HL 55 Photonic crystals

Time: Friday 11:30–13:15 Room: BEY 154

HL 55.1 Fri 11:30 BEY 154

Probing Photonic Crystals with Single CdSe/ZnS Quantum Dots — •Frank Cichos[1], Michael Barth[2], Roman Schuster[3], and Achim Gruber[1] — [1]Photonics and Optical Materials, Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz — [2]Nano-Optics Group, Institute of Physics, Humoldt University Berlin, Hausvogteiplatz 5-7, 10117 Berlin — [3]Leibniz Institute for Solid State and Materials Research Dresden, PF 27 01 16, 01171 Dresden

Within this presentation we demonstrate for the first time the application of single quantum dots to measure local optical properties of a 3D photonic crystal (PC). We have doped artificial polystyrene opals with a low concentration of core-shell CdSe/ZnS quantum dots, which emit in the region of the photonic stop band. With the help of fluorescence microscopy we demonstrate, that individual quantum dots can be imaged with high quality even though they are more than 30 lattice planes inside the PCs. Based on a comparison of defocused fluorescence images with numerical calculations, we show that the angular radiation characteristics of single quantum dots is modified by the photonic stop band. The variation of the photonic stop band position with the orientation of the crystal prevents light emission from the quantum dot in certain directions. This is to our knowledge the first measurement of photonic stop band effects based on a single emitter inside a PC and opens up a new class of experiments studying the local optical properties of 3D PCs. The results of this study can be advantageously used to manipulate the angular radiation characteristics of single photon sources.

HL 55.2 Fri 11:45 BEY 154

Dynamics of Optical Wavepackets in Coupled Microcavities — •Markas Sudzius, Vadim G. Lyssenko, Robert Gehlhaar, Marco Swoboda, Michael Hoffmann, and Karl Leo — Institut für Angewandte Photophysik, TU Dresden, D-01062 Dresden, Germany

We investigate the oscillating amplitudes and phases of a 150 fs laser pulse, transmitted through coupled microcavities, using time- and spectrally-resolved cross-correlation techniques. Careful monitoring of the upconverted signal allows the determination of frequencies, amplitudes, damping rates, and relative phases of spectral components of the wavepacket. The experimental observations can be explained by a Fourier-transform-based analytical model, leading to a better understanding of the origin of the temporal and spatial terahertz oscillations (optical Bloch oscillations) and allowing to reconstruct their evolution in coupled microcavities. In particular, we investigate how the real time evolution of the upconverted signal depends on the interplay between central laser wavelength, laser halfwidth and cavity mode splitting. These parameters are of crucial importance for both qualitative and quantitative behavior of the signal.

HL 55.3 Fri 12:00 BEY 154

Cavity-polariton interaction mediated by coherent acoustic phonons — •Mauricio de Lima[1], Rudolf Hey[1], Paulo Santos[1], Mike van der Poel[2], and Jørn Hvam[2] — [1]Paul-Drude-Institut für Festkörperelektronik — [2]Research center COM, Technical University of Denamark

The strong coupling between excitons in a quantum well (QW) and photons inserted in a semiconductor microcavity leads to the formation of quasi-particles known as cavity-polaritons. In this contribution, we investigate the interaction of the polaritons with coherent acoustic phonons in the form of surface acoustic waves (SAWs). The studies were performed in a GaAs QW embedded in a (Al,Ga)As/AlAs microcavity. The periodic modulation introduced by the phonons folds the cavity-polariton dispersion within a mini-Brillouin zone (MBZ) defined by the phonon wave vector (k_{SAW}). The appearance of well-defined mini-gaps at the edge of the MBZ as well as folded modes in the center of the MBZ are observed for different phonon densities and different cavity polariton detuning energies. The experimental results are in good agreement with calculations that take into account the modulation of the the band-gap and of the optical thickness of the microcavity spacer layer by the SAW strain field.

HL 55.4 Fri 12:15 BEY 154

Polarization splitting and terahertz oscillations from a single planar Fabry-Perot microcavity — •R. Gehlhaar[1], M. Swoboda[1], M. Sudzius[1], H. Wendrock[2], M. Hoffmann[1], H. Fröb[1], V. G. Lyssenko[1], and K. Leo[1] — [1]Institut für Angewandte Photophysik, Technische Universität Dresden, 01062 Dresden, Germany, www.iapp.de — [2]Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden, PF 27 01 16, 01171 Dresden, Germany

We report the experimental observation of polarization splitting and terahertz oscillations of transmitted coherent light from a single planar optical microcavity consisting of two SiO_2/TiO_2-dielectric mirrors. The samples are prepared by reactive electron-beam deposition. Optical anisotropy leads to two perpendicularly polarized transmission modes at ~ 800 nm with a splitting of 2.5 nm. We ascribe the anisotropy to oblique columnar structures in the dielectrics, resulting from off-axial growth of the microcavity structure. Therefore the beating frequency is widely tunable in the GHz and THz range by variations in the fabrication process. We apply an up-conversion setup for temporally and spectrally resolved measurements and obtain a corresponding beating of 0.8 ps period or 1.25 THz oscillation frequency. Time resolved measurements yield a cavity photon lifetime of 0.65 ps, corresponding to a Q-value of 1600. To explain our observations, we introduce a Fourier-transform-based analytical model.

