HL 23 II-VI Halbleiter II

Zeit: Samstag 10:45–13:15 Raum: TU P-N202

HL 23.1 Sa 10:45 TU P-N202

EPR study on the valence state of 3d transition-metal ions in ZnO based diluted magnetic semiconductors — •Mariana Diaconu, Heidemarie Schmidt, Andreas Pöppl, Rolf Böttcher, Joachim Höntsch, Holger Hochmuth, Michael Lorenz, and Marius Grundmann — Institut für Experimentelle Physik II, Fakultät für Physik und Geowissenschaften, Universität Leipzig, Linnéstrasse 3-5, 04103 Leipzig, Germany

In this paper we discuss theoretical and experimental results of electron paramagnetic resonance (EPR) for 3d transition-metal (TM) doped ZnO films, system belonging to a new class of materials called diluted magnetic semiconductors (DMS). Ferromagnetism at room-temperature was found on DMS, for example on Mn-alloyed ZnO films grown by pulsed laser deposition (PLD) [1,2]. For explaining the physical origin of the observed ferromagnetism, the valence state of 3d TM ions in ZnO has to be known.

For Mn-doped ZnO we performed EPR measurements on films obtained by PLD with Mn concentrations ranging from 0.1 to 10 at%. We observed the typical Mn^{2+} spectrum for low doping (0.1 at% Mn). For higher Mn-concentrations the hyperfine lines are not visible, but we see the fine-structure lines, broadened by dipole-dipole interactions. Onto these lines an intense broad single line was superposed. The broad single line, also found in Mn-alloyed nanostructures, is due to Mn ions in higher local concentrations. We modelled the EPR spectra and obtained the fine and hyperfine splitting parameters of Mn-alloyed ZnO.

[1] P. Sharma et al., Nature Materials **2** (2003), 673.
[2] M. Diaconu et al., submitted to Phys. Rev. B.

HL 23.2 Sa 11:00 TU P-N202

Electrical characterization of ZnO using Schottky contacts — •Holger von Wenckstern, Swen Weinhold, Rainer Pickenhain, Gisela Biehne, Holger Hochmuth, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Linnéstraße 5, 04103 Leipzig

We have investigated electron traps in ZnO thin films using admittance and deep level transient spectroscopy. The c-oriented ZnO thin films are grown epitaxially on a-plane sapphire by pulsed laser deposition. The Schottky contacts are realized by thermal evaporation of Ag or Pd. The ohmic contacts are realized by an eutectic mixture of indium and germanium. The properties of the contacts were investigated by current-voltage and capacitance-voltage measurement. For that, the diodes were investigated in a temperature range from 10 K to 330 K.

Thermal admittance spectroscopy was carried out between 10 and 330 K. Deep level transient spectroscopy (DLTS) was done in two different setups. In one of them the diodes were investigated between 10 and 300 K. The other allows investigations between 80 and about 500 K. Up to now we have identified by DLTS defects lying about 290 meV or 710 meV below the conduction band minimum, respectively.

HL 23.3 Sa 11:15 TU P-N202

Electron effective mass and transport properties of n-doped $Zn_{1-x}Mn_xSe$ epilayers studied by infrared reflection spectroscopy — •K. C. Agarwal, B. Daniel, C. Klingshirn, and M. Hetterich — Institut für Angewandte Physik and Center for Functional Nanostructures (CFN), Universität Karlsruhe, D-76131 Karlsruhe, Germany

Zn(Mn)Se is a diluted magnetic II-VI semiconductor material with a variety of potential applications in optoelectronic devices, e.g. light-emitting diodes and blue-green laser diodes as well as optoelectronic spin devices. For a full utilization of these materials, it is vitally important to have a solid knowledge of material parameters like the electron effective mass and transport properties in these materials. In this contribution, we present the results of our studies on the slope electron effective mass as a function of doping concentration in n-doped $Zn_{1-x}Mn_xSe$:Cl epilayers ($0 \leq x \leq 0.13$). The doping concentration in our samples was determined using Hall measurements in the van-der-Pauw geometry. The electron-plasma frequency was extracted from experimental reflectivity data by making a Drude-Lorentz type multi-oscillator fit taking into account the effects of free charge carriers in doped semiconductors, background dielectric constant as well as the ZnSe-, MnSe- and GaAs-like phonons. In addition we also discuss the optical mobility and resistivity in these samples calculated from our determined fit parameters.

