HL 9: III-V semiconductors (other than nitrides)

Time: Monday 15:00–17:30 Location: EW 202

HL 9.1 Mon 15:00 EW 202

Resonant inelastic light scattering on indirect excitons and overflow of dipolar traps at high magnetic fields

— •Lukas Sponfeldner[1], Sebastian Dietl[1], Lukas Sigl[1], Katarzyna Kowalik-Seidl[2], Dieter Schuh[3], Werner Wegscheider[4], Jörg Kotthaus[2], Aron Pinczuk[5], Ursula Wurstbauer[1], and Alexander W. Holleitner[1] — [1]Walter Schottky Institut und Physics Department, Am Coulombwall 4a, Garching, TU Munich, Germany. — [2]Center for Nanoscience and Fakultät für Physik, LMU, Germany. — [3]Institute of Experimental and Applied Physics, University of Regensburg, Germany. — [4]Solid State Physics Laboratory, ETH Zurich, Switzerland. — [5]Department of Applied Physics and Applied Mathematics, Columbia University, New York, USA.

We present resonant inelastic light scattering (RILS) studies to explore the many-body quantum phase diagram and respective phase transitions of indirect excitons (IXs). The photogenerated IXs are confined in very clean GaAs double quantum well structures and electrostatically trapped by local gate electrodes. The IXs coexist with a photogenerated excess 2D hole system located in one of the quantum wells. The RILS studies of such ensembles reveal a collective excitation mode at the transferred in-plane momentum and an energy of only 0.44 meV at low temperatures. The mode is consistent with a plasma excitation of the 2D excess holes coherently coupled to the IXs.

HL 9.2 Mon 15:15 EW 202

Carbon doping of GaAs grown by molecular beam epitaxy on GaAs(100) and GaAs(111)B

— •Alexander Trapp, Tobias Henksmeier, and Dirk Reuter — Optoelektronische Materialien und Bauelemente, Universität Paderborn, 33098 Paderborn, Germany

Bipolar devices, e. g., diodes, require n- as well as p-type doping. In GaAs, a material important for optoelectronic applications, carbon, beryllium, zinc and silicon are possible acceptors. Carbon is especially attractive because of its low diffusivity, very weak amphoteric behavior and high solubility in GaAs. Carbon doping in molecular beam epitaxy (MBE) grown GaAs(100) employing a solid source for carbon is already well studied. However, for GaAs(111)B this has not been studied so far.

In this work we compare the incorporation of carbon into GaAs grown on GaAs(100) and GaAs(111)B with a 1° miscut towards (211). A carbon sublimation source, where a pyrolytic graphite filament is directly heated by an electric current, is used to generate the carbon flux. GaAs layers with carbon concentrations from 10^{16} to 10^{19} per cm^3 have been grown by solid source MBE. The samples are characterized by temperature-dependent Hall measurements using the van-der-Pauw method and photoluminescence spectroscopy. It is shown that the activation energy of the p-dopant found in GaAs(100) and GaAs(111)B are nearly identical. The dependence of free carrier concentration on the surface orientation is weak and will be discussed in detail.

HL 9.3 Mon 15:30 EW 202

Magnetic properties of InP wurtzite nanowires from theory: g-factors and exciton Zeeman splitting

— •Paulo E. Faria Junior[1], Davide Tedeschi[2], Marta De Luca[2,3], Benedikt Scharf[1,4], Antonio Polimeni[2], and Jaroslav Fabian[1] — [1]University of Regensburg — [2]Sapienza Università di Roma — [3]University of Basel — [4]University of Würzburg

Spin-dependent phenomena in III-V wurtzite (WZ) semiconductor nanowires (NWs) have recently attracted great attention. For instance, recent experiments showed that InP WZ NWs exhibit an unconventional and unexplained nonlinear Zeeman splitting (ZS) under high magnetic fields[1,2]. Starting with a robust k.p Hamiltonian[3], we investigate the magnetic properties of InP in the WZ phase, specifically focusing on g-factors and excitonic ZS. Our calculated values of effective g-factors are in excellent agreement with experimental data[1,2] and also show the independent contributions of electron and hole g-factors, typically entangled in experiments due to excitonic effects. Regarding the nonlinear ZS of excitons in large magnetic fields, we showed that the origin for such nonlinearity is the interaction between heavy and light hole bands with spin up from different Landau level indices[2,4]. [1] De Luca et al., Nano Lett. 14, 4250 (2014). [2] Tedeschi et al., in preparation. [3] Faria Junior et al., PRB 93, 235204 (2016). [4] Faria Junior et al., in preparation. Supported by: Alexander von Humboldt Foundation, Capes, DFG SFB 689, DFG SFB 1170, ENB Topological Insulators, Awards2014 and Avvio alla Ricerca (Sapienza Università di Roma).

