Q 25 Photonische Kristalle II

Zeit: Dienstag 13:45–16:00 Raum: HI

Q 25.1 Di 13:45 HI

Resonant modes and lasing in deterministically aperiodic nanopillar arrays — •Sergei V. Zhukovsky, Dmitry N. Chigrin, and Johann Kroha — Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn, Germany

As shown previously [1], periodic one-dimensional nanopillar arrays can function as waveguides. We consider an analogous system of nanopillars arranged in a deterministically aperiodic (DA) fashion, namely, according to quasiperiodic Fibonacci and fractal Cantor sequences [2]. It has been shown that such a nanopillar structure can exhibit both waveguide-like and resonant properties. The resonant modes present in a fractal nanopillar structure are highly localized and possess a Q-factor comparable with the resonant mode of a point defect embedded in a periodic waveguide. At the same time, the modes in a DA waveguide show much better coupling with a coaxially placed terminal allowing energy exchange of a resonator with other optical components. The coupling is especially increased when the symmetry of a DA structure is slightly broken, which does not diminish the Q-factor or mode localization. It can be shown that owing to increased coupling, such a resonant system can be used as a microlaser when nanopillars contain an active medium.

[1] D. N. Chigrin, A. V. Lavrinenko, C. M. Sotomayor-Torres, Opt. Express **12**, 617 (2004).
[2] A. V. Lavrinenko, S. V. Zhukovsky, K. S. Sandomirskii, S. V. Gaponenko, Phys. Rev. E **65**, 036621 (2002).

Q 25.2 Di 14:00 HI

Photonic crystal cavities with high quality factors on GaAs membranes — •Thomas Sünner, Rafael Herrmann, Andreas Löffler, Johann-Peter Reithmaier, Martin Kamp, and Alfred Forchel — Technische Physik, Am Hubland, D-97074 Würzburg, Germany

Cavities in photonic crystals (PhCs) can confine light in mode volumes of less than one cubic wavelength with quality factors of several hundred thousand. These properties make PhC cavities very promising candidates for studies of cavity QED and non-linear optics.

We have investigated PhC cavities in GaAs membranes. The layer structure consists of a 250 nm thick GaAs layer on top of a $2\mu m$ thick $Al_{0.6}Ga_{0.4}As$ sacrificial layer. The geometry of the cavity is based on a PhC heterostructure [1]. This design uses a variation of the lattice period along a waveguide defined by one missing row of holes (W1) in a hexagonal PhC lattice. The light is confined in a short waveguide section with 410 nm period, sandwiched between 'mirror' waveguides with 400 nm lattice period. The 'mirror' waveguides have a stopgap at the wavelength of the cavity resonance and therefore act as reflectors. An access guide connects the cavity to the facets of the sample. The PhC pattern is first etched into the GaAs layer, which is then undercut by selective wet etching of the sacrificial layer.

Transmission measurements were performed using a tunable laser source at $1.5\mu m$ We have observed cavity resonances with quality factors in excess of 100000.

[1] B.S. Song et al., Nature Materials 4, 207 (2005)

Q 25.3 Di 14:15 HI

Integrated Photonic Crystal Circuits: Comparison of FDTD Simulations and Scattering Matrix Calculations Based on Wannier Functions — •Javad Zarbakhsh[1], Daniel Hermann[2,3], Sergei Mingaleev[2,3], Kurt Hingerl[1], and Kurt Busch[2,3,4] — [1]Christian Doppler Labor für oberflächenoptische Methoden, Institut für Halbleiter und Festkörperphysik, Johannes-Kepler-Universität Linz — [2]Institut für Theoretische Festkörperphysik, Universität Karlsruhe — [3]DFG Forschungszentrum Center for Functional Nanostructures (CFN), Universität Karlsruhe — [4]Institut für Nanotechnologie, Forschungszentrum Karlsruhe in der Helmholtz-Gemeinschaft

We present a detailed comparison between Finite Difference Time Domain (FDTD) simulations and Scattering Matrix calculations based on Wannier functions [1,2] for the characterization of large-scale photonic crystal circuits. A complex photonic crystal circuit consisting of several waveguides, splitters, and bends, which have individually been optimized, using the S-matrix method based on Wannier functions, has been studied. Our results show that the Scattering Matrix formalism is much more efficient than FDTD when dealing with large systems that are composed of several smaller functional elements embedded in an overall periodic environment. Complementary comparisons with local density of photonic states and plain wave expansion methods are presented as well [3].

