HL 54: Optical Properties

Time: Wednesday 11:00–12:45 Location: EW 203

HL 54.1 Wed 11:00 EW 203

Exciton-polariton condensates in a ZnO-based microcavity — Helena Franke[1], Chris Sturm[1], •Rüdiger Schmidt-Grund[1], Tom Michalsky[1], Gerald Wagner[2], and Marius Grundmann[1] — [1]Universität Leipzig, Institut für Experimentelle Physik II, Linnéstr. 5, 04103 Leipzig — [2]Universität Leipzig, Institut für Mineralogie, Kristallographie und Materialwissenschaft, Josephinenstr. 7, 04317 Leipzig

We report on the observation of macroscopically coherent states of exciton-polaritons in a ZnO-based bulk planar microcavity (MC) up to 250 K. The threshold behaviour of the photoluminescence intensity as a function of the laser excitation power together with the corresponding spectral narrowing of the emission reveals clear signatures of a Bose-Einstein condensate for negative detunings. For positive detunings however, no condensation occurred but the emission from an electron-hole plasma was detected. At low temperatures and very negative detuning, we find ballistic propagation of the condensate polaritons in the pump-induced potential landscape, which makes these ZnO-based MC promising candidates for application based on polariton transport. The determined propagation length amounts to several μm, similar to values which can be estimated from data on GaAs-based wire-MC [1]. Our effect is caused by strong repulsive interactions of excitons in our system, leading to an immense blueshift of the condensate emission up to 30 meV and hence to pronounced dynamic effects. Due to photonic disorder in our samples the condensate reveals signatures of Bose-glass like states at certain detuning/temperature values.

[1] E. Wertz *et al.*, Nature Phys. **6**, 860 (2010).

HL 54.2 Wed 11:15 EW 203

Zero-dimensional periodic array of polariton condensates — •Edgar Cerda-Mendez[1], Dmitry Krizhanovski[2], Klaus Biermann[1], Maurice Skolnick[2], and Paulo Santos[1] — [1]Paul Drude Institut for Solid State Physics, Berlin, Germany — [2]Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom

Polaritons are quasiparticles arising from the strong coupling between excitons and photons in a semiconductor microcavity. Being dilute bosons, they show a transition to a non-equilibrium macroscopical single quantum state (condensate), at a critical density N_c. Polaritons inherit a long de Broglie wavelength from their photonic component, so N_c is low and condensation occurs at temperatures in the kelvin range. The condensate has extended length (L) and time coherence. In this work, we demonstrate the controlled fragmentation of an extended exciton-polariton condensate (L$\sim$30 μm) in an (Al,Ga)As-based microcavity into a periodical array of zero-dimensional condensates of size $<$4 μm. Fragmentation is induced by the periodic potential created by the spatial interference of two surface acoustic waves (SAWs) of wavelength λ_{SAW} =8 μm. The SAWs modulates the exciton and microcavity energies forming potential minima, where polaritons can condense. The threshold of condensation is reduced by modification of the scattering process and spatial confinement of the polaritons, which reduces the local losses. Condensation in high orbital states produced by the periodic potential is also observed allowing to observe the screening of the acoustic potential by nonlinear polariton-polariton interactions.

HL 54.3 Wed 11:30 EW 203

Microscopic optical investigation of a GaN based semi microcavity for fabricating a full resonant hybrid structure — •A. Franke, B. Bastek, O. August, S. Petzold, S. Sterling, T. Hempel, P. Veit, J. Christen, P. Moser, C. Berger, J. Bläsing, A. Dadgar, and A. Krost — Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Universitätsplatz 2, 39106 Magdeburg, Germany

For the investigation of strong coupling between an excitonic and a cavity mode we fabricated a hybrid GaN based microcavity (MC). The sample consists of an epitaxially grown bottom DBR of 40.5 lattice matched AlInN/GaN $\lambda/4$ layer pairs and a $3\lambda/2$ cavity containing a fivefold InGaN/GaN multi quantum well. First the microscopic reflectivity and emission properties of the MC structure without top DBR were investigated across the full 2" wafer size at identical positions on the sample. The center wavelength of the bottom DBR stop band exhibits a red shift of 8 nm from the center to the middle part of the wafer. A similar behavior is observed for the MQW emission wavelength. Resonance, i.e., a match of both wavelengths, is found at a circular region near the center part of the wafer. Full resonance of the sample was achieved by dry etching of the cavity layer to the optimal optical cavity thickness of $3\lambda/2$. No influence of the etching process on the emission properties of the active layer was observed. The microcavity was completed by depositing an eightfold dielectric Ta_2O_5/SiO_2 top DBR. Local photoluminescence spectra show a strong narrowing of emission peaks compared to the half MC.