HL 23.4 Sa 11:30 TU P-N202

Morphology and electronic structure of MOMBE grown ZnO surfaces — •Stefan Andres, Tilo Plake, and Christian Pettenkofer — Hahn-Meitner-Institut, Glienicker Str. 100, 14109 Berlin

ZnO is deposited by metal organic molecular beam epitaxy (MOMBE) in an ultrahigh vacuum (UHV) system on various substrates such as Si(111), Al_2O_3, ZnO($10\bar{1}0$) and glass at temperatures between 200°C and 500°C. Films are investigated in-situ by low energy electron diffraction (LEED), photoelectron spectroscopy (PES) and scanning tunneling microscopy (STM). For deposition with the precursor system diethylzinc/water significantly lower OH admixtures were found in the O1s region by monochromated x-ray photoelectron spectroscopy (MXPS) in comparison to magnetron sputtered films. The surface electronic structure is investigated by angle resolved PES (ARPES) with respect to the admixture of hydrogen during film growth and subsequent annealing of the films. Thus the hydrogen incorporation into the film and the termination of the surface can be determined. For ZnO films on Al_2O_3 the electrical properties (doping and resistivity) are determined ex-situ and compared to the data obtained from the valence band spectra.

HL 23.5 Sa 11:45 TU P-N202

Strukturelle Eigenschaften des Donators Indium in nanokristallinem ZnO — •Th. Agne[1], V. Koteski[2], H.-E. Mahnke[2], H. Wolf[1] und Th. Wichert[1] — [1]Technische Physik, Universität des Saarlandes, D-66041 Saarbrücken — [2]Bereich Strukturforschung, Hahn-Meitner-Institut Berlin, D-14109 Berlin

Nanokristallite des II-VI Halbleiters ZnO wurden mit dem Donator Indium in einem relativen Konzentrationsbereich von 10^{-5}-10^{-3} dotiert und anschließend bei 473 K einer Hydrothermalbehandlung unterzogen, wobei sich eine mittlere Korngröße von ca. 11 nm einstellt.

PAC-Untersuchungen an der Sonde $^{111}In/^{111}Cd$ in hoch In-dotiertem nano-ZnO zeigen bis zu einer Konzentration von 10^{-4}, dass die ^{111}In-Atome auf Zn-Plätzen eingebaut werden. Bei dieser Konzentration zeigen sich aber auch zwei In-Defektkomplexe, die bei einer höheren In-Konzentration von 10^{-3} das PAC-Spektrum dominieren. Es konnte abgeschätzt werden, dass sich in ZnO Nanokristallen diese In-Defektkomplexe dann bilden, wenn sich mehr als ein In-Donator in einem Nanokristallit befindet. Die lokale Umgebung der In-Atome in hoch In-dotiertem ZnO Nanokristallen wurde auch mit der EXAFS-Methode untersucht. Die EXAFS-Messungen an der K-Kante der In-Dotieratome zeigen eine deutliche Aufweitung des Kristallgitters hin zur O_{NN}-Schale. Es wurde eine Abwesenheit von Zn_{NNN}-Atomen beobachtet, für die bis jetzt keine Erklärung gefunden werden konnte. Möglicherweise steht diese Beobachtung mit der Struktur der In-Defektkomplexe in Zusammenhang, die in den PAC-Experimenten beobachtet werden.

Gefördert durch die DFG im Rahmen des SFB277.

HL 23.6 Sa 12:00 TU P-N202

Optical Properties of Colloidal CdSe-Nanocrystals: Size, Shape and Temperature Dependence of Luminescence Dynamics. — •Oliver Schöps[1], E. Herz[2], M.V. Artemyev[3], C. Arens[4], N. Rousseau[4], D. Schikora[4], K. Lischka[4], and U. Woggon[1] — [1]Universität Dortmund, Institut für Physik, Experimentelle Physik IIb, Otto-Hahn-Strasse 4,D-44227 Dortmund — [2]Cornell University,Ithaca, NY — [3]Belarussian State University, Minsk — [4]Universität Paderborn

CdSe nanocrystals show enormous potential concerning their applications in photonic devices due to the size tunability of their emission wavelength and their high quantum yield. The wet chemical preparation allows the control of size and shape from spherical nanocrystals to elongated nanorods. Here the spectrally as well as temporally resolved photoluminescence (PL) data is analysed. Transitions between excitonic fine structure levels govern the population dynamics and therefore the PL decay times. With increasing size the nanorods' PL properties display a transition from a fully confined, zero dimensional to a one dimensional structure. We furthermore address the modification of the PL, when a novell overgrowth technique is applied to incorporate colloidal nanoparticles in a MBE grown ZnSe Matrix.

