Q 43: Quantum Optics and Photonics

Time: Thursday 11:00–13:00 Location: f342

Q 43.1 Thu 11:00 f342

Two-Color Ultrashort Soliton Molecules — Oliver Melchert[1,2,3], •Stephanie Willms[1,2], Surajit Bose[2], Alexey Yulin[4], Bernhard Roth[1,3], Fedor Mitschke[5], Uwe Morgner[1,2,3], Ihar Babushkin[1,2], and Ayhan Demircan[1,2,3] — [1]Cluster of Excellence PhoenixD, Welfengarten 1, 30167 Hannover, Germany — [2]Institute of Quantum Optics, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany — [3]Hannover Centre for Optical Technologies, Nienburger Str. 17, 30167, Hannover, Germany — [4]Department of Nanophotonics and Metamaterials, ITMO University, 197101 St. Petersburg, Russia — [5]Institute for Physics, University of Rostock, 18059 Rostock, Germany

We present previously unreported soliton bound states in the nonlinear Schrödinger equation, whose peculiarity lies in the vastly separated center frequencies of the constituent light pulses that are bound by Kerr-forces. This kind of soliton compound exhibits peculiar analogies to quantum mechanical binding energy, vibration, dissociation and dipolelike radiation. The key point relies on a formal analogy of trapping in potential wells in quantum mechanics, which can be realized by the interaction between two incoherent ultrashort solitons. The properties of the molecule states are investigated in detail and different ways for their creation are demonstrated.

Q 43.2 Thu 11:15 f342

General framework for the analysis of imperfections in integrated nonlinear devices for quantum optics applications — •Matteo Santandrea, Michael Stefszky, and Christine Silberhorn — Integrated Quantum Optics, Paderborn University, Warburgerstr. 100, 33098, Paderborn, Germany

Integrated nonlinear (NL) devices are necessary for the efficient realisation of many quantum communication and computation protocols and their future implementation in everyday life. However, the performance metrics of these devices, such as maximum conversion efficiency and spectral purity, are drastically affected by the presence of imperfections, e.g. fabrication errors or inhomogeneous operating conditions. Therefore, it is important to study the impact of imperfections on the NL properties of integrated devices.

Here, we present a novel framework for the analysis of performance degradation in NL systems in the presence of imperfections. Our framework highlights the hidden similarities among NL processes realised in different technological platforms and is thus able to describe the behaviour of a wide variety of integrated NL systems. We show that this framework provides a simple design rule to ensure the realisation of devices with nearly ideal spectral properties and we apply it to study the impact of imperfections on the performance of lithium niobate and lithium niobate on insulator waveguides.

Q 43.3 Thu 11:30 f342

High Q-Factor double resonant Bragg-Cavities: towards efficient Second Harmonic Generation in MoS2 and WS2 — •Heiko Knopf[1,2,3], Mathias Zilk[1], Simon Bernet[2], Franz Löchner[1], Nils C. Geib[1], Tobias Vogl[1], Ulrike Schulz[2], Frank Setzpfandt[1], Sven Schröder[2], and Falk Eilenberger[1,2,3] — [1]Institute of Applied Physics, Friedrich-Schiller-University, Albert-Einstein-Straße 15, 07745 Jena — [2]Fraunhofer Institute of Applied Optics and Precision Engineering IOF, Albert-Einstein-Straße 7, 07745 Jena — [3]Max Planck School of Photonics, Albert-Einstein-Straße 7, 07745 Jena

Transition metal dichalcogenides (TMDCs) are 2D-materials with a direct bandgap in a range of 1.0 to 2.5 eV. They exhibit strong second-order nonlinearity per unit thickness, making them interesting for nonlinear light-conversion devices. Due to their small thickness, an interaction enhancement is, however, required for efficient operation. Here we analyze dielectric Bragg mirror based resonators (DBR) for SHG-enhancement, where the DBR provides resonances for both, the fundamental wave and the second harmonic alike. Through careful design and optimization, we optimize the design to exhibit high Q-factors. We then report on the fabrication of such cavities, with an ion-assisted deposition process. We show that high Q-factors at the pump wavelength and the second harmonic is achieved. We then demonstrate enhanced second-harmonic generation and discuss possible generalization schemes.

Q 43.4 Thu 11:45 f342

Nonlinear integrated waveguides with CVD-grown MoS2 and WS2 monolayers on exposed-core fibers — •Gia Quyet Ngo[1], Robin Klaus Tristan Schock[1], Antony George[2], Emad Najafidehaghani[2], Tobias Bucher[1], Heiko Knopf[1], Christof Neumann[2], Heike Ebendorff-Heidepriem[3], Andrey Turchanin[2], Markus Schmidt[4], and Falk Eilenberger[1] — [1]Institute of Applied Physics, Friedrich Schiller University, Jena, Germany — [2]Institute of Physical Chemistry, Friedrich Schiller University, Jena, Germany — [3]ARC Centre of Excellence for Nanoscale BioPhotonics, University of Adelaide, Australia — [4]Leibniz Institute for Photonics Technologies IPHT, Jena, Germany

We demonstrate a novel type of waveguide functionalization, where crystalline MoS2 and WS2 monolayers are directly grown on the core of exposed-core fibers (ECFs) using CVD. These fibers opens up potential applications in nonlinear optics and real-time sensing. They overcome the sub-nanometer light-matter interaction length found in free-space interaction geometries. The TMDs interact with the guided light by the evanescent field of the fiber's guided mode. The successful deposition of MoS2 and WS2 layers on the core region was observed with a light microscope, Raman- and photoluminescence-spectroscopy. The excitonic peaks were recorded in photoluminescence and transmission spectroscopy. We will present and discuss experimental data, related to the fibers capability for sensing and for enhanced nonlinear interaction.

