FM 9: Quantum Networks: Platforms and Components I

Time: Monday 14:00–15:45 Location: 1098

FM 9.1 Mon 14:00 1098

Fabrication of Diamond Membranes for Photonic Structures — •Julia Heupel, Johann Peter Reithmaier, and Cyril Popov — Institute of Nanostructure Technologies and Analytics, Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

Due to its exceptional physical and chemical characteristics, diamond in a form of thin membranes is a particularly promising material for high quality photonic devices. In this work we address at first the fabrication of two-dimensional photonic crystal slabs utilizing nanocrystalline diamond (NCD) membranes deposited on silicon dioxide/silicon substrates. For adjusting the NCD film thickness as well as for smoothening the intrinsically rough surface, a planarization process utilizing polymerized spin-on glass (SOG) was developed. The photonic crystal structures were prepared in NCD samples with planarized surface by means of electron beam lithography (EBL) and inductively coupled plasma reactive ion etching (ICP RIE). By underetching of the sacrificial silicon dioxide layer with a hydrofluoric acid solution, the photonic crystals were suspended in air. Additionally, we report on the structuring progress for thin monocrystalline diamond (MCD) membranes by ICP RIE, utilizing a diamond bulk mask with angled holes as an etch mask and different etching mixtures.

FM 9.2 Mon 14:15 1098

Demonstration of ultra stable single quantum defects in silicon carbide nanophotonics structures — •Charles Babin, Timo Goerlitz, Naoya Moriaka, Roland Nagy, Rainer Stöhr, Matthias Niethammer, Yu-Chen Chen, Florian Kaiser, and Jörg Wrachtrup — 3rd Institute of Physics, University of Stuttgart and Institute for Quantum Science and Technology IQST, Germany

Solid state quantum systems with optically interfaced spins are promising platforms for quantum information processing. A scalable system should be insensitive to the environment, and emit a large fraction of photons resonantly. [1]. As we have recently shown, those criteria are met by the silicon vacancy center (VSi) in silicon carbide [2].

A remaining bottleneck is the low fluorescence rate, which is limited by a strong phonon coupling to a metastable state manifold. Further, the associated spin flip processes represent a limitation for the single shot readout fidelity. This talk addresses strategies to overcome these issues. I will show the first promising results on the stability of single defects inside nano-waveguide structures. This marks the first step toward the incorporation of single emitters in nano-photonics cavities to increase fluorescence rates via Purcell enhancement. I will also present a pathway to realize a deterministic readout of the electron spin via a nuclear spin memory [3].

[1] David D. Awschalom, Ronald Hanson, Jörg Wrachtrup & Brian B. Zhou, Nature Photonics 12, 516*527 (2018)

[2] R. Nagy & al., Nature Communications 10, 1954 (2019)

[3] P. Neuman& al., Science 329, 542*544 (2010)

FM 9.3 Mon 14:30 1098

Remote two-Photon interference in the telecom C-band of frequency converted quantum dots — •Simone Luca Portalupi[1], Jonas H. Weber[1], Benjamin Kambs[2], Jan Kettler[1], Simon Kern[1], Julian Maisch[1], Hueseyin Vural[1], Michael Jetter[1], Christoph Becher[2], and Peter Michler[1] — [1]IHFG-University of Stuttgart, IQST and SCoPE, Stuttgart, Germany — [2]Fachrichtung Physik, Universität des Saarlandes, Saarbrücken, Germany

Nowadays, efforts are made to transfer quantum technology from laboratory-based demonstrations to real world applications, such as the implementation of quantum networks for the secure transmission of information over long distances. Within the required components, sources of non-classical light are of key importance. Semiconductor quantum dots are one of the most promising candidates for the generation of single, indistinguishable, and entangled photons. Currently, the best emitters are operating well inside the near infrared regime (∼780-900 nm), so not compatible with existing silica-based fibre networks. Here we make use of quantum frequency conversion (QFC) to change the wavelength of the photons emitted by two distinct quantum dots from ∼900 nm to ∼1550 nm. We perform two-photon interference between two remote emitters to prove one of the fundamental quantum operations needed in future quantum networks. We prove that the QFC does not modify the photon properties, making this approach very appealing in realistic long-distance quantum applications [1].

[1] J. H. Weber, et al. Nat. Nanotechnol. 14, 23 (2019).

