HL 62 Photonische Kristalle IV

Zeit: Mittwoch 10:45–13:30 Raum: TU P164

HL 62.1 Mi 10:45 TU P164

A novel technique for near-field mapping of photonic crystal eigenmodes — •F. Intonti[1], C. Ropers[2], M. Colocci[1], C. Lienau[2], P. Bettotto[3], and L. Pavesi[3] — [1]LENS, 50019 Sesto Fiorentino (FI), Italy — [2]Max-Born-Institut für Nichtlineare Optik und-Kurzzeitspektroskopie, 12489 Berlin — [3]Università di Trento, 38100 Trento, Italy

Photonic crystals (PCs) are predicted to drastically influence the light propagation (1) and these predictions are currently actively tested by experiments. Most studies probe the band structure by analyzing amplitudes of scattered electromagnetic waves (2) and thus provide only indirect microscopic information about the optical modes of the PC. Near-field optical microscopy allows for a direct spatial imaging of these modes. So far, however, only few near-field studies have been reported, mainly due to inherent experimental difficulties.

Here, we report a novel, efficient and easy-to-use technique for near-field mapping of PC eigenmodes. The technique is based on non-metalized dielectric near-field probes and can be applied in a wide wavelength range from 400 to $>$ 2000 nm. Experiments at λ=1.55 μm, probing the the local reflectance from periodically ordered air pores in a crystalline silicon matrix, demonstrate an optical resolution of less than $\lambda/5$ and are well reproduced by numerically solving the PC master equation.

HL 62.2 Mi 11:00 TU P164

Ultrafast light transmission and subradiant damping in plasmonic crystals — •C. Ropers[1], D. J. Park[2], G. Stibenz[1], G. Steinmeyer[1], D. S. Kim[2] und C. Lienau[1] — [1]Max-Born-Institut für Nichtlineare Optik undKurzzeitspektroskopie, 12489 Berlin — [2]School ofPhysics, Seoul National University, Seoul 151-742, Korea

Surface-bound electromagnetic waves on metals, surface plasmon polaritons (SPP), will play an important role in novel photonic structures, promising an unprecedented amount of light control on the nanoscale. Periodic arrays of subwavelength slits and holes in metallic films serve as important SPP model systems. Here, the SPP lifetime is generally limited to few tens of femtoseconds by the strong SPP coupling to far-field radiation, limiting their use in new photonic elements such as nano-resonators or waveguides. Here, we discuss a novel approach for tailoring the radiative damping in metallic nanohole arrays. Amplitude and phase-resolved transmission experiments with ultrashort, 10 fs light pulses demonstrate a more than 15-fold increase in radiative SPP lifetime to more than 200 fs, induced by the coherent coupling between different SPP resonances. In close analogy to the famous subradiant damping in radiatively coupled atomic systems [1], the formation of antisymmetric coupled SPP eigenmodes leads to this pronounced damping suppression. In plasmonic systems, the spatial structure of the SPP eigemodes can directly be imaged by near-field microscopy, providing insight into the microscopic origin radiative coupling phenomena.

[1] R. H. Dicke, Phys. Rev. **93**, 99 (1954)

HL 62.3 Mi 11:15 TU P164

Microwave modelling of disorder in photonic crystal slab waveguides — •Jan Brosi, Christopher Poulton, and Wolfgang Freude — Institut für Hochfrequenztechnik und Quantenelektronik, Universität Karlsruhe, Engesserstr. 5, D-76128 Karlsruhe

Disorder due to imperfect fabrication processes of photonic crystals is unavoidable and has a significant effect on the loss of photonic crystal waveguides.

We studied the influence of positional and radial disorder of the air holes in a high-index triangular lattice photonic crystal slab with line defect. For the experimental investigation, we used a microwave model, where the frequency was downscaled by a factor of 20,000 to 10 GHz and the dimensions of the structure were upscaled by the same factor. This way, ideal structures could be fabricated and well-defined disorder introduced. From the measurements, amplitude and phase data could be obtained, and the results were compared to numerical results.

HL 62.4 Mi 11:30 TU P164

Giant Purcell Effect for InGaAs self-assembled Quantum Dots in Photonic Crystal Microcavities — •A. Kress, F. Hofbauer, N. Reinelt, M. Kaniber, G. Böhm, and J. J. Finley — Walter Schottky Institut, TU München, 85748 Garching, Germany

We present investigations of the coupling of InGaAs self-assembled quantum dots (QD) to localised optical modes in 2D photonic crystal defect microcavities, where a very strong enhancement of the light-matter interaction in the weak coupling regime was directly measured.

Our samples consist of thin active GaAs membranes into which a layer of QDs are incorporated. The photonic crystal cavities are formed by single missing hole defects in an etched 2D hexagonal lattice of air holes. Finally the membranes are fabricated by removing a sacrificial AlAs layer in a wet etching process.

