Q 61: Photonics II

Time: Friday 14:00–16:00 Location: UDL HS3038

Q 61.1 Fri 14:00 UDL HS3038

Twisted waveguides and three-dimensional chiral photonic lattices — •Alessandro Zannotti, Falko Diebel, Patrick Rose, Martin Boguslawski, and Cornelia Denz — Institut für Angewandte Physik und Center for Nonlinear Science (CeNoS), Westfälische Wilhelms-Universität Münster, 48149 Münster, Germany

The ability to control nonlinear light propagation in a large variety of photonic lattices allows for the discovery of new interesting propagation effects in structured media. To realize reversible two-dimensional refractive index patterns by optical induction, complex nondiffracting beams, such as Bessel, Mathieu, Weber, and discrete beams, can be used as writing beams. Here, these beams are well suited since they show a transversely modulated intensity while being invariant in the direction of propagation.

Breaking this longitudinal symmetry by introducing additional interfering plane waves extends this concept and provides new fascinating lattice structures modulated in all three spatial dimensions. In this contribution, we present the realization of three-dimensionally modulated photonic lattices benefiting from the large structural diversity that nondiffracting beams already offer in two dimensions. Chiral lattices, for instance, based on vortex-bearing nondiffracting beams offer an intriguing combination of transverse periodicity and longitudinal twist. In particular, the extension of Mathieu beams to three dimensions allows the creation of twisted waveguide arrays, which are of special interest for the investigation of soliton and vortex soliton dynamics.

Q 61.2 Fri 14:15 UDL HS3038

Direct laser writing of 3D nanostructures using a blue 405nm quasi-CW laser diode — •Patrick Müller[1,3], Michael Thiel[2,3], and Martin Wegener[1,2,3] — [1]Institute of Applied Physics and DFG-Center for Functional Nanostructures (CFN), Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — [2]Institute of Nanotechnology (INT), Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany — [3]Nanoscribe GmbH, 76344 Eggenstein-Leopoldshafen, Germany

Direct laser writing (DLW) is a well-known and established technology for manufacturing 3D micro- and nanoscale structures. Usually, red femtosecond laser sources with wavelengths of about 800nm are used for DLW. Here, using a blue 405nm quasi-CW laser diode as the exciting laser source the linear wavelength dependence of the Abbe resolution limit, $a = \lambda/(2{\cdot}\mathrm{NA})$, is exploited in order to improve structures in terms of decreasing feature size and line distance. A nonlinear multiphoton polymerization process is necessary for manufacturing true 3D structures. We have observed such nonlinearities in a resist system based on the monomer pentaerythritol triacrylate. To benefit from the improved theoretical resolution it is necessary to achieve a close to diffraction limited focal spot. A dip-in DLW writing scheme was realized by reducing the mismatch in refractive index between the objective lens and the photoresist. Woodpile photonic crystal structures as well as line gratings serve as benchmarks to prove the performance of the system and were analyzed with different experimental methods.

Q 61.3 Fri 14:30 UDL HS3038

Polarization control of quantum dot emission by chiral photonic crystal slabs — •Sergey Lobanov[1,2], Nikolay Gippius[2], Sergei Tikhodeev[1,2], Thomas Weiss[3], Kuniaki Konishi[4,5], and Makoto Kuwata-Gonokami[4,5,6] — [1]M.V.Lomonosov Moscow State University, Moscow, Russia — [2]A. M. Prokhorov General Physics Institute, Moscow, Russia — [3]4th Physics Institute and Research Centers Scope,, University of Stuttgart, Stuttgart, Germany — [4]Photon Science Center, The University of Tokyo, Tokyo, Japan — [5]Core Research for Evolutional Science and Technology(CREST), Tokyo, Japan — [6]Department of Physics, The University of Tokyo, Tokyo, Japan

We investigate theoretically the polarization properties of the emission from a layer of quantum dots placed inside chiral photonic crystal structure consisting of achiral materials in the absence of external magnetic field. The mirror symmetry of the local electromagnetic field is broken in this system due to the decreased symmetry of the chiral modulated layer. As a result, the radiation of randomly polarized quantum dots normal to the structure becomes partially circularly polarized. The sign and degree of circular polarization are determined by the geometry of the chiral modulated structure and depend on the radiation frequency. We show that the degree of circular polarization can reach up to 99% for randomly distributed quantum dots, and can be close to 100% for some single quantum dots.

Q 61.4 Fri 14:45 UDL HS3038

Group Theory of Circular-Polarisation Effects in Chiral Photonic Crystals with Four-Fold Rotation Axes — •Matthias Saba[1], Mark D. Turner[2], Min Gu[2], Klaus Mecke[1], and Gerd E. Schröder-Turk[1] — [1]Theor. Physik, Friedrich-Alexander Universität Erlangen-Nürnberg, Germany — [2]CUDOS & Centre for Micro-Photonics, Swinburne University of Technology, Australia

We use group or representation theory and scattering matrix calculations to derive analytical results for the band structure topology and the scattering parameters, applicable to any chiral photonic crystal with body-centered cubic symmetry $I432$ for circularly-polarised incident light. We demonstrate in particular that all bands along the cubic [100] direction can be identified with the irreducible representations $E_\pm$, A and B of the C_4 point group. E_+ and E_- modes represent the only non-interacting transmission channels for plane waves of right (E_-) and left (E_+) circular polarization, respectively. Scattering matrix calculations provide explicit relationships for the transmission and reflectance amplitudes through a finite slab which guarantee equal transmission rates for both polarisations and vanishing ellipticity below a critical frequency, yet allowing for finite rotation of the polarisation plane. All results are verified numerically for the so-called 8-srs geometry, consisting of eight interwoven equal-handed dielectric Gyroid networks embedded in air. The combination of vanishing losses, vanishing ellipticity, near-perfect transmission and optical activity comparable to that of metallic meta-materials makes this geometry an attractive design for nanofabricated photonic materials.

