Q 40: Poster – Photonics

Nanophotonics; 3D Printing; Microscopy; Biophotonics; General Photonics

Time: Wednesday 17:00–19:00 Location: Philo 1. OG

Q 40.1 Wed 17:00 Philo 1. OG

Photonic integrated top-hat beam profiler for multi-ion clock application — •Matthias Ludwig[1,2], Carl-Frederik Grimpe[1], Guochun Du[1], Fatemeh Salahshoori[1], André Kulosa[1], Elena Jordan[1], and Tanja E. Mehlstäubler[1,3,4] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany — [3]Leibniz Universität Hannover, Institut für Quantenoptik, Hannover, Germany — [4]Leibniz Universität Hannover, Laboratorium für Nano- und Quantenengineering, Hannover Germany

Multi-ion optical clocks offer improved precision by reducing the averaging time. To minimise intensity-dependent AC Stark shifts on individual ions, highly homogeneous illumination is essential. The optimal beam shape for this purpose is a top-hat intensity profile. This has previously been achieved using holographic waveplates in free space, but this approach limits spatial uniformity [1]. We demonstrate that an extreme mode converter, implemented on an Al_2O_3 photonic material platform, can generate this top-hat profile for the 370 nm Doppler cooling transition of Yb^+ ions, thereby increasing the modal area of the waveguide mode by a factor of $\sim 10^4$. This integrated photonic approach provides a path towards improved beam homogeneity and scalable multi-ion clocks, overcoming the limitations imposed by free-space optics.

[1] J. Yu et al., "Precision Spectroscopy in Yb+ ions," 2024 European Frequency and Time Forum (EFTF), Neuchâtel, Switzerland, 2024, pp. 334-336, doi: 10.1109/EFTF61992.2024.10722611.

Q 40.2 Wed 17:00 Philo 1. OG

Fabrication approach for all-diamond nano-cavity structures in submicron membranes — •Kilian Mark, Jan Fait, and Christoph Becher — Universität des Saarlandes, Campus E2.6, 66123 Saarbrücken, Germany

Tin-vacancy (SnV) centers in diamond combine excellent optical properties with long spin-coherence times, making them promising candidates for spin-photon interfaces in quantum technologies [1]. However, photon collection efficiency from bulk diamond is low due to total internal reflection at the diamond-air interface [2]. It is crucial for most applications to improve the collection efficiency of photons, which can be achieved by using nanophotonic structures. This contribution presents the individual fabrication steps towards bull's eye cavities in thin diamond membranes, focusing on the use of a thin silicon (Si) layer as a hard mask to etch the diamond via inductively coupled plasma reactive ion etching (ICP-RIE). The Si layer is patterned in an SF_6:C_4F_8 plasma to obtain sharp features with vertical sidewalls, which are subsequently transferred into the diamond using an Ar:O_2 plasma. *Tests on bulk diamond with feature dimensions adapted to the SnV emission wavelength (619 nm) show promising results with steep angles and small roughness of the sidewalls. We will report on first experiments on deterministic implantation of SnV centers at the center of the bullseye structures. *[1] J. Görlitz et al., npj Quantum Inf 8(45), 2022 *[2] E. Janitz et al., Optica 7(10), 2020

Q 40.3 Wed 17:00 Philo 1. OG

Passive photonic structures in transition metal dichalcogenides for integrated quantum photonics — •Anita Kohlwes[1], Zengya Li[2], Timur Shegai[2], and Doris Reiter[1] — [1]TU Dortmund, Germany — [2]Chalmers University of Technology, Gothenburg Sweden

Integrated photonics relies on nanostructured materials, including single-photon emitters, waveguides, and photonic cavities. While most existing approaches use different materials for the various components, we aim to realize a single-material, all-in-one photonic platform based on transition-metal dichalcogenides (TMDCs). With this goal in mind, we simulate passive photonic TMDC structures using Maxwell solvers such as FDTD or FEM and optimize their performance. The first part of the study examines simple rectangular waveguides and how geometry affects mode confinement, effective index, and propagation. From this, we derive clear design rules toward experiments that maximize performance while remaining compatible with planar processing. In the second part, we introduce a periodic array of holes in the waveguide to create a photonic bandgap. By tuning the period and hole diameter, we design efficient mirrors and a stopband at the target wavelength for TMDC single-photon emitters. Our results represent a first step towards a single-material TMDC photonic platform.

