presented and discussed.

[1] T. Meier, P. Thomas, and S. W. Koch, Coherent Semiconductor Optics: From Basic Principles to Nanostructure Applications, Springer, Berlin, 2007.
[2] W. Dahmen, T. Rohwedder, R. Schneider, and A. Zeiser, Numer. Math. 110, 277-312 (2008).
[3] C. Burstedde and A. Kunoth, Numer. Algor. 48, 161-188 (2008).

HL 60.2 Thu 18:00 Poster D1

Influence of Coulomb correlations on the quantum well intersubband absorption — •Thi Uyen-Khanh Dang, Andreas Knorr, Carsten Weber, and Marten Richter — Institut für Theoretische Physik, Technische Universität Berlin, Germany

We present a non-Markovian theory for the description of quantum well intersubband dynamics, focusing on the influence of the electron-electron interaction on the absorption properties at low temperatures. The many-body problem is treated within a density-matrix approach using the correlation expansion to obtain equations of motion for the electron density and the intersubband coherence [1]. The inclusion of the electron-electron interaction leads to a correlated electronic ground state and a self-consistently determined broadening of the intersubband absorption spectrum. The resulting influence on the absorption line shape is investigated and discussed for different quantum well widths and doping densities.

[1] I. Waldmüller et al., Phys. Rev. B 69, 20530766 (2004).

HL 60.3 Thu 18:00 Poster D1

Degree of ionization and excitonic BEC window in Cu_2O and ZnSe — •Felix Richter, Dirk Semkat, Günter Manzke, Dietrich Kremp, and Klaus Henneberger — Institut für Physik, Universität Rostock, 18051 Rostock

We evaluate the ionization equilibrium in the high-density electron–hole plasma of Cu_2O and ZnSe. The influence of many-particle effects on the chemical potentials of carriers, the exitonic binding energy, and the Mott transition (density ionization) is investigated over a wide range of temperatures and carrier densities. In contrast to simplifying approximations used in the literature we consider full dynamical screening between carriers and find the Mott transition to occur at densities more than one order of magnitude higher than estimated before.

The results are given as a phase diagram of the ionization. Special attention is directed to the determination of the region where an excitonic fraction can reach the critical density and, therefore, Bose–Einstein condensation can occur.

[1] D. Semkat, F. Richter, D. Kremp, G. Manzke, W.-D. Kraeft, and K. Henneberger, *Phys. Rev. B* **80**, 155201 (2009) [2] F. Richter, D. Semkat, D. Kremp, and K. Henneberger, *Phys. Status Solidi C* **6**, 532 (2009) [3] G. Manzke, D. Semkat, F. Richter, D. Kremp, and K. Henneberger, submitted for publication (2009)

HL 60.4 Thu 18:00 Poster D1

Quantum-optical radiation laws for confined semiconductor systems — •Felix Richter and Klaus Henneberger — Institut für Physik, Universität Rostock, 18051 Rostock

We present a quantum-kinetically exact theoretical framework for the propagation, emission and scattering of light in bounded media in the context of semiconductor optics. The theory is based on the nonequilibrium photon Green's functions. Its advantage is that the spatial inhomogeneity inherent to bounded media and, hence, to many semiconductor optics problems, is fully and exactly considered. The electromagnetic properties of media are treated microscopically rather than in an effective approximation, and media may be arbitrarily dispersive and absorptive.

Relations for the propagation of quantized (squeezed) light are given. In this respect, our approach may serve as a replacement for the input-output formalism in quantum optics, which implies some severe approximations as a concession to its simplicity.

The theory yields a generalized Kirchhoff–Planck radiation law which provides insight into the interplay of emission and absorption in nonequilibrium steady-state systems.

[1] F. Richter, M. Florian, and K. Henneberger, *Phys. Rev. B* **78**, 205114 (2008) [2] K. Henneberger and F. Richter, *Phys. Rev. A* **80**, 013807 (2009)

HL 60.5 Thu 18:00 Poster D1

Coupling plasmons and excitons — •Markus Pfeiffer[1,2], Klas Lindfors[1,2], Markus Lippitz[1,2], Harald Giessen[2], Paola Atkinson[3], Armando Rastelli[3], and Oliver G. Schmidt[3] — [1]Max Planck Institut für Festkörperforschung, Stuttgart — [2]4. Physikalisches Institut, Universität Stuttgart — [3]IFW Dresden

The spontaneous emission of a single quantum system may be significantly modified by changing the local density of states at the position of the emitter. This allows controlling the light emission properties, e.g., emission rate and direction, using a suitable nanostructure. Plasmon resonant metal structures are a particularly interesting choice since the electromagnetic field is significantly enhanced at the plasmon resonance wavelength. This offers exciting possibilities in both fundamental light-matter studies as well as in applications.

