Q 44: Photonics II

Time: Thursday 11:00–13:00 Location: P 11

Q 44.1 Thu 11:00 P 11

Amorphous silicon-doped titania films for on-chip photonics — •Thomas Kornher[1], Kangwei Xia[1], Roman Kolesov[1], Stefan Lasse[1], Cosmin S. Sandu[2], Estelle Wagner[2], Scott Harada[2], Giacomo Benvenutti[2], Bruno Villa[4], Hans-Werner Becker[3], and Jörg Wrachtrup[1] — [1]3. Physikalisches Institut, Universität Stuttgart, Germany — [2]3D-OXIDES, Saint Genis Pouilly, France — [3]RUBION, Ruhr-Universität Bochum, Germany — [4]Semiconductor Physics Group, Cambridge, UK

High quality optical thin film materials form a basis for on-chip photonic micro- and nano-devices, where several photonic elements form an optical circuit. Their realization generally requires the thin film to have a higher refractive index than the substrate material. Here, we demonstrate a method of depositing amorphous 25% Si doped TiO_2 films on various substrates, a way of shaping these films into photonic elements, such as optical waveguides and resonators, and finally, the performance of these elements. The quality of the film is estimated by measuring thin film cavity Q-factors in excess of 10^5 at a wavelength of 790 nm, corresponding to low propagation losses of 5.1 db/cm. The fabricated photonic structures were used to optically address chromium ions embedded in the substrate by evanescent coupling, therefore enabling it through film-substrate interaction. Additional functionalization of the films by doping with optically active rare-earth ions such as erbium is also demonstrated. Thus, Si:TiO_2 films allow for creation of high quality photonic elements, both passive and active and provide access to a broad range of substrates and emitters embedded therein.

Q 44.2 Thu 11:15 P 11

Towards integrating superconducting detectors on lithium niobate waveguides — •Jan Philipp Höpker[1], Evan Meyer-Scott[1], Moritz Bartnick[1], Frederik Thiele[1], Nicola Montaut[1], Harald Hermann[1], Sebastian Lengeling[1], Raimund Ricken[1], Viktor Quiring[1], Stephan Krapick[1], Matteo Santandrea[1], Adriana Lita[2], Varun Verma[2], Thomas Gerrits[2], Sae Woo Nam[2], Christine Silberhorn[1], and Tim J. Bartley[1] — [1]Universität Paderborn, Integrierte Quantenoptik, Warburger Str. 100, D-33098 Paderborn — [2]National Institute of Standards and Technology, 325 Broadway, Boulder, CO, 80305, USA

Depositing superconducting detectors onto optical waveguides is a promising way to achieve precise single photon detection in integrated optical circuits. We have taken the initial steps in depositing transition edge sensors (TES) and superconducting nanowire single photon detectors (SNSPDs) on titanium in-diffused lithium niobate waveguides. At room temperature, the excess transmission loss is measured with a Fabry-Pérot etalon technique, which gives information about the detector absorption of the deposited TES and SNSPDs without wiring them. Furthermore, simulations are carried out to optimize the detector structures and include additional dielectric layers for better absorption efficiencies. To test the devices at cryogenic temperatures, the coupling to optical fibres via end-face pigtailing is investigated, using a precise motorized stage and UV-glue. Together with our pigtailing technique and the superconducting detectors we expect to be able to make a functional integrated single photon detection device.

Q 44.3 Thu 11:30 P 11

Optimisation of luminescence in multi-layered photonic structures to increase the efficiency of upconversion processes — •Fabian Spallek, Andreas Buchleitner, and Thomas Wellens — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg

Upconversion materials, which convert two low-energy photons into one photon with higher energy, in combination with photonic structures, open promising possibilities to improve the efficiency of silicon solar cells by utilising the full range of the solar spectrum [1].

By tuning the thickness of each individual layer in a multi-layered photonic structure, we show that it is possible to trap incident photons of a given wavelenght inside this structure, and thus considerably increase the local irradiance in those layers which contain the upconverter material. We compare the achievable enhancement of the local irradiance, as well as its robustness under manufactoring errors, as obtained for the resulting optimal geometries to thus far experimentally implemented [1] Bragg structures.

[1] C. L. M. Hofmann, B. Herter, S. Fischer, J. Gutmann, and J. C. Goldschmidt, „Upconversion in a Bragg structure: photonic effects of a modified local density of states and irradiance on luminescence and upconversion quantum yield“, Opt. Express 24, 14895-14914 (2016)

Q 44.4 Thu 11:45 P 11

Diffraction-limited imaging with 3D printed complex mesoscale objectives — •Simon Ristok[1], Simon Thiele[2], Timo Gissibl[3], Alois Herkommer[2], and Harald Giessen[1] — [1]Universität Stuttgart, 4. Physikalisches Institut — [2]Universität Stuttgart, Institut für technische Optik — [3]Nanoscribe GmbH, Eggenstein-Leopoldshafen

Complex three dimensional structures on the micrometer scale can be fabricated by focusing a femtosecond laser at 780 nm into a UV sensitive photoresist. The photoresist is polymerized via two-photon absorption at 390 nm in a small volume element around the laser focus, resulting in sub-micrometer resolution. By moving the focus through the photoresist arbitrary shapes can be produced.

Particularly the high resolution renders this direct laser writing technique suitable for the fabrication of high quality optical elements. The achievable size ranges from a few micrometers up to several millimeters. Apart from simple spherical lenses, optical systems with multiple lenses, such as doublet or triplet objectives can be printed.

