HL 37 Photonische Kristalle I

Zeit: Montag 10:00–12:15 Raum: TU P270

HL 37.1 Mo 10:00 TU P270

Enhanced light-matter interaction in semiconductor quantum wells embedded in one-dimensional photonic crystals — •Bernhard Pasenow[1], Matthias Reichelt[1], Tineke Stroucken[1], Torsten Meier[1], Stephan W. Koch[1], Armis R. Zakharian[2], and Jerome V. Moloney[2] — [1]Department of Physics and Material Sciences Center, Philipps University, Renthof 5, D-35032 Marburg — [2]Arizona Center for Mathematical Sciences, University of Arizona, Tucson, AZ 85721, USA

The development of photonic crystals has offered novel possibilities to improve the characteristics of optoelectronic devices such as light-emitting diodes and lasers. Here, we analyze the optical properties of semiconductor quantum wells embedded in one-dimensional photonic crystals using a microscopic theory. It is shown that the linear optical spectra of such structures exhibit signatures of non-perturbative light-matter coupling if the exciton is resonant with a field mode that occurs slightly below the optical gap. Due to light focusing and slow light propagation, optical gain enhancement is predicted, exceeding that of a homogeneous medium by more than one order of magnitude. If the structures are placed inside a microcavity, the gain increases superlinearly with the number of wells and for more than five wells exceeds the gain of a corresponding vertical-cavity surface-emitting laser.

[1] B. Pasenow, M. Reichelt, T. Stroucken, T. Meier, S.W. Koch, A.R. Zakharian, and J.V. Moloney, submitted.

HL 37.2 Mo 10:15 TU P270

Optical properties of semiconductor photonic-crystal structures: Spatially-inhomogeneous excitonic resonances and optical gain — •Torsten Meier, Matthias Reichelt, Bernhard Pasenow, Tineke Stroucken, and Stephan W. Koch — Department of Physics and Material Sciences Center, Philipps University, Renthof 5, D-35032 Marburg

Significant aspects of the light-matter interaction can be tailored in suitably designed systems consisting of semiconductor nanostructures and dielectric photonic crystals. Such effects are described by a microscopic theory which provides a self-consistent solution of the dynamics of the electromagnetic field and the material excitations. The theory is applied to investigate spatially-inhomogeneous excitonic resonances, which arise as a consequence of the modified Coulomb interaction in the vicinity of a structured dielectric medium [1-3]. It is demonstrated that these inhomogeneities lead to distinct modifications of the optical spectra [3].

[1] R. Eichmann, B. Pasenow, T. Meier, T. Stroucken, P. Thomas, and S.W. Koch, Appl. Phys. Lett. **82**, 355 (2003).
[2] T. Meier and S.W. Koch, in *Photonic Crystals - Advances in Design, Fabrication and Characterization*, Eds. K. Busch, S. Lölkes, R.B. Wehrspohn, and H. Föll, (Wiley-VCH, Berlin, 2004) pp. 43-62.
[3] M. Reichelt, B. Pasenow, T. Meier, T. Stroucken, and S.W. Koch, submitted.

HL 37.3 Mo 10:30 TU P270

Frequency-Selective Modification of the Radiation Pattern of Emitters in Photonic Crystals — •Michael Barth and Frank Cichos — Photonics and Optical Materials, Institute of Physics, Chemnitz University of Technology

We have studied the angle-dependent spontaneous emission of dye molecules in single, highly ordered domains of three-dimensional photonic crystals using a new microscopy setup. A strongly modified radiation pattern has been found for frequencies near the photonic stop band, including a highly directional four-fold intensity enhancement at its high-frequency edge. For the first time, the experimental observations are directly compared to numerical calculations of the angle-dependent local optical density of states. The excellent agreement between experiment and theory suggests, that the angular emission probability of the dye molecules is directly modified by the optical mode structure of the photonic crystal. This leads to a spectral and spatial redistribution of the emitted light without significant change of the radiative lifetime.