HL 55.5 Fri 12:30 BEY 154

Coexistence of Left- and Righthanded Propagation in Photonic Crystals — •Ronald Meisels[1], Rados Gajic[1,2], Friedemar Kuchar[1], Javad Zarbakhsh[3], and Kurt Hingerl[3] — [1]Institute of Physics, University of Leoben, Austria — [2]Institute of Physics, University of Belgrade, Serbia and Montenegro — [3]CDL of Surface Optics, Johannes Kepler University, Linz, Austria

Photonic Crystals (PhC) are structures with a periodic spatial modulation of, e.g., the dielectric constant causing a photonic band structure. These PhC show peculiar phenomena, e.g. negative refraction (NR). For NR the directions of incident and refracted beams (parallel to $\mathbf{v}_g = \partial\omega/\partial k$), when projected on the interface, are opposite. NR and positive refraction (PR) can be both accomponied by righthanded (RH) or lefthanded (LH) behavior of the wave in the PhC. In this work, the PhC consists of a square lattice of alumina rods. For this structure we present results of band structure calculations demonstrating the coexistence of a) NR and RH (1st band), b) NR and LH (2nd band), c) two waves with the same frequency and same angle of incidence showing NR with LH and RH, respectively (2nd band). These results are compared with FDTD simulations. An analysis using only field values at lattice points eliminates the periodic parts of the Bloch waves and shows only the envelopes. This allows to separate two coexisting waves as in case c).

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HL 55.6 Fri 12:45 BEY 154

Negative Refraction in Ferromagnet/Superconductor Superlattices — •A. Pimenov[1], P. P. Przyslupski[2], B. Dabrowski[3], and A. Loidl[1] — [1]Experimentalphysik V, Center for Electronic Correlations and Magnetism, Universität Augsburg, 86135 Augsburg, Germany — [2]Institute of Physics, Polish Academy of Sciences, 02-668 Warszawa, Poland — [3]Department of Physics, Northern Illinois University, 60115 DeKalb, Illinois, USA

Negative refraction, which reverses many fundamental aspects of classical optics, can be obtained in systems with negative magnetic permeability and negative dielectric permittivity. During the last five years this negative refraction has been experimentally verified in a number of metamaterials and photonic crystals. In this work we demonstrate an experimental realization of negative refraction at terahertz frequencies and finite magnetic fields utilizing a multilayer stack of ferromagnetic and superconducting thin films [1]. In the present case the superconducting $YBa_2Cu_3O_7$ layers provide negative permittivity while negative permeability is achieved via ferromagnetic (La:Sr)MnO_3 layers for frequencies and magnetic fields close to the ferromagnetic resonance. In these superlattices the refractive index can be switched between positive and negative regions using external magnetic field as tuning parameter.

[1] A. Pimenov, P. P. Przyslupski, B. Dabrowski, and A. Loidl, Phys.

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Realization of Electrically Active Photonic Crystal Nanocavities — •Simon Grimminger, Felix Hofbauer, Michael Kaniber, Susanne Dachs, Hubert J. Krenner, Gerhard Abstreiter, and Jonathan J. Finley — Walter Schottky Institute, TU München, 85748 Garching, Germany

We present investigations of electrically tunable InGaAs self-assembled quantum dots (QDs) embedded in 2D photonic crystal (PC) defect nanocavities. The samples consist of (Al)GaAs p-i-n diodes with a single layer of dots in the intrinsic region. Low mode volume ($V < (\lambda/n)^3$), high-Q (∼2000) nanocavities are formed by etching a hexagonal lattice of air holes through the p-i-n junction and introducing defects to produce reduced symmetry H1-cavities. A 180nm thick freestanding membrane containing the p-i-n diode is then realized by selective wet etching and electrical contacts to the p and n-doped regions enable us to apply static electric field perturbations to QDs in the cavity.

Such active PC nanocavities were studied using spatially resolved luminescence and photocurrent absorption spectroscopy. The experiments show that the electric field is uniform over the $200 \times 200\mu m$ diode structure. Furthermore, quenching of the PL is observed for fields >50kV/cm due to carrier tunneling escape from the dots that occurs faster than the radiative lifetime. By measuring the PL quenching as a function of position on the PC and nanocavity we electrically probe the local density of photonic states. Furthermore, the devices have the potential to study cavity-single QD coupling in an electrically tunable system.