Q 20 Photonische Kristalle I

Zeit: Dienstag 10:40–12:55 Raum: HI

Q 20.1 Di 10:40 HI

Bloch-mode Formation and Disorder in Coupled-Cavity Chains — •Björn M. Möller[1], Ulrike Woggon[1], and Mikhail V. Artemyev[1,2] — [1]Department of Physics, University of Dortmund — [2]Institute for Physico-Chemical Problems of Belarussian State University

The coupled-microresonator model is an important concept to describe loss-less waveguiding, photonic circuits, and slowing down light [1-3].

In this work, we discuss a coupled oscillator model for photon states in finite 1D-periodic structures. Experimentally, we explore the coherent photon coupling in linear chains of up to 14 spherical microcavities. Coherent coupling is evidenced by (i) collapse of individual whispering gallery modes, (ii) splitting of modes into a fine structure, (iii) the strong variation of the field intensity and splitting features between adjacent spheres in a chain.

We demonstrate how intensity modifications along the coupled resonator chain can originate from two different phenomena: The observed intensity variations are explained using a coupled oscillator model predicting locally varying oscillator strengths. Both Bloch-mode formation and size disorder can lead to significant field variations in a coupled resonator structure. The transition between both effects are transparently explored in terms of this coupled-oscillator model.

[1] A. Yariv *et al.*, Opt. Lett. **24** (11), 711 (1999)
[2] B. M. Möller, *et al.*, Opt. Lett. **30** (16), 2116 (2005)
[3] B. M. Möller, *et al.*, J. Appl. Opt. A, in press (2006)

Q 20.2 Di 10:55 HI

Near field studies of resonances in multistep photonic crystal heterostructure nanocavities. — •Sushil Mujumdar[1], A. Femius Koenderink[2], and Vahid Sandoghdar[1] — [1]Laboratory of Physical Chemistry, ETH Zurich, CH-8093 Zurich, Switzerland. — [2]FOM-Institute for Atomic and Molecular Physics (AMOLF), Kruislaan 407, 1098 SJ Amsterdam, The Netherlands.

We report on near-field studies of resonances in photonic crystal nanocavities realized in thin GaAs membranes. The nanocavities were created under a multistep photonic heterostructure design, wherein five crystal slabs, with lattice constants a_1, a_2, a_1, a_2 and a_1 respectively ($a_1 > a_2$) were seamlessly welded together[1]. A collinear $W1$ waveguide created through the structure exhibits an offset in the band diagram for the guided mode in the regions with different lattice constants. The confinement in the spatially narrow (width $2a_1$) region yields resonances of quality factors $\sim 10^4$, depending on the width of the a_2 region. An optical fiber tip mounted in a shear-force setup explored the near-field distribution of light in the nanocavity on and off resonance frequencies. The high-resolution (< 100 nm) intensity map in the nanocavity at the resonant frequency shows excellent agreement with 3D finite difference time domain simulations. Furthermore, the pre-resonant evolution of light intensity in the nanocavity shows an interesting behaviour as the mode-gap is scanned in frequency.

[1] Samples were fabricated by the Nanodevices for Photonics and Electronics group, Institute of Experimental Physics, University of Würzburg.

Q 20.3 Di 11:10 HI

Interaction of Nanoscopic Particles with the Near Field of Photonic Crystal Structures — •Michael Barth and Oliver Benson — Nano Optics, Institute of Physics, Humboldt University Berlin

Nanostructured dielectric materials provide new ways of guiding and manipulating light, most prominently realized in photonic crystal waveguides and cavities. The specific optical properties of these structures make them promising candidates for novel sensing techniques, as small changes in the dielectric environment can significantly alter the propagation of light. For this purpose we have studied the interaction of nanoscopic dielectric particles with the near field of various photonic crystal structures by means of numerical simulations. We investigate the resulting changes in the optical properties of the photonic crystals as well as the mechanical forces acting on the particles. Both effects turn out to be strongest for cavity-like defect structures, which exhibit sharp resonances and large field enhancements, thereby ensuring intense matter-light interaction. These results will be exploited in experimental studies, which are currently in progress, using an optical tweezer to position and manipulate dielectric particles on planar photonic crystals.