HL 23.7 Sa 12:15 TU P-N202

Elektrische Eigenschaften von $ZnO_{1-x}S_x$: (H, Al) — •Thorsten Krämer, Angelika Polity, Changzhong Wang und Bruno K. Meyer — Justus-Liebig-Universität Gießen, 1. Physikalisches Institut, Heinrich-Buff-Ring 16, 35392 Gießen

Das Legierungssystem $ZnO_{1-x}S_x$ zeigt einen parabolischen Verlauf der Bandlücke bei variierender Zusammensetzung x zwischen den binären Endpunkten ZnO (Eg=3,3 eV) und ZnS (Eg=3,6 eV). Dieses Verhalten läßt sich mit $E_{ZnOS}(x) = xE_{ZnS} + (1-x)E_{ZnO} - bx(1-x)$ beschreiben, wobei der Bowingfaktor b für $ZnO_{1-x}S_x$ etwa 3 eV annimmt. Die Bandlücke kann also durch Wahl der Zusammensetzung Werte zwischen 3,6 eV und 2,6 eV annehmen. Durch ein Radiofrequenz-Sputterverfahren wurden dünne $ZnO_{1-x}S_x$-Schichten auf Saphir und Glas hergestellt und zur Erhöhung ihrer elektrischen Leitfähigkeit mit Aluminium und/oder Wasserstoff dotiert. Zur Bestimmung der Ladungsträgerdichte, der Beweglichkeit und des spezifischen Widerstandes wurden Halleffektmessungen in der van-der-Pauw Geometrie durchgeführt. 4-Punkt-Leitfähigkeitsmessungen konnten zur Überprüfung der Widerstandswerte herangezogen werden. Weiterhin werden Messungen der optischen Transmission vorgestellt.

HL 23.8 Sa 12:30 TU P-N202

Synthesis and Characterization of Co-doped ZnO Nanocrystals — •Niklas Volbers, Daniel Pfisterer, Joachim Sann, Bruno Meyer und Detlev Hofmann — I. Physikalisches Institut, Justus-Liebig-Universität-Giessen, Heinrich-Buff-Ring 16, D-35392 Giessen, Germany

Transition-metal doped ZnO is a promising candidate for transparent ferromagnetic semiconductors and its technical application will demand nanoscale structures. We have prepared Co-doped ZnO nanoparticles using a wet-chemical synthesis route. Recently, it was shown that nanocrystals prepared in a similar way show roomtemperature ferromagnetism [1]. We have studied the growth mechanism of the doped nanoparticles and the incorporation of Co into the nanocrystals. Compared to undoped nanocrystals the doping results in a reduced growth rate and reduced size of the nancrystals. The incorrporation of the Co dopant in the form of Co^{2+} substituting Zn is confirmed by the observation of the internal crystal field transitions in absorption and emission spectroscopy. It is in line with electron paramagnetic resonance experiments. However, no evidence for ferromagnetism is found so far. This is probably related to the small size of our nanocrystals (∼3nm), while ferromagnetism was observed for much bigger nanocrystals (>100 nm) [1].

[1] Schwartz et al.: Magnetic Quantum Dots: Synthesis, Spectroscopy, and Magnetism of Co^{2+}- and Ni^{2+}-Doped ZnO Nanocrystals. J. Am. Chem. Soc., 125: 13205-13218, June 2003.

HL 23.9 Sa 12:45 TU P-N202

Doping of group I acceptors in ZnO — •Joachim Sann, Arndt Zeuner, Niklas Volbers, and Bruno K. Meyer — I. Physikalisches Institut, Justus-Liebig-Universität-Giessen, Heinrich-Buff-Ring 16, D-35392 Giessen, Germany

We report on the optical properties of ZnO bulk crystals subjected to different treatments to study the incorporation of group I acceptors. Salts containing Sodium, Lithium or Potassium were used for diffusion into bulk ZnO at temperatures between 400 and 800 °C. The films were investigated by steady state and temperature-dependent photoluminescence (PL). In the case of Lithium (Na) we were able to introduce acceptors which give rise to a donor acceptor pair band around 3.05 eV. According to previous investigations the acceptor may be a pair defect which compensates the shallow Li (Na) donors but does not lead to p-type conduction. We compare our results with in-situ doped CVD grown ZnO epitaxial films.

HL 23.10 Sa 13:00 TU P-N202

Phosphordotierung in ZnO — •Christian Neumann[1], Joachim Sann[1], Ute Haboeck[2] und Bruno K. Meyer[1] — [1]I. Physikalisches Institut, Justus-Liebig-Universität-Giessen, Heinrich-Buff-Ring 16, D-35392 Giessen, Germany — [2]Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin

Phosphor ist ein möglicher Kandidat für eine p-Dotierung von ZnO. Wir berichten über den Einbau von Phosphor in mittels CVD epitaktisch abgeschiedenen ZnO-Dünnschichten sowie Diffusionsexperimenten an ZnO-Einkristallen. Röntgendiffraktometrie, temperaturabhängige Photolumineszenzmessungen im Bereich von 4 - 300 K sowie Ramanspektroskopie von 50 - 2750 cm^{-1} mit verschiedenen Anregungswellenlängen zeigen den Einfluß der Phosphordotierung im ZnO.