HL 9.4 Mon 15:45 EW 202

Mutual Indirect Exciton Interactions in Double Quantum Well Stacks

— •Colin Hubert[1], Yifat Baruchi[2], Yotam Harpaz[2], Kobi Cohen[2], Ronen Rapaport[2], and Paulo Santos[1] — [1]Paul Drude Institut, Berlin, Deutschland — [2]Racah Institut, Jerusalem, Israel

Indirect excitons (IXs) in double quantum well (DQW) structures subjected to a transverse electric field Ez form dipoles oriented along the field direction. The interaction between intraplanar IXs, i.e. IXs in the same DQW, is always repulsive. If, however, the IXs are placed in two different DQWs stacked along the z direction, the interaction becomes attractive as the dipoles orient themselves coaxially.

We have investigated the attraction between IXs in stacked DQW in GaAs structures by spatially resolved photoluminescence spectroscopy. The experiments are carried out by selectively exciting IXs in each of the two DQWs using tunable laser beams. Specifically the population in one of the wells is perturbed locally, while surrounded by a reservoir of IXs in the second well, whose population is kept constant. By observing the corresponding changes in density in the second DQW, we show the existence of the attractive interplanar interaction. The effect increases with increasing IX density. Single indirect exciton pairs in coupled DQWs stacks are predicted to have a very low binding energy of 0.2 meV. The IXs at high density show larger energy shifts and can reach as large as 4 meV. We will present both these results and our current understanding of interactions that cause a larger than predicted binding energy, especially at higher densities.

HL 9.5 Mon 16:00 EW 202

Phase coherent transport and spin-orbit coupling in GaAs/InSb core/shell nanowires

— •Anna Linkenheil[1,2], Patrick Zellekens[1,2], Thorsten Rieger[1,2], Nataliya Demarina[1,2], Hans Lüth[1,2], Mihail Ion Lepsa[1,2], Detlev Grützmacher[1,2], and Thomas Schäpers[1,2] — [1]Peter Grünberg Institute, Forschungszentrum Jülich — [2]JARA Fundamentals of Future Information Technology (FIT)

InSb nanowires are very interesting for future spin-based devices because of the large g-factor and the strong spin-orbit coupling. Furthermore, InSb has the highest electron mobility of all III/V semiconductors. However, growing bulk InSb nanowires directly was found to be very difficult. In order to tackle this issue we introduced a new concept, where InSb is grown as a shell around a GaAs nanowire core. At room temperature the GaAs/InSb nanowires were conductive, revealing an ambipolar behavior depending on the shell thickness and gate voltage.

We conducted low temperature transport measurements on GaAs/InSb core/shell nanowires. In a perpendicular magnetic field information on phase coherence length and spin-orbit coupling strength was extracted from weak antilocalization and universal conductance fluctuation measurements. In an axially oriented magnetic field Aharonov-Bohm-type conductance oscillations were observed. They are caused by angular momentum states in the InSb shell, representing the radial component of the electron propagation through the nanowire. They are thus directly related to the dimensions of the InSb shell.

15 min. break.

HL 9.6 Mon 16:30 EW 202

AlAsSb/GaSb Double Barrier Quantum Well Resonant Tunneling Diodes with Ternary Prewell-Emitters

— •Andreas Pfenning[1], Georg Knebl[1], Robert Weih[1], Manuel Meyer[1], Andreas Bader[1], Monika Emmerling[1], Lukas Worschech[1], and Sven Höfling[1,2] — [1]Technische Physik, Physikalisches Institut and Röntgen Center for Complex Material Systems (RCCM), Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany — [2]SUPA, School of Physics and Astronomy, University of St. Andrews, St. Andrews, KY16 9SS, United Kingdom

Recently, we proposed and demonstrated for the first-time room temperature resonant tunneling in GaSb-based double barrier quantum well resonant tunneling diodes (RTDs) by electron injection from ternary GaInSb and GaAsSb prewells. In the present study, we investigate the impact of an increasing As concentration in the emitter prewell on the electrical transport characteristics of these resonant tunneling diodes over a broad temperature range. We observe that room temperature resonant tunneling can be boosted up to 2.4 by increasing the As mole fraction up to 11 % and attribute this to an enhanced population of the Γ-valley within the emitter prewell. The incorporation of As in the tunneling structure however degrades the crystal quality as observed by the resonant tunneling characteristic obtained at cryogenic temperatures that leads to enhanced defect scattering at the interfaces and hence lowers the PVCR.

