk theory showed that superconducting gap (Δ) of YBCO and interface dependent ZnO/YBCO barrier strength (Z) amount to $\Delta \leq 20.4$ (± 1) meV and $Z \geq 0.74$ (± 0.23) respectively. Smaller junction area AR measurements and Point contact AR measurements are underway. [1] L. Hartmann,etal, J. Phys. D.: Appl. Phys. 39(2006)1. [2] M.Lorenz, etal,IEEE Transactions on Applied Superconductivity 11 (2001) 3209.

HL 27.4 Wed 15:00 H13

II-VI based magnetic resonant tunneling devices — •Daniel Supp[1], Taras Slobodskyy[1], Anatoly Slobodskyy[1], Tanya Borzenko[1], Charles Gould[1], Georg Schmidt[1], Laurens W. Molenkamp[1], and David Sanchez[2] — [1]Experimentelle Physik 3, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany — [2]Departament de Fisica, Universitat de les Illes Baleares, E-07122 Palma de Mallorca, Spain

Resonant tunneling diodes (RTDs) with magnetic materials are promising spin-transport devices, since their spin-dependent filter effect makes it possible to manipulate and detect the spins of electrons. To realize such a device in ZnMnSe is itself generally quite arduous. We have however developed a technique using a proper buffer stack to not only reliably fabricate them, but also to produce different variations of the layout, as for example RTDs with a magnetic injector, double RTDs or RTDs with a double quantum-well. Structured devices at the micron and sub-micron scale allow us to further analyze them and enhance their usability. Our structures confirm the spin-polarization of the current and gated RTDs are good candidates for transistor effects and studies of vertical quantum dots.

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HL 27.5 Wed 15:15 H13

Optimierung von ZnSe-basierten leitfähigen Bragg-Spiegeln — •Kai Otte, Carsten Kruse und Detlef Hommel — Institut für Festkörperphysik, Universität Bremen, Otto-Hahn-Allee, 28359 Bremen

Hochreflektive Bragg-Spiegel (DBR) sind ein Schlüsselbaustein für oberflächenemittierende Laserdioden mit Vertikalresonator (VCSEL). Diese Spiegel, bestehend aus einer ZnSSe Schicht als Hochindexmaterial und einem MgS/ZnSe Übergitter als Niedrigindexmaterial wurden mittels Molekularstrahlepitaxie auf GaAs Substraten gewachsen. Mit diesen Schichten können Reflektivitäten von über 99% erreicht werden. Das ZnSe Materialsystem ermöglicht das Wachstum von DBRs im Wellenlängenbereich von 460nm bis über 600 nm.

Die Optimierung des Wachstums dieser Spiegel ist von entscheidender Bedeutung hinsichtlich der optischen und elektrischen Eigenschaften von VCSELn.

Dotierte DBRs ermöglichen die Herstellung von elektrisch betriebenen VCSEL-Strukturen. Die erzielbare Leitfähigkeit hängt stark von der Art der Dotierung und der Periodenzahl der Bragg-Spiegel ab.

HL 27.6 Wed 15:30 H13

Spin polarization in $Zn_{0.95}Co_{0.05}O$:(Al,Cu) thin films — •Lars Hartmann, Qingyu Xu, Heidemarie Schmidt, Holger Hochmuth, Michael Lorenz, Chris Sturm, Christoph Meinecke, Annette Setzer, Pablo Esquinazi, and Marius Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik II, Linnéstrasse 5, D-04103 Leipzig, Germany

ZnCoO:Al, ZnCoO:(Al,Cu), and reference samples without Co have been grown by pulsed laser deposition to investigate the influence of Co-dopants and Cu-codopants on the magneto transport properties of ZnO. Positive magnetoresistance (MR) and anomalous Hall effect (AHE) have been observed for ZnCoO:(Al,Cu). Negative MR was observed in the Cu-codoped ZnO reference sample without Co [1]. Spin dependent scattering by isolated magnetic Cu impurities causes the observed negative MR in the reference sample [2]. The modeling of negative MR yields an electron spin polarization of 42% at 5 K and a Curie temperature T_C of 45 K. Possibly due to the complete ionization of intrinsic donors or Al donors in ZnO, above 50 K the MR is dramatically reduced. We also observed clear AHE in the Cu-codoped ZnCoO thin film. The AHE cannot be observed in ZnCoO without Cu-codopants. The observed temperature dependence of positive MR and magnetization hints towards a direct dependence of both effects. The simulation and understanding of the positive MR will provide key information for the enhancement of the intrinsic magnetization.