We experimentally investigate the influence of plasmon resonant gold nanostructures on the photoluminescence properties of individual semiconductor quantum dots (QDs). The quantum dots are epitaxially grown AlGaAs/GaAs QDs which are buried a few nanometers beneath the semiconductor surface and photoluminesce at approximately 760 nm wavelength. The advantage of this system is that the optical properties of the QDs are very stable and the transition dipole moments have a fixed orientation. The thin barrier layer allows efficient coupling between the exciton in the quantum dot and a plasmon resonant gold nanostructure on the semiconductor surface. We observe modifications in both the photon emission rate and excited state lifetime when the quantum dot is close to a gold nanostructure.

HL 60.6 Thu 18:00 Poster D1

Simulation of Photonic Crystal Microcavities in Silicon-on-Insulator Waveguides — •Lin Zschiedrich[1], Jan Pomplun[2], Frank Schmidt[1,2], and Sven Burger[1,2] — [1]JCMwave GmbH, Berlin — [2]Zuse Institute Berlin (ZIB)

Photonic crystal microcavities can strongly confine light within a small volume. High Q factors of such structures have been reported [1,2].

We have developed finite-element method (FEM) based solvers for the Maxwell eigenvalue and for the Maxwell scattering problems. The method is based on higher order vectorial elements, adaptive unstructured grids, and on a rigorous treatment of transparent boundaries.

We have simulated experimental setups reported in the literature [1,2]. We present a convergence analysis of the numerical results, and we present very good agreement with experimental results. We further investigate the influence of structural parameters, such as placement and tilt of photonic crystal air holes, on the microcavity Q factor.

[1] P. Velha et al., New J. Phys. 8, 1 (2006).
[2] A. R. M. Zain et al., Opt. Expr. 16, 12084 (2008).

HL 60.7 Thu 18:00 Poster D1

Gain photonic crystal resonators for THz quantum-cascade lasers — •Alexander Benz[1], Christoph Deutsch[1], Gernot Fasching[1], Karl Unterrainer[1], Aaron M. Andrews[2], Pavel Klang[2], Werner Schrenk[2], and Gottfried Strasser[2] — [1]Photonics Institute and Center for Micro- and Nanostructures, Vienna University of Technology, Gusshausstrasse 29/387, A-1040 Vienna, Austria — [2]Institute of Solid-State Electronics and Center for Micro- and Nanostructures, Vienna University of Technology, Floragasse 7/362, A-1040 Vienna, Austria

The terahertz (THz) spectral region is very attractive for applications such as real-time imaging, heterodyne detection or spectroscopy. The preferred, monolithic sources are quantum-cascade lasers (QCLs). Due to inhomogeneous gain broadening a multi-mode emission is typically observed. Photonic crystals (PhCs) are excellent systems for laser resonators, as the full dispersion relation can be designed.

Here, we present the design are realization of microcavity lasers based on active PhCs. The PhC consists of an array of isolated, subwavelength pillars and is fabricated directly from the active region of the THz-QCLs [1, 2]. Thereby, we are able to realize a spatially distributed gain, a central gain region is not required. This resonator concept offers a stable single-mode emission, independently of the driving conditions, and a lithographic tuning range of 15 % of the center lasing frequency.