Q 20.4 Di 11:25 HI

Lauebeugung von sichtbarem Licht an periodischen Strukturen mit endlicher Ausdehnung — •Oliver Henneberg[1], Ullrich Pietsch[2] und Norbert Lauinger[3] — [1]Universität Potsdam — [2]Universität Siegen — [3]Corrsys-Datron

v.Laue-Beugung mit Röntgenstrahlung wird seit langem zur Charakterisierung von Einkristallen eingesetzt. Lauespots entstehen, wenn eine Netzebene hkl mit dem Netzebenenabstand d(hkl) die Braggbedingung für eine spezielle Wellenlänge λ aus dem einfallendem weissen Röntgenlicht erfüllt. Das selbe Prinzip kann angewendet werden, um aus weissem sichtbaren Licht, Spots verschiedene Farbe zu selektieren. Die dazu nötigen Kristalle mit Gitterkonstanten im Micrometer Bereich sind im Prinzip als Photonische Kristalle verfügbar. Im Gegensatz zu den Röntgenobjekten sind diese aber in ihrer räumlichen Ausdehnung begrenzt was die Energieunschärfe der möglichen Reflexe begrenzt.

Im folgenden stellen wir ein Experiment vor, mit dem man Lauebilder eines Kristalls mit Mikrometer Gitterkonstante nach Beugung mit sichtbarem Licht auswerten kann. Mit Hilfe eines Computerprogramms läßt sich die Streuung am endlichen Kristall simulieren. Numerischen Ergebnisse werden mit gemessenen Lauebeugungsaufnahmen verglichen.

Q 20.5 Di 11:40 HI

Unconditionally stable time-domain simulations using Krylov-subspace methods — •Jens Niegemann[1,2], Martin Pototschnig[1], Lasha Tkeshlashvili[3,2], and Kurt Busch[1,3,2] — [1]Institut für theoretische Festkörperphysik, Universität Karlsruhe — [2]DFG Forschungszentrum Center for Functional Nanostructures (CFN), Universität Karlsruhe — [3]Institut für Nanotechnologie, Forschungszentrum Karlsruhe in der Helmholtz-Gemeinschaft

Over the past decades, many numerical methods have been developed to solve the time-dependent Maxwell equations. The most popular one is the so-called Finite-Difference Time-Domain (FDTD) method. While FDTD is very easy to implement and relatively fast, it exhibits some inherent problems. In particular, it is only of second order in time and only conditionally stable. Therefore, to obtain accurate results one has to take very small timesteps. We propose to solve Maxwell's equations with an unconditionally stable and more accurate method based on operator exponentials using Krylov-subspace techniques. We compare the performance of our method with standard FDTD and other methods. In addition, we demonstrate how to include absorbing boundary conditions and sources into this method while still maintaining the unconditional stability. Furthermore, we show how this method can be extended to nonlinear and coupled systems, by using nonlinear exponential integrators.

Q 20.6 Di 11:55 HI

Characterization of macroporous silicon devices for Photonic Crystal-based spectroscopic gas sensors — •Stefan L. Schweizer[1], Torsten Geppert[2], Andreas von Rhein[1], Daniel Pergande[1], and Ralf B. Wehrspohn[1] — [1]Dept. Physik, Universität Paderborn, 33095 Paderborn — [2]MPI Halle, 06120 Halle

Photonic crystals (PhC) offer the potential to allow the realization of compact spectroscopic gas sensors. The working principle is based on low group velocities. However, the fabrication of corresponding PhC structures is demanding. We improved the macroporous Si fabrication process to fabricate promising structures. Growth of deep (450 μm) trenches next to ordered macropore arrays was successfully achieved during photoelectrochemical etching. In addition, this approach allows in-situ realization of an efficient coupling scheme of low group velocity modes as well as manual separating of the gas sensor devices with sub-μm precision. Transmission through macroporous Si PhCs of several hundred pore rows has been achieved. Homogeneity issues related to this are also discussed.