[1] J. Phys.: Condens. Matter 15, R1233 (2003)
[2] Opt. Lett. 28, 619 (2003)
[3] Appl. Phys. Lett. 84, 4687 (2004)

Q 25.4 Di 14:30 HI

Nonlinear-optical response of metamaterials: Experimental demonstration of second-harmonic generation — •Matthias W. Klein[1], Christian Enkrich[1], Martin Wegener[1], Jens Förstner[2], Jerome V. Moloney[2], Walter Hoyer[3], Tineke Stroucken[3], Torsten Meier[3], Stephan W. Koch[3], and Stefan Linden[4] — [1]Institut für Angewandte Physik, Universität Karlsruhe (TH), 76131 Karlsruhe — [2]Arizona Center for Mathematical Sciences, University of Arizona, Tucson, AZ 85721, USA — [3]Fachbereich Physik und Wissenschaftliches Zentrum für Materialwissenschaften, Universität Marburg, 35032 Marburg — [4]Institut für Nanotechnologie, Forschungszentrum Karlsruhe, 76021 Karlsruhe

The fabrication of metamaterials [1] has recently [2,3] reached resonance frequencies in the near-infrared or even visible regime. This development has triggered many experiments in linear optics, however, the nonlinear optics of metamaterials is mostly unexplored so far. We present experiments on second-harmonic generation (SHG) by lithographically defined Split-Ring Resonators (SRRs) arranged in planar 2D arrays with "lattice constants" between 300-630 nm. Using different arrays of SRRs with different resonances tuned to the fixed laser wavelength of 1500 nm, we show that the SHG efficiency strongly depends on the nature of the excited resonance. We find that by far the largest signal arises from exciting the magnetic-dipole resonance.

[1] D. R. Smith *et al.*, Science **305**, 788 (2004)
[2] S. Linden *et al.*, Science **306**, 1351 (2004)
[3] C. Enkrich *et al.*, Phys. Rev. Lett. **95**, 203901 (2005)

Q 25.5 Di 14:45 HI

Nonlinear-optical response of metamaterials: Theory — •Walter Hoyer[1], Tineke Stroucken[1], Torsten Meier[1], Stephan W. Koch[1], Jens Förstner[2], Jerome V. Moloney[2], Matthias W. Klein[3], Christian Enkrich[3], Martin Wegener[3], and Stefan Linden[4] — [1]Fachbereich Physik und Wissenschaftliches Zentrum für Materialwissenschaften, Universität Marburg, 35032 Marburg — [2]Arizona Center for Mathematical Sciences, University of Arizona, Tucson, AZ 85721, USA — [3]Institut für Angewandte Physik, Universität Karlsruhe (TH), 76131 Karlsruhe — [4]Institut für Nanotechnologie, Forschungszentrum Karlsruhe, 76021 Karlsruhe

Metamaterials composed of sub-wavelength structures are known to result in fascinating physical effects in the microwave regime[1]. Lately, similar materials have been fabricated also in the optical regime and many of the linear properties are well understood[2]. Here, we present a theoretical approach suitable for the study of nonlinear effects as e.g. second-harmonic generation. The theory is based on a microscopic Vlasov-Maxwell approach which in its classical limit results in an equation for the current density coupled to Maxwell's equations. Numerical solutions for the case of split-ring resonators are compared to our experiments.

[1] R. A. Shelby, D. R. Smith, S. Schultz, Science **292**, 77 (2001)
[2] S. Linden et al., Science **306**, 1351 (2004)

Q 25.6 Di 15:00 HI

Femtosecond Laser Fabricated Components for Guiding and Focussing of Surface Plasmon Polaritons — •Sven Passinger, Carsten Reinhardt, and Boris N. Chichkov — Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover

In this contribution, we study applications of two-photon polymerization (2PP) technique for the fabrication of dielectric structures on metal films, which can be used for guiding and manipulation of surface plasmon polaritons (SPPs). Dielectric SPP components, e.g. waveguides, bends and splitters are fabricated. SPP properties of these structures are investigated by scanning near-field optical microscopy (SNOM), demonstrating guiding and reflection of SPPs by polymer lines. SPP excitation on dielectric ridges and point structures is observed by far-field