HL 63: II-VI-Compounds

Time: Wednesday 15:45–18:30 Location: POT 151

HL 63.1 Wed 15:45 POT 151

Band gap bowing of binary alloys: Experimental results compared to theoretical tight-binding supercell calculations for $Cd_xZn_{1-x}Se$ — •Daniel Mourad[1], Gerd Czycholl[1], Carsten Kruse[2], Sebastian Klembt[2], Reiner Retzlaff[2], Detlef Hommel[2], Mariuca Gartner[3], and Mihai Anastasescu[3] — [1]Institut für Theoretische Physik, Universität Bremen — [2]Institut für Festkörperphysik, Universität Bremen — [3]Institute für Physikalische Chemie "Ilie Murgulescu", Rumänische Akademie

Compound semiconductor alloys of the type $A_xB_{1-x}C$ find widespread applications as their electronic bulk band gap varies continuously with x, and therefore a tayloring of the energy gap is possible by variation of the concentration. We model the electronic properties of such semiconductor alloys by a multiband sp^3 tight-binding model on a finite ensemble of supercells and determine the band gap of the alloy. This treatment allows for an intrinsic reproduction of band bowing effects as a function of the concentration x and is exact in the alloy-induced disorder. In the present talk, we concentrate on bulk $Cd_xZn_{1-x}Se$ as a well-defined model system and give a careful analysis on the proper choice of the basis set and supercell size, as well as on the necessary number of realizations. The results are compared to experimental results obtained from ellipsometric measurements of $Cd_xZn_{1-x}Se$ layers prepared by molecular beam epitaxy (MBE) and photoluminescence (PL) measurements on $Cd_xZn_{1-x}Se$ nanowires reported in the literature.

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Optical properties of photonic molecules on base of the II-VI material system — •Moritz Seyfried, Kathrin Sebald, Arne Gust, Carsten Kruse, Detlef Hommel, and Jürgen Gutowski — Institute of Solid State Physics, University of Bremen, P.O. Box 330 440, D-28334 Bremen, Germany

Photonic molecules (PMs), consisting of pillar microcavities (MCs) which are connected by a small bar, offer the possibility to couple spatially separated quantum dots (QDs) in the individual pillars via the moderation of the electromagnetic field. Therefore, PMs with pillar diameters of 2.78μm and different center-to-center (CC) distances of the individual pillars were prepared out of planar monolithic VCSEL structures by using focused-ion-beam etching. The structures were grown by molecular beam epitaxy containing either one CdSe/ZnSSe QD layer or, as a more homogeneous illumination source for the far field studies, three quantum well layers as active material. Quality factors of up to 6000 could be determined from the measured discrete mode spectra of the PMs. The photoluminescence spectra were studied in dependence on the excitation position on the PM as well as on the CC distance of the individual pillars. A reduction of the spectral separation of the fundamental mode and the first higher mode with increasing CC distance was found and attributed to the reduced mode coupling for PMs with a larger CC distance. Furthermore, the electromagnetic field distribution was studied by means of the far-field pattern and is discussed with respect to the different CC distances. For a better insight the experimental data are compared with simulations.

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Long-lived electron spincoherence in ZnSe-based quantum wells — •Alexander Schwan[1], Evgeny A. Zhukov[2], Dmitri R. Yakovlev[1], and Manfred Bayer[1] — [1]Experimentelle Physik 2, TU Dortmund, 44221 Dortmund — [2]Faculty of Physics, M. V. Lomonosov Moscow State University, 119992 Moscow, Russia

Carrier spin coherence in low-dimensional structures is in focus of current interest due to spintronics applications. We have studied carrier spin coherence in ZnSe/(Zn,Be,Mg)Se quantum wells (QWs) characterized by a type-I band alignment and binary QW material. The spin dephasing time T_2^* of the electron spin coherence is experimentally determined by time-resolved Kerr rotation (TRKR) and resonant spin amplification (RSA) measurements in magnetic fields up to 4 Tesla. The Larmor precession of the electron spins in the ZnSe layers is clearly observed in both the TRKR and RSA signals. Times T_2^* up to 30 ns have been evaluated for localized resident electrons of a temperature of 2 K. The temperature dependence of the electron spin coherence is investigated up to 150 K. For higher temperatures exceeding 20 K, where the electrons are delocalized, the dominant spin dephasing mechanism is the D'yakonov-Perel mechanism.

