HL 36: Heterostructures

Time: Thursday 10:00–12:15 Location: H14

HL 36.1 Thu 10:00 H14

Exciton-exciton interaction in coupled quantum wells: Quantifying conditions for Bose-Einstein condensation — •Christoph Schindler and Roland Zimmermann — Institut für Physik der Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin, Germany

Spatially indirect electron-hole pairs in coupled quantum wells (CQW) have a reduced Coulomb attraction across the barrier, leading to a small binding energy of the indirect exciton. The repulsion between equal charges (electrons and holes), however, remains strong. Consequently, the interaction between two indirect excitons is dominated at large distances d by a strong dipole-dipole repulsion. Using CQW parameters for the GaAs/AlGaAs system we investigate the XX interaction as a function of d, improving the usual Hartree-Fock approach towards a full solution of the four particle problem. At small d, the fermionic exchange leads to a hard-core repulsive behavior, while at intermediate d van-der-Waals forces appear (depending on the singlet or triplet spin configuration). However, for realistic CQW parameters, no bound state (excitonic molecule) is formed. The generated XX potential is used to calculate XX scattering phase shifts and subsequently a full T matrix which is at the core for describing the approach towards Bose-Einstein condensation of indirect excitons.

HL 36.2 Thu 10:15 H14

Quantum Stark confined strongly correlated indirect excitons in quantum wells — •Patrick Ludwig[1,2], Alexej Filinov[1], Heinrich Stolz[2], and Michael Bonitz[1] — [1]CAU zu Kiel, ITAP, Leibnizstrasse 15, D-24098 Kiel — [2]Universität Rostock, Institut für Physik, Universitätsplatz 3, D-18051 Rostock

We consider small ensembles of optically excited indirect excitons (IE) in a single quantum well (QW). Using Path Integral Monte Carlo (PIMC) we compute from first principle the spatial separation of electrons (e) and holes (h) and the lateral quantum Stark confinement of the IE in the QW which is produced by an external electric field of a single tip electrode. [1] In the proposed setup the e-h pairs form permanent dipoles aligned perpendicular to the QW planes. The accompanied repulsive mutual dipole-dipole-like interaction of the IE prevents formation of biexcitons and e-h droplets and masks, at the same time, the fermionic character of the IE constituents, so that the IE are approximately of bosonic nature [2]. By changing the field strength, the tip to sample distance, the excitation intensity (exciton number) and temperature, the IE properties as well as the IE-IE correlations can be varied in broad ranges. Investigating systems of several tens to hundreds of IE in a ZnSe-based QW with PIMC technique we predict the parameter range at which interesting many-particle states, including exciton crystallization should be observable in experiments.[3]

[1] P. Ludwig et al., phys. stat. sol. (b) **243**, No. 10 2363-2366 (2006)

[2] A. Filinov et al., phys. stat. sol. (c) **3**, No. 7, 2457-2460 (2006)

[3] A. Filinov et al., J. Phys: Conf. Series **35**, 197 (2006)

HL 36.3 Thu 10:30 H14

Semiconductor Laser Emission in Realistic Dielectric Structures — •Martin Schafer[1], Walter Hoyer[1], Mackillo Kira[1], Stephan W. Koch[1], Matthias Reichelt[2], Joerg Hader[2], and Jerome Moloney[2] — [1]Department of Physics and Material Sciences Center, Philipps-University, Renthof 5, D-35032 Marburg, Germany — [2]Arizona Center for Mathematical Sciences, University of Arizona, Tucson, Arizona

Photoluminescence measurements provide an important tool for the characterization of laser devices. It is well known that realistic dielectric structures can strongly alter the quantum-well photoluminescence with respect to its emission in free space.

In order to investigate the modifications of photoluminescence spectra for different dielectric structures, a microscopical many-body theory is combined with a quantum theory of the electro-magnetic field, that is expanded in terms of the mode functions of the dielectric structure. In the strong coupling regime, a complete treatment of the stimulated emission is essential. For weak coupling between the quantum-well and the light field, the luminescence modifications can be obtained by multiplying the pure quantum-well emission with a frequency dependent filter function.