[1]L. Hartmann et al., J. Phys. D: Appl. Phys. **39** (2006). [2]M. Csontos et. al, Phys. Rev. Lett. **95** (2005).

15 min. break

HL 27.7 Wed 16:00 H13

Sputter deposition at high substrate temperatures and char-

acterization of ZnO, ZnO:P and ZnO:N films — •Sebastian Eisermann, Joachim Sann, Swen Graubner, Christian Neumann, Stefan Lautenschläger, Niklas Volbers, Angelika Polity, and Bruno Meyer — I. Physikalisches Institut, Justus-Liebig-Universität Gießen, Heinrich-Buff-Ring 16, 35392 Gießen, Deutschland

Pure ZnO, phosphorous and nitrogen doped ZnO thin films have been prepared on quartz glass, sapphire, gallium nitride, and zinc oxide substrates at temperatures up to 750°C by radio-frequency (RF) sputtering using pure ZnO and doped ZnO/P2O5 (1wt%) ceramic targets in pure argon, in a mixture of argon and oxygen or in a mixture of argon, oxygen and nitrogen (N2).

By optimizing the sputter parameters, such as sputtering power, temperature of the substrate or Ar/O2/N2 sputtering gas ratios, high quality films were obtained. The thin film crystallinity and surface morphology has been investigated with X-ray diffraction (XRD), atomic force (AFM) and scanning electron microscopy (SEM). Optical properties have been examined by measuring optical transmission and photoluminescence (PL) spectra. Hall measurements were carried out to check electric properties. Secondary Ion Mass Spectrometry (SIMS) measurements have been performed to determine the distribution of phosphor and nitrogen, respectively, in the doped layers.

HL 27.8 Wed 16:15 H13

Magnetization dynamics in parabolic and half-parabolic quantum wells based on (Cd,Mn)Te diluted magnetic semiconductors — •Marcel Arlt, Martin Kneip, Dimitri Yakovlev, and Manfred Bayer — Experimentelle Physik 2a, Otto-Hahn-Str.4, 44227 Dortmund

The technological concept of "digital alloying" brought about by molecular-beam epitaxy turned out to be a very effective tool for tailoring static and dynamic properties of diluted magnetic semiconductor nanostructures. We have investigated parabolic and half parabolic quantum wells (PQWs and HPQWs) by digital growth technique and show the possibility to accelerate the temporal evolution of magnetization dynamics. Spin-lattice relaxation dynamics of the Mn-spin system has been measured by time-resolved photoluminescence for the sample temperature of 2.5K and external magnetic fields up to 10T. Mn spin system has been heated by pulsed photoexcitation and evolution of emission line energy has been detected by gated CCD (1). Two-exponential decay was found in HPQW, contrary to single-exponential one in PQW. Effects of spin diffusion in the Mn spin system on the magnetization dynamics are discussed. (1) M.K. Kneip et al., Appl. Phys. Lett. 88, 152105 (2006).

HL 27.9 Wed 16:30 H13

Near bandgap photoluminescence spectroscopy of ZnO nanowires embedded in PMMA — •Jan-Peter Richters, Lars Wischmeier, Ilja Rückmann, and Jürgen Gutowski — Institute of solid state physics, University of Bremen, P.O. Box 330440, D-28334 Bremen

Due to their large surface-to-volume ratio and the photon confinement, ZnO nanowires are expected to be good candidates for applications in nanoscaled optoelectronics in the blue spectral region and for sensor applications. For some reasons it is useful to embed the ZnO nanowires into a surrounding matrix to influence the surface or interface states and the waveguiding properties. Here, we report about studies of the low-temperature photoluminescence (PL) of ZnO nanowires embedded in the polymer PMMA. For this we used VLS grown ZnO nanowire ensembles to prepare insular wire samples. Wires were stripped from the ensemble, dissolved in PMMA and acetone, and finally spin-coated on aluminium substrates. For measurements on single wires we used a micro-PL setup. PL spectra of the nanowire ensemble, of single wires without matrix and single wires embedded in PMMA were studied and compared. In general the near-band-edge spectra are dominated by D^0X bound-exciton lines, by an asymmetric surface exciton band (SX), and by phonon replicas. Due to the PMMA matrix the intensity ratios of the above mentioned lines are strongly changed. Additionally the green defect luminescence is suppressed.

