HL 22: Photonic crystals II

Time: Tuesday 14:00–16:45 Location: H13

HL 22.1 Tue 14:00 H13

Three-dimensional polymer and silicon inverse photonic quasicrystals for infrared frequencies — •Alexandra Ledermann[1], Ludovico Cademartiri[2], Martin Hermatschweiler[1], Costanza Toninelli[3], Geoffrey Ozin[2], Diederik Wiersma[3], Martin Wegener[1], and Georg von Freymann[1] — [1]Institut für Nanotechnologie, Forschunszentrum Karlsruhe, DFG-Center for Functional Nanostructures (CFN) and Institut für Angewandte Physik, Universität Karlsruhe (TH) — [2]Department of Chemistry, University of Toronto — [3]European Laboratory for Nonlinear Spectroscopy (LENS) and INFM, Firence

Quasicrystals (QC) represent a class of solids which lack translational symmetry, but exhibit perfect long-range order and reveal well-defined rotational symmetries, not necessarily consistent with periodicity. Using direct laser writing [1] we fabricate three-dimensional icosahedral SU-8 photonic QC of high quality, characterized by electron microscope images and visible-light Laue diffraction experiments [2]. Reflectance measurements indicate a stop band in the infrared. These SU-8 structures serve as templates for a subsequent novel silicon inversion procedure [3]. Electron microscope images and Laue diffraction patterns prove the successful fabrication of the silicon inverse photonic QC. This work paves the road for future work on low- or high-index contrast photonic QC.

[1] M. Deubel et al., Nature Materials, 3, 444 (2004).
[2] A. Ledermann et al., Nature Materials, 5, 942 (2006).
[3] M. Hermatschweiler et al., submitted (2006).

HL 22.2 Tue 14:15 H13

Group delay measurements on photonic crystal resonators — •Magdalena Gellner, Thomas Sünner, Andreas Löffler, Martin Kamp, and Alfred Forchel — Technische Physik, Am Hubland, D-97074 Würzburg

We have investigated the group delay of light propagating through photonic crystal (PhC) resonators. The resonators are defined in 250nm thick GaAs membranes. The design of the resonators is based on a PhC heterostructure, which combines waveguide sections with different lattice constants along a W1 waveguide to confine the light. The 'mirrors' of the resonator have a lattice constants of 400nm along the waveguide, the lattice constant of the cavity is 410nm. The lattice constant perpendicular to the waveguide remains unchanged in order to maintain matching lattices. The group delay was measured by detecting the phase shift of a microwave signal which was modulated onto the light of a tunable laser source with an emission wavelength of 1.5μm. The group delay was found to increase linearly with the quality factor of the resonator, in good agreement with the prediction of a model where the PhC resonator is replaced by an equivalent Fabry-Perot resonator. A maximum group delay of 132ps was observed for a resonator with a quality factor of 82000. The mirror segments of this resonator had a length of 12 lattice periods. Taking this as a measure of the length of the resonator, we have achieved an effective propagation speed of 7.9*10ˆ4 m/s, which is equivalent to c/3800.

HL 22.3 Tue 14:30 H13

Corrugated metallic surfaces for negative permeability in the visible spectral range — •Heinz Schweizer[1], Liwei Fu[1], Hedwig Gräbeldinger[1], Hongcang Guo[1], Na Liu[1], Stefan Kaiser[2], and Harald Giessen[1] — [1]4. Physikalisches Institut, Universität Stuttgart, 70550 Stuttgart — [2]1. Physikalisches Institut, Universität Stuttgart, 70550 Stuttgart