HL 36.4 Thu 10:45 H14

Exciton-Polaritons at room temperature in a planar ZnO resonator structure — •Rüdiger Schmidt-Grund, Bernd Rheinländer, Christian Czekalla, Gabriele Benndorf, Holger Hochmuth, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Linnéstr. 5, 04103 Leipzig

The wurtzite-structure II-VI-semiconductor ZnO has currently gained substantial interest because of its attractive properties for possible applications in optoelectronics. Due to the large binding energy of about 60meV, excitons in ZnO are stable at room temperature. This makes ZnO based resonators attractive for Bose-Einstein condensation of exciton-polaritons and therefore for the realization of cavity coupled exciton-polariton lasers operating at room temperature.

We report on coupling of exciton and photon modes observed in an all oxide planar resonator consisting of a $\lambda/2$ ZnO cavity, which acts simultaneously as active medium. It is embedded between lower and upper Bragg reflectors consisting of $\lambda/4$ stacks of the materials ZrO_2 and MgO (each 10.5 layer pairs). The resonator structure has been deposited using pulsed-laser deposition on sapphire substrate. The exciton-polariton modes have been observed in both reflectivity and photoluminescence measurements at temperatures between 4K and 306K and at room temperature at various incidence angles respective exit angles of the light. We have observed an energy splitting of the exciton-polariton branches of about 50meV, which is as large as the best values reached for the well known material system AlInGaN.

HL 36.5 Thu 11:00 H14

Drift Mobility of Long-living Excitons in Coupled GaAs Quantum Wells — •Andreas Gärtner[1], Dieter Schuh[2], Alexander Holleitner[1], and Jörg Kotthaus[1] — [1]Department für Physik and Center for NanoScience, Ludwig-Maximilians-Universität, D-80539 München, Germany — [2]Institut für Angewandte und Experimentelle Physik, Universität Regensburg, D-93040 Regensburg, Germany

Photo-generated electron-hole pairs in quantum well devices can be manipulated in lifetime and position via a mesoscopic voltage-controlled electrostatic landscape [1]. Here we employ the quantum confined Stark effect in a coupled double quantum well to generate spatially indirect excitons with lifetimes exceeding 1 μs and to study their motion induced by a controlled spatial variation of the out-of-plane electric field [2,3]. Macroscopic drift of excitons is studied in a time-of-flight experiment employing a laterally graded electrostatic potential induced via a current-carrying resistive gate [2]. This allows us to determine the drift mobility of such long-living excitons. Across several hundreds of microns a drift mobility exceeding 10^5 cm^2/eVs is observed for temperatures below 10 K. With increasing temperature the excitonic mobility decreases due to exciton-phonon scattering.

[1] for a recent review, see e.g.: J. P. Kotthaus, Phys. Stat. Sol. b **243**, 3754 (2006). [2] A. Gärtner, A. W. Holleitner, J. P. Kotthaus, D. Schuh, Appl. Phys. Lett. **89**, 052108 (2006). [3] A. Gärtner, D. Schuh, J. P. Kotthaus, Physica E **32**, 195 (2006).

HL 36.6 Thu 11:15 H14

Intersubband-dephasing in an undoped multi-quantum well — •Martin Wagner[1], Dominik Stehr[1], Harald Schneider[1], Stefan Winnerl[1], Manfred Helm[1], Max Andrews[2], Tomas Roch[2], and Gottfried Strasser[2] — [1]Institut für Ionenstrahlphysik und Materialforschung, Forschungszentrum Dresden-Rossendorf, Postfach 510119, 01314 Dresden — [2]Institut für Festkörperelektronik, TU Wien, Floragasse 7, 1040 Wien, Österreich

We have investigated the dephasing time associated with intersubband transitions of photocarriers in an undoped GaAs/AlGaAs multi quantum-well heterostructure. Our measurements were performed directly in the time-domain. After optical generation of electron-hole pairs across the band-gap, a resonant THz-pulse excited the electrons to the second subband and generated a coherent polarization involving the ground and the first excited subbands. The re-radiation from this polarization was detected by a cross-correlation technique with a second THz-pulse. The polarization was observed to decay with short decay-times between 50 fs and approx. 200 fs. They depend on the carrier concentration which was adjusted by the optical excitation power. These time constants determine directly the linewidth of this intersubband transition. At low temperatures, the dephasing signals show a pronounced beating at all optical excitation powers which we attribute to excitonic effects such that more than two energy levels are involved in the interaction with the THz-pulse.