The investigated cavity modes have Q-factors of >2500 and mode-volumes $V < (\lambda/n)^3$. Up to a 50x enhancement of the emission intensity is observed for QDs on-resonance with the cavity modes suggesting the presence of significant cavity QED phenomena. Time resolved luminescence measurements reveal a shortening of the spontaneous emission lifetime by a factor $\sim$20, for single QDs inside our cavities on-resonance with the optical modes compared with QD emission outside any cavity. Furthermore, over a spectral range of >40nm we obtain factor >2 longer excitonic lifetimes for QDs inside these cavities but off-resonance with optical modes.

HL 62.5 Mi 11:45 TU P164

Disorder in metallic photonic crystal slabs — •Dietmar Nau[1], Anja Schönhardt[1], Harald Giessen[1], André Christ[2], and Jürgen Kuhl[2] — [1]Institut für Angewandte Physik, Universität Bonn, Wegelerstraße 8, D-53115 Bonn — [2]Max-Planck-Institut für Festkörperforschung, Heisenbergstraße 1, D-70569 Stuttgart

It is well known that the optical properties of gold nanostructures can be tailored by arranging them periodically on top of a dielectric waveguide material [1]. This effect can be explained by the formation of a new quasi-particle, a so-called waveguide-plasmon polariton [2]. In this work we present a detailed study of the influence of disorder in these structures. Samples with a controlled amount and type of disorder are fabricated. We vary the positions of the nanostructures with respect to the original grid. We consider frozen-phonon disorder, where the nanostructures are shifted similar to phonons in a solid, and another model with far-field disorder. The models are characterized in detail by their two-particle correlation functions, and the optical properties of the different structures are determined. We find that the linear optical properties are changed dramatically. The modulation in the extinction due to the polariton formation decreases for increasing disorder. Also, the bandstructure is influenced. Disorder causes the splitting of the bands to decrease due to a reduced spatial overlap of the wavefunctions of plasmon and waveguide mode. Different disorder models influence the specific optical properties in different ways.

[1] S. Linden et al., Phys. Rev. Lett. 86, 4688 (2001) [2] A. Christ et al., Phys. Rev. Lett. 91, 183901 (2003)

HL 62.6 Mi 12:00 TU P164

Designing and Engineering of High-Q Photonic Crystal Defect Cavities — •F. Hofbauer, A. Kress, N. Reinelt, H. J. Krenner, M. Bichler, D. Schuh, and J. J. Finley — Walter Schottky Institut, TU München, 85748 Garching, Germany

We present investigations and calculations on localized light states in 2D photonic crystal defect cavities (PCDC). Our results enable us to control the spectral position of photonic modes inside the photonic bandgap and engineer their Q-factors.

Our samples consist of thin GaAs membranes into which a layer of InGaAs self assembled QDs are incorporated. The 2D photonic crystals consist of an etched hexagonal lattice of air holes. The defect cavities are either formed by a line of three missing holes (L3)[1] or by one missing hole and the redistribution of the six surrounding holes (Y1)[2].

Controlling the spectral position of single photonic modes over a range of $\sim$200nm in different PCDC together with 3D simulations of the PCDC enables us to tune and select the position of cavity modes relative to the photonic bandgap. Our investigations demonstrate a one order of magnitude change of the Q-factor for these designed photonic modes. The fine-tuning of the different PCDC designs enabled us to obtain Q-factors up to 8000 and mode-volumes less than $0.5(\lambda/n)^3$.

[1] Y. Akahane et al., Nature, 425, 944 (2003)

[2] J. Vučković and Y. Yamamoto, APL 82, 2374 (2003)

HL 62.7 Mi 12:15 TU P164

Spontaneous parametric scattering of microcavity polaritons in momentum space — •Wolfgang Langbein — Department of Physics and Astronomy, Cardiff

We measure the spontaneous parametric emission from a semiconductor microcavity after resonant pulsed coherent excitation. Resolving the emission in time and two-dimensional momentum space, the underlying scattering processes, which were theoretically treated by Ciuti *et al.*, Phys. Rev. B **63**, 041303 (2001), are validated. The predicted figure-8 shaped distribution of the final states of the parametric scattering is observed. We find a narrowing of the momentum distribution with time, which is a feature of memory effects in the scattering due to parametric correlation. Additionally, the influence of higher-order scattering and pump depletion are observed in the experiment.

