HL 86: Photonic crystals and cavities

Time: Thursday 9:30–11:15 Location: POT 051

HL 86.1 Thu 9:30 POT 051

Transverse Mode Localization in Three-Dimensional Deterministic Aperiodic Structures — •Michael Renner[1] and Georg von Freymann[1,2] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Erwin-Schrödinger-Str. 56, 67663 Kaiserslautern — [2]Fraunhofer-Institute for Physical Measurement Techniques (IPM), Erwin-Schrödinger-Str. 56, 67663 Kaiserslautern, Germany

We study the propagation of light in three-dimensional deterministic aperiodic structures fabricated by Dip-in direct-laser-writing. This fabrication technique enables us to investigate previously inaccessible thick polymer structures containing more than 100 elements of the underlying aperiodic sequence along the vertical direction. We employ one general construction scheme derived from the square Fibonacci tiling to obtain structures of different lattice spectral types, namely pure-point (Fibonacci sequence), singular-continuous (Thue-Morse) and absolute-continuous (Rudin-Shapiro). Characteristic reflectance spectra confirm the presence of the desired spatial correlations in the fabricated samples. By measuring the effective width of an incoherent beam traversing structures of different heights we deduce sub-diffusive behavior for all sequences in the near-infrared spectral range. The slowest broadening is observed for Rudin-Shapiro structures for which we find exponentially decaying lateral mode profiles indicating the existence of localized states.

HL 86.2 Thu 9:45 POT 051

The impact of nanoperforation on persistent photoconductivity and optical quenching effects in suspended GaN nanomembranes — •Olesea Volciuc[1], Tudor Braniste[2], Ion Tiginyanu[2], Marion Stevens-Kalceff[3], Jakob Ebeling[1], Timo Aschenbrenner[1], Detlef Hommel[1], Veaceslav Ursaki[4], and Jürgen Gutowski[1] — [1]Institute of Solid State Physics, University of Bremen, Bremen 28334, Germany — [2]National Center for Materials Study and Testing, Technical University of Moldova, Chisinau 2004, Moldova — [3]School of Physics, University of New South Wales, Sydney NSW 2052, Australia — [4]Institute of Applied Physics, Academy of Sciences of Moldova, Chisinau 2028, Moldova

GaN being ≈ 15-nm thick membranes and nanoperforated in an ordered fashion were fabricated using direct writing of negative charges by focused ion beam and subsequent photoelectrochemical etching of GaN epilayers. The characterization of the photoelectrical properties shows that both continuous and nanoperforated membranes exhibit pronounced persistent photoconductivity (PPC) which can be optically quenched under excitation by 546-nm radiation via impurity levels. We found that optical quenching of PPC occurs also under relatively intense intrinsic excitation of nanoperforated membranes by 355-nm radiation at temperatures T ¡ 100 K. The results are explained by taking into account strong surface localization of charge carriers in nanoperforated membranes and UV-induced reactions occurring at the surface states under intense intrinsic excitation.

HL 86.3 Thu 10:00 POT 051

ZnO based two-dimensional photonic crystal resonators. — •Sandro Hoffmann, Marcel Ruth, Thomas Zentgraf, and Cedrik Meier — University of Paderborn, Experimental Physics & CeOPP, Warburger Str. 100, 33098 Paderborn.

With emission in the UV region, ZnO is a promising material system for photonic resonator based devices. In particular, photonic crystals (PhCs) have the potential for realizing high quality resonators and waveguides.

The fabrication of fully undercut ZnO based photonic crystal membranes is presented in this talk. Initially, the ZnO is grown by plasma assisted molecular beam epitaxy (MBE) on a dry oxidized SiO_2 layer on top of a Si(111) substrate and is subsequently covered with SiO_2 via chemical vapor deposition (CVD). Thereafter, the heterostructure is patterned by electron beam lithography and reactive ion etching, followed by wet etching in a KOH solution. Additionally, high temperature rapid thermal annealing (RTA) is used in order to enhance the photoluminescence (PL) of the ZnO layer. Measurements of a H3 cavity by cw excitation and two-photon absorption result in resonances within the photonic band gap for TE-polarization between 2.9 eV and 3.2 eV. Finite-differences time-domain (FDTD) simulations support the experimental data. Providing emission in the UV region and photonic waveguiding, this is essential for the realization of numerous applications, including quantum information and photonic circuits.

HL 86.4 Thu 10:15 POT 051

Photonic Crystal Grating Couplers for Quantum Applications — •Janik Wolters[1], Andreas W. Schell[1], Carlo Barth[1], Jürgen Probst[2], Max Schoengen[2], Bernd Löchel[2], and Oliver Benson[1] — [1]Humboldt-Universität zu Berlin, Institut für Physik, AG Nano-Optik, Newtonstraße 15, 12489 Berlin — [2]Helmholtz Zentrum Berlin, Institut Nanometeroptik und Technologie, Albert-Einstein-Str. 15, 12489 Berlin

Photonic crystals [1] are a promising platform for integrated quantum networks. In recent years, coupling of single emitters to photonic crystal cavities as first step towards such systems has been demonstrated [2].