Q 61.5 Fri 15:00 UDL HS3038

Circular polarization converters based on coupled pairs of oppositely-handed single helices — •Leonard Blume[1], Johannes Kaschke[1], Michael Thiel[2], Lin Wu[3], Zhenyu Yang[3], and Martin Wegener[1,2] — [1]Institute of Applied Physics and DFG-Center for Functional Nanostructures (CFN), Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany — [2]Institute of Nanotechnology (INT), Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany — [3]Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology, Wuhan, China

Photonic Metamaterials based on periodic arrays of gold helices have been introduced as broadband circular polarizers. For a polarizer, low circular polarization conversions are desired. However, large conversion might also find application. Here, we introduce a new chiral architecture that achieves high conversion in transmission for one circular polarization, while keeping all other elements of the jones matrix small. One unit cell of an array consists of a pair of coupled single helices with a mutual helix axis but opposite handedness. We present a fabrication method using direct laser writing and electrochemical deposition to fabricate these broadband circular polarization converters for infrared frequencies. Furthermore, we compare optical measurements and numerical calculations.

Q 61.6 Fri 15:15 UDL HS3038

Discrete set of states of dispersion-managed soliton molecules — •Alexander Hause and Fedor Mitschke — Universität Rostock, Institut für Physik, Universitätsplatz 3, 18051 Rostock

Bound states of two and of three solitons in dispersion-managed fibers (soliton molecules) were experimentally demonstrated recently. These compounds potentially allow a two bit per time slot data transmission [1]. A perturbation treatment is developed to predict equilibria of the relative positions of the solitons in the molecule. We find a multitude of quantized separations, alternatingly stable and unstable. Next neighbor solitons can have the same or opposite phase. The number of possible equilibria is limited by the level of the radiation background. The state with the smallest separation and the highest binding energy (ground state) always occurs for opposite-phase pulses, the lowest-order state for in-phase pulses is always unstable. Stable chains of solitons can be built with a mixture of different next-neighbor separations and phases. Stable and unstable ground states are confirmed by experiments.

[1] P. Rohrmann et al., Phys. Rev. A **87**, 043834 (2013)

Q 61.7 Fri 15:30 UDL HS3038

Waveguide coupling of high index whispering gallery mode resonators in the THz domain — •Martin F. Schneidereit[1], Florian Sedlmeir[1,2,3], Sascha Preu[4], Antti V. Raisanen[5], Luis Enrique García-Muñoz[6], Gerd Leuchs[1,2], and Harald G. L. Schwefel[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Intitute for Optics, Information and Photonics, Univ. of Erlangen-Nuremberg, Germany — [3]SAOT, School of Adv. Opt. Technologies, Univ. of Erlangen-Nuremberg, Germany — [4]Chair of Applied Physics, Univ. of Erlangen-Nuremberg, Germany — [5]Aalto Univ. Finland — [6]Univ. Carlos III de Madrid, Spain

Whispering Gallery Mode resonators (WGMs) have high Q factors and small modal volumes and can thus show strong nonlinear interactions. Furthermore, they are used as passive narrow-band filters and as frequency references. The evanescent coupling process of optical light into WGMs is straightforward. For THz radiation however, it proves a challenge as many interesting materials have high refractive bulk indices of 3 to 6, but high index coupling devices are not yet well established. In our experiments we investigate the influence of the geometry and coupling distance with respect to their impact on the coupling process. Our approach is to match the effective refractive indices between coupler and WGM by using their respective geometric dispersions. In the experiments we used a photomixing THz source, directly attached to a tapered GaAs waveguide, which then couples to a high index WGM resonator. Due to the long wavelengths of sub-THz and THz light, the coupling distance and the geometrical shape are rather easy to control.

Q 61.8 Fri 15:45 UDL HS3038

Vertically Rolled-Up High Quality TiO2 Optical Microcavities and Integration with Optical Waveguides — •abbas madani, stefan böttner, matthew r. jorgensen, and oliver g. schmidt — Institute for Integrative Nanosciences, IFW Dresden, Helmholtzstr. 20, 01069 Dresden, Germany

Recently, vertically rolled-up optical microcavities (VRUMs), as a novel form of cavities, have opened up several attractive applications. Key features of VRUMs include their flexibility in materials choice,the capability for on-chip integration,their ultra-thin walls and hollow core structure. While recent demonstrations of VRUMs have highlighted their potential use in optoelectronic applications,improvements are possible with respect to the choice of material. TiO2 has many properties favorable for VRUMs including a high refractive index, a large Kerr nonlinearity, a wide transparency window,and biocompatibility. In this work, design and fabrication of high Q-factor TiO2 VRUMs with diameters on the order of micrometers, very thin and smooth tube walls, operation at both telecom and visible wavelengths are reported. These VRUMs are achieved by the controlled release and roll-up of differentially strained TiO2 bilayered nanomembranes. Optical characterization of these resonators reveals quality factors as high as 3.8*103 in the telecom wavelength range when a TiO2 VRUM is interfaced with a tapered optical fiber [1].Finally, the importance and challenge of integration of TiO2 resonators with optical waveguides will be discussed along with the first results of transmission measurements in the telecom ranges.[1]A.Madani et al,Optics Letter(in press,2013).