By varying the excitation power, we also found a strong depolarization shift of the absorption line.

HL 36.7 Thu 11:30 H14

Interface and Luminescence Properties of Pulsed Laser Deposited $Mg_xZn_{1-x}O$/ZnO Quantum Wells with Strong Confinement — •Susanne Heitsch, Gregor Zimmermann, Alexander Müller, Jörg Lenzner, Holger Hochmuth, Gabriele Benndorf, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik II, Linnéstraße 5, D-04103 Leipzig, Germany

$Mg_xZn_{1-x}O$/ZnO/$Mg_xZn_{1-x}O$ quantum wells (QWs) ($0.12 \leq x \leq 0.15$) have been grown on *a*-plane sapphire substrates by pulsed laser deposition. The nominal ZnO well layer thickness ranges from 1.2 nm to 6 nm. Atomic force microscopy (AFM) investigations on $Mg_xZn_{1-x}O$ thin films and on ZnO/$Mg_xZn_{1-x}O$ heterostructures confirm the smoothness of the interfaces in the QWs (root mean square roughness of $\sim$ 0.5 nm) and the film-like structure of the ZnO layers. We confirmed the lateral homogeneity of the Mg distribution in the $Mg_xZn_{1-x}O$ barrier layers by scanning cathodoluminescence measurements. The QWs show a bright and laterally homogeneous luminescence, suggesting good crystalline quality of the ZnO wells. The measured QW photoluminescence energies are compared with calculated values and display the presence of the quantum-confined Stark effect. As a result of quantum confinement a high-energy shift of the ZnO excitonic photoluminescence of 222 meV is observed in the thinnest QW.

HL 36.8 Thu 11:45 H14

Two-dimensional electron systems under microwave irradiation: Influence of contacts. — •Sergey Mikhailov[1] and Akira Satou[2] — [1]Institute for Theoretical Physics II, University of Augsburg, D-86135 Augsburg, Germany — [2]Computer Solid State Physics Laboratory, University of Aizu, Aizu-Wakamatsu 965-8580, Japan

A growing interest to the behavior of two-dimensional (2D) electron systems under the microwave irradiation was being observed in the few past years. A number of recently discovered phenomena, such as the retardation effects, the microwave induced zero resistance states, frequency sensitive detection and spectroscopy of microwave radiation, have attracted attention due to their importance for basic and applied physics.

At low (microwave) frequencies the influence of realistic dielectric environment, in particular, the presence of metallic contacts, may be crucially important. In this work we theoretically study the role of contacts in the excitation of plasma waves in 2D electron systems. We show that, dependent on parameters of the system, the energy of the incident radiation may be effectively transformed into the 2D plasmons or 2D plasmon-polaritons, or reflected back from the 2D layer without exciting any eigen modes of the system. Results of this work may be important for proper understanding of the recently observed microwave induced phenomena in 2D electron systems.

HL 36.9 Thu 12:00 H14

Tunneling Spectroscopy on the Interface of an Operating pin-Diode — •S. Loth[1], M. Wenderoth[1], K. Teichmann[1], L. Winking[1], R. G. Ulbrich[1], S. Malzer[2], and G. H. Döhler[2] — [1]Universität Göttingen, IV. Physikalisches Institut, Germany — [2]Universität Erlangen-Nürnberg, Max-Planck-Research Group, Institute of Optics, Information, and Photonics, Germany

The interface of a GaAs pin-diode heterostructure is investigated by means of Cross Sectional Scanning Tunneling Microscopy at 8K. The internal electric field of the diode is of the order of $10^8 V/m$ and is externally controlled by source and drain contacts during the measurement. The variable field of the diode structure acts perpendicular to the tip induced field. In the experiment this enables the manipulation of charge states and energetic surroundings of single dopant atoms located in the pin-interface. At a fixed tunneling bias voltage the applied source drain voltage allows to shift the different surface resonances of the {110} cleavage surfaces in and out of the tunneling channel. In spatially resolved I(V)-spectroscopies the impact of the changing internal electric field on the band gap conductivity near the dopant atoms and its influence on the tip induced states is deduced.

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