Q 40.4 Wed 17:00 Philo 1. OG

Cryogenic-Temperature ODMR Analysis of Nitrogen-Vacancy Centers in Nanodiamonds — •Wanrong Li[1], Keisuke Oshimi[2], Masazumi Fujiwara[2], and Oliver Benson[1] — [1]Humboldt-Universität, Berlin, Germany — [2]Okayama University, Okayama, Japan

Nitrogen-Vacancy (NV) defect centers in diamond have demonstrated remarkable quantum properties and have enabled diverse applications in quantum technology and sensing. NV centers in nanodiamond exhibit temperature-dependent shifts in their zero-field splitting (ZFS), but the underlying mechanisms may differ from those observed in bulk diamond [1] due to surface effects [2], lattice strain, impurity-induced perturbations, and other nanoscale mechanisms. In this work, we investigate the Optically Detected Magnetic Resonance (ODMR) of ensemble NV centers in nanodiamond over a range of cryogenic temperatures. These measurements enable direct probing and modeling of the temperature-dependent NV zero-field splitting. Looking ahead, we aim to investigate fundamental physical phenomena in nanodiamond using single NV defects.

References

[1] M. C. Cambria et al., Physically motivated analytical expression for the temperature dependence of the zero-field splitting of the nitrogen-vacancy center in diamond, Phys. Rev. B 108, L180102 (2023).

[2] M. Sow et al., Millikelvin intracellular nanothermometry with nanodiamonds, Adv. Sci. 12, e11670 (2025).

Q 40.5 Wed 17:00 Philo 1. OG

Light modulation in electrically switchable metasurfaces using organic electro-optical materials — •Paul Bingel[1], Monika Ubl[1], Masis Sirim[2], Patrick Kern[2], Stefan Bräse[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany — [2]Institute of Organic Chemistry, Karlsruhe Institute of Technology (KIT), Germany

Classical electro-optic materials, including liquid crystals, transition-metal oxides, and conducting polymers, are widely used in display technologies, adaptive optics, and tunable photonic systems. Recently developed organic-electro-optic (OEO) materials have demonstrated coefficients more than an order of magnitude higher than those of conventional systems. This advancement enables the integration of plasmonic metasurfaces with the high-performance OEO chromophore JRD1 to realize electrically switchable devices based on the Pockels effect. In this presentation, we demonstrate that a gold metasurface coated with JRD1 exhibits strong and fast electro-optic tunability. By tailoring the metasurface geometry, we achieve exceptionally high transmission modulation in the infrared, particularly at technologically relevant telecom wavelengths. These active hybrid structures offer a promising route toward compact, efficient, and reconfigurable components for next-generation photonics and telecommunications.

Q 40.6 Wed 17:00 Philo 1. OG

Enhancing Light-Matter Interactions In Integrated Platforms — •Malaika Waheed[1], Christian Koller[1], and Sarah Margaretha Bayer-Skoff[2] — [1]FH Wiener Neustadt, Johannes Gutenberg-Straße 3, 2700 Wiener Neustadt 2700 Wiener Neustadt, Austria — [2]TU Wien, Stadionallee 2, 1020 Wien, Austria

Two-dimensional van der Waals materials, such as hexagonal boron nitride hosting carbon-related defects, represent a versatile platform for quantum technologies at room temperature. These defects offer the properties of emitting single photons, as well as they offer optically detectable spin resonances under controlled environment. Also, the single-photon detection and correlation need to be measured with high time resolution to improve the quantum efficiency and fast detection. Thus, our work presents the study of carbon-related point defects in hBN, including single photon emission and their optically detectable magnetic resonances. For the detection system of these single photons, the design and characterization of an on-chip CMOS-compatible single photon detector with an integrated correlator module is important to implement. With on-chip detector design and behavioural analysis of point defects in hBN, this work will potentially contribute towards scalable, high-performance solutions for quantum photonics and sensing applications.

Q 40.7 Wed 17:00 Philo 1. OG

Optical feedback for the photo-induced deformation of thin films — •Kenneth Lütticke and Carsten Henkel — Universität Potsdam, Institut für Physik und Astronomie, Germany

Photo-induced deformations in photoactive polymer thin films have been intensively studied for decades due to their potential use in inscribing topographical relief patterns with high information density. These deformations arise from trans–cis photoisomerization cycles, and various theoretical models have been developed to bridge the molecular processes with the resulting macroscopic structures [1,2,3]. While several theoretical frameworks address mass transport or anisotropic reorientation [4,5], they fall short of predicting realistic deformation scales or feedback effects during holographic exposure. In this work, we analyze the possibility of an optical feedback where holographic illumination gets reinforced by the growing relief, as an alternative to the conventional orientation approach.