In this work we focus on objectives with diameters of several 100 micrometers. They show excellent imaging properties, with optical resolution close to the diffraction limit, even for large fields of view. Furthermore, we are able to print our microoptics directly on various surface materials, e.g. CMOS sensors or optical fibers, opening up a wide range of possible applications.

Q 44.5 Thu 12:00 P 11

Photon-statistics-based ghost imaging with one single detector — •Lydia Fischer, Simone Kuhn, Sébastien Blumenstein, and Wolfgang Elsässer — Institute of Applied Physics, TU Darmstadt, Germany

Ghost Imaging is an imaging technique in which intensity correlations of light are exploited. A light beam is directed onto an object and the entirely transmitted or reflected light is collected by a single pixel detector. By the correlation of this beam with a second, spatially resolved, highly correlated reference beam which does not interact with the object, an image can be formed.

Here we demonstrate a novel ghost imaging scheme. Instead of the two detector concept, the light from the object and reference beam is superimposed and then detected by one single photon counting detector. The combination of a fast single photon avalanche diode (SPAD) and a time tagged time resolved (TTTR) photon counting module allows acquiring photon count time traces. The statistical evaluation of these time traces yields the combined photon number probability distribution. Thereby one can compute all moments of the photon distribution and thus the correlation coefficients. In combination with the spatial information of the reference arm a ghost image can be formed. By presenting a proof-of-principle ghost imaging experiments in one and two dimensions, the feasibility of the photon statistics based GI experiment is demonstrated.

[1] S.Kuhn, S.Hartmann, and W. Elsäßer, Opt.Lett.41, 2863-2866 (2016)

Q 44.6 Thu 12:15 P 11

Automated aberration compensation in high numerical aperture systems for arbitrary laser modes — •Julian Hering[1], Erik H. Waller[1], and Georg von Freymann[1,2] — [1]Physics department and state research center OPTIMAS, University of Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Fraunhofer Institute for Physical Measurement Techniques (IPM), 67663 Kaiserslautern, Germany

In three-dimensional laser lithography, controlling the point-spread-function (PSF) is crucial for fabricating structures with highest resolution and minimal feature sizes. Aberrations present within most optical systems have to be physically compensated prior to the writing process.

Here, we report on a modified Gerchberg-Saxton algorithm (GSA) for spatial-light-modulator (SLM) based automated aberration com-

pensation for arbitrary laser modes like, e.g., doughnut, bottlebeam, and multi-foci modes in a high numerical aperture system. First-guess initial amplitude and phase conditions of the pupil function and circularly polarized light allow for a non-vectorial phase retrieval of the distorted PSF and thus, its shape optimization. Our approach outperforms recent algorithms considering vectorial corrections.

Besides direct laser writing also applications like stimulated emission depletion based microscopy or optical tweezer arrays might benefit from the presented method.

Q 44.7 Thu 12:30 P 11

Attosecond scale coherent control of electron recombination in the polarization plane — •Ofer Kfir[1,2], Sergey Zayko[1], Christina Nolte[3], Stefan Mathias[3], Oren Cohen[2], and Claus Ropers[1] — [1]IV. Physical Institute, University of Göttingen, Göttingen, Germany — [2]Solid State Institute and Physics Department, Technion, Haifa, Israel — [3]I. Physical Institute, University of Göttingen, Göttingen, Germany

The strong-field ionization of atoms and molecules in intense optical laser fields leads to a sequence of coherent recollisions of electrons with their parent ion, with attosecond timing information imprinted onto the emitted high-order harmonic radiation [1].

Here, we use a bi-chromatic field characterized by two orthogonal Jones vectors [2,3] that precisely control the phase, timing and orientation of attosecond recollisions in the two-dimensional polarization plane, under conditions that maintain a high recollision probability. Besides the generation of circularly polarized harmonics [2], we demonstrate the selective suppression or enhancement of different classes of harmonic orders by tuning the interference conditions of three subsequent attosecond recollisions. For example, we convert the typically suppressed harmonics in bi-circular fields to be bright and circularly polarized. This new control scheme provides attosecond access to the study of various two-dimensional phenomena in molecules, including sub-cycle charge redistribution.

[1] Shafir, Nature 485, 343 (2012). [2] Fleischer, Nat. Phot. 8, 543 (2014). [3] Milošević PRA 62, 11403 (2000).

Q 44.8 Thu 12:45 P 11

Effective Medium Theory for infinitely-long polaritonic cylinders — •Charalampos P. Mavidis[1,2], Maria Kafesaki[1,2], Eleftherios N. Economou[1,3], and Costas M. Soukoulis[1,4] — [1]Institute of Electronic Structure and Laser, FORTH, 71110 Heraklion, Crete, Greece — [2]Department of Materials Science and Technology, University of Crete, Heraklion, Crete, Greece — [3]Department of Physics, University of Crete, Heraklion, Greece — [4]Ames Laboratory and Department of Physics and Astronomy, Iowa State University, Ames, Iowa 50011, USA

In this work we present an effective medium theory for infinitely-long cylinders in a host medium. Based on the scattering by a single cylinder we derive analytic expressions for all components of the effective electric permittivity and effective magnetic permeability tensors cylinder beyond the Maxwell-Garnett approximation of a system.

The derived equations are applied to systems of cylinders made of polaritonic materials (e.g. LiF, SiC, etc) immersed in dielectric materials in the THz part of the spectrum. Using different combinations of materials and radii many interesting phenomena arise, including hyperbolic dispersion relation, negative refractive index and Near-Zero index media. Finally, we test the results with full-wave numerical calculations using a Finite Element-based solver.