HL 21: Photonic Crystals I

Time: Monday 17:00–18:15 Location: EW 203

HL 21.1 Mon 17:00 EW 203

Spectral compression of light by ultrafast tilting of the dispersion of a photonic crystal — •Tobias Kampfrath[1,2], Daryl Beggs[2], Thomas Krauss[3], and L. Kuipers[2] — [1]Fritz Haber Institute of the Max Planck Society, Berlin, Germany — [2]FOM Institute AMOLF, Amsterdam, The Netherlands — [3]University of St. Andrews, Scotland, UK

Photonic crystals are well known for their ability to control the dispersion relation $\omega(k)$ of light. Here, we demonstrate that $\omega(k)$ can even be tuned on ultrafast timescales by means of a femtosecond pump pulse exciting the silicon parts of a photonic-crystal waveguide. We shape the cross section of the pump beam with a nanometric shadow mask such that different waveguide eigenmodes acquire different spatial overlap with the perturbing pump. In this way, a local flattening of the dispersion curve by as much as 11 % is obtained. This value is two orders of magnitude higher than the relative pump-induced variations $\Delta n/n$ of the silicon refractive index.

We show that such partial mode perturbation can be used to adiabatically compress the spectrum of a light pulse traveling through the waveguide.

HL 21.2 Mon 17:15 EW 203

High frequency tuning of photonic crystal nanocavity modes using surface acoustic waves — •Daniel A. Fuhrmann[1,2,3], Susanna M. Thon[4], Hyochul Kim[3], Dirk Bouwmeester[4,5], Pierre M. Petroff[3], Achim Wixforth[1], and Hubert J. Krenner[1,2] — [1]Lehrstuhl für Experimentalphysik I, Universität Augsburg, Germany — [2]Emmy Noether Group, Universität Augsburg, Germany — [3]Materials Department, University of California, Santa Barbara, USA — [4]Physics Department, University of California, Santa Barbara, USA — [5]Huygens Laboratory, Leiden University, The Netherlands

We propose and demonstrate high frequency dynamic modulation of localized optical modes of photonic crystal membrane (PCM) defect nanocavities employing surface acoustic waves (SAWs). The mechanical deformation induced by SAW distorts the PCM periodicity and gives rise to pronounced modulation of the nanocavity mode. In time-integrated and SAW-phase resolved photoluminescence (PL) experiments we demonstrate tuning speeds > 1.7 GHz using this approach. In the experimental data we observe a pronounced sinusoidal shift of the cavity resonance over one cycle of the SAW. Shifts of more than 5 times the cavity linewidth are achieved. In addition, a high quality factor is preserved. These experimental observations are found in excellent agreement with FDTD simulations for the same cavity design and realistic SAW amplitudes. Our FDTD calculations show no resolvable shift of the field distribution of the cavity mode making our technique attractive for both real-time control of solid state cQED experiments and coherent mechanical excitation of cavity optomechanical systems.

HL 21.3 Mon 17:30 EW 203

Fast structural analysis of photonic crystals — •Rebecca Wagner, Lars Heerklotz, and Frank Cichos — Molecular Nanophotonics, University of Leipzig, Germany

Photonic crystals (PCs) are materials where the dielectric constant varies periodically on the length scale of visible wavelengths. This results in the formation of a photonic band structure, which gives one the possibility to modify the propagation of light.

Inexpensive and simple methods for the production of 3D PCs are based on self assembly of colloidal beads, leading to close packed structures. However, these methods usually create polycrystalline structures, with differently stacked domains and other defects.

These stacking faults are hidden in the 3D structure and difficult to characterize experimentally. However, the PC's optical properties depend on its structure. Therefore a method to locally characterize the 3D order of the PC is desirable.

Here we present a method for fast microscopic characterization of PCs based on back focal plane (BFP) imaging. After local excitation by a focused laser the luminescence from inside the PC is collected by a high NA objective. The BFP of the objective contains information about the angel dependence of the emission. When imaging it onto a CCD for a selected wavelength, stop bands are visible for certain directions, showing the local symmetry of the PC. Thus, a fast determination of the orientation of domains is possible. The change between different kinds of stacking (twin structure) can be observed.

HL 21.4 Mon 17:45 EW 203

Influence of cracks on photonic stop bands — •Lars Heerklotz, Rebecca Wagner, and Frank Cichos — Molecular Nanophotonics, University of Leipzig, Germany

Periodical spatial variations of a materials properties lead, via the Bloch condition, to the formation of bands, causing partial and total band gaps. That holds for electrons in a semiconductor, where the core potential is periodic, as well as for photons in a photonic crystal (PC), where the dielectric constant is periodic. In the photonic case this means, that light cannot propagate in the stop band directions and thus the fractional density of states (fDOS) vanishes. To observe these features we produced face-centered cubic (fcc) PCs by vertical deposition. We used our home-built confocal setup to investigate the behavior of light emitted from the polystyrene inside the PC. Imaging the light of the objectives back focal plane onto a slit and afterwards onto a spectrometer leads to angle dependent spectra. The novel advantage is the acquisition of 100 spectra for up to 73.5° of emission in one measurement. This method, angle resolved fluorescence spectroscopy, is applied to measure the fDOS locally (lateral resolution of 300 nm) in order to observe the three folded structure of the first Brillouin-zone of the fcc-lattice. Due to non-confocal detection there is no resolution along the optical axis. We use this method to analyze the influences a crack has on the fDOS.

HL 21.5 Mon 18:00 EW 203

Photonic crystal slab based on nitride semiconductors — •Dominik Heinz[1,2], Robert A. R. Leute[1], Klaus Thonke[2], Frank Lipski[1], Tobias Meisch[1], Thomas Wunderer[3], Ingo Tischer[2], Matthias Hocker[2], and Ferdinand Scholz[1] — [1]Institute of Optoelectronics, Ulm University, Albert-Einstein-Allee 45, 89081 Ulm, Germany — [2]Institute of Quantum Matter / semiconductor physics group, Ulm University, Albert-Einstein-Allee 45, 89081 Ulm, Germany — [3]now at Palo Alto Research Center, Inc., 3333 Coyote Hill Road, Palo Alto, California 94304, USA

Photonic crystals are periodically modulated dielectric structures with a periodicity comparable to the considered wavelength regime. For realization of photonic crystals in the visible spectrum of light, sub-μm patterning is necessary. In this work, UV laser interference lithography has been used to realize photoresist structures with a periodicity of approximately 240 nm on areas of several square centimeters. These patterns were subsequently transfered to a mechanically stable titanium layer deposited on a gallium nitride (GaN) epitaxial layer using a lift-off technique. Finally, GaN-stripes with triangular cross section and GaInN quantum wells integrated on their side facets were grown by selective area metalorganic vapour phase epitaxy. For better selectivity, an in-situ nitridation step in hot ammonia atmosphere was performed before epitaxy. The resulting structures were characterized by angle resolved photoluminescence (ARPL) and cathodoluminescence. Directional modal extraction of guided light was observed in ARPL, and the respective photonic dispersion relation was determined.