FM 9.4 Mon 14:45 1098

High-repetition-rate frequency comb conversion in synchronously driven non-centrosymmetric optical microresonators — •Jan Szabados[1], Ingo Breunig[1,2], and Karsten Buse[1,2] — [1]Laboratory for Optical Systems, Department of Microsystems Engineering - IMTEK, University of Freiburg, Georges-Köhler-Allee 102, D - 79110 Freiburg, Germany — [2]Fraunhofer Institute for Physical Measurement Techniques IPM, Heidenhofstraße 8, D - 79110 Freiburg, Germany

We demonstrate the broadband conversion of a high-repetition rate frequency comb from the near-infrared (NIR) to the mid-infrared (MIR), visible (VIS) and ultraviolet (UV) spectral ranges. The employed lithium niobate microresonators are synchronously pumped by a frequency comb with a repetition rate in excess of 10 GHz and pico- to femtosecond pulse duration. Cascaded second-order nonlinear-optical processes transfer significant parts of the fundamental frequency comb to harmonic and sub-harmonic optical frequencies. This way, the second and the third harmonics in the visible and the fourth harmonic in the ultra-violet spectral region are generated. Also, subharmonic generation of the fundamental comb lines into the mid-infrared spectral range via degenerate parametric oscillation is demonstrated. Nondegenerate processes enable wavelength-tunable signal- and idler-comb generation. Furthermore, first steps towards generating frequency combs based purely on second-order nonlinearities will be discussed.

FM 9.5 Mon 15:00 1098

Adiabatic frequency conversion in high-Q lithium niobate whispering gallery resonators — •Yannick Minet[1], Luís Reis[1], Ingo Breunig[1,2], and Karsten Buse[1,2] — [1]Laboratory for Optical Systems, Department of Microsystems Engineering, IMTEK, University of Freiburg, Georges- Köhler-Allee 102, D-79110 Freiburg, Germany — [2]Fraunhofer Institute for Physical Measurement Techniques IPM, Heidenhofstraße 8, D-79110 Freiburg, Germany

Over the past two decades, optical frequency conversion techniques with whispering gallery resonators (WGRs) have evolved remarkably. The frequency conversion process is mostly based on the nonlinear response of material polarization caused by intense laser light. For example, in mm-sized WGRs made of non-centrosymmetric materials, tunable optical parametric oscillators have been realized. Another way for frequency conversion is the so-called adiabatic tuning. Here, the optical path length of the circumference of the resonator is changed during its ringdown time. This induces a frequency shift for the circulating light. An advantage of adiabatic tuning is, in contrast to nonlinear optical conversion methods, that this process has an efficiency of 100 %. So far, adiabatic tuning has been achieved by changing the refractive index by generating free electrons or via the AC-Kerr effect. Both schemes require an additional pump laser. We present a setup omitting a second pump laser and employing the Pockels effect for the refractive index change needed. Using this method, we can generate almost arbitrary frequency shifts of several tens of GHz. Furthermore, the use of this technique in the field of LIDAR will be discussed.

FM 9.6 Mon 15:15 1098

Polarisation Modulation in Lithium Niobate Waveguides at 0.8K — •Frederik Thiele[1], Jan Philipp Höpker[1], Patrick Bartkowiak[2], Felix vom Bruch[2], Viktor Quiring[2], Raimund Ricken[2], Christof Eigner[2], Christine Silberhorn[2], and Tim J. Bartley[1] — [1]Mesoskopische Quantenoptik, Department Physik, Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany — [2]Integrierte Quantenoptik, Department Physik, Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany

Lithium niobate is an important platform for integrated quantum photonics given its high second-order nonlinearity and electro-optic properties. In this material, high-speed electro-optic modulation and polarization conversion can be realised, typically at room temperature. However, superconducting detectors as well as some other quantum optic devices require cryogenic temperatures to operate. The aim of this work is to implement modulators at cryogenic temperatures to demonstrate that these techniques have compatible operating conditions. We report on the realisation of a cryogenic polarisation modulator at 0.8K, based on periodically poled, titanium in-diffused lithium niobate waveguides. High coupling efficiency from single mode fibres from room temperature to the device inside a closed cycle cryostat have been realised, as well as adapting quasi-phase matching to cryogenic temperatures.

FM 9.7 Mon 15:30 1098

Integration of electro-optical devices in $LiNbO_3$ for quantum-optic applications — •Felix vom Bruch, Silia Babel, Raimund Ricken, Victor Quiring, Harald Herrmann, and Christine Silberhorn — Universität Paderborn, Warburger Str. 100, 33098 Paderborn

The interest in practical quantum technologies has been steadily increasing over the last years. Many concepts are based on the utilisation of light and its quantum properties for encoding and transferring information. Comparable to integrated electronic devices, integrated electro-optical elements enable one to scale complex laboratory setups down to convenient and handy dimensions. Furthermore, this approach is suitable for an effective reduction of the expense for setups and experiments. From many numerous telecom applications it is well known that ferroelectric $LiNbO_3$ provides an excellent platform for devices, e.g. frequency converters or phase and polarization modulators. For this purpose, the non-linear electro-optic properties of this material can be used to tailor conversion processes and modulators. Functionalities and characteristics of the latter are mainly governed by the design of the deployed electrodes. However, scaling and integration of devices for quantum-optic applications remains challenging in terms of performance and robustness. To overcome this challenge, detailed studies of different concepts and architectures are required. Here the influence of silicon dioxide layers, used as buffer layers for modulator electrodes, is examined systematically in terms of e.g. excess loss, switching behaviour and long-term stability.