HL 4: III-V semiconductors: mainly wells and surfaces

Time: Monday 9:30–12:30 Location: H15

HL 4.1 Mon 9:30 H15

Modulating plasmons in two-dimensional hole gas systems by spin-orbit interactions — •Andreas Scholz, Tobias Dollinger, Paul Wenk, Klaus Richter, and John Schliemann — Institute for Theoretical Physics, University of Regensburg, Germany

We study the dynamical dielectric function of a two-dimensional hole gas, exemplified on [001]-GaAs and InAs quantum wells, within the four band Luttinger model including bulk and structure inversion asymmetric terms. The plasmon dispersion shows a pronounced anisotropy for GaAs and InAs based systems. In GaAs this leads to a suppression of plasmons due to Landau damping in some orientations while others are virtually undamped. Due to the large Rashba contribution in InAs based heterostructures, the lifetime of long-wavelength plasmons can be controlled efficiently by changing the electric field. This effect might be useful in plasmon field effect transistors as already proposed for electron gases.

HL 4.2 Mon 9:45 H15

Spin dynamics in high-mobility (110) GaAs-based quantum wells — •Roland Völkl[1], Tobias Korn[1], Markus Schwemmer[1], Michael Griesbeck[1], Sergey Tarasenko[2], Dieter Schuh[1], Werner Wegscheider[3], and Christian Schüller[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg — [2]A. F. Ioffe Physical-Technical Institute, Russian Academy of Sciences, St. Petersburg, Russia — [3]ETH Zurich, Switzerland

Here, we present a study of electron spin dynamics in symmetrical, high mobility (110)-grown, GaAs-based quantum wells. The Hanle-MOKE method is used to determine the spin lifetime and the spin polarization of electrons. These properties are studied regarding to changing parameters like temperature or pump power. Additionally the electron density can be tuned using the optical gating technique. Samples with a quantum well width of 20 nm and 30 nm are investigated. In the 30 nm quantum well the Bir-Aronov-Pikus mechanism is dominating, in the investigated temperature range between 4 and 60 K therefore high excitation intensity leads to a faster decay of electron spins. In the 20 nm quantum well this behavior is found at temperatures above 30 K. Below this temperature the Dyakonov-Perel mechanismus dominates. This results in an increase of the spin lifetime for increasing excitation intensities. Financial support by the DFG via SFB 689 and SPP 1285 is gratefully acknowledged.

HL 4.3 Mon 10:00 H15

Coherence measurements of dipolar, indirect excitons — J. Repp[1,2], •S. Dietl[1], G.J. Schinner[2], E. Schubert[2], A.K. Rai[3], D. Reuter[3], A.D. Wieck[3], A.O. Govorov[4], A. Högele[2], J.P. Kotthaus[2], and A.W. Holleitner[1] — [1]Walter Schottky Institut and Physik Department, Technische Universität München — [2]Fakultät für Physik and Center for Nanoscience, Ludwig-Maximilians-Universität München — [3]Angewandte Festkörperphysik, Ruhr-Universität Bochum — [4]Department for Physics and Astronomy, Ohio University, Athens, Ohio 45701, USA

We report on electrostatically widely tunable trapping devices for dipolar indirect excitons in InGaAs-based double quantum wells. Resonantly excited direct excitons transform into such indirect excitons which are then collected in electrostatically shaped energy landscapes. With their electron and hole confined to two different quantum wells, these indirect excitons exhibit a large dipole moment and long lifetimes. Employing a 3He-cooled confocal microscope at temperatures below 250 mK, we generate indirect excitons at a location outside the traps and measure their photoluminescence from the trap center after they have been cooled to lattice temperatures. Since the thermal de Broglie wavelength exceeds the excitonic separation in this temperature regime, many-body correlations between trapped indirect excitons are expected. We report on measurements of the temporal and spatial coherence of the emitted photoluminescence and discuss the coherence of the exciton ensemble.