[1] H. Zhang et al., Opt. Express 15, 16818 (2007)
[2] A. Benz et al., Opt. Express 17, 941 (2009)

HL 60.8 Thu 18:00 Poster D1

Optical properties of high-Q conical polymeric microcavities — •Simone Schleede[1], Mario Hauser[1], Tobias Grossmann[1,2], Julian Fischer[1], Torsten Beck[1], Christoph Vannahme[2], Timo Mappes[2], and Heinz Kalt[1] — [1]Institut für Angewandte Physik, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany — [2]Institut für Mikrostrukturtechnik, Karlsruhe Institute of Technology

(KIT), Karlsruhe, Germany

We report on the fabrication of novel high-Q microresonators made of low loss, thermoplastic polymer poly(methyl methacrylate) (PMMA), which are directly processed on a silicon substrate. Using this polymer-on-silicon material in combination with a thermal reflow step enables cavities of conical shape and ultra smooth surface, dramatically reducing the optical losses caused by surface scattering of the whispering-gallery-modes (WGMs). The cavity Q factor is above two million in the 1300 nm wavelength region and can theoretically reach values greater than ten million in the visible spectral range. Finite element simulations show the existence of a variety of higher order radial and axial WGMs explaining the complexity of the transmission spectra measured using a tunable diode laser coupled to a tapered optical fiber waveguide.

Furthermore, integration of dyes as gain media to the polymer cavities, offers a new possibility for realization of optically pumped, low-threshold, organic microlasers.

HL 60.9 Thu 18:00 Poster D1

Mode Behavior of Coupled Photonic Cavities — •Dennis Ehmer, Matthias Reichelt, and Torsten Meier — Department Physik, Universität Paderborn, Warburger Str. 100, D-33098 Paderborn, Germany

The mode behavior of several coupled photonic cavities embedded in a dielectric Bragg structure is investigated numerically using the finite-difference time-domain algorithm [1]. It is shown that for the case of three cavities the well-known symmetry of the eigenmodes leads to a zero field in one of the cavities which has also been recently measured for three coupled microdisk resonators [2]. Furthermore, the coupling strength between two cavities depending on geometrical parameters is determined. [3] It is planned to additionally introduce semiconductor quantum dots into the cavities.

[1] A. Taflove, *Advances in Computational Electrodynamics*, Artech House, (1998).
[2] C. Schmidt *et al.*, Phys. Rev. A **80**, 043841 (2009).
[3] D. Ehmer, *Modellrechnungen zu eindimensionalen gekoppelten photonischen Resonatoren und Zweiniveausystemen* , Bachelor Thesis, University of Paderborn, to be published.

HL 60.10 Thu 18:00 Poster D1

Fiber Coupled Waveguided Metallic Photonic Crystals — •Shengfei Feng[1,2], Peter J. Klar[2], Achim Kronenberger[2], Torsten Henning[2], and Xinping Zhang[1] — [1]College of Applied Sciences, Beijing University of Technology, Beijing 100124, P. R. China — [2]Institute of Experimental Physics I, Justus-Liebig-University Giessen, Germany

Fabrication and characterization of waveguided metallic photonic crystals on the facets of multimode fibers are demonstrated. A layer of zinc oxide (ZnO) is used as the waveguide in the device. The ZnO layer is deposited on the facet of the fiber by radio-frequency magnetron sputtering. The one-dimensional gold-grating on top of the ZnO layer is fabricated using electron beam lithography and a lift-off process. This device combines the unique property of waveguide metallic photonic crystal structure with the transmission property of a fiber. When a beam of broadband white light is coupled into the fiber from the non-structured end, a strong and narrow band signal can be obtained in the reflected light, which is transmitted back through the fiber. The wavelength of the reflection peak of the narrow-band reflection is sensitive to the refractive index of the environment. Therefore, this device may be used to detect the refractive index changes of the opaque liquids.

HL 60.11 Thu 18:00 Poster D1

2D photonic crystals for manipulation of emission of the InGaAs/GaAs — •Sabrina Darmawi[1], Torsten Henning[1], Peter J. Klar[1], Wolfgang Stolz[2], Kerstin Volz[2], and Sangam Chatterjee[2] — [1]I. Physikalisches Institut, Justus-Liebig-Universität, Heinrich-Buff-Ring 16, 35392 Gießen — [2]FB Physik, Philipps-Universität, Renthof 5, 35032 Marburg

We aim at suppressing local losses in III-V based vertical emitters by using two-dimensional photonic crystals. As a proof of principle we fabricated a hexagonal 2D photonic crystal in GaAs layers and a single InGaAs/GaAs quantum well structure. Electron beam lithography was used to define the pattern. The pattern was transferred into the specimens by wet-chemical etching. The structures obtained were characterized by atomic force microscopy and scanning electron microscopy. The luminescence of the structures with and without 2D photonic crystals will be compared.

