HL 21: III-V semiconductors II

Time: Tuesday 11:00–13:00 Location: H17

HL 21.1 Tue 11:00 H17

The Mn Acceptor in InAs: Depth-Dependent Shape and Supression of the Conduction Band — Jens Wiebe[1], •Felix Marczinowski[1], Jian-Ming Tang[2], Michael E. Flatté[2], Markus Morgenstern[3], and Roland Wiesendanger[1] — [1]Institut für Angewandte Physik, Universität Hamburg — [2]Optical Science and Technology Center and Department of Physics and Astronomy, University of Iowa, USA — [3]II. Institut für Physik B, RWTH Aachen

Recent work using scanning tunneling spectroscopy (STS) revealed that acceptors in III/V semiconductors appear strongly anisotropic and their mirror asymmetry regarding the (001) plane depends on the binding energy E_b. While the energetically deep acceptor Mn in GaAs has a symmetric cross like shape [1], shallow acceptors like Zn show an asymmetric triangular feature [2]. We analyzed the relatively deep acceptor Mn in InAs ($E_b = 30meV$) by STS and find a dependency of the shape on the depth below the (110) surface. Deeper Mn acceptors appear as a cross with a low asymmetry which is reproduced by a bulk tight-binding model (TBM). Mn acceptors closer to the surface show a strong asymmetry of the cross resulting in a triangular feature. A possible explanation is the strengthening of the asymmetry by surface relaxation. The influence of the acceptor on the conduction band (CB) has also been studied by STS and TBM calculations. The CB density of states shows a supression close to the Mn which is surrounded by an oscillation reflecting the anisotropy of the acceptor state.

[1] A. M. Yakunin et al., Phys. Rev. Lett. 92, 216806 (2004)
[2] S. Loth et al., Phys. Rev. Lett. 96, 066403 (2006)

HL 21.2 Tue 11:15 H17

Exciton transport by surface acoustic waves — •Jörg Rudolph, Rudolf Hey, and Paulo Santos — Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5-7, 10117 Berlin

We present a novel approach for the transport of excitons in GaAs quantum wells (QW) using the mobile strain field of a surface acoustic wave (SAW). The strain field of a SAW travelling along the [100] direction on a (001)GaAs structure leads to a moving lateral type-I band gap modulation. Long-living indirect excitons photoexcited in a double-quantum well structure are trapped close to the positions of minimum band gap and transported with the acoustic velocity. The transport is detected by spatially resolved photoluminescence (PL) to image excitonic recombination away from the excitation spot. We investigate the dependence of the transport on the applied acoustic power and extract information about the exciton mobility. Mechanisms for exciton confinement in the SAW-induced potential are discussed.

HL 21.3 Tue 11:30 H17

The Fe center in III-V and II-VI semiconductors — •Enno Malguth and Axel Hoffmann — Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

A comprehensive review of the Fe impurity in binary III-V and II-VI compounds is given with focus on GaN and ZnO. In this context, new results on the effective-mass-like state consisting of a valence band hole bound to Fe^{2+} are presented. In connection with diluted magnetic semiconductors, transition metal impurities particularly in wide band semiconductors have regained considerable interest. Focussing on Fe we give an overview on general phenomena such as charge states, electronic structure, charge transfer processes, Jahn-Teller effect etc. which have been investigated over the last couple of decades. The (Fe^{2+}, h_{VB}) state which has been observed in a range of III-V materials may play a central role in realizing carrier mediated ferromagnetism. By means of temperature and stress dependent absorption experiments we are able to give a good understanding of an experimentally observed deviation of the ground state from effective-mass theory. A conclusive model of the bound state's ground state is given taking into account exchange interaction between the hole and Fe^{2+} states.

HL 21.4 Tue 11:45 H17

Formation of MOVPE grown InAs quantum dots on GaAs(001):Si investigated with in-situ STM — •Raimund Kremzow[1], Markus Pristovsek[1], Bert Rähmer[1], Markus Breusing[1], Michael Kneissl[1], and Wolfgang Richter[2] — [1]TU-Berlin, Institut für Festkörperphysik, Sekr. PN6-1, Hardenbergstraße 36, 10623 Berlin, Germany — [2]Dipartimento di Fisica, Roma II (Tor Vergata), Via della Ricerca Scientifica 1, 00133 Rome, Italy

Metal-Organic Vapour Phase Epitaxy (MOVPE) is the most important growth method for III-V-semiconductor structures. However, in-situ measurement techniques during MOVPE are constrained by the typical pressures of 20-100 mbar and temperatures of 450°C - 1100°C to optical techniques, which do not reveal microscopic details. Therefore, we have designed and built the first in-situ scanning tunnelling microscope (STM) capable of measuring the topography of semiconductor surfaces continuously during the growth of nanostructures in MOVPE up to 700°C. We will present our latest results, e.g. the first measurements of Ostwald-ripening of InAs quantum dots on a GaAs(001) surface. After the growth of InAs quantum dots a sequence of in-situ STM images were recorded at a sample temperature of 475°C. Three different structures (quantum dots, small and big clusters) could be differentiated. During the Ostwald-ripening the density of the small clusters seems to be constant, while the small quantum dots vanished exponentially and the big clusters increased slightly.

