Q 30: Photonics 2

Time: Wednesday 10:30–13:00 Location: SCH A118

Q 30.1 Wed 10:30 SCH A118

Sensing with coupled microcavity systems — •Sandra Isabelle Schmid and Jörg Evers — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

In recent years microresonators have become more and more important for optical research. Their special properties as low loss rates and ultra high Q values offer a lot of advantages for applications and experiments. They can be used as optical filters or even as ultra fast switching devices [1,2].

We consider systems of coupled Whispering Gallery Mode (WGM) resonators. In such toroidal cavities WGM modes always occur in pairs of modes of the same frequency but opposite propagation directions. If another cavity or object is located very close to a resonator, an interaction via the evanescent field can take place. In our research we investigate the transmission and reflection properties of arrays built of microresonators. Our observables are the transmission and reflection intensities.

Moreover, we study systems consisting of microcavities coupled to nearby atoms. In [3] was shown, that a nearby two-level atom crucially influences the output fluxes of a single cavity. Therefore, we are interested in the impact of a nearby atom on an array of microcavities. We study the transmission and reflection spectra in detail and discuss possible applications.

[1] K. Vahala, Nature **424**, 839 (2003).
[2] M. A. Popovic et al., Optics Express **14**, 3 (2006).
[3] B. Dayan et al., Science **319**, 1062 (2008).

Q 30.2 Wed 10:45 SCH A118

Microcavity Biosensing: recent advances — •Frank Vollmer — Max Planck Institute for the Science of Light, Erlangen, Germany

Optical resonance is created by confining coherent light inside a miniature dielectric structure such that it interferes constructively. Ideally, such optical resonators (microcavities) would confine light indefinitely and real-world divergence from this condition is described by the finite cavity quality (Q) factor. Ultimate (absorption limited) Q-factors have been reported in microsphere whispering-gallery mode optical resonators where light is efficiently confined by total-internal reflection. The high Q-factor (up to 10^9) enables precise measurements of resonance frequency and changes thereof. Such changes occur, for example, due to the binding of molecules or particles to the outer surface of the microsphere cavity. Since microcavities can be immersed in a liquid without significant damping of the optical resonance, measurements of resonance frequency shifts have been exploited to construct ultra-sensitive label-free biosensor devices.

I will give an overview of our recent advances in microcavity biosensor development, which have resulted in an improvement of the detection capability down to the single particle (single virus) level. I will also highlight other modalities of microcavity biosensors, such as approaches that use resonant evanescent fields for nanoparticle trapping and manipulation, as well as for enhanced detection with plasmonic nanoparticles.

Q 30.3 Wed 11:00 SCH A118

Nonlinear Photonic Lattices based on Complex Nondiffracting Beams — •Falko Diebel, Patrick Rose, Martin Boguslawski, Julian Becker, and Cornelia Denz — Institut für Angewandte Physik and Center for Nonlinear Science (CeNoS), Westfälische Wilhelms-Universität Münster, 48149 Münster, Germany

The fascinating field of nonlinear light propagation in photonic lattices comprises a variety of effects caused by the interplay between periodicity and nonlinearity. Reams of recent publications account for the importance of this topic.

In particular, the technique of optical induction facilitates the creation of reconfigurable nonlinear photonic structures. In order to induce these one- or two-dimensional functional refractive index patterns, typically so-called nondiffracting beams are used. These beams are characterized by transversely modulated intensity patterns that are translation invariant in the direction of propagation. They can be expressed as solutions of the Helmholtz equation and – depending on the coordinate system – belong to different families, namely Bessel, Mathieu, Weber, and discrete nondiffracting beams.

In this contribution, we present a novel technique for the optical induction of all these complex photonic structures using only one spatial light modulator to manipulate the phase as well as the amplitude of the light field at the same time. The resulting lattices are subsequently analyzed in detail. These complex photonic structures are of particular interest since they offer exciting possibilities to engineer the diffraction properties of light and facilitate the existence of new soliton families.