Q 43.5 Thu 12:00 f342

Planar-Optical Polymer Transmission Line for 2D Distributed Sensing — •Axel Günther[1,3], Wolfgang Kowalsky[1,3], and Bernhard Roth[2,3] — [1]TU Braunschweig, Institute of High Frequency Technology, Schleinitzstr. 22, 38106 Braunschweig — [2]Leibniz Universität Hannover, Hannover Centre for Optical Technologies, Nienburger Str. 17, 30167 Hannover — [3]Cluster of Excellence PhoenixD (Photonics, Optics and Engineering - Innovation Across Disciplines), Hannover

Planar-optical microstructures will become important for a large variety of future applications ranging from integrated photonic sensors to short distance communication. Hereby polymers offer a various advantages such as electromagnetic immunity, biocompatibility, as well as easy and cheap fabrication capability. They also provide a high flexibility in manufacturing and design compared to their semiconductor counterparts.

We compared different coupling concepts for horizontally and vertically emitting light sources into planar polymer-optical structures including light sources and detectors to form a polymer transmission path. We focus on low-cost, easy-to-fabricate and optically efficient coupling structures. Also, a transmission line is presented which contains a side emitting laser diode coupled to polymer waveguides by self-written-waveguides. As sensing element, a photo diode chip was integrated above a grating coupler. We discuss optical characterization of the components regarding losses and signal propagation.

Q 43.6 Thu 12:15 f342

VCSEL-Based Planar Optical Near Field Sensor for Precision Measurement Applications — •Axel Günther[1,3], Bernhard Roth[2,3], and Wolfgang Kowalsky[1,3] — [1]TU Braunschweig, Institute of High Frequency Technology, Schleinitzstr. 22, 38106 Braunschweig — [2]Leibniz Universität Hannover, Hannover Centre for Optical Technologies, Nienburger Str. 17, 30167 Hannover — [3]Cluster of Excellence PhoenixD (Photonics, Optics and Engineering - Innovation Across Disciplines), Hannover

During the last years, optical information technology relying on semiconductor materials, light sources, and detectors as well as lithographic fabrication techniques gained increasing attention due to the high integration density and large transmission rates. In this field, novel sensor concepts which can easily be incorporated into an optical network array for flexible and versatile measurement, e.g., the 2D spatially resolved acquisition of physical quantities such as strain, shape deformation, and temperature, or the sensitive and specific detection of liquid and gaseous trace substances offer great application potential.

We present a new type of near-field optical sensor which has potential to be used as a high-resolution measurement device with axial

resolution at the micrometer scale or below. The concept relies on an optical feedback signal generated in a VCSEL-based compound cavity and might enable fast and reliable topography determination of diverse structures. Preliminary experiments will be presented and compared to simulation results indicating the measurement capabilities of the device.

Q 43.7 Thu 12:30 f342

Nanophotonic tantalum pentoxide devices for integrated quantum technology — •Martin A. Wolff[1,2,3,4], Lukas Splitthoff[1,2,3], Thomas Grottke[1,2,3], Simon Vogel[1,2,3], and Carsten Schuck[1,2,3] — [1]Physics Institute, University of Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany — [2]CeNTech - Center for NanoTechnology, Heisenbergstr. 11, 48149 Münster, Germany — [3]SoN - Center for Soft Nanoscience, Busso-Peus-Str. 10, 48149 Münster, Germany — [4]martin.wolff@wwu.de

Tantalum Pentoxide (Ta2O5) is a new dielectric material system for realizing all key functionalities required for a versatile quantum technology platform on silicon chips. Here we show active and passive photonic integrated circuit components for realizing reconfigurable nanophotonic networks from Ta2O5 thin-films on insulator. Low-loss waveguides, wide-band grating couplers, micro-ring resonators with high quality factors of 356,000 and tunable directional couplers provide crucial passive linear optic functionality. Nanoelectromechanical phase shifters further enable active functionality, thus allowing for network reconfigurability, feedback and feedforward control as desired in many quantum technology applications. Waveguide-integrated superconducting nanowire single-photon detectors with efficiencies of 86% complement the quantum photonic toolbox. Our work paves the way for realizing the full suite of photonic integrated quantum technology applications with Ta2O5 nanophotonic devices.

Q 43.8 Thu 12:45 f342

Nanophotonic inverse design: A dynamic binarization function for the "objective-first" algorithm — •Marco Butz[1,2,3] and Carsten Schuck[1,2,3] — [1]Physics Institute, University of Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany — [2]CeNTech - Center for NanoTechnology, Heisenbergstr. 11, 48149 Münster, Germany — [3]SoN - Center for Soft Nanoscience, Busso-Peus-Str. 10, 48149 Münster, Germany

Photonic integrated circuits are being employed for an increasing number of complex quantum optics experiments on compact and interferometrically stable chips. The integration of ever-increasing numbers of circuit components poses challenging requirements on the footprint and performance of individual nanophotonic devices. Here we show how inverse design algorithms based on the "objective-first" method can be employed for finding highly efficient and compact device layouts. We improve on existing implementations by introducing a dynamic binarization penalty function that removes limitations in the iterative evolution of the algorithm towards an efficient solution. We exploit the dynamic binarization in the design of waveguide mode converters with high efficiency and small footprint that outperform existing designs relying on intuitive design concepts and brute force optimization. It is straightforward to adapt our approach for a wide range of circuit components, thus providing new possibilities for scaling nanophotonic networks to large system size as well as realizing novel functionalities in such networks.