This newly developed in-situ STM tool could also enable effective control of semiconductor nanostructures during MOVPE growth.

HL 21.5 Tue 12:00 H17

Temperature dependent Electron Landé g-Factor and Interband Matrix Element in GaAs — •Jens Hübner, Stefanie Döhrmann, Daniel Hägele, and Michael Oestreich — Institute for Solid State Physics, Gottfried Wilhelm Leibniz University Hannover, Appelstr. 2, 30167 Hannover

High precision measurements of the electron Landé g-factor in GaAs are presented using spin quantum beat spectroscopy at low excitation densities and temperatures ranging from 2.6 to 300 K. Influences of nuclear spin polarization at low temperatures have been fully compensated. Comparing these measurements with available data for the temperature dependent effective mass reveals an unexpected strong temperature dependence of the interband matrix element and resolves a long lasting discrepancy between experiment and kp - theory. The strong decrease of the interband matrix element with increasing temperature is explained by phonon induced fluctuations of the interatomic spacing and adiabatic following of the electrons.

HL 21.6 Tue 12:15 H17

Spin Noise Spectroscopy in GaAs — •Michael Römer, Jens Hübner, and Michael Oestreich — Institute for Solid State Physics, Gottfried Wilhelm Leibniz University of Hannover, Appelstr. 2, 30167 Hannover

We successfully employ spin noise spectroscopy in semiconductor materials as a new sensitive tool to measure the spin-coherence time of electrons and the electron Landé g–factor in n-GaAs nearly interaction free [1]. Our technique avoids common problems like carrier heating and electron spin relaxation due to spin interaction with optically created holes.

Spin noise spectroscopy in semiconductors empowers us to measure extremely long spin coherence times in excess of 200 ns at low temperatures, which may have been masked in the past by effects like those mentioned above.

We furthermore discuss the measured noise power and spin-coherence time in dependence of the probe energy position, sample temperature and doping concentration. The results compare very well with a theory based on Poisson distribution probability.

The spin noise spectrum is measured by below band-gap Faraday-rotation in n-doped GaAs at low temperatures with high frequency spectrum analysis techniques.

[1] M. Oestreich, M. Römer, R. Haug, and D. Hägele, "Spin Noise Spectroscopy in GaAs", Phys. Rev. Lett. **95**, 216603 (2005).

HL 21.7 Tue 12:30 H17

Scanning Tunneling Spectroscopy of Si donors in GaAs {110} — •K. Teichmann, M. Wenderoth, S. Loth, and R. G. Ulbrich — Universität Göttingen, IV. Physikalisches Institut, Germany

Silicon donors in highly n-doped GaAs ($6.5\times10^{18}\mathrm{cm}^{-3}$) are investigated by Cross-Sectional Scanning Tunneling Microscopy in UHV at 8K. Donors near the surface of the {110} cleavage planes are studied by spatially resolved I(V)-spectroscopy.

The dopant atoms are identified by their bias dependent topographic and spectroscopic properties. In addition to the known features at negative and small positive voltages, our measurements on single donors show an additional transport channel for larger positive bias voltages. The current distribution has a circular symmetric structure. The diameter is bias dependent, and can extend up to several nanometers around the donor. The minimal bias voltage of the current onset is localized above the donors. We discuss different scenarios - including tip induced band bending - that can lead to the observed ring-like shapes.

This work was supported by the DFG, SFB 602.

HL 21.8 Tue 12:45 H17

GaMnAs grown on (001), (311) and (110) GaAs — •Ursula Wurstbauer, Dieter Schuh, and Werner Wegscheider — Universität Regensburg

In order to realize new spintronic devices based on Mn-doped GaAs heterostructures, one has to understand in detail and improve the properties in GaMnAs. For this reason, an accurate control of the effective Mn x concentration and the carrier density is necessary in this hole mediated ferromagnetic semiconductor GaMnAs. So far it is known, that these parameters critically depend on the incorporation of Mn atoms in the host lattice and on lattice defects, mainly As antisites and Mn interstitials, both acting as double donors, which are caused by the unavoidable low temperature MBE growth. In our experiments, we have grown GaMnAs layers on differently oriented GaAs substrates to compare the influence of growth and post-growth-treatment parameters on the Mn incorporation and, hence on T_C. We obtain the carrier density p by measuring the anomalous Hall Effect and the concentration of As-antisites from the lattice constant of LT-GaAs layers by X-ray diffraction. Further we show, that by avoiding As-antisites with a low As_4/Ga flux ratio and by reducing the Mn-interstitials by post growth annealing the carrier density and corresponding T_C increases to 152K for layers grown on (001) GaAs, to 110K for layers on (311)A and 89K for layers on (110). In addition, the possibility to overgrow cleaved (110) surfaces with GaMnAs of a high quality enables the growth of more complicated heterostructures like magnetic bipolar heterojunctions. We acknowledge the support by the DFG via SFB 689.