[1] M. Saphiannikova, V. Toshchevikov and N. Tverdokhleb, Soft Matter 20 (2024) 2688
[2] M. Merkel, A. Elizabeth, M. Böckmann, H. Mönig, C. Denz and N. L. Doltsinis, J. Chem. Phys. 158 (2023) 104905
[3] H. Leblond, R. Barille, S. Ahmadi-Kandjani, J.-M. Nunzi, E. Ortyl and S. Kucharski, J. Phys. B 42 (2009) 205401
[4] F. Ledoyen, P. Bouchard, D. Hennequin and M. Cormier Phys. Rev. A 41 (1990), 4895
[5] M. Saphiannikova, V. Toshchevikov, and J. Ilnytskyi, Nonlin. Opt. Quantum Opt. 41 (2010) 27

Q 40.8 Wed 17:00 Philo 1. OG

Polarization measurements of nanophotonic outcouplers for quantum technology applications — •Nasimalsadat Mousavi Savadkouhi[1], Carl-Frederik Grimpe[2], Guochun Du[2], Steffen Sauer[1,3], Anastasiia Lüssmann-Sorokina[1,3], Afonso Alcape Meyer[1,3], Liam Shelling Neto[1,3], Elena Jordan[2], Tanja E. Mehlstäubler[2,4,5], and Stefanie Kroker[1,2,3] — [1]Institut für Halbleitertechnik, Technische Universität Braunschweig, Germany — [2]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [3]Laboratory for Emerging Nanometrology, Braunschweig, Germany — [4]Institut für Quantenoptik, Leibniz Universität Hannover, Germany — [5]Laboratorium für Nano- und Quantenengineering, Hannover, Germany

Controlling the polarization state of light is crucial for photonic and quantum optical applications, such as cooling and state preparation of ions for quantum computing and quantum sensing. Integrated nanophotonic outcouplers provide an on-chip interface for directing light fields onto these quantum emitters, making their ability to generate well-defined circular polarization important. In this work, we investigate the polarization of light emitted from an outcoupler at 760 nm based on a QR-Code structure. We use a rotating quarter-wave plate method to characterize the polarization state, reconstruct the set of Stokes parameters, and obtain the degree of linear and circular polarization of the outcoupled beam. We demonstrate that this measurement method enables verification of the circular polarization by the outcoupler and allows quantification of polarization imperfections.

Q 40.9 Wed 17:00 Philo 1. OG

Simulation Framework for Athermal Silicon Nitride Waveguide Design — •Ekin Bircan Bosdurmaz, Max de Jager, and Pepijn W. H. Pinkse — MESA+ Institute for Nanotechnology, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands

We present a simulation framework to engineer athermal integrated waveguides in silicon nitride photonic platforms. Starting from realistic Si_3N_4/SiO_2 stacks with optional overlay layers, we compute the temperature dependence of the guided modes by combining electromagnetic eigenmode solvers with temperature-dependent refractive index models. Thermo-optic finite-element simulations provide the local temperature distribution allowing us to find contributions to the effective index shift. By sweeping core geometry, cladding composition, and overlay thickness, we map the design space where the net thermo-optic coefficient of the fundamental mode approaches or crosses zero, and we quantify the spectral bandwidth over which this athermal condition is maintained. The methodology provides a practical, simulation-driven route to identify and optimize athermal Si_3N_4/SiO_2 waveguide geometries for temperature-stable operation in precision photonic integrated circuits.

Q 40.10 Wed 17:00 Philo 1. OG

Fabrication of High Quality Factor Resonators in Ta_2O_5 for Integrated Nonlinear Photonics — •Jan Wulkotte[1,2,3], David Lemli[1,2,3], Tim Buskasper[1,2,3], and Carsten Schuck[1,2,3] — [1]Department for Quantum Technology, University of Münster, Heisenbergstr. 11, 48149 Münster, Germany — [2]Center for Soft Nanoscience, Busso-Peus-Str. 10, 48149 Münster, Germany — [3]Center for Nanotechnology, Heisenbergstr. 11, 48149 Münster, Germany

Integrated nonlinear photonics enables the generation of quantum light through sub-wavelength waveguide confinement and high-quality-factor resonators to enhance nonlinear light-matter interactions. Within this framework, tantalum pentoxide (Ta_2O_5) has emerged as a compelling material platform owing to its high refractive index, low propagation loss, and strong third-order optical nonlinearity.