HL 37.4 Mo 10:45 TU P270

Ferroelectric Liquid Crystals as tunable optical stop-band materials — •Wolfgang Haase[1], Vladimir Bezborodov[2], Valery Lapanik[2], Fedor Podgornov[1], and Artisom Lapanik[1] — [1]Teschnische Universität Darmstadt, Eduard-Zintl-Institut für Anorganische und Physikalische Chemie, Petersenstr. 20, D-64287 Darmstadt, Germany — [2]Institute of Applied Physics Problems, Minsk 220064, Belarus

Ferroelectric Liquid Crystals (FLCs) have unique combination of optical and electrooptical properties (fast response time and periodically modulated structure) which makes them attractive for application as tunable stop band materials. As it was showed in our early works, the FLCs was successfully utilised for tuneable laser generation in dye-doped samples at the edge of the photonic band gap and its tunability due to temperature and the electric field was demonstrated. In the present report, we will demonstrate new type of the FLC mixtures with very high birefringence (around 0.3). These materials are based on phenyl and biphenyl pirimidines and a four ring chiral compound with high optical anisotropy. The combination of these components allowed us to have chiral SmC phase in wide temperature range, vary the helical pitch over the whole optical band as well as greatly increase its birefringence. In addition, these mixtures have excellent alignment properties (both for planar and for homeotropic orientation). The lasing properties of these mixtures doped with laser dyes (DCM, Rhodamine 590) will be discussed.

HL 37.5 Mo 11:00 TU P270

Photonic Crystal Based Spectroscopic Gas Sensors — •Torsten M. Geppert[1,2], Daniel Pergande[2], Andreas v. Rhein[2], Stefan L. Schweizer[2], Ralf B. Wehrspohn[2] und Armin Lambrecht[3] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle — [2]Universität Paderborn, Dept. Physik, Warburgerstr. 100, D-33098 Paderborn — [3]Fraunhofer-Institut für Physikalische Messtechnik, Heidenhofstr. 8, D-79110 Freiburg

Gas sensors are important for a broad range of technical fields. Among other types, spectroscopic gas sensors are a very general approach, applicable for the detection of a variety of different gases due to their high selectivity to specific absorption lines for each gas. A drawback of such systems is their relatively large size caused by the necessary size of the interaction volume of the dilute gas medium and the light. The use of 2D photonic crystals (PhCs), e.g. made of macroporous silicon, allows a dramatic decrease in size of of the interaction volume by exploitation of certain features of the PhC bandstructure such as a very low group velocity v_g. However, a low v_g leads to high reflection at the PhC interface, resulting in low transmission and therefore an unfavorable signal-to-noise-ratio. Investigations of different strategies to improve the transmission led to the development of a novel taper concept, the so-called *Anti-Reflection-Layer*. Its working principle is different from classical anti-reflection-coatings and based on mode-matching of the incoming plane wave and the Bloch-modes in the photonic crystal.

HL 37.6 Mo 11:15 TU P270

Zeitaufgelöste THz-Spekroskopie von Oberflächenplasmonpolaritonen auf Halbleitergitterstrukturen — •Martin Kuttge, Jaime Gomez Rivas, Peter Haring Bolivar und Heinrich Kurz — Institut für Halbleitertechnik, RWTH Aachen, Sommerfeldstrasse 24, 52074 Aachen

Das Gebiet der Plasmonik steht derzeit im Fokus einer Reihe physikalischer Arbeiten und technologischer Entwicklungen. Es umfasst die Untersuchung von Oberflächenplasmonpolaritonen (engl. Surface Plasmon Polaritons, SPPs), einer kollektiven Anregung von Ladungsträgern an der Grenzfläche zwischen einem Dielektrikum und einem Metall, und hat in den letzten Jahren zu einer großen Anzahl von Forschungsaktivitäten in Bereichen der Sensorik und der subwellenlängen Manipulation von Strahlung geführt. Die Beeinflussung der SPP-Propagationseigenschaften ist dabei von besonderem Interesse. Hierfür bieten periodische Halbleiterstrukturen eine Möglichkeit.

