HL 26: III-V semiconductors I

Time: Tuesday 15:45–18:15 Location: EW 202

HL 26.1 Tue 15:45 EW 202

Current-regulated giant anisotropic magnetoresistance in ultra thin (Ga,Mn)As — •Rashid Gareev[1], Markus Schlapps[1], Janusz Sadowski[2], Werner Wegscheider[1], and Dieter Weiss[1] — [1]Institute of Experimental and Applied Physics, University of Regensburg, Universitätstrasse 31, 93040 Regensburg, Germany — [2]MAX-Lab, Lund University, 22100 Lund, Sweden

We describe the way to regulate giant anisotropic magnetoresistance (GAMR) in ultra thin (Ga,Mn)As by changing the amplitude of alternating current across a Hall bar. The GAMR effect is observed in the planar geometry of current below the metal-insulator transition (MIT) at T<10K in 5 nm-thick Ga0.95Mn0.05As films after annealing in optimized conditions. The GAMR manifests itself in magnetization-dependent high- and low-resistance states along different crystallographic directions. From the angular dependences of GAMR in magnetic fields of different orientation we show that in high resistive state holes are strongly localized. We demonstrate that in the localized regime a decrease of the current amplitude is accompanied by an enhancement of the GAMR. The longitudinal resistance(corresponds to the sheet resistance) change between non-equivalent easy axes exceeds ˜100% at a current amplitude I=0.2nA. The dependence of the GAMR on the current strength we ascribe to suppression of e-e interactions and hole delocalization by electric field.

HL 26.2 Tue 16:00 EW 202

Magnetic properties of GaMnN/AlGaN Heterostructures — •D. Mai, A. Bedoya Pinto, D. Ruttke, J. Malindretos, A. Rizzi, H. Schuhmann, and M. Seibt — IV. Physikalisches Institut and Virtual Institute of Spin Electronics (VISel), Georg-August-Universität Göttingen, D-37077 Göttingen, Germany

GaMnN is a prototype GaN-based dilute magnetic semiconductor. In the past we have carefully studied the growth process and epitaxial GaMnN layers with diluted concentration of Mn up to some percent have been grown. They reproducibly show a room temperature magnetization, however with a weak saturation M_S = 0.03 emu cm^{-3} and a small coercive field of 250 Oe. With the aim of investigating the effect of the Fermi level position relative to the Mn induced impurity band deep in the energy gap, AlGaN/GaMnN/AlGaN heterostructures have been grown. In fact due to the polarization charges at the interfaces a strong band bending is expected in the structure, which might change the Mn charge state in certain regions of the GaMnN layer. Magnetization measurements by SQUID show ferromagnetic behaviour at room temperature with saturation magnetization by a factor 40 higher than in the samples described above. Diverse heterostructure configurations have been characterized concerning the magnetic and electric properties and the results are discussed with reference to the assumed double-exchange mechanism for the magnetic coupling.

HL 26.3 Tue 16:15 EW 202

Electronic properties of ferromagnetic (Ga,Mn)As from a tight-binding model — •Marko Turek, Jens Siewert, and Jaroslav Fabian — Universität Regensburg

We present the results of several numerical investigations of bulk (Ga,Mn)As based on a tight-binding approach. In particular we study the density of states, the absorption rate and the inverse participation ratio as a function of the concentration of substitutional Mn-disorder. We find that the impurity band merges with the valence band for Mn concentrations larger than ˜1%. The Fermi-level lies within this impurity band. The impurity states show a significantly increased inverse participation ratio which reflects their localized character. This work is supported by the SFB 689.

HL 26.4 Tue 16:30 EW 202

Magnetic circular dichroism of Cr and Gd doped GaN — •David Wenzel[1,4], Klaus Schmalbuch[1,4], Bernd Beschoten[1,4], Gernot Güntherodt[1,4], Nicoleta Kaluza[2,4], Yong Suk Cho[2,4], Hilde Hardtdegen[2,4], Thomas Schäpers[2,4], Martin Röver[3,4], Jörg Malindretos[3,4], and Angela Rizzi[3,4] — [1]II. Physikalisches Institut, RWTH Aachen, Templergraben 55, 52056 Aachen — [2]Institut für Bio- und Nanosysteme IBN-1 Forschungszentrum Jülich, 52425 Jülich — [3]IV. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen — [4]Virtuelles Institut für Spinelektronik (VISel), Aachen-Jülich-Göttingen

We have investigated magnetic properties of Cr and Gd doped GaN epilayers grown by MOVPE and MBE, respectively. Ferromagnetism is observed in 0.1% Cr-doped samples with Curie temperatures exceeding 600 K.

Magnetic circular dichroism (MCD) has been studied in order to probe the involved magnetic states and to reveal the nature of the magnetic exchange interaction.

