QI 24: Integrated Photonics II (joint session Q/QI)

Time: Wednesday 17:00–19:00 Location: A320

QI 24.1 Wed 17:00 A320

Integrated bright broadband PDC source for quantum metrology — •René Pollmann, Franz Roeder, Victor Quiring, Raimund Ricken, Christof Eigner, Benjamin Brecht, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098 Paderborn, Germany

Broadband quantum light is a vital resource for quantum metrology applications such as quantum spectroscopy, quantum optical coherence tomography or entangled two photon absorption. For entangled two photon absorption especially very high brightness combined with high spectro temporal entanglement is crucial to observe a signal. So far these conditions could be met by using high power lasers driving bulk degenerate type 0 spontaneous parametric down conversion (SPDC) sources. This naturally limits the available wavelength ranges and precludes deterministic control over the output state. In this work we show an integrated two colour SPDC source utilising a group-velocity matched lithium niobate waveguide, reaching both high brightness ($> 6.7 \cdot 10^{11}$ pairs/Ws) and large bandwidth (> 6 THz) while using less than 5 mW of continuous wave pump power. Since the product of the measured correlation time of the photons $\Delta\tau \approx 80$ fs and the pump bandwidth of $\Delta\omega_p \ll 1$ MHz violates the classical Fourier limit, the source shows very strong time frequency entanglement. Furthermore our process can be adapted to a wide range of central wavelengths.

QI 24.2 Wed 17:15 A320

Diced ridge waveguides in titanium indiffused lithium niobate — •Michelle Kirsch, Christian Kiessler, Christof Eigner, Harald Herrmann, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098 Paderborn, Germany

Lithium niobate (LN) is a widely used platform for integrated optical devices due to its optical properties, especially the high second order nonlinearity. Well-established titanium indiffused waveguides (Ti:LN) are limited in the ability of creating tightly confined fields due to the low index contrast. Another limitation in Ti:LN waveguide devices is the occurrence of intensity induced photorefractive damage inhibiting applications with high optical intensities in the waveguides. To counteract these challenges we use a ridge waveguide structure to achieve higher confinement in horizontal direction by precision diamond blade dicing in Ti:LN. We analysed the properties of the guided modes in dependence of the waveguide geometry for 1550 nm. Furthermore, we fabricated periodically poled ridge waveguides and characterized the second harmonic generation process by measuring the phase matching function at a pump wavelength of 1550 nm and the efficiency. Here we show an efficiency of 9.44 $\%\mathrm{W}^{-1}\mathrm{cm}^{-2}$. Moreover, we investigated the occurrence of photorefractive damage in the ridge waveguides by measuring the second harmonic power in dependence of the pump power. Here we show a high damage resistance up to a pump power of 500 mW.

QI 24.3 Wed 17:30 A320

Waveguide-Intergrated Superconducting Nanowire Avalanche Single-Photon Detectors — •Connor A. Graham-Scott[1,2,3], Matthias Häussler[1,2,3], Mikhail Yu. Mikhailov[4], and Carsten Schuck[1,2,3] — [1]University of Münster, Physics Institute, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany — [2]CeNTech - Center for NanoTechnology, Heisenbergstr. 11, 48149 Münster, Germany — [3]Center for Soft Nanoscience (SoN), Busso-Peus-Straße 10, 48149 Münster, Germany — [4]B. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine, 61103 Kharkiv, Ukraine

Superconducting nanowire single-photon detectors (SNSPDs) are of great interest for applications in quantum communication, quantum information and quantum computing. A drawback of SNSPDs, however, is the low signal-to-noise ratio of their electrical output signals, resulting from operating at bias currents below the critical current of the ultra-thin superconducting nanowires.

High signal-to-noise ratio can be achieved by implementing a superconducting nanowire avalanche single photon detector (SNAP) architecture that connects several SNSPD elements in parallel, thus realising operation at high bias current and successive switching of elements upon photon absorption and current redistribution.

Here we show the design, fabrication and measurements of a successive-avalanche architecture SNAP with amorphous molybdenum silicide nanowires integrated with nanophotonic waveguides for on-chip single-photon counting with ultra-high signal-to-noise ratios.

QI 24.4 Wed 17:45 A320

Lithium-niobate microcombs for dual-comb spectroscopy — •Stephan Amann[1], Bingxin Xu[1], Yang He[2], Theodor W. Hänsch[1,3], Qiang Lin[2], Kerry Vahala[4], and Nathalie Picque[1] — [1]Max Planck Institute of Quantum Optics, Garching, Germany — [2]Department of Electrical and Computer Engineering, University of Rochester, Rochester, New York 14627, USA — [3]Faculty of Physics, Ludwig-Maximilian University of Munich, Munich, Germany — [4]T.J. Watson Laboratory of Applied Physics, California Institute of Technology, Pasadena, California 91125, USA

On-chip optical microresonators with a high Q-factor can generate soliton microcombs, broad spectra consisting of narrow lines with equal linespacing corresponding to the free spectral range of the resonator. Thin-film lithium niobate is a promising platform due to its large transparency window, strong second- and third-order nonlinearity and electro-optic effect. Here by driving a high-Q thin-film lithium niobate resonator with a picosecond electro-optic comb at 1.5 micron, we report stable soliton generation at a repetition rate locked by the electro-optic comb. Its high peak power grants an oscillation threshold at lower average powers than those necessary with continuous-wave pumping. The microcombs with a line spacing of 100GHz are well suited for spectroscopy in the condensed matter, where the linewidths of absorption features are often of the order of several hundreds of GHz. Dual-comb spectroscopy will leverage the time-domain interference of two microcombs to measure broad spectra within short measurement times.