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Energy transfer dynamics of the Mn $3d^5$ luminescence in ZnS:Mn nanostructures — •Uwe Kaiser[1], Limei Chen[1], Wolfram Heimbrodt[1], Sebastian Geburt[2], and Carsten Ronning[2] — [1]Dept. Physics, Philipps-University Marburg, Germany — [2]Institute of Solid State Physics, Friedrich-Schiller University, Germany

The energy transfer characteristics of $Zn_{1-x}Mn_xS$ bulk material can be described by the well known Förster model. For wires and belts in the range of several nanometers, which where studied in this work, this transfer model has to be modified, becuase of the reduced dimensionality. To prove this modified Förster model $Zn_{1-x}Mn_xS$ samples were prepared, which permited access to the different parameters of the model. The temporal behavior of the internal $Mn^{2+}(3d^5)$ luminescence, which enables access to the energy transfer, was measuered over four orders of magnitude. Different concentrations of Manganese from $4 \cdot 10^{-6}$ % to 4 % were incorporated by ion implantation into ZnS structures of differnet morphologies. For wires as well as for belts an enhancement of the effective dimensionality with the increase of the manganese concentration could be shown. To examine the influence of nonradiative killer centers different attempts for the introduction of defects were studied. With 1) ion implantation of neon as well as 2) different temperature treatements the concentration of killercenters could be controlled. The aim of this work was to prove the validitiy of the modified Förster model for a variety of $Zn_{1-x}Mn_xS$ nanostructures by the transients of the Mn photoluminescence.

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Einfluss von Metallfilmen auf die Diffusion von Ag in CdTe — •Johannes Lehnert[1], Jörg Kronenberg[1], Herbert Wolf[1], Thomas Wichert[1] und ISOLDE Collaboration[2] — [1]Technische Physik, Universität des Saarlandes, D-66123 Saarbrücken — [2]CERN, CH-1211 Geneva 23

Es ist bekannt, dass für Gruppe I Elemente in CdTe, wie z.B. Ag, unter geeigneten externen Bedingungen bei ca. 800 K peakförmige Konzentrationsprofile erzeugt werden können [1]. In diesem Beitrag wird gezeigt, dass mit Hilfe von aufgedampften Metallfilmen solche Profile bei signifikant niedrigeren Temperaturen von unter 600 K gebildet werden können. Im ersteren Fall war nach einseitiger Implantation von ^{111}Ag in Te-reiches, p-leitendes CdTe (Dicke ca. 800 μm) die Probe bei 800 K (60 min) unter Cd-Dampfdruck diffundiert worden. Das ^{111}Ag-Profil spiegelt bei diesem Prozess die sukzessive Umwandlung des Te-reichen, p-leitenden Material in Cd-reiches, n-leitendes Material wider. Im zweiten Fall wird nach der Implantation, aber vor der Diffusion, ein Metallfilm auf die Oberfläche aufgedampft. In Fall von aufgedampftem Au genügt dann bereits eine Diffusionstemperatur von 580 K (30 min), um das entsprechende Profil zu erzeugen. Der Einfluss unterschiedlicher Metallfilme auf diesen Prozess wird diskutiert werden. Aufgrund der in beiden Experimenten übereinstimmenden Form der Ag-Profile gehen wir davon aus, dass die aufgedampften Metallfilme Ursache für eine Quelle von eindiffundierenden Cd-Atomen sind.
Gefördert durch das BMBF, Projekt 05 KK7TS1
[1] H. Wolf et al., Phys. Rev. Lett. 94 (2005) 125901

15 min. break

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Ion-beam-induced damage formation in CdTe at 15K — Carl Willem Rischau, •Claudia Sarah Schnohr, Elke Wendler, and Werner Wesch — Friedrich-Schiller-Universität Jena, Institut für Festkörperphysik, Max-Wien-Platz 1, 07743 Jena, Germany

Ion implantation studies on CdTe are of interest regarding a possible application of this technique in the fabrication of CdTe devices, but also with respect to the fundamental understanding of ion-beam-induced damage formation in II-VI compounds. Studies at room temperature exhibit some interesting features like defects extending much deeper into the crystal than the calculated range of the ions and a high resistance to amorphization even after prolonged irradiation with ion fluences as high as several 10^{16}ions/cm^2.

In order to study a possible thermal origin of these effects, we irradi-

ated CdTe single crystals with 270keV Ar and 730keV Sb ions at 15K and analyzed the damage formation in-situ using Rutherford backscattering spectrometry (RBS) in channeling direction. Defect profiles calculated from the RBS spectra using the computer code DICADA show a flat defect distribution which extends to a depth of up to five times the projected range of the ions despite the very low temperature. The post-range defects in CdTe thus do not seem to be of thermal origin, but are instead believed to result from migration driven by the electronic energy loss. Furthermore, CdTe is not rendered amorphous at 15K even after irradiation with several 10^{16}ions/cm^2, suggesting that the high resistance to amorphization of CdTe is caused by the high ionicity of the material rather than thermal effects.