Efficient nonlinear processes require precise dispersion engineering, which necessitates the use of thick films and introduces substantial nanofabrication challenges. In this work, we demonstrate microring resonators with high quality factors at 1550 nm based on 600 nm-thick Ta_2O_5 films on SiO_2 substrates with air cladding. In addition, we show an efficient coupling scheme based on polymer-printed couplers with minimal simulated back reflection, which is expected to facilitate precise control of Kerr nonlinear dynamics.

These high-quality-factor Ta_2O_5 microring resonators constitute a key building block for integrated nonlinear and quantum photonic circuits, paving the way toward on-chip Kerr nonlinear processes and the generation of non-classical states of light.

Q 40.11 Wed 17:00 Philo 1. OG

Enhanced light matter interaction for quantum technologies and sensing applications — •Adam Lafferty, Raphael Neubacher, Helmut Hörner, Malaika Waheed, Ambika Shorny, Fritz Steiner, Alex Götz, Adarsh Prasad, Stefan Walser, and Sarah M. Skoff — Atominstitut, TU Wien, Stadionallee 2, 1020 Vienna, Austria

Strong light-matter interactions are important both for quantum networks and for sensing applications.

Achieving such coupling has long been a challenge for conventional bulk optical platforms. Recent advances in nanofabrication have opened the door to nanophotonics as a powerful platform for enhancing light matter interaction. Here, we will show how different types of nanophotonics can be employed to enhance the interaction between single quantum emitters and a light field. We will also show that such platforms can be employed for sensing applications, even in the wider context of environmental sensing, where we have demonstrated that we can detect and identify nanoplastic particles down to sizes of 100nm.

Q 40.12 Wed 17:00 Philo 1. OG

Investigating Non-Hermiticity in Photonic Waveguides With Higher Modes — •Sabrina Hammel, Julian Schulz, and Christina Jörg — Physics Department and Research Center OPTIMAS, RPTU Kaiserslautern-Landau, Germany

Non-Hermitian photonic systems host a range of striking physical phenomena - such as loss-induced topological states, exceptional points, and non-orthogonal mode dynamics - that are impossible in Hermitian settings [1]. These effects are typically realized by engineering spatial distributions of gain and loss. Here, we demonstrate a fundamentally different and highly versatile approach: implementing non-Hermiticity directly in the orbital degree of freedom. Using 3D micro-printed inverse waveguides infiltrated with absorptive materials, we create photonic structures that support both the fundamental mode (TEM_{00}) and higher-order transverse modes. Certain geometries, such as an elliptical shape, allow the orthogonal TEM_{10} and TEM_{02} modes to couple between neighboring sites, while experiencing different amounts of absorption. This mode-dependent loss produces a non-Hermitian two-mode system without requiring spatially patterned gain or loss. Crucially, because the non-Hermiticity resides in the modal degree of freedom, it can be externally switched simply by choosing which mode is guided. This enables a new class of reconfigurable non-Hermitian photonic platforms capable of realizing and dynamically controlling non-Hermitian phenomena, including exceptional points and loss-stabilized topological states.

[1]: S. K. Gupta et al., Adv. Mater. 32, 1903639 (2020)

Q 40.13 Wed 17:00 Philo 1. OG

The SSH model in non-dimerized chains via multimode waveguides — •Ian Heil, Julian Schulz, and Christina Jörg — Physics Department and Research Center OPTIMAS, RPTU Kaiserslautern-Landau

Topological photonic waveguide arrays based on the Su-Schrieffer-Heeger (SSH) model typically rely on an alternating spacing between neighboring waveguides. Therefore, the distinction between the trivial and topological phases is sensitive to the geometric layout and the presence or absence of individual sites. In this work, we introduce a fundamentally different strategy. We investigate a non-dimerized chain of multimode waveguides whose elliptical geometry enables control over the coupling between s-, p-, and d-like modes [1]. Here, the topology arises because two distinct transverse modes form an effective two-site basis within each real-space waveguide, yielding a synthetic dimerization even though the physical lattice contains only a single site per unit cell. This effective model reproduces SSH-like physics without requiring any spatial alternation of waveguide positions. Because the topological phase is encoded in the modal degrees of freedom rather than real-space geometry, edge states persist regardless of the number of waveguides, and adding or removing sites at the boundaries does not affect the topological character. Through changes in ellipticity or spacing between waveguides, we demonstrate controllable transitions between trivial and topological phases. This mode-based strategy offers a route to reconfigurable topological photonic systems.