HL 54.4 Wed 11:45 EW 203

Second harmonic generation from strained silicon grating structures — •Clemens Schriever[1], Christian Bohley[1], Johannes de Boor[2], Christian Eisenschmidt[1], Jens Lange[1], and Jörg Schilling[1] — [1]Martin-Luther-Universität Halle-Wittenberg, Halle (Saale), Germany — [2]Max-Planck Institut für Mikrostrukturphysik, Halle (Saale), Germany

The second harmonic signal of structured and unstructured, strained and unstrained silicon is investigated. Strain is applied by a thermally grown oxide layer and a surface grating is created by means of laser interference lithography and a dry etching process. The strain distribution inside the grating ridges is investigated by means of high resolution x-ray diffraction (HRXRD) and compared with finite element simulations. The azimuthal distribution of the second harmonic signal is measured in a reflection geometry and the signals of unstructured planar and structured grating samples are compared. The reduced rotational symmetry due to the nanostructuring has a profound effect on the second harmonic signal of the (111)-surface and leads to an increased directionality of the SHG-signal. A first simple model, approximating this effect as a convolution of the SHG-signal of the original (111)-surface and the characteristic reflection properties of the silicon grating structure shows good agreement with the experimental data.

HL 54.5 Wed 12:00 EW 203

Optical Rolled-Up Microtube Resonators Operating in the Visible Spectral Range — •Christian Strelow[1], Andreas Schramm[2], Stefanie Kietzmann[1], Alf Mews[1], and Tobias Kipp[1] — [1]Institute of Physical Chemistry, University of Hamburg, Germany — [2]Optoelectronics Research Centre, Tampere University of Technology, Tampere, Finland

We report on rolled-up optical microtube resonators that operate in the visible spectral range. The microtubes are formed by the self-rolling mechanism of strained semiconductor bilayers grown by molecular beam epitaxy. Recently, we reported on hybrid systems in which microtubes, that act as passive optical resonators, are coupled to chemically synthesized nanocrystals, that act as active light emitters.[1] A solution of nanocrystals was filled into the hollow core of the microtubes. Their coupling to optical modes of the microtubes is made possible by the microtubes' thin walls (typically 40 to 100 nm) that lead to long-ranging evanescent fields into the microtube core. The use of AlInGaAs-based microtubes restricted the choice of possible nanocrystals to systems emitting below 1.65 eV, i.e., the band gap of the layer system. In this work we report on the successful fabrication of AlInP-based microtubes with larger band gap allowing to operate the resonators in the visible spectral range. We demonstrate optical modes in these microtube resonators by coupling them to highly luminescent CdSe-based core-shell colloidal nanocrystals.

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[1] K. Dietrich *et al.*, Nano Letters **10**, 627 (2010).

HL 54.6 Wed 12:15 EW 203

Near-infrared Photoluminescence of Nanostructured Graphite — •Markus Glaser, Rupert Langegger, Alois Lugstein, and Emmerich Bertagnolli — Vienna University of Technology, Institute of Solid State Electronics, Vienna, Austria

The recent research on graphene and its unique physical properties led to the emergence of a new field of technology, called graphene electronics, with possible applications in transistors or optoelectronic devices. As graphene is a single layer of a graphite crystal, the research on graphene also brought the complex physical properties of graphite back into the center of attention. Recently we presented a method for extracting graphite sheets of varying thickness on bulk HOPG by focused ion beam processing at elevated sample temperatures. These graphite sheets were found to exhibit a distinct near-infrared photoluminescence (PL) signal at 532 nm laser excitation. Further investigation of this unexpected PL was done on several synthetic and natural graphite samples that were mechanically exfoliated with a scotch tape and deposited on silicon substrates with an isolating sacrificial layer. The PL signal is found to be stable at cw laser excitation with power densities of about 400 kW/cm^2 to tens of MW/cm^2 where no destruction of the sample flakes was observed. A possible dependence of PL on the flake thickness and its lateral dimensions is proposed. Furthermore we assume that crystalline graphite is essential for the PL, which was verified by Raman spectroscopy. Electrical characterization and photocurrent measurements where done to determine a possible application in optoelectronic devices.

HL 54.7 Wed 12:30 EW 203

Bethe-Salpeter Equation in the Tamm-Dancoff Approximation and beyond — •Tobias Sander, Ronald Starke, and Georg Kresse — Computational Materials Physics, University of Vienna, Sensengasse 8/12, 1090, Austria

Within the framework of many body perturbation theory, optical absorption spectra are usually calculated using the GW method followed by a subsequent solution of a Bethe-Salpeter like equation. The second step usually involves several approximations. First, the Green function is represented by a one-particle Green function. Second, in solid state calculations, the coupling between resonant (positive frequency branch) and anti-resonant (negative frequency branch) excitations is usually neglected. This approximation is referred to as Tamm-Dancoff approximation. In this work we (i) discuss an efficient method to remove the Tamm-Dancoff approximation for solids, (ii) apply the new approach to three prototypical systems, Si, LiF and Ar. To this end, the recently suggested quasi-particle GW (QPGW) of Shilfgaarde et al. is used to perform the GW calculations [1], followed by a solution of the BSE [2]. We find that the Tamm-Dancoff approximation underestimates the excitonic binding energy by about 300 meV in LiF and Ar, whereas only negligible changes are observed for Si.

[1] M. van Schilfgaarde, T. Kotani, and S. Faleev, Phys. Rev. Lett. 96, 226402 (2006).
[2] S. Albrecht, L. Reining, R. Del Sole, and G. Onida, Phys. Rev. Lett. 80, 4510 (1998).