Additional key ingredients are efficient photon guiding and coupling to the far-field. The latter is crucial since it forms the interface between photonic chips and the macroscopic measurement environment.

We present our latest results on the design and characterization of efficient grating couplers with large directivity and small footprint, as well as their integration into photonic networks.

[1] J. Wolters, et al., Thermo-optical response of photonic crystal cavities operating in the visible spectral range. Nanotechnology 24, 315204 (2013).

[2] J. Wolters, et al., Enhancement of the zero phonon line emission from a single nitrogen vacancy center in a nanodiamond via coupling to a photonic crystal cavity. Applied Physics Letters 97, 141108 (2010).

HL 86.5 Thu 10:30 POT 051

Thermo-optical response of photonic crystal cavity resonances — •Niko Nikolay[1], Janik Wolters[1], Max Schoengen[2], Andreas Schell[1], Jürgen Probst[2], Bernd Löchel[2], and Oliver Benson[1] — [1]Nano-Optics, Institute of Physics, Humboldt-Universität zu Berlin, Newtonstraße 15, D-12489 Berlin, Germany — [2]Institute for Nanometre Optics and Technology, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Albert-Einstein-Straße 15, D-12489 Berlin, Germany

Two-dimensional photonic crystal cavities are promising candidates for scalable integrated optical devices. Hence, they have increasing importance for quantum optics, photonics and sensing applications [1,2]. We focus on thermo-optical effects in photonic crystal slab resonators made of gallium phosphide. The thermal shift of the resonance wavelength and the underlying change of the refractive index are explored. An increased Q-factor is observed at low temperatures. Our results are the first systematic study of these properties over the wide temperature range between 5 and 300 K at a wavelength of about 605 nm [3]. In addition, experimental studies and theoretical analysis of thermo-optical switching of visible light by local heating of ultra-small attoliter volumes are discussed.

[1] Vahala, Nature 424, 839-846 (2003), doi:10.1038/nature01939

[2] Wolters et al., APL 97, 141108 (2010), doi:10.1063/1.3499300

[3] Wolters et al., Nanotech. 24, 315204 (2013), doi:10.1088/0957-4484/24/31/315204

HL 86.6 Thu 10:45 POT 051

Phononic Crystal Waveguides in GaAs — •Golnaz Azodi and James Stotz — Queen's University, Kingston, Canada

Surface acoustic waves (SAWs) provide a unique platform to create dynamically modulated semiconductor nanostructures for use in quantum information processing. The use of plane wave SAWs is the most practical and have been applied to a number of different quantum systems. However, as the complexity of a quantum system increases, the acoustic energy may be required to be delivered locally. In leveraging the tremendous success of photonic crystals, the use of phononic crystals enables the creation of phononic waveguide cavities to control the delivery of the acoustic modulation. To this end, we will discuss the development and recent results of fabricating phononic crystal waveguides on GaAs. While an unusual platform for SAW devices, GaAs is a rich platform for quantum systems, and it uniquely balances the demands for such hybrid systems. We will present FDTD modelling of the devices, and discuss the limitations that are placed on the design of the waveguides. To measure the effectiveness of the phononic crystal waveguides, we can image the SAW using a Sagnac interferometer, which provides a spatial mapping of the SAW as it travels through the waveguide structures.

HL 86.7 Thu 11:00 POT 051

Influence of the number of ZnSe QWs on the light-matter interaction in microcavities — •SK. Shaid-Ur Rahman[1], Merle Cornelius[1], Thorsten Klein[2], Carsten Kruse[2], Detlef Hommel[2], Jürgen Gutowski[1], and Kathrin Sebald[1] — [1]Semiconductor Optics, Institute of Solid State Physics, University of Bremen, P.O. Box 330440, 28334 Bremen, Germany — [2]Semiconductor Epitaxy, Institute of Solid State Physics, University of Bremen, P.O. Box 330440, 28334 Bremen, Germany

The strong light-matter coupling in semiconductor microcavities (MCs) exhibits a high potential to realize novel types of optoelectronic devices such as thresholdless lasers based on polariton lasing. In order to operate such devices at elevated temperatures, high oscillator and high coupling strengths are required. For this purpose II-VI semiconductors with large excitonic binding energies are advantageous. The coupling strength can be enhanced by increasing the number of quantum wells (QWs) and by optimizing the amplitude of the cavity field at the QW position. We investigate binary ZnSe QW-based microcavities with different numbers of QWs and cavity thicknesses. The samples are characterized by micro-reflectivity and micro-photoluminescence measurements at different temperatures. The distributed Bragg reflector (DBR) stopband is centered at about 2.78eV. The QW emission can be tuned into resonance with the cavity mode by changing the sample temperature. Measurements show, that both are in resonance at about 200K. By increasing the number of QWs, a tendency to reach the strong coupling regime can be observed.