In order to achieve left-handed metamaterials, simultaneous negative permittivity and permeability are sufficient. Negative permittivity is normally realized through plasmonic oscillation of electrons in metals. However, a naturally occurring negative permeability does not exist at optical frequencies. At GHz frequencies, negative permeability can be realized by split ring resonators (SRR) with the magnetic field component penetrating the ring and the electric field component along the SRR-arms. At optical frequencies SRRs can be fabricated, but the plane matrix configuration of SRRs is usually unfavorable to achieve a negative n. We design a novel metallic meander structure which acts as an SRR, to fully couple the magnetic field into U-shaped metallic structures for obtaining negative permeability at optical frequencies. The structure is realized on ridge-patterned dielectric substrates with deposition of 20 nm Au. Samples with a period of 200-350 nm in steps of 50 nm were fabricated using E-beam lithography. With the H-field along the ridge and the k-direction normal to the substrate, the S-parameters were simulated and the effective parameters were retrieved. Simulations show that large values of permeability down to -7 between 600 nm and 900 nm can be obtained.

HL 22.4 Tue 14:45 H13

Silicon-based photonic crystal waveguides — •Daniel Pergande[1], Alexey Milenin[2], Werner Sievers[3], and Ralf Wehrspohn[1] — [1]Microstructure-based Materials Design Group, Institute of Physics, University of Halle-Wittenberg — [2]Max Planck Institute of Microstructure Physics, Halle — [3]Department of Physics, University Paderborn

In PhCs the photonic band structure (PhBS) replaces the dispersion relation of photons in a homogenous dielectric medium. The PhBS results from scattering and interference of light at periodically alternating domains of material with different dielectric constants.

Silicon is the dominating material in today's microelectronics, especially in modern telecommunications, and therefore a lot of experience in microstructuring of silicon exists. Its high dielectric constant makes it a promising candidate for PhC fabrication. Furthermore, the possibility of integrating electronics and optics on one chip is of great advantage for silicon-based PhC devices.

We present ridge waveguides and PhC waveguides etched in a high-index-contrast material made of a thin silicon slab embedded in two silica layers. Hence fully symmetrical structures can be realized and two important conditions for low-loss guiding of light in PhC waveguides can be matched: The symmetry avoids polarization mixing and the high index contrast leads to strong confinement of light, so the PhC waveguides allow theoretically lossless guiding of light because of operating completely below the lightcone. This opens the door for fully new applications.

HL 22.5 Tue 15:00 H13

Numerical study of optical negative index metamaterials based on embedded nano-meander structures — •Liwei Fu, Heinz Schweizer, Hongcang Guo, Na Liu, and Harald Giessen — 4. Physikalisches Institut, Pfaffenwaldring 57, 70550 Stuttgart

For the realization of a left-handed metamaterial or negative index metamaterial, a longitudinal capacitance and a shunt inductance in a transmission line model are required to achieve simultaneously negative permeability and permittivty. In our new approach to negative index materials at optical frequencies, a meander metallic structure on a ridge-patterned substrate is designed for obtaining the longitudinal capacitance. Thin metal films are added for shunt inductance. In this way, two degrees of freedom can be used to adjust the permeability and permittivity spectrum with respect to each other in frequency. The distance of the metal films to the meander can be used as a parameter to obtain an overlap of the real part of negative permittivity and permeability. With this composite nanostructure embedded in SiO2, a negative refractive index can be obtained between 800 nm to 1200 nm with a real part of -2 and a figure of merit of 1.5.

15 min. break

HL 22.6 Tue 15:30 H13

Defocused Imaging of Single Quantum Dots in Photonic Crystals — •Rebecca Wagner and Frank Cichos — Molecular Nanophotonics, Universität Leipzig, Linnéstraße 5, 04103 Leipzig

Photonic crystals are materials with a periodically varying dielectric constant, which introduces a photonic band structure and photonic band gaps by multiple scattering of light on this spatially modulated refractive index. The spatial variation of the refractive index immediately implies that the optical density of states inside a photonic crystal has to be a local property too. Thus a detailed examination and especially the efficient use of even weak photonic systems requires a local probe for the study of local optical properties. So far this has only been achieved for 2D photonic structures by means of near field scanning microscopy. We show with extensive numerical calculations and experimental studies, that single quantum dots can be used as local