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Birefringent effect in a two dimensional electron gas — •Mathias J. Mühlbauer, Christoph Brüne, Timo Wagner, Hartmut Buhmann, and Laurens W. Molenkamp — Physikalisches Institut (EP3), Universität Würzburg, 97074 Würzburg, Germany

Rashba spin-orbit interaction is one of the most promising effects for the creation and manipulation of spin polarizations in low-dimensional electronic semiconductor systems without using external magnetic fields. In systems with strong spin orbit coupling (SOC) it should be possible to observe the electronic analogue of the birefringent effect for polarized light as proposed by M.Khodas et al. [1]. The polarization takes place at an interface between regions with different SOC. HgTe/HgCdTe quantum wells are the basis for our studies. In theses heterostructures, electron beam injection and detection can be realized by Quantum point contacts (QPC) while the SOC can be altered through gate electrodes. However, the realization of QPCs in HgTe/HgCdTe is not trivial due to the narrow band gap and the presence of the Quantum Spin Hall Effect [2]. Here, we demonstrate the possibility to fabricate QPCs using electron beam lithography and dry etching and to control its transmission with a top gate. We will present measurements of conductance and beam collimation. The conductance sequence shows steps of e^2/h suggesting that spin polarization is already taking part within the QPC. Additionaly we will show and discuss measurements on two coupled QPCs separated by a beamsplitter.

[1] M. Khodas et al.,PRL 92, 086602 (2004).
[2] M. König et al. Science, 318, 766, (2007).

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optical properties of ZnO-nanowire/CdSe-colloidal-quantum-dot hybrid structures — •dongchao hou, jan-peter richters, apurba dev, and tobias voss — Semiconductor Optics, Institute of Solid State Physics, University of Bremen

One of the research interests in modern nanotechnology is the assembly and study of hybrid heterostructures composed of different materials that offer enhanced properties through the interactions between their different constituents. ZnO nanowires functionalized with colloidal semiconductor quantum dots (QDs) display tailored optical properties due to energy and electron transfer processes between these two components, and have a huge potential for applications in light-emitting and photovoltaic devices.

Using a facile method, we synthesized water-soluble CdSe QDs with cadmium acetate and sodium selenosulfate as Cd and Se precursors, respectively. 3-mercaptopropionic acid (MPA) was used to cap the QDs, acting as the stabilizer, making the QDs water soluble and preventing them from agglomeration. TEM measurements demonstrated a narrow size distribution of the as-prepared QDs with the average diameter around 3 nm, consistent with UV-Vis absorption measurements. The carboxylic groups at the outer surface of the MPA-capped CdSe QDs render a tight and uniform attachment onto the surface of ZnO nanowires with high coverage efficiency possible. We studied the optical properties of the hybrid structures by photoluminescence spectroscopy under different temperatures to analyze the energy and electron transfer dynamics between the nanowires and the QDs.

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Infrared absorption study of hydrogen shallow donors in rutile TiO_2 — •Frank Herklotz, Eduard Lavrov, and Jörg Weber — Technische Universität Dresden, 01062, Dresden, Germany

An IR absorption study of hydrogen-related defects in rutile TiO_2 has been performed. The previously reported O–H vibrational mode at 3288 cm^{-1} [1] is found to consist of two components. The modes are assigned to an acceptor-hydrogen complex of an unidentified acceptor and a hydrogen located in the open *c*-channels [2,3]. The latter is split into two modes due to the neutral and positively charge states of the defect. Based on the temperature dependence of the stretch mode intensities we identify this defect as a shallow donor with an ionization energy of 10 meV. The effective mass of electrons in the conduction band of TiO_2 is found to be $17m_e$.

[1] B. Soffer, J. Chem. Phys. **35**, 940 (1961).
[2] M. Koudriachova, S. de Leeuw, and N. M. Harrison, Phys. Rev. B **70**, 165421 (2004).
[3] S. Klauer and M. Wöhlecke, Phys. Rev. B **49**, 158 (1994).

HL 63.10 Wed 18:15 POT 151

Investigation on multibarrier Schottky contacts — •Stefan Müller[1], Holger von Wenckstern[1], Otwin Breitenstein[2], Jörg Lenzner[1], and Marius Grundmann[1] — [1]Universität Leipzig, Semiconductor Physics Group, Institut für Experimentelle Physik II, Leipzig, Germany — [2]Max-Planck-Institut für Mikrostrukturphysik Weinberg 2, D-06120 Halle, Germany

We present current-voltage(I-V)-characteristics of multi-barrier PdO_y/ZnO-Schottky contacts fabricated by reactive dc-sputtering. The ZnO nominally undoped thin films were grown by pulsed-laser deposition on a ZnO:Al buffer on a-Al_2O_3[1].

The I-V-characteristics were fitted by assuming a parallel connection of two or three individual diodes with different barrier heights(e.g. $\phi_{B1} = 0.872\,\text{eV}$, $\phi_{B2} = 0.66\,\text{eV}$, $\phi_{B3} = 0.547\,\text{eV}$ at room temperature), ideality factors ($n_1 = 2.1$, $n_2 = 2.4$, $n_3 = 1.8$) and areas(A_0, $0.03A_0$, $4 \cdot 10^{-4}A_0$)[2]. Using dark lock-in thermography low-barrier patches were visualized for small forward currents.

These regions were investigated with additional techniques, like electron beam induced current and scanning electron microscope revealing origins for the local decrease of barrier height.

[1] H. von Wenckstern, Appl. Phys. Lett. 88, 092102 (2006)
[2] D. Defives, IEEE Trans. Electron Devices 46, 449 (1999)