HL 3: Heterostructures

Time: Monday 10:15–12:45 Location: BEY 154

HL 3.1 Mon 10:15 BEY 154

Optical Modes in ZnO Nano-Pillar Resonators — •Annekatrin Hinkel, Rüdiger Schmidt-Grund, Helena Hilmer, Jesús Zúñiga Pérez, Chris Sturm, Christian Czekalla, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Linnéstraße 5, 04103 Leipzig, Germany

We report on cylindrical resonators, whose cavities are made of ZnO nano-wires with diameters of (50 ... 700) nm and length in the range of 10 μm . The cavities, simultaneously acting as active medium, are coated with concentric cylindrical shell Bragg reflectors (BR) consisting of 10.5 pairs of YSZ and Al_2O_3. The ZnO nano-wires and the BRs have been fabricated by using two-step pulsed laser deposition in the high- and low-pressure regime, respectively. Both, photoluminescence and reflectivity measurements were performed on the lateral surface of the wires in dependence on the wire diameter, the temperature and the exit angle and polarization of the light. The spectroscopic features can be assigned to exciton-polariton branches in photonic wires.

Exciton-polaritons are a subject of current research. Because of its large exciton oscillator strength and binding energy, polaritons in ZnO are stable at room temperature and above. In photonic wires the photonic modes are 2D quantized, leading to modification of spontaneous emission and radiative recombination rates with respect to the 1D quantized case. Especially, lateral leakage of energy can be strongly restricted. Furthermore, the amount of polariton branches is increased. As interbranch scattering is possible, condensation of polaritons in the ground state would be enhanced.

HL 3.2 Mon 10:30 BEY 154

Successful fabrication of h-BN/ZnO heterojunction diodes — •Marc Brötzmann, Hayo Zutz, Anne-Katrin Nix, and Hans Hofsäss — II. Institute of Physics, University of Göttingen

In this work we investigated the electrical properties of h-BN/ZnO-heterostuctures. For this purpose several h-BN-films with thicknesses between 60nm and 80nm were grown on ZnO-substrates using Mass Separated Ion Beam Deposition (MSIBD). The deposition was performed with a substrate-bias of 100eV at room temperature.

The electrical properties were investigated using a two point measurement to record current-voltage (I-U) characteristics in the temperature range of 20-300K. The devices show a distinctive diode characteristic with threshold voltages of 6-8V and breakdown voltages of about 60-80V. We can not verify any satisfying agreement with common conduction mechanisms; therefore an extended conduction model based on the Shockley theory has been developed. In addition we observe huge ideality factors in the range of 75-160 due to high defect density (verified using Transmission Electron Microscopy measurements) and a resulting strong recombination current.

In this presentation we will discuss the development of the conduction model on the basis of temperature dependent I-U characteristics and TEM-measurements. In Addition, first results on photoconductivity behavior are also presented.

HL 3.3 Mon 10:45 BEY 154

Formation of Exciton-Polaritons up to 410 K in ZnO based planar resonators — •Chris Sturm, Helena Hilmer, Rüdiger Schmidt-Grund, Christian Czekalla, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Linnéstraße 5, 04103 Leipzig

Exciton-polaritons are quasi particles formed by the coupling of excitons with photonic modes. They can undergo a Bose-Einstein-Condensation (BEC) even at elevated temperatures; for ZnO based resonators the critical temperature at which BEC can occur was predicted up to 560 K. In this work we will present the observation of exciton-polaritons in a ZnO based resonator up to 410 K. This represents the first observation of exciton-polaritons above room temperature. The resonator consists of a half wavelength ZnO microcavity [1] embedded between two Bragg reflectors made of 10.5 layer pairs of YSZ and Al_2O_3. The exciton-polaritons were observed by means of photoluminescence (PL) and reflectivity (R) measurements at temperatures $(10 - 410)$ K. Taking into account the coupling between only one exciton mode and one cavity-photon mode we were able to describe the observed polariton dispersion as well as its broadening behaviour. Thereby, we obtain a Rabi splitting of about 95 meV (R) and about 90 meV (PL) at 10 K. Furthermore, non-resonant excitation dependent PL measurements of the resonator yield a saturation of the occupation of the ground state, i.e. there is a saturation of the relaxation from an excited state to the ground state.

[1] R. Schmidt-Grund *et al.*, Appl. Phys. B **93**, 331 (2008).