HL 60.12 Thu 18:00 Poster D1

Multiple Bragg diffraction in photonic crystals — •Georg Kropat, Rebecca Wagner, and Frank Cichos — Molecular Nanophotonics Group, University Leipzig, Linnéstr. 5, 04103 Leipzig

We investigated colloidal fcc crystals made of polystyrene spheres in air by angle resolved reflectivity measurements. Bragg reflections occur due to constructive interference of the light which is diffracted by the crystalline structure of the photonic crystal. For angles of incidence of around 35°, multiple reflection peaks are observed at points of intersecting planes. The dependence of this multiple reflection on the turning angle around the surface normal of the incident plane was checked. Simulated photonic band structures reveal that the multiple peaks are caused by simultaneous Bragg diffraction at (111) and (200) planes. We demonstrate that this leads to significant deviations from simple Bragg diffraction. As the emission of dye molecules inside the photonic crystal is also influenced by Bragg reflections, we expect this band repulsion also to be of importance for the modification of the angular emission of dye doped beads in photonic crystals.

HL 60.13 Thu 18:00 Poster D1

Macroscopically Homogeneous Inverse Opal Films — •Parvin Sharifi Rajabi and Frank Marlow — Max-Planck-Institut für Kohlenforschung, Mülheim (Ruhr), Germany

Slow photons are states with low group velocity in the photonic crystals. They exist at energies just above and below the photonic stop bands. These states can be used for enhancing chemical reactions of photocatalysts in photonic crystal shape. Then the material structure on the sub-micrometer scale manipulates the light propagation and influences the photochemical reaction rate. For fabricating the microstructured photocatalyst, polystyrene opal films [1] were used as templates for titania inverse opals. The capillary deposition method (CDM) was used for the opal film preparation [2] and the titania was synthesized in a sol-gel process also inside thin capillary cells. Macroscopically homogeneous titania inverse opal films with visible opalescence were successfully prepared. The influence of inverse opal structure on the optical properties and photochemical activity of these films is investigated.

[1] F. Marlow, Muldarisnur, P. Sharifi, R. Brinkmann, C. Mendive, Angew. Chem. Int. Ed. 2009, 48, 6212.
[2] H. L. Li, W. Dong, H. J. Bongard, F. Marlow, J. Phys. Chem. B 2005, 109, 9939.

HL 60.14 Thu 18:00 Poster D1

Local Infiltration of Individual Pores with multiple Dyes in Macroporous Silicon Photonic Crystals — •Peter W. Nolte[1], Daniel Pergande[1], Roland Salzer[3], Brian T. Makowski[2], Stefan L. Schweizer[1], Markus Geuss[2], Martin Steinhart[4], Christoph Weder[2] und Ralf B. Wehrspohn[1,3] — [1]Martin-Luther-University Halle-Wittenberg — [2]University of Fribourg — [3]Fraunhofer Institute for Mechanics of Materials — [4]University of Osnabrück

Photonic crystals (PhC) are promising candidates for novel optical components. Passive devices realized with PhC, e.g. complex waveguides, are widely known. However, for many applications active devices are required. One possible way to realize such devices is the functionalization of 2D PhC. This can be done by combining 2D PhC with polymers, liquid crystals or dyes. Especially the functionalization of individual pores is of great interest. We present a method that allows the infiltration of individual pores of 2D silicon PhC with various materials in one sample. For the infiltration of individual pores we use 2D PhC templates made of macroporous silicon, electron beam physical vapor deposition, focused ion beam technique, electrochemical deposition and the wetting assisted templating (WASTE)-process.

HL 60.15 Thu 18:00 Poster D1

Nonlinear Optical Spectroscopy of Metamaterials — •Mathieu Gentile[1], Richard Taubert[2], Mario Hentschel[2], Harald Giessen[2], and Manfred Fiebig[1] — [1]Helmholtz-Institut für Strahlen- und Kern- physik, Universität Bonn, Germany — [2]4. Physikalisches Institut, Universität Stuttgart, Germany

Optical metamaterials are the gateway to fundamentally new optical properties: they allow materials with negative values for the effective electric permittivity, ε, and magnetic permeability, μ.

We present a set of second harmonic generation (SHG) spectra of