The Cr doped samples show large MCD at the band edge, which is typical for diluted magnetic semiconductors. In addition, there is a large MCD between 1.9 eV and 2.3 eV.

Similar spectral features are observed in Gd doped samples with doping concentrations up to 0.1% suggesting that the MCD is not directly linked to the magnetic dopants.

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HL 26.5 Tue 16:45 EW 202

Mn modulation-doped two-dimensional hole systems — •Ursula Wurstbauer, Matthias Habl, Dieter Schuh, and Werner Wegscheider — Institut für Experimentelle und Angewandte Physik, Universität Regensburg

In order to study the interplay of localized magnetic ions with low-dimensional charge carrier systems, we have fabricated Mn modulation-doped two-dimensional hole gases in the InGaAs/InAs material system and report on magnetotransport measurements herein. For preparation of such systems, we grow shallow single InAs quantum well (QW) structures on a strain relaxed buffer on GaAs substrates by molecular beam epitaxy. Our investigations are focused on the dependence on the doping density and the symmetry of the QW structures. Magnetotransport measurements at low temperatures exhibit pronounced SdH-oscillations in the longitudinal resistance and well developed Hall-plateaus in the Hall-resistance. Furthermore, the temperature dependent sheet resistivity increases dramatically at lower temperatures, indicating a strongly localized system for both, the inverted and double sided doped QW structures. These structures show in the mK region below a critical magnetic field insulating and hysteretic behaviour. Additional jumps in the resistance can be observed, indicating ferromagnetic interaction between the holes in the two-dimensional hole system and the magnetic moments of the Mn^{2+} ions.

HL 26.6 Tue 17:00 EW 202

Current pulse induced coherence of spin packets injected across a Fe/GaAs interface — •C. Schwark[1,5], J. Moritz[1,5], L. Schreiber[1,5], B. Beschoten[1,5], G. Güntherodt[1,5], M. Lepsa[2,5], C. Adelmann[3], C. Palmstrøm[3], and P. Crowell[4] — [1]II. Physikalisches Institut, RWTH Aachen, Templergraben 55, 52056 Aachen — [2]Institut für Bio- und Nanosysteme IBN-1, Forschungszentrum Jülich, 52425 Jülich — [3]Department of Chemical Engineering and Materials Science, University of Minnesota, Minneapolis, MN, USA — [4]School of Physics and Astronomy, University of Minnesota, Minneapolis, MN, USA — [5]Virtuelles Institut für Spinelektronik (VISel), Aachen-Jülich-Göttingen

Efficient electrical spin injection from a ferromagnet into a semiconductor has been demonstrated for various material systems by steady-state experiments. We introduce a novel time-resolved technique based on electrical pumping and optical probing. As a pump we apply ultrafast current pulses (≥ 200ps) to electrically inject spin packets from an iron layer through a reverse biased Schottky barrier into a 5 μm thick n-GaAs layer, which exhibits spin dephasing times exceeding 50 ns at 20 K. Probing the electrically injected spin packets by time-resolved Faraday rotation using a pulsed probe laser beam, we observe up to 10 lamor precessions and resonant spin amplification [1] in a transverse magnetic field. This evidences that the current pulses trigger the phase coherence of the electrically injected spin packets.

Work supported by BMBF, DFG, and HGF.

[1] J. M. Kikkawa et al., Phys. Rev. Lett. 80 (1998)

HL 26.7 Tue 17:15 EW 202

Observation of dynamic nuclear polarization in GaAs(001) quantum wells close to a GaMnAs layer — •R. Schulz, A. Wagner, T. Korn, U. Wurstbauer, D. Schuh, W. Wegscheider, and C. Schüller — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany

GaMnAs 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 AlGaAs barriers close to a ferromagnetic GaMnAs layer. The samples contain two QWs, where one QW (12nm width) is close to the GaMnAs layer, separated by a thin AlGaAs layer and a short-period superlattice AlAs/GaAs. The second QW (10 nm width) is farther away (120 nm) and serves as a reference.
Time-resolved Faraday rotation experiments reveal a significantly increased spin lifetime in the upper QW (12 nm) of about 3 ns compared to the lower QW (10 nm) of about 130 ps. This long spin lifetime causes a dynamic nuclear polarization via the hyperfine interaction and thus an effective magnetic field. By tilting the sample with respect to the pump beam, this effective magnetic field has an in-plane component, which may add to or subtract from an external in-plane magnetic field, changing the Larmor precession frequency of the electron spins depending on the sign of the magnetic field, the intensity and helicity of the circularly-polarized pump beam.
We acknowledge support by the DFG via project SCHU1171/1 and SFB 689 TP B4.