[1] G. Liu et al. PRB 110, 214110 (2024)

Q 40.14 Wed 17:00 Philo 1. OG

Integrated Optics for efficient Fluorescent collection for single NV centers — •Robert Bruss[1], Lucas Kirchbach[1,2], and Andreas Stute[1,2] — [1]Faculty AMP, Keßlerpl. 12, 90489 Nürnberg — [2]Faculty EFI, Wassertorstr. 10, 90489 Nürnberg

Efficient collection of fluorescence light is essential for all optically adressable qubit platforms. For the nitrogen-vacancy (NV) center in diamond, the high refractive index of the host medium poses a major challenge as it limits the solid angle under which fluorescence light can leave the crystal. To enhance collection efficiency from single NV centers, we design and simulate micro-optical elements that shall be directly fabricated on the diamond surface using two-photon polymerization. Several optical designs and photoresists are evaluated for their expected coupling efficiency into single-mode fibers and their tolerance to fabrication errors. Additionally, an analytical solution for single lens collimation of the emission of a point source in diamond at a specific wavelength is presented, as well as considerations regarding the degradation of wavefront quality in multi-wavelength Fresnel designs.

Q 40.15 Wed 17:00 Philo 1. OG

Refractive index characterization and luminescence spectra of photoresists for 3D printing — •Leonardo Guimaraes, Leander Siegle, and Harald Giessen — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

With the development of two-photon polymerization 3D printers, optical and mechanical characterization of their printing material, the photoresist, became crucial. Properties such as transmission have been well characterized recently. The luminescence of these photoresists, of major interest for biomedicine and quantum applications, however, has been underreported. In this work, we characterize the spectral response at multiple excitation wavelengths in the ultra-violet and visible. The refractive index of these photoresists is a key parameter for any optical component. We measure the refractive index of several photoresists over the visible and near-infrared spectral region. Our data shortens the search for the ideal photoresist across a different range of applications, be it the required low autofluorescence necessary for biomedicine, quantum light devices, or optimal refractive index for micro-optical components.

Q 40.16 Wed 17:00 Philo 1. OG

Complex-structured beam produced by modulated phase mask — •Zihao Zhang and Harald Giessen — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany

Super-resolution technologies for both imaging and measurement have become major research frontiers over the past decade, driven by advances such as Stimulated Emission Depletion (STED) microscopy and Structured Illumination Microscopy (SIM). STED routinely achieves resolutions down to 30 nm with strong depletion, while SIM offers enhanced resolution with compatibility for live-cell imaging. However, both methods rely on complex-structured beams, typically donut-shaped or otherwise spatially engineered, whose generation often requires bulky and intricate optical assemblies. Many practical applications, therefore, demand compact, easily integrated solutions for producing such illumination fields. In this work, we exploit state-of-the-art Two-Photon Grayscale Lithography (2GL) to fabricate customizable, continuous, and freeform microscale phase masks capable of generating advanced beam profiles. We demonstrate multiple design strategies, including aspect-ratio tuning, controlled phase-rotation gradients, and phase extraction from superposed fields. These approaches enable the realization of complex-structured beams in a highly compact form factor, suitable for straightforward implantation into existing optical systems. Our results establish 2GL-fabricated phase masks as a versatile platform for next-generation super-resolution illumination engineering.

Q 40.17 Wed 17:00 Philo 1. OG

Mid- to long-wave-infrared nanoscopy with lanthanide transducers — •Junyu Guan[1], Hanyu Zhang[1], Yanan Li[2], Kun Huang[2], and Kangwei Xia[1] — [1]Laboratory of Spin Magnetic Resonance, School of Physical Sciences, University of Science and Technology of China — [2]State Key Laboratory of Precision Spectroscopy, East China Normal University