HL 62.8 Mi 12:30 TU P164

Structure and Properties of Low-n Mesoporous Silica Films for Optical Applications — •Denan Konjhodzic[1], Helmut Bretinger[1], Siegmund Schröter[2], and Frank Marlow[1] — [1]Max-Planck-Institut für Kohlenforschung, D-45470 Mülheim an der Ruhr — [2]Institut für Physikalische Hochtechnologie, D-07745 Jena

The properties and structure of the mesoporous silica films are investigated. Because of their ultra low refractive index (n = 1.14), these films are used as optical waveguide supports especially for 2D photonic crystals. The films are synthesized by a template-modified sol-gel process using triblock copolymers. A significant dependence of the formed structure on the processing conditions has been revealed allowing an appreciable structure tuning. One set of processing conditions allows the reproducible synthesis of low-n films. They are optically clear, mechanically and chemically resistant, very smooth, and sufficiently thick (1000 nm) with the pore size of 8 nm. Under other processing conditions, a novel sustained lamellar structure remaining stable upon calcination was synthesized.

The films were characterized by angular-dependent interferometry, small angle x-ray scattering, transmission electron microscopy and atomic force microscopy. Onto these films, 2D photonic crystals of different materials, such as polymers (PMMA/DR-1)[1], niob pentoxide and tantal pentoxide have been fabricated. The first investigations of such Ta2O5 and ferroelectric PZT films will be presented.

[1] M. Schmidt et al., Appl. Phys. Lett. 85, 16 (2004)

HL 62.9 Mi 12:45 TU P164

A new optical method to investigate the director field of liquid crystals appearing in a photonic crystal template — •Heinz Kitzerow[1], Heinrich Matthias[1], Thorsten Röder[1], Sven Matthias[2], Ralf Wehrspohn[1], and Stephen Picken[3] — [1]Faculty of Science, University of Paderborn, Warburger Str. 100, 33098 Paderborn — [2]Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle — [3]Delft University of Technology, Dept Material Science and Technology, Julianalaan 136, Delft 2628 BL, The Netherlands

Photonic crystals can be actively tuned by filling these porous structures with liquid crystals. We report on results using fluorescence confocal polarizing microscopy (FCPM) to examine the director field of liquid crystals confined to modulated micrometer pores. The photonic crystal was filled with a glass-forming liquid crystalline polymer and cooled below the glass transition temperature to conserve the director field. After removing the photonic crystal template, we studied the remaining liquid crystal rods by FCPM. Evidences of a spatially periodic director field containing a lattice of disclination rings are found.

HL 62.10 Mi 13:00 TU P164

Nonlinear optical tuning demonstrated on 2D photonic crystals — •Stefan L. Schweizer[1], Ralf B. Wehrspohn[1], Hong W. Tan[2], Henry M. van Driel[2], and Ulrich Gösele[3] — [1]Dept. Physik, Universität Paderborn — [2]Dept. of Physics, University of Toronto — [3]Max-Planck-Institut für Mikrostrukturphysik, Halle

Optical switching can be achieved by changing the refractive index. For this nonlinear optical effects are used. We used pump and probe reflectivity experiments with 130fs laser pulses. Both the Kerr effect and the Drude effect shifting the band edges of a stop gap of a photonic crystal are identified. The Drude effect (based on real carriers) shows a fast rise time but a slow fall time whereas the Kerr effect (virtual carrier excitation) has a very fast rise and fall response. On the other hand the Kerr effect is limited to high pump light intensities.

HL 62.11 Mi 13:15 TU P164

Interplay between Auger and ionisation processes in nanocrystal quantum dots — •Robert Kraus[1], Pavlos Lagoudakis[1], Dmitry Talapin[2], Andrey L. Rogach[1], John M. Lupton[1], Jochen Feldmann[1], and Horst Weller[2] — [1]Lehrstuhl für Photonik und Optoelektronik, Ludwig-Maximilians-Universität München — [2]Institut für Physikalische Chemie, Universität Hamburg

A detailed understanding of the radiative and non-radiative decay channels in semiconductor nanocrystal quantum dots (NQDs) is necessary for tuning their fluorescence dynamics in photonic structures. In photonically confined systems it is particularly important to know if there is an influence of increased excitation density on the decay dynamics, as such an intrinsic effect may mark extrinsic changes in lifetime due to photonic confinement [1]. As a first step we present here spectrally resolved fluorescence decay measurements on CdSe/ZnS core/shell NQDs embedded in a polystyrene matrix. We show that there is an monotonic increase of the fluorescence decay rate with excitation power in the high excitation density regime. Our results suggest that Auger recombination accelerates ionisation processes that lead to the formation of dark, non-emissive nanocrystal states. A detailed kinetic model is proposed in the quantised Auger regime describing these experimental observations and providing an estimate of the Auger assisted ionisation rates. We conclude that great caution has to be exerted when employing NQDs as light sources under photonic confinement due to their intrinsic field strength dependence of the fluorescence decay. [1] P. Lodahl *et al.*, Nature **430**, 654 (2004)