Q 20.7 Di 12:10 HI

Tunable photonic crystal laser with integrated wavelength monitor — •Christian Ulzhöfer, Helmut Scherer, Martin Kamp, and Alfred Forchel — Technische Physik, Am Hubland, D-97074 Würzburg, Germany

We have investigated the integration of tunable photonic crystal (PhC) lasers with a wavelength monitor. The tunable lasers are based on two coupled PhC waveguides with slightly different length. PhC mirrors are placed at the end, joint and front of the two waveguides. Tuning is achieved by a variation of the injection currents in the two segments. The wavelength monitor, which is placed behind the rear mirror of the laser, consists of a multi-mode PhC waveguide. Mode coupling between the fundamental mode and a higher order mode results in dips in the waveguide transmission (mini-stopband). The operating point of the laser is chosen on either side of the mini-stoband, so that any change of the wavelength will lead to a change of the transmission. An integrated photodiode at the end of the waveguide records the transmitted intensity.

The devices are fabricated from InP laser layers with $1.5\mu m$ emission wavelength. Electron beam lithography is used to define the PhC patterns, which are then etched through the complete laser structure to a depth of more than $3.5\mu m$. The lasers have high sidemode suppression ratios between 30 and 45 dB and output powers above 25 mW. The tuning range of the devices is around 20 nm. The photocurrent of the integrated diode shows a clear dependence on the laser wavelength, in good agreement with simulations of the wavelength monitor transmission.

Q 20.8 Di 12:25 HI

Single mode photonic-crystal distributed feedback lasers — •Holger Hofmann, Helmut Scherer, Stefan Deubert, Johann-Peter Reithmaier, Martin Kamp, and Alfred Forchel — Technische Physik, Am Hubland, D-97074 Würzburg, Germany

High power single-mode emission with diffraction-limited beam quality is advantageous for many applications such as optical fiber amplifiers, frequency doubling or optical sensors. We investigate a widely unexplored approach to achieve these objectives in semiconductor lasers: The Photonic-Crystal distributed-feedback (PCDFB) laser, which combines the best features of conventional DFB and α-DFB lasers in order to achieve single-mode emission and good beam quality over a broad range of apertures [1].

A PCDFB laser uses a rectangular, 2D photonic crystal lattice for optical feedback. This lattice, in our case realized as an array of etched air holes, is tilted with respect to the cleaved facets of the device. The laser light has to undergo multiple Bragg reflections during a roundtrip in the cavity, which leads to the selection of a single lateral and longitudinal mode.

We use InGaAs/AlGaAs laser layers for the fabrication of the devices. The air holes are defined by e-beam-lithography and dry etching through the upper cladding and close to the waveguid layer. We observe single mode emission at wavelengths around $\lambda = 980nm$ with a sidemode supression of over 30dB.

[1] I. Vurgaftman and J.R. Meyer, Appl. Phys. Lett. 78, 1475 (2001)

Q 20.9 Di 12:40 HI

Electrically tunable lasing based on Ferroelectric Liquid Crystals — •Wolfgang Haase[1], Fedor Podgornov[1], Yuko Matsuhisa[2], Katsumi Yoshino[2], and Masanori Ozaki[2] — [1]Institute of Physical Chemistry, Darmstadt University of Technology, Darmstadt/Germany — [2]Department of Electrical, Electronic and Information Engineering, Osaka University, Osaka/Japan

Ferroelectric Liquid Crystals (FLCs) are characterized by a helical structure and a layered arrangement. Due to the 1-D structure the incoming light will be selectively reflected. In dye-doped FLCs lasing appeared on the edge of the so called stop band, where light can not propagate. The wavelength of the laser light can be easy tuned by changing the voltage of the applied field or by changing the temperature. On the other hand photons can be localized by introducing defects along the helix. This can be done in different ways. One is creating defects due to local heating of a dye doped FLC. Other way is the use of dielectric multilayers out of pairs of SiO2 and TiO2, were the distance between the multilayer blocks can be varied. So a 1-D hybrid photonic crystal can be received. Introducing defects lead to a lot of advantages, namely the lasing threshold is much lower as in arrangements without defects. During the lecture, an overview on the status of research will be given.