HL 3.4 Mon 11:00 BEY 154

Influence of strain on Mn codoped 2DHGs — •Ursula Wurstbauer[1,2], Stefan Knott[1], Werner Wegscheider[2], and Wolfgang Hansen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, 220355 Hamburg — [2]Institut für Experimentelle und Angewandet Physik, Universität Regensburg, 93040 Regensburg

The properties of two-dimensional hole gases (2DHG) in a strained InAs quantum well structure strongly depend on the interaction of magnetic moments with itinerant holes. For low-temperature magnetotransport experiments weakly Mn codoped InAs QWs with InGaAs/InAlAs barriers and modulation-doped with Mn and/or C are grown on (001) GaAs substrates by means of molecular beam epitaxy. Metamorphic step graded buffer layers are used for strain engineering. The strain in the doping layer and QW can be precisely tailored by changing the In concentration in the buffer and the distance between buffer and active region. In the magnetic 2DHGs the strain plays an important role because band structure, incorporation of the Mn ions as well as orientation of their magnetic moments are strongly affected by the strain situation in the active QW region. We report on a detailed study of the impact of strain on morphology, doping efficiency and low-temperature magnetoresistance behaviour of such Mn co-doped 2DHGs.

HL 3.5 Mon 11:15 BEY 154

Dynamics of Dipolar Excitons in Coupled GaAs Quantum Wells — •Xaver Vögele[1], Dieter Schuh[2,3], Werner Wegscheider[2], Alexander Holleitner[1,3] und Jörg Kotthaus[1] — [1]Center for NanoScience, Ludwig-Maximilians-Universität, D-80539 München — [2]Institut für Angewandte und Experimentelle Physik, Universität Regensburg, D-93040 Regensburg — [3]Technische Universität München, Walter Schottky Institut, 85748 Garching

Photo-generated electron-hole pairs in double quantum well devices can be manipulated both in lifetime and position via a mesoscopic voltage-controlled electrostatic landscape. The quantum-confined Stark effect allows us to create long-living indirect excitons[1].

Recently, we demonstrated a novel electrostatic trap for indirect excitons in coupled GaAs quantum wells embedded in a field-effect device. There, the indirect excitons are trapped in the quantum wells just below the perimeter of SiO2-layers, which are sandwiched between the surface of the GaAs heterostructure and a semitransparent metallic top gate[2].

Here, we present time resolved measurements on the dynamics of the excitons inside the trap. We find that the expansion of the trapped excitons occurs on a much shorter time-scale than in the untrapped case. We attribute this to effective screening of quantum well disorder.

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[1] A. Gärtner et al. Appl. Phys. Lett 89, 052108 (2006). [2] A. Gärtner et al. Phys. Rev. B 76, 085304 (2007).

15 min. break

HL 3.6 Mon 11:45 BEY 154

High-Quality AlGaAs/GaAs Quantum Well-Microcavities for Exciton-Polariton Studies — •Arash Rahimi-Iman[1], Georgius Roumpus[2], Christian Schneider[1], Sven Höfling[1], Stephan Reitzenstein[1], Alfred Forchel[1], and Yoshihisa Yamamoto[2] — [1]Technische Physik, Universität Würzburg, D-97074 Würzburg, Germany — [2]E. L. Ginzton Laboratory, Stanford University, Stanford, CA 94305-4088, USA

In a semiconductor microcavity with embedded quantum wells (QWs) new eigenmodes are formed called the polaritons when the confined cavity photon modes strongly couple to the QW excitons. Cavity polaritons and their ability to undergo Bose-Einstein condensation have been intensively studied in the last decade. As quasiparticles in semiconductors, polaritons have typically relatively short lifetimes, thus it is generally difficult to cool hot polaritons to the lattice temperature before they decay. Significantly higher polariton lifetimes would allow further progress in this field, e.g., the generation of a condensate in thermal equilibrium featuring macroscopic coherence.

We report on the observation of polaritons in an optically pumped planar high-quality (high-Q) AlGaAs/GaAs microcavity containing 12 GaAs QWs in a $3/2\ \lambda$ AlAs cavity sandwiched between a lower and an upper distributed Bragg reflector with 32 and 36 mirror pairs, respectively. Moreover, time resolved photoluminescence from the lower polariton branch was measured with a streak camera in order to estimate the photon lifetime τ_{ph} and the Q-factor of the cavity, respectively. Thereby, a Q-factor of $> 10,000$ was determined for cavity photons.