Mid- to long-wave infrared (MIR-LWIR) microscopy provides a non-invasive and label-free tool to acquire rich spectroscopic and structural information about chemical materials and biomedical samples. However, the lateral resolution is typically limited by severe optical diffraction at long infrared wavelengths, which hinders imaging systems from observing intricate details beyond the diffraction limit. Here, we report a MIR-LWIR to near infrared (NIR) transducer based on a rare-earth-doped crystal, which enables room-temperature MIR-LWIR imaging within a broad spectral coverage of 7-10.6 μm. The presented lanthanide-based transducer is compatible with close positioning to nano-/micro-structures, facilitating near-field MIR-LWIR imaging with an improved spatial resolution from 50 μm to sub-μm. Notably, hidden objects can be accurately identified with high axial precision owing to the confocal excitation configuration, which enables high-resolution MIR-LWIR depth imaging. In addition, experimental validation using two-dimensional materials such as hexagonal boron nitride reveals distinct MIR-LWIR response characteristics, demonstrating the system's capability for high-resolution imaging and spectroscopic characterization across extended infrared wavelengths.

Q 40.18 Wed 17:00 Philo 1. OG

Machine learning driven texture analysis of laser speckle imaging for early breast cancer detection — •Doaa Youssef — Department of Engineering Applications of Lasers, National Institute of Laser Enhanced Sciences (NILES), Cairo University, Egypt

Breast cancer remains one of the most prevalent malignancies, and early detection is crucial for improving patient outcomes. We present an image-guided breast cancer detection method based on laser speckle imaging and machine learning. The approach exploits the distinct absorption and scattering properties of healthy and malignant breast tissue. A dual-wavelength optical system using low-power 532 nm and 632 nm lasers was developed to record speckle patterns from ex vivo breast samples. Diagnostic information is extracted using a strategy that combines multi-neighborhood local entropy with a Gabor filter bank to generate texture maps that reveal subtle structural changes. These maps are fused to form a single informative image, from which texture features are obtained using two histogram-based methods and refined through data reduction techniques. The discriminative capability of the extracted features was assessed using three supervised classification models: support vector machine (SVM), ensemble k-nearest neighbor (E-kNN), and extreme gradient boosting (XGB). Combining information from both wavelengths improved overall diagnostic performance, yielding an accuracy of 98.48% and a weighted F1 score of 98.54%. These findings demonstrate the potential of laser speckle-based optical diagnostics integrated with AI for affordable, non-destructive early breast lesion detection.

Q 40.19 Wed 17:00 Philo 1. OG

Fiber Fabry-Perot Cavities: Design, Arrays, and Interfaces — •Jana Blechmann, Daniel Stachanow, Lukas Tenbrake, Florian Giefer, Gian-Marco Schnueriger, Hannes Pfeifer, and Sebastian Hofferberth — Institute of Applied Physics, University of Bonn, Germany

Fiber Fabry-Perot cavities (FFPCs) offer many advantages, including their miniature size and robustness, in applications like sensing. In the Bonn Fiber Lab, we specialize in the precise fabrication and analysis of FFPCs and the integration with fiber interfaces.

This poster will showcase three ongoing projects, focusing on both the development of fiber cavities and their applications.

We will present our current research on a novel, monolithic, passively stable, fiber-based crossed-cavity, including the manufacturing of fiber mirrors with the in-house shooting setup.

Further, we will showcase our recent steps in manufacturing cavity arrays on optical multicore fibers. Among the numerous possible applications, we aim to use them as an interface for mechanical metamaterials.

We will also present our latest progress in the investigation of interfaced micro-mechanical resonators fabricated through 3D direct laser writing, covering techniques for optimizing Q-factors, such as dissipation dilution and the use of glassy structures with inherently higher intrinsic Q.

Q 40.20 Wed 17:00 Philo 1. OG

Rydberg quantum optics based on integrated photonic waveguides immersed in a hot atomic vapor — •Alexandra Köpf[1,2], Annika Belz[1], Xiaoyu Cheng[1], Benyamin Shnirman[1,2], Hadiseh Alaeian[3], Harald Kübler[1], Robert Löw[1], and Tilman Pfau[1] — [1]5. Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Germany — [2]Institut für Mikroelektronik Stuttgart (IMS-Chips), Stuttgart, Germany — [3]Departments of Electrical & Computer Engineering and Physics & Astronomy, Purdue University, West Lafayette, USA

The combination of thermal atomic vapors with nanophotonic structures provides a unique platform for the exploitation of atom-photon and light induced atom-atom interactions. One major goal is to enhance the corresponding non-linearities from the few to the single photon level by either strong enough coupling or the Rydberg blockade effect. In detail, we study a chip-scale platform based on silicon nitride waveguides integrated into a rubidium vapor cell where the evanescent fields of the photonic waveguides can interact with the atoms in specific regions. By underetching the structures we can further enhance the coupling of the evanescent fields with the atomic vapor. The main focus lies currently in the combination of underetched tapered waveguides with high resolution spectroscopy. In a first experiment it was shown that the transit time broadening is reduced to a level, that sub-Doppler features can be observed, such as EIT. In a second approach we excite Rydberg atoms (in the 32S state) within the evanescent field of a tapered nanowaveguide.