HL 4.4 Mon 10:15 H15

MOVPE-growth and characterisation of GaPN/Si(100) for photoelectrolysis — •Helena Stange[1,2], Oliver Supplie[1,2], Matthias M. May[1,2], Christian Höhn[1], Wolf-Dietrich Zabka[1,2], Christian Koppka[3], Katja Tonisch[3], Henning Döscher[1,3,4], and Thomas Hannappel[1,3,5] — [1]Helmholtz-Zentrum Berlin, Institute of Solar Fuels — [2]Humboldt-Universität zu Berlin — [3]TU Ilmenau, Institut für Physik, Fachgebiet Photovoltaik — [4]NREL, Golden, USA — [5]CiS Forschungsinstitut für Mikrosensorik und Photovoltaik, Erfurt

Among III-V semiconductors, the dilute nitride GaPN offers a bandgap close to the optimum for the top cell of a photoelectrochemical tandem device with Si as bottom cell [1,2]. Bandgap engineering permits to adjust the bandgap of GaP to a suitable value by the incorporation of N, while simultanouesly converting it to a direct semiconductor [3] and achieving lattice match to Si. We used reflection anisotropy spectroscopy (RAS) and mass spectrometry to monitor GaP and GaPN growth on Si(100) in situ during metalorganic vapour phase epitaxy. Via a contamination-free transfer system, we related RAS results with UHV surface science techniques, such as low-energy electron diffraction and photoelectron spectroscopy. We applied high-resolution X-ray diffraction and AFM ex situ to analyse the dependence of crystal quality and surface morphology on MOVPE-parameters such as growth temperature, growth rate, P/N ratio and annealing conditions.
[1] Döscher et al., *ChemPhysChem* **13** (2012) 2899. [2] Geisz et al., *EUPVSEC* **19** (2004). [3] Wu et al., *PRB* **65** (2002) 241303.

HL 4.5 Mon 10:30 H15

Study of the disorder effects in Ga(AsBi) single quantum wells — •Mohammad Khaled Shakfa[1], Dimitri Kalincev[1], Alexey Chernikov[1], Sangam Chatterjee[1], Xianfeng Lu[2], Shane R. Johnson[2], Dan A. Beaton[3], Thomas Tiedje[4], and Martin Koch[1] — [1]Department of Physics and Materials Sciences Center, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany — [2]Department of Electrical Engineering, Arizona State University, Tempe, Arizona 85287-6206, United States — [3]Department of Physics and Astronomy, University of British Columbia, Vancouver, British Columbia V6T 1Z4, Canada — [4]Department of Electrical and Computer Engineering, University of Victoria, Victoria, British Columbia V8W 3P6, Canada

Ga(AsBi) semiconductor alloys have attracted increasing interest in recent years due to their special physical properties and potential application in optoelectronic and spintronic devices. These materials typically exhibit a certain degree of disorder due the potential fluctuation associated with the Bi content and to the existence of Bi clusters within the alloy structure. Here, we report on the studies to clarify the impact of the Bi content on disorder effects in Ga(As1-xBix)/GaAs SQWs. The experimental techniques employed are continuous-wave and time-resolved photoluminescence. Two theoretical models are used to quantify the disorder parameters: Firstly, a simple model with a single energy scale based on the carrier dynamics at very low temperatures. Secondly, a model of hopping excitons with two energy scales based on the features of the PL spectra.

HL 4.6 Mon 10:45 H15

Temperature-dependent external quantum efficiency of Ga(NAsP) quantum wells — •Robin Döring[1], Nils Rosemann[1], Bernardette Kunert[2], Wolfgang Stolz[1,2], Kerstin Volz[1], and Sangam Chatterjee[1] — [1]Faculty of Physics and Materials Sciences Center, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany — [2]NAsP III/V GmbH, Am Kechtacker 19, D-35041 Marburg, Germany