HL 27.10 Wed 16:45 H13

Photocurrent spectroscopy of deep levels in ZnO thin films — •Heiko Frenzel, Holger von Wenckstern, Alexander Weber, Heidemarie Schmidt, Gisela Biehne, Holger Hochmuth, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik II, Linnéstr. 5, 04103, Leipzig, Germany

Fourier transform infrared photocurrent (FTIR-PC) spectroscopy has been used as complementary method to deep level transient spectroscopy (DLTS) to investigate deep defect levels in ZnO thin films grown by pulsed laser deposition (PLD) on *a*-sapphire substrate. FTIR-PC spectra of undoped ZnO layers show several well-resolved features between 100 meV and 500 meV due to transitions from deep defect states either to the conduction band or to the valence band. In addition to the commonly observed intrinsic levels E1 at ∼110 meV and E3 at ∼320 meV, FTIR-PC is also able to probe transitions with smaller electron capture cross-sections like L1 at ∼160 meV and L2 at ∼260 meV which are typically not observable in ZnO thin films via DLTS. Influences of growth and annealing conditions have been investigated to gather informations about the microscopic origin of deep levels in ZnO. Further results will be shown including Co- and Mn-doped ZnO thin films [1] and a N^+-implanted ZnO single crystal [2], where acceptor like transitions are visible.

[1] M. Diaconu *et al.*, Solid State Communications **137**, 417 (2006).
[2] G. Brauer *et al.*, Phys. Rev. B **74**, 045208 (2006).

HL 27.11 Wed 17:00 H13

Density of states and optical properties of MgO, ZnO and CdO — •André Schleife, Frank Fuchs, Claudia Rödl, and Friedhelm Bechstedt — Institut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany

In the last years ZnO attracted interest because of its potential application for optical devices. Alloys or heterostructures of ZnO with MgO and CdO or even magnetic materials (for spintronic applications) are discussed. From a theoretical point of view the (semicore) *d*-electrons are a challenging problem.

Employing first-principles calculations, the theoretical understanding has been pushed forward into two directions: First, using nonlocal functionals in the context of a generalized Kohn-Sham approach we obtain a DFT starting point which is more suitable for a perturbation-theory calculation of quasiparticle energies using the GW-approximation. This enables us to compute densities of states (DOS) from first principles which are in good agreement with experimental results. Second, ab initio optical spectra for the bulk have been calculated by solving the Bethe-Salpeter equation. This approach allows the investigation of bound states below the quasiparticle-gap as well as the computation of the dielectric function which is compared with measurements.

We present promising results and we are confident of being able to extend the application of this approach towards the parameter-free description of alloys or even heterostructures of these oxides.

HL 27.12 Wed 17:15 H13

Resonant Raman Scattering and Recombination Dynamics in Homoepitaxial-Grown and Single Crystal ZnO — •Markus R. Wagner[1], Patrick Zimmer[1], Axel Hoffmann[1], Stefan Lautenschläger[2], Joachim Sann[2], and Bruno K. Meyer[2] — [1]Institut für Festkörperphysik, Technische Universität Berlin — [2]I. Physikalisches Institut, Justus-Liebig-Universität Gießen

Resonant Raman scattering in ZnO at low temperatures is investigated by applying a frequency doubled titan-saphire laser as tunable excitation source. The influence of exciton phonon interactions such as the deformation potential for non-polar optical phonons and the Fröhlich interaction for polar LO modes are discussed. We present experimental evidence for resonant Raman scattering in ZnO involving bound exciton. A strong enhancement of the $2E_1(LO)$ Raman mode for resonant excitation at energies of the dominant bound exciton lines is apparent. The magnitude of the resonance enhancement for the $2E_1(LO)$ Raman mode is found to vary in dependence of the resonantly excited bound exciton complex and is particular strong for excitation energies matching the I_8 line. These results will be discussed in terms of different coupling strengths of the Fröhlich interaction with the neutral and ionized bound exciton complexes. In addition, the recombination and decay dynamics of the bound excitons, phonon replicas and resonantly enhanced Raman modes are discussed. For resonant excitation, a decay constant of the $2E_1(LO)$ Raman mode is found, which is considerably longer as for regular Raman scattering. This result is discussed considering scattering via real excitonic versus virtual states.