Q 30.4 Wed 11:15 SCH A118

Femtosecond Induced Optical Elements In Fused Silica — •Janning Herrmann, Wolfgang Horn, and Cornelia Denz — Institut für Angewandte Physik, Westfälische Wilhelms-Universität Münster, 48149 Münster, Germany

Optical waveguides and large-scale integrated photonic devices, such as couplers, splitters, amplifiers and add-drop multiplexers are of increasing interest for today's high speed optical networks. One of the most attractive fabrication techniques for these devices is point-by-point ultra-fast laser writing of photonic structures that permit rapid prototyping by multiphoton absorption in otherwise nonphotosensitive technical glasses. Femtosecond induced refractive index modifications are long term stable, have true 3D capability, and exhibit a higher degree of freedom for the design of integrated photonic circuits compared to traditional procedures like mask-based lithography. We demonstrate writing of diffractive optical elements, single-mode waveguide couplers, three-dimensional splitters, and Mach-Zehnder interferometers. Fabricated prototypes are fiber-coupled to lightwave circuits to determine mode confinement and loss characteristics. We also produced waveguides with integrated Bragg-gratings for narrowband multichannel filters in the telecom waveband and characterized their reflection and transmission properties. The used point-by-point writing techniques allows to easily induce defects that break the symmetry of the lattice. Therefore, magnitude and phase response of the filter transfer function can be customized to achieve tailored phase modification of propagating signals.

Q 30.5 Wed 11:30 SCH A118

Spatial analysis of optically induced photonic lattices — •Sybille Niemeier, Patrick Rose, Martin Boguslawski, and Cornelia Denz — Institut für Angewandte Physik and Center for Nonlinear Science (CeNoS), Westfälische Wilhelms-Universität Münster, 48149 Münster, Germany

In optics, periodic refractive index structures have been utilized to demonstrate a multitude of fascinating nonlinear effects. These so-called photonic lattices may for instance be generated via optical induction in photorefractive crystals. The electro-optic properties of these crystals as e.g. strontium barium niobate allow for the generation of highly reconfigurable nonlinear refractive index patterns modulated in one, two, or three dimensions.

Up to now, only rather qualitative methods like waveguiding and Brillouin zone spectroscopy are used to analyze the spatial properties of optically induced lattices. In this contribution, we develop methods for a quantitative analysis of these structures. For birefringent materials, the exploitation of an induced birefringence modulation due to the anisotropy of the electro-optic coefficients is a very promising approach. Beneath, the measurement of the underlying band structure allows to infer information of the investigated photonic lattice structure as well.

These new approaches grant a well-grounded analysis of the induced refractive index structure, which will certainly lead to a better understanding of many sophisticated effects in photonic lattices such as discrete and vortex solitons, Zener tunneling, Bloch oscillations, or Anderson localization.

Q 30.6 Wed 11:45 SCH A118

Simulation and design of electro-optic modulator based on SOI waveguides — •Aws Al-Saadi[1], Bülent A. Franke[1], Miroslaw Szczambura[1], Sebastian Kupijai[1], Shaimaa Mahdi[1], Viachaslau Ksiandzou[2], Sigurd Schrader[2], Hans J. Eichler[1], and Stefan Meister[1] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, Berlin, Germany — [2]Technische Fachhochschule Wildau, Institut für Plasma- und Lasertechnik, Wildau, Germany

We present the simulation and design of single-mode e-o modulators based on 1-D photonic crystal micro resonator fabricated in silicon-on-insulator (SOI) (220nm x 445nm) rib waveguides. The device operates by change the refractive index in the resonator microcavity region produce shifting in center wavelengthof the transmission peak. The refractive index in the microcavity is varied by using the free-carrier dispersion effect. The carrier density is modulated by a p-i-n diode formed about the microcavity. The change in refractive index as well as absorption produced from free carrier dispersion was included in the simulation to analyze the performance of the modulator. The device has been modeled and analyzed using 3D simulation software based on FDTD method.

Q 30.7 Wed 12:00 SCH A118

Linear and Nonlinear Measurements on Silicon-Organic Hybrid Waveguide Structures — •Peter W. Nolte, Clemens Schriever, and Jörg Schilling — Centre for Innovation Competence SiLi-nano, Martin-Luther-University Halle-Wittenberg, Germany

In the last years great efforts lead to a strong miniaturization of optical components, as several devices were realized on the silicon-on-insulator (SOI) platform which is completely compatible to CMOS technology. The very high refractive index contrast between the Si core (n=3.5) and the oxide cladding (n=1.45) and air (n=1), respectively, leads to a high confinement of light inside a waveguide. However, for many applications active devices exhibiting a nonlinear optical behavior are needed. One possible way to boost the nonlinear optical properties in integrated optics is the functionalization of SOI-structures. This is achieved by a combination of Silicon with strongly nonlinear organic materials such as dyes. SOI-ridge-waveguides have been fabricated using standard CMOS-processing and coated with molten dyes. Linear poperties like mode index and propagation losses are determined from a Fourier evaluation of the Fabry Perot oscillations of the transmission spectra. Finally the nonlinear properties of these devices have been studied by degenerated four-wave-mixing measurements.