Silicon is the basis for today's microelectronics and even some optoelectronic components such as waveguides; however, it is not considered useful as an active medium for lasers due to the nature of its indirect bandgap. Various approaches have been pursued to add this functionality to Si microelectronics such as Raman-or nanocrystal-based concepts both native to silicon or hybrid integration. An alternative concept is the quasi-lattice matched integration of direct-gap GaP based quaternary alloys. Here, electrically pumped lasing has already been demonstrated[1]. Nevertheless, many challenges such as low-temperature operation and comparatively large laser thresholds remain. To help tackle these, we investigated a series of Ga(NAsP)/GaP multiple quantum well (MQW) samples by temperature-dependent absolute photoluminescence spectroscopy using an integrating sphere mounted inside a cryostate. The results are compared to a standard laser material, a high-quality (GaIn)As/GaAs MQW. At low temper-

atures, the reference sample outperforms the Ga(NAsP) structures. While the EQEs of both materials are comparable at room temperature for our experimental conditions. [1]Appl. Phys. Lett. 99, 071109, (2011)

Coffee break

HL 4.7 Mon 11:15 H15

Bandgap modification of GaP and GaAs achieved by N-implantation and ultra-short thermal treatment — •Kun Gao, Slawomir Prucnal, Wolfgang Skorupa, Manfred Helm, and Shengqiang Zhou — Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), P.O. Box 510119, 01314 Dresden, Germany

The giant band gap bowing effect observed in III-V dilute nitride alloys is promising for modification of III-V semiconductors to increase their flexibility in virtue of the strong electronegativity and small size of nitrogen atoms.

In this contribution we present the bandgap modification of GaAs and GaP by N-implantation followed by flash lamp annealing (FLA) and pulsed laser melting (PLM). In both GaAs and GaP wafers, N was implanted to form a 100 nm thick layer on top with an atomic concentration of about 1 %. After implantation, within the as-implanted range, both GaAs and GaP become amorphous. Post-implantation thermal treatment (FLA for GaAs:N and PLM for GaP:N) leads to the recrystallization of GaAs and GaP, as well as the incorporation of the N atoms into the lattice effectively, which is confirmed by micro-Raman and photoluminescence studies. The results show that about 40 % of the implanted N atoms are successfully incorporated into the lattice. According to our investigation, ion-implantation followed by ultrashort thermal treatment, which is quite efficient and low-cost, exhibits a promising prospect on bandgap engineering of semiconductors.

HL 4.8 Mon 11:30 H15

Indirect Excitons transport and manipulation in Double Quantum Wells — •Adriano Violante[1], Snežana Lazić[2], Klaus Biermann[1], Rudolph Hey[1], Paulo Santos[1], Kobi Kohen[3], and Ronen Rapaport[3] — [1]Paul-Drude-Institut für Festkörperelektronik, Berlin, Germany — [2]Departamento de Física de Materiales, Universidad Autónoma de Madrid, Madrid, Spain — [3]Racah Institute of Physics, Hebrew University of Jerusalem, Jerusalem, Israel

A spatially indirect exciton (IX) is a bound state of an electron and a hole localized in different quantum wells of a double quantum well structure. Due to their long lifetimes and strong non-linear properties arising from dipole-dipole interactions IXs are particularly interesting for applications in optoelectronic devices [1]. In this contribution, we demonstrate that a high degree of control of IX fluids can be obtained by combining their manipulation via electrostatic gates with the long - range IX transport achieved by Surface Acoustic Waves (SAW). The moving type-I band-gap modulation induced by the SAW strain field traps and transports the long-living IXs [2]. The spatial and energetic distributions of IXs are investigated using spatially and spectrally resolved photoluminescence. In addition, time resolved techniques are used to study the space and temporal dynamics of the IXs packets transported by SAW.

[1] A. A. High et al., Science 321, 229-231 (2008)

[2] J. Rudolph, R. Hey and P. V Santos, Phys. Rev. Lett. 99, 047602[4] (2007)

HL 4.9 Mon 11:45 H15

Interaction of potassium with InN(0001)-(2×2)-surfaces — •Stephanie Reiss, Anja Eisenhardt, Stefan Krischok, and Marcel Himmerlich — Institut für Physik and Institut für Mikro- und Nanotechnologien, TU Ilmenau, PF 100565, 98684 Ilmenau, Germany