Q 40.21 Wed 17:00 Philo 1. OG

Simulations of inverse taper structures for efficient edge coupling in TFLN — •Micha Jonas, Filip Sosnicki, Laura Padberg, Harald Herrmann, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098 Paderborn, Germany

Thin-film lithium niobate (TFLN) emerges as a promising platform for photonic integrated circuits due to notably electro-optic and nonlinear properties. It makes it particularly suitable for quantum photonics where one can apply frequency-mixing schemes or electro-optic modulation to single-photon pulses. Such applications require low losses within a broad spectral bandwidth. Currently, in- and out-coupling efficiencies are fundamental limitations due to the mode-mismatch of waveguide eigenmodes (MFD ca. $1\mu m$) and fiber mode (MFD ca. $10\mu m$). Here we investigate inverse tapers that enlarge the optical mode at the waveguide facet to match it to the fiber mode increasing coupling efficiency. We perform numerical simulations of taper structures in TFLN to optimize fiber in- and out-coupling of a waveguide. For this purpose, we use Eigenmode Expansion (EME) to calculate the optical mode distribution at the end of the taper while varying its dimensions, compatible with TFLN chip fabrication tolerances. We investigate impact of the inverse taper on the edge-coupling efficiency for various in-coupling optical beam dimensions as well as possible alignment tolerances and their spectral bandwidth. Our work will enable low-loss coupling into TFLN photonic integrated circuits paving the way for on-chip quantum photonics.

Q 40.22 Wed 17:00 Philo 1. OG

Simulating Surface Roughness Effects on TIR Coupling Losses in Thermally Annealed SLE Structures — •Thilo Danner, Veronica Montoya, Patrick Hildebrand, Yassin Nasr, Andreas Michalowski, and Tobias Menold — Institut für Strahlwerkzeuge (IFSW), Pfaffenwaldring 43, 70569 Stuttgart, Germany

Femtosecond laser-written structures in fused silica offer a versatile platform for integrated photonic devices, leveraging their 3D processing capabilities to enable integrated light handling, including guiding, reflecting, and focusing. Integrated light reflection is achieved via Selective Laser Etching (SLE) on a specific surface, where light is reflected through total internal reflection (TIR). Unfortunately, the SLE process inherently yields a rough surface, introducing scattering losses that degrade performance and cause unwanted mode distortion. Thermal annealing is a common method of reducing surface roughness. Using experimental roughness data, we simulated the influence of roughness after various annealing times to obtain the resulting coupling losses of a Gaussian beam into a waveguide. Various design parameters are simulated using electromagnetic solvers, specifically the Finite-Difference Time-Domain (FDTD) and Finite Difference Eigenmode (FDE) methods, to evaluate how much annealing is required to approach the surface quality demanded for low-loss coupling.

Q 40.23 Wed 17:00 Philo 1. OG

Simulation of light guiding and coupling in direct laser-written integrated optical elements — •Veronica Montoya, Thilo Danner, Patrick Hildebrand, Yassin Nasr, Andreas Michalowski, and Tobias Menold — Universität Stuttgart, Institut für Strahlwerkzeuge (IFSW), Pfaffenwaldring 43, 70569 Stuttgart

The trend to construct on-chip three-dimensional devices is growing, and direct laser-written structures (DLW) in glass represent a versatile key technology for integrated photonic systems. Major challenges lie in the currently insufficient theoretical understanding of the influence of the resulting refractive index profiles of DLW waveguides, as well as in the development of scalable and robust light coupling between a waveguide and other integrated optical element. Therefore, simulation-based preliminary work is essential. The goal of this project is to analyze and optimize the light-guiding behavior and coupling properties of DLW waveguides and coupling structures using simulation tools such as Ansys Lumerical. A realistic implementation of the refractive index profile resulting from DLW, along with the resulting mode structure, losses, and coupling functionality facilitated by Ansys' time, space, and frequency solutions, can provide the foundation for the targeted design of complex structures in the future.