HL 9.7 Mon 16:45 EW 202

Increased sensitivity of spin noise spectroscopy using homodyne detection in n-doped GaAs — •Aleksandr Kamenskii[1], Mikhail Petrov[2], Dmitry Smirnov[3], Manfred Bayer[1], and Alex Greilich[1] — [1]Experimentelle Physik 2, Technische Universität Dortmund, 44221 Dortmund, Germany — [2]Spin Optics Laboratory, Saint Petersburg State University, 198504 St. Petersburg, Russia — [3]Ioffe Physical-Technical Institute, Russian Academy of Sciences, 194021 St. Petersburg, Russia

Optical spin noise spectroscopy is a minimally invasive method of obtaining dynamical information on carrier spins by measuring mesoscopic time-dependent spin fluctuations [1-3]. We implement the homodyne detection scheme to increase the polarimetric sensitivity of the spin noise spectroscopy. Controlling the laser intensity of the local oscillator, which travels around the sample and does not perturb the measured spin system, we are able to amplify the signal. This opportunity of additional amplification allows us to reduce the probe laser intensity incident onto the sample and therefore to approach a nonperturbative regime. The efficiency of this scheme with enhancement of the detected signal by more then a factor 3 at low probe powers is demonstrated on bulk n:GaAs. Additionally, the control of the optical phase provides us a possibility to switch between the measurements of Faraday rotation and Faraday ellipticity without changes in optical elements. [1] Crooker et al., Nature 431, 49 (2004). [2] Li et al., New J. Phys. 15, 113038 (2013). [3] Lucivero et al. Phys. Rev. A 93, 053802 (2016).

HL 9.8 Mon 17:00 EW 202

Infrared nanoscopy on Si-doped GaAs-InGaAs core-shell nanowires — •Denny Lang[1,2], Leila Balaghi[1,3], Emmanouil Dimakis[1], René Hübner[1], Susanne C. Kehr[2], Lukas M. Eng[2,3], Stephan Winnerl[1], Harald Schneider[1], and Manfred Helm[1,2,3] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Germany — [2]Technische Universität Dresden, Germany — [3]cfaed - Center for Advancing Electronics Dresden, Germany

Semiconductor-based nanowires (NWs) are highly promising nm-sized building-blocks for future (opto-)electronic devices (i.e. photovoltaics, LEDs, THz detectors, polarizers, and lasers). Knowledge on the electrical characteristics of individual NWs is mandatory for any such application. Here, we investigate the plasma resonance of the free charge carriers in Si-doped GaAs-InGaAs core-shell NWs by applying scattering-type scanning near-field infrared microscopy (s-SNIM [1]) in the mid- to far-infrared wavelength range [2]. The shell doping may be varied over a broad range, revealing a plasma resonance around 10 μm for the highest doping level [3]. We compare IR-s-SNIM results obtained by both a CO_2 laser and the pulsed free-electron laser light source, and observe a power-dependent red-shift of the plasma resonance, most probably arising through nonlinear effects such as intervalley scattering [4] occurring in strong electric fields.

[1] Stiegler, J. M. et al. Nano Lett. 10, 1387−1392 (2010).
[2] Kuschewski, F. et al., Appl. Phys. Lett. 108, 113102 (2016).
[3] Dimakis, E. et al., Nano Res. 5, 796−804 (2012).
[4] Razzari, L. et al., Phys. Rev. B 79, 193204 (2009).

HL 9.9 Mon 17:15 EW 202

Properties of In-Plane Gate transistors for use in sensing gaseous and liquid dielectric environments. — •Benjamin Feldern, Sascha R. Valentin, Arne Ludwig, and Andreas D. Wieck — Angewandte Festkörperphysik, Ruhr-Universität Bochum, Bochum, Germany

For the purpose of sensing dielectrics, In-Plane-Gate (IPG) transistors are written in Gallium-Arsenide based high-electron-mobility-transistor (HEMT) structures using focused ion beam (FIB) implantation. These FIB-implanted IPGs are to be used to sense dielectrics in different compositions.

Using the Petrosyan-Stikh formula for the depletion length of the implanted region in addition to the representation of the IPG by a parallel-plate geometry by de Vries and Wieck, the dielectric constant of the environment can be calculated and analysed. Additionally, varied mobility of the underlying HEMT is taken into consideration. We demonstrate an influence of the dielectric on the properties, while a quantitative analysis still shows some deviations.

Beyond this, also surface treatments were performed and tested on their influence of the sensing capability. It was found that surface depletion was increased by both exposure of the IPGs to a N_2-Plasma as well as dipping in N_2H_8S.

Simulations of the electric field reveal the influence of the geometry and the charge carrier density in the HEMT.