In this work we investigate the interaction of potassium with InN(0001)-(2×2)-surfaces. The 2×2 reconstructed InN-films were grown by plasma assisted molecular beam epitaxy (PAMBE) on GaN/Sapphire-templates. Immediately after epitaxy the samples were in-situ characterised by photoelectron spectroscopy (PES). Potassium was offered via an alkali metal dispenser while performing PES-measurements. The potassium adsorption leads to a strong reduction of the work function of the InN indicating the formation of a positive potassium-induced surface dipole acting as an electron donator. In parallel, the core levels and valence band (VB) maximum shift by 0.2 eV towards lower binding energies. Thus potassium adsorption leads to a reduction of the surface downward band bending from originally 0.6 eV to 0.4 eV. Furthermore, complex changes in the valence band region are observed and will be discussed with particular emphasis on the occupied states close to E_F. Here, the potassium adsorption leads to the appearance of new states at 1.2 eV and 0.6 eV whereas a depletion of the surface state at the Fermi edge caused by the 2×2-surface reconstruction is observed.

HL 4.10 Mon 12:00 H15

Influence of adsorbates on the surface electronic properties of polar InN — •Anja Eisenhardt, Stephanie Reiss, Stefan Krischok, and Marcel Himmerlich — Institut für Physik and Institut für Mikro- und Nanotechnologien, TU Ilmenau, PF 100565, 98684 Ilmenau, Germany

Thin stoichiometric InN(0001)-2×2 (In-polar) and InN(000-1) (N-polar) samples were grown by plasma-assisted molecular beam epitaxy and in-situ characterized by photoelectron spectroscopy (XPS, UPS). While the InN(0001)-2×2 surface shows a valence band maximum (VBM) to Fermi-level distance (E_F - VBM) of 1.4 eV, indicating a strong surface electron accumulation, the band bending at the InN(000-1) surfaces is reduced (E_F - VBM $\sim$ 1.0 eV). This difference can be microscopically explained by surface states that influence the position of the surface Fermi level. For InN(0001)-2×2 they are located above the conduction band minimum while at InN(000-1) an occupied surface state is located at the VBM. We will show how the interaction with adsorbates (especially oxygen and water) and the corresponding dipole formation change the surface electronic properties and the band alignment at InN surfaces. At In-polar InN surfaces, oxygen adsorbates as electron acceptors strongly reduce the electron accumulation due to the interaction with the free dangling bonds of the In-adatoms. At N-polar InN surfaces, oxygen has no further impact on the already reduced band bending. Water instead tends to increase the downward band bending at N-polar InN surfaces, while it has minor effect on the initial band alignment at In-polar InN surfaces.

HL 4.11 Mon 12:15 H15

Si–doping of AlGaN with high aluminum mole fractions by MOVPE — •F. Mehnke[1], T. Wernicke[1], C. Kuhn[1], C. Reich[1], J. Stellmach[1], F. Brunner[2], V. Kueller[2], A. Knauer[2], M. Weyers[2], and M. Kneissl[1,2] — [1]Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany

Currently one of the main challenges of III–nitride growth is the doping of AlGaN layers with high aluminum mole fraction. Only very few reports exist that show conductive AlGaN:Si layers with an aluminum content of more than 80 %. In this contribution we will present a study on the influence of the aluminum content and the SiH_4 supply on the resistivity and the optical properties of silicon doped $Al_xGa_{1-x}N$ layers ($0.8 < x < 1$) grown pseudomorphically on defect reduced AlN–sapphire templates. With increasing aluminum content the resistivity increases exponentially but even for $Al_{0.95}Ga_{0.05}N$ n–conductivity is observable with a resistivity of 4.3 Ω cm. Defect luminescence at 4.4 eV was observed by photoluminescence measurements (PL) becoming more dominant with increasing aluminum content and shifting towards higher energy. By increasing the SiH_4 supply during the growth of $Al_{0.82}Ga_{0.18}N$ layers a minimum resistivity of 0.026 Ω cm was obtained. By further increasing the SiH_4 supply the resistivity increased strongly. PL show dominant defect luminescence at 3 eV hinting to a compensation by point defect formation e.g. group–III vacancies or vacancy–oxygen–complexes.