HL 26.8 Tue 17:30 EW 202

Intersubband Spin Relaxation Mechanism in n-doped [110] GaAs Quantum Wells — •Lena Schmid[1], Shijian Chen[1], Stefanie Döhrmann[1], Stefan Oertel[1], Dieter Schuh[2], Werner Wegscheider[2], Jens Hübner[1], and Michael Oestreich[1] — [1]Institute for Solid State Physics, Gottfried Wilhelm Leibniz University Hannover, Appelstr. 2, 30167 Hannover, Germany — [2]Institute of Experimental and Applied Physics, University of Regensburg, Universitätsstraße 31, 93040 Regensburg, Germany

The intersubband spin relaxation mechanism most likely represents the major spin dephasing channel in room temperature applications based upon heterostructures in (110) oriented GaAs for spins oriented along the growth direction.[1] The electron spin relaxation time τ_s in n-doped (110) GaAs/AlGaAs quantum wells is investigated by time- and polarisation-resolved photoluminescence measurements in dependence on the subband energy splitting and subband occupancy. The influence by the subband energy splitting on τ_s is deduced from well width dependent measurements, whereas different occupancies are adjusted by different sample temperatures. The n-doping suppresses the spin dephasing influence of holes created by the optical excitation. The (110) structure suppresses the Dyakonov-Perel relaxation mechanism for spins pointing in growth direction. Therefore the resulting spin relaxation times are long even at room temperature and the intersubband spin relaxation mechanism becomes the dominating spin relaxation mechanism.
[1] S. Döhrmann et al., Phys. Rev. Lett. **93**, 147405 (2004))

HL 26.9 Tue 17:45 EW 202

Current-induced spin polarization (CISP) in InGaAs monitored by Faraday-microscopy — •A. Müller[1,3], S. Glatthaar[1,3], S. Goebbels[1,3], K. Schmalbuch[1,3], B. Beschoten[1,3], G. Güntherodt[1,3], M. Hagedorn[2,3], and T. Schäpers[2,3] — [1]II. Physikalisches Institut, RWTH Aachen, Templergraben 55, 52056 Aachen — [2]Institut für Bio- und Nanosysteme IBN-1, Forschungszentrum Jülich, 52425 Jülich — [3]Virtuelles Institut für Spinelektronik (VISel), Aachen-Jülich-Göttingen

Most prominent methods to create spin-polarised carriers in semiconductors include optical orientation and electrical spin injection from a ferromagnetic electrode. A novel electrical method to create spin-polarised carriers without electric or magnetic fields has recently been demonstrated by Kato et al. [1]. The so-called Current-Induced-Spin-Polarisation (CISP) as observed in InGaAs is related to internal electric fields as a result of crystal strain in the material. We investigate the steady state spin polarisation in 160 μm wide Si-doped InGaAs channels grown on GaAs, with a cw laser using a high resolution Faraday microscope in Voigt geometry. Hanle images of the CISP are systematically acquired as a function of voltage, magnetic field, and temperature. Information on the spin dephasing times and the spatial homogeneity of the CISP is extracted from these measurements. Surprisingly, we observe symmetric Hanle curves in contrast to results by Kato et al. [1], demonstrating that the spins are oriented in the out-of-plane direction.
[1] Y. K. Kato et al., PRL 93, 176601 (2004)
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HL 26.10 Tue 18:00 EW 202

Interactions of space-charge waves with magnetic fields in the semiconductor InP:Fe — •Burkhard Hilling[1], Michaela Lemmer[1], Micro Imlau[1], Manfred Wöhlecke[1], Valerij Bryksin[2], and Mikhail Petrov[2] — [1]Department of Physics, University of Osnabrück — [2]Ioffe Physico-Technical Institute, St. Peterburg, Russia

We report on the interaction of space-charge waves (SCW) with magnetic fields in semi-insulating InP:Fe single crystals. SCW are eigenmodes of spatial-temporal oscillations of a space-charge density. The optical excitation of SCW is performed with an oscillating interference pattern at a wavelength of $\lambda = 514$ nm and externally applied static electric fields of several kV/cm. The interference pattern is generated with a two beam interferometer, where one of the beams is phase-modulated using an electro-optic modulator. An influence of the magnetic field of up to $B = 0.86$ T on the amplitude of the SCW is observed. This influence reveals a quadratic behavior and depends strongly on the orientation of the magnetic field. The observed dependences give strong evidence for a dominant contribution of the magnetoresistance to this effect. The dependence of the variations of the amplitude on the wavevector of the SCW implies that measurements with SCW inside a magnetic field can be more precise than ordinary techniques to determine the magnitude of the magnetoresistance. Furthermore, advantages of this technique for material analysis are discussed. Financial support from the Deutsche Forschungsgemeinschaft (GRK 695) is gratefully acknowledged.