Wir haben zum ersten Mal zeitaufgelöste Messungen zur Erzeugung und Propagation von SPPs im THz-Frequenzbereich durchgeführt[1]. Die Verwendung von Halbleitern statt Metallen eröffnet zudem neue Möglichkeiten zur Kontrolle der SPP-Propagation. In weiteren Messungen haben wir gezeigt, dass eine periodische Strukturierung der Oberfläche die Propagation der SPPs für ein Band von Frequenzen beeinflussen kann[2].

[1] J. Saxler et al., Phys. Rev. B 69, 155427 (2004)
[2] J.G. Rivas et al. submitted to Phys. Rev. Lett.

HL 37.7 Mo 11:30 TU P270

Photonic crystals with negative refraction focus light beams below the diffraction limit — •Anton Husakou and Joachim Herrmann — Max Born Institute, Max Born Str. 2a, D-12489 Berlin, Germany

The resolution limit of all conventional optical devices is determined by the fact that all evanescent components of an electromagnetic wave are lost during propagation. It has been suggested that evanescent waves can be amplified by a slab with a negative refraction index leading to a sub-wavelength resolution of image. Up to now this superlensing effect was studied for imaging of sub-wavelength features. We show that a photonic crystal with negative refraction amplifying evanescent waves, combined with an aperture which creates seed evanescent waves, can focus light beams below the diffraction limit of half of the wavelength. We describe beam focusing both in the context of effective-medium theory as well as using the numerical solution for a realistic photonic crystal structure. We show that an input beam is focused to a spot with FWHM of 0.14λ in the case of effective-medium theory and 0.25λ for the realistic structure of a photonic crystal.

HL 37.8 Mo 11:45 TU P270

Light-emitting biological photonic crystals — •Melanie El Rharbi-Kucki and Thomas Fuhrmann-Lieker — Makromolekulare Chemie und Molekulare Materialien, FB Naturwissenschaften, Universität Kassel, Heinrich-Plett-Str. 40, 34109 Kassel

Biological nanostructures are widespread in nature. They are extremely diverse in material composition, structural complexity and function. In many animal phyla photonic crystal structures in the range of the wavelength of visible light are used to produce brilliant structural colours. Here we present one of the few examples of photonic crystal structures in plants. The silica cell wall of the centric diatoms Coscinodiscus granii and Coscinodiscus wailesii can be regarded as slab waveguide photonic crystals with hexagonal and square structure. The lattice constants of the photonic structures are in the dimension of the UV to NIR range. Light is the main energy source for diatoms and an essential factor giving information about the environment they are living in. We investigate the optical properties of the diatom shell with respect to the biological function and the possibility for technological application. To explore the control of absorption and emission of light by the photonic structures, various laser dye molecules were incorporated into the diatom shell by the use of an in vivo-technique. We give an overview on dye classes that are incorporated into the photonic crystal structure and present recent results on the microscopically resolved emission behaviour. This project is part of the DFG priority program on photonic crystals.

HL 37.9 Mo 12:00 TU P270

Trapping and manipulating dielectric nanoparticles on Photonic Crystals using an optical tweezer — •Oliver Benson and Franz Boczianowski — Humboldt-Universität zu Berlin

We perform a controlled experiment where we manipulate sub-micron particles (polystyrene beads and single cells) on Photonic Crystal (PC) structures in aqueous solution with an optical tweezer. The goal of the experiment is to investigate the potential of PC structures for (bio-)sensing applications. We introduce the setup and report on first tests where we trapped and manipulated dielectric particles from 10 μm down to 50 nm. The smaller particles were doped with dye molecules in order to establish optical detection and imaging via their fluorescence light. Additionally, we trapped biological specimen, such as single yeast and blood cells. As a very important result we could demonstrate that it is possible to trap and manipulate 500 nm particles close to the surface of a silicon PC structure which was immersed in water. The results are very promising for future experiments aiming towards sensing and ultra-sensitive force as will be discussed in this talk.