Q 30.8 Wed 12:15 SCH A118

Electro-optical induced waveguides in isotropic phase liquid crystals-oil mixtures — •Martin Blasl, Kirstin Bornhorst, and Florenta Costache — Fraunhofer Institut for Photonic Microsystems, Maria-Reiche-Str. 2, 01109 Dresden, Germany

Optical multiplexers based on electro-optical (EO) materials are used to route signals in sensor applications. EO induced wave-guides are of interest for wavelength independent multi-mode and wavelength selective mono-mode operation and fast multiplexing.

Liquid crystals exhibit above their clear point (nematic-isotopic transition temperature) the second order EO effect. We created novel EO mixtures of 5CB liquid crystals-immersion oil with modified clear point as it was determined by DSC-technique.

The temperature dependent Kerr effect as well as the refractive indices were measured with a combined refractometric - interferometric technique. We observed that the Kerr activity is still present in the mixtures.

Designs of basic EO induced waveguides containing the new mixtures and various ITO-electrodes pathways were fabricated for switching, attenuation and deflection of light.

We show that dynamic optical waveguides with low insertion loss and bandwidth larger than kHz could be generated in the new mixtures for a broad temperature range.

We compare the measured optical guiding efficiency in the fabricated devices with FEM-simulations of designed EO induced waveguide devices using the measured Kerr constants.

Q 30.9 Wed 12:30 SCH A118

Control of light transmission through opaque scattering media in space and time — •Jochen Aulbach[1,2], Bergin Gjonaj[1], Patrick M. Johnson[1], Allard P. Mosk[3], and Ad Lagendijk[1] — [1]FOM Institute for Atomic and Molecular Physics AMOLF, Science Park 113, 1098 XG Amsterdam, The Netherlands — [2]Institut Langevin, ESPCI ParisTech, CNRS, 10 rue Vauquelin, 75231 Paris Cedex 05, France — [3]Complex Photonic Systems, MESA+ Institute, University of Twente, Post Office Box 217, NL-7500 AE Enschede, The Netherlands

We report the first experimental demonstration of combined spatial and temporal control of light trajectories through opaque media. This control is achieved by solely manipulating spatial degrees of freedom of the incident wave front. As an application, we demonstrate that the present approach is capable to form bandwidth-limited ultra-short pulses from the otherwise randomly transmitted light with a controllable interaction time of the pulses with the medium. Our approach provides a new tool for fundamental studies of light propagation in complex media and has potential for applications for coherent control, sensing and imaging in nano- and bio-photonics.

Q 30.10 Wed 12:45 SCH A118

Erzeugung von höheren räumlich transversalen Moden mittels eines "Spatial Light Moldulators" — •Dirk Puhlmann, Axel Heuer und Ralf Menzel — Universität Potsdam, Institut für Physik und Astronomie, Photonik, Karl-Liebknecht-Str. 24-25, 14476 Potsdam

Bei der Konzeption und Realisierung der meisten Lasersysteme wird ein möglichst perfekter Gaußstrahl angestrebt. Für Anwendungen in der Mikroskopie, der Quantenoptik und gegebenenfalls bei der Materialbearbeitung können höhere transversale Moden von Interesse sein. Für solche Versuche stehen aus den oben genannten Gründen kaum käufliche Quellen zur Verfügung. Ein Weg zur Lösung, ist die Umwandlung der TEM_00 Mode in entsprechend höhere transversale Moden mit Hilfe eines diffraktiven Elements. In diesem Vortrag präsentieren wir die Möglichkeiten der Erzeugung höherer räumlich transversaler Moden mit Hilfe eines "Spatial Light Modulator" (SLM), mit dem beliebige Gauss-Laguerre als auch Gauss-Hermite-Moden generiert werden können. Die Vor- und Nachteile dieser Methode werden diskutiert und vorgestellt.