HL 3.7 Mon 12:00 BEY 154

Internal quantum confined Stark effect in embedded IV-VI semiconductor nanodots — •Roman Leitsmann[1], Frank Ortmann[1], Friedhelm Bechstedt[1], Wolfgang Heiss[2], and Friedrich Schäffler[2] — [1]European Theoretical Spectroscopy Facility (ETSF) and Institut für Festkörpertheorie und -optik, Friedrich-Schiller Universität Jena, Germany — [2]Institut für Halbleiter- und Festkörperphysik, Johannes-Kepler-Universität Linz, Austria

The characterization of nanostructure properties versus dimension is of increasing importance for the nanotechnology. Especially the stoichiometry, geometry, and the electronic states of IV-VI semiconductor nanodots are of special interest [1,2]. We use ab initio methods to calculate structural and electronic properties of PbTe nanodots embedded in a CdTe semiconductor matrix as a function of the dot diameter. The arrangement of polar dot-matrix interfaces induces an electrostatic field, which strongly influences the geometric and electronic properties and reduces the symmetry of the system. In particular, the localization of HOMO (highest occupied molecular orbital) and LUMO (lowest unoccupied molecular orbital) states at opposite nanodot corners can be explained by an internal quantum confined Stark effect (IQCSE) [3]. Using a parabolic model potential for the electron and hole confinement it can be shown that the IQCSE lead to a strong reduction of the integrated photoluminescence yield at low temperatures.

[1] New J. Phys. 8, 317 (2006) [2] JACS 128, 3516 (2006); JACS 129, 11354 (2007) [3] Phys. Rev. B 78, 205324 (2008)

HL 3.8 Mon 12:15 BEY 154

Tight-binding CPA Theory of Semiconductor Alloys — •Daniel Mourad und Gerd Czycholl — Institut für Theoretische Physik, Universität Bremen

Alloys of the type A_xB_{1-x} can be realized for a wide class of semiconductor materials, e.g. for $Al_xGa_{1-x}As$, $In_xGa_{1-x}As$, $Cd_xZn_{1-x}Se$, Si_xGe_{1-x} ,$Al_xGa_{1-x}N$, $Ga_xIn_{1-x}N$, and many others. These substitutional semiconductor alloys find widespread applications in particular in nanoelectronic devices as quantum wells, quantum wires and quantum dots (QDs), as the band gap varies continuously with x, and therefore a band structure tayloring is possible by varying x. To calculate the electronic properties of such semiconductor alloys we start from multiband (sp^3) tight-binding (TB) models for the pure bulk semiconductor material A and B and apply the coherent potential approximation (CPA) to calculate the (configurationally averaged) electronic density of states and effective band structure. This treatment allows, in particular, for a reproduction of band bowing effects as a function of the concentration x and leads automatically to finite lifetime effects due to the loss of translational invariance. We compare the CPA results with results obtained in the much simpler virtual crystal approximation (VCA) and with ensemble averaged finite supercell calculations. Additionally, the application to QDs by combining this CPA-TB treatment with the recently developed TB models of nanostructures is hinted.

HL 3.9 Mon 12:30 BEY 154

Inhomogeneous and homogeneous broadening of excitonic spectra due to disorder — •Noemi Gögh[1], Peter Thomas[1], Irina Kuznetsova[1], and Torsten Meier[2] — [1]Department of Physics and Material Sciences Center, Philipps University Marburg — [2]Department of Physics, University Paderborn

In a disordered semiconductor heterostructure the excitonic line is both homogeneously and inhomogeneously broadened. While it is evident that disorder is responsible for inhomogeneous broadening, it is less obvious that disorder also contributes to homogeneous broadening (disorder-induced dephasing). We apply a one-dimensional tight-binding model of a disordered semiconductor. The optical polarization is calculated for a large number of configurations of the disorder potential and an ensemble average is performed at the end. We focus on homogeneous broadening due to disorder. Excitonic states in a disordered semiconductor are mutually coupled in the sense of Fano-resonances. At a certain spatial position the dominant energetic low-lying transition (corresponding to the 1s-exciton in an ordered three-dimensional situation) may be degenerate with the center-of-mass continuum of neighbouring excitonic transitions. Coupling of these states due to disorder, leading to homogeneous broadening, can be identified by Two-Dimensional-Fourier-Transfom-Spectroscopy (2DFTS), a variant of Four-Wave-Mixing. In order to illustrate the spectral features originating from such Fano situations, 2DFT-spectra are calculated first for conventional Fano situations. Then spectra of the disordered semiconductor model are interpreted in terms of Fano-coupling.