QI 24.5 Wed 18:00 A320

Design of a satellite-based single photon source for quantum communication — •Najme Ahmadi for the QUICK3-Collaboration — Institute of Applied Physics, Abbe Center of Photonics, Friedrich Schiller University Jena, 07745 Jena, Germany

Technologies of the so-called second quantum revolution have matured such they can now be used in space applications, e.g., long-distance quantum communication. Here we present the design of a compact true single photon source that can enhance the secure data rates in satellite-based quantum key distribution scenarios compared to conventional laser-based light sources. Our quantum light source is based on a fluorescent color center in hexagonal boron nitride. The emitter is off-resonantly excited by a diode laser and coupled to an integrated optics circuit that routes the photons to different experiments. These experiments either characterize the source directly by the second-order correlation function or test extended physical theories beyond the standard model. Our payload is currently being integrated into a 3U CubeSat and scheduled for launch in 2024 into the low Earth orbit. We can therefore evaluate the feasibility of true single photon sources in space and provide a promising route toward a high-speed quantum internet.

QI 24.6 Wed 18:15 A320

Influence of doping on the optical characteristics in lithium niobate — •Laura Bollmers, Laura Padberg, Christof Eigner, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098 Paderborn, Germany

Lithium niobate (LN) is a well-established material in integrated optics, and it is commonly used in nonlinear photonics. To make LN more versatile, material doping is crucial in improving the device's applicability. Depending on the doping material and concentration, different applications can be realised, e.g. Titanium doping can be used for waveguide fabrication, an essential part of integrated optics. Zinc doping can shift a bandgap to the UV region, enabling the material for UV/VIS application. Erbium doping enables applications for optical amplification, used for integrated laser sources, or quantum optical applications like memories.

Thus, doping LN can lead to a performance boost for optical applications. Especially in thin-film lithium niobate there are completely new application possibilities for doped substrate material. For optimi-

sation, the interplay of experimental analysis and theoretical material modelling is crucial. So, we investigate the absorption spectra influenced by different dopants at different temperatures and show our latest results.

QI 24.7 Wed 18:30 A320

Towards Reconfigurable Lithium-Niobate-on-Insulator integrated non-von Neumann processors — •Julian Rasmus Bankwitz[1,2], Seongmin Jo[2], Francesco Lenzini[1], and Wolfram Pernice[2] — [1]Institute of Physics, University of Münster, Germany — [2]Kirchhoff Institute for Physics, University of Heidelberg, Germany

In recent years Artificial neural networks (ANNs) showed great advantages in a variety of fields like autonomous driving or language recognition. Fast and efficient efficient matrix-vector-multiplications (MVMs) are the building blocks of ANNs, as they represent the mathematical description of the interconnects of the ANN's neurons. With the exponentially increasing amount of data the world is generating every year, classical von-Neumann structured computers are facing their limits in computation speed and energy consumption. Overcoming those boundaries is a crucial task for modern computing, giving rise to alternative platforms like photonic integrated circuits (PICs). Lithium-Niobate-on-Insulator (LNOI) is an emerging material platform due to its broad optical bandwidth, low propagation loss and high second-order nonlinearity, enabling small footprint electro-optically reconfigurable circuits like adjustable ring resonators for non-classical light sources and Mach-Zehnder-Interferometers (MZIs) for electrically tunable optical switches. Here we demonstrate novel approaches of optical ANN matrices utilizing MZIs from LNOI for ultra-fast MVMs. From high precision fabrication engineering and modular PIC design we show high MZI extinction rations above 24 dB combined with GHz range modulation speed.

QI 24.8 Wed 18:45 A320

Light manipulation via integrated focusing grating couplers for quantum computing applications — •Anastasiia Sorokina[1,2], Guochun Du[3], Pascal Gehrmann[1,2], Carl- Frederik Grimpe[3], Steffen Sauer[1,2], Elena Jordan[3], Tanja Mehlstäubler[3,4,5], and Stefanie Kroker[1,2,3] — [1]Institut für Halbleitertechnik, Technische Universität Braunschweig, Braunschweig, Germany — [2]Laboratory for Emerging Nanometrology, Braunschweig, Germany — [3]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [4]Institut für Quantenoptik, Leibniz Universität Hannover, Hannover, Germany — [5]Laboratorium für Nanound Quantenengineering, Leibniz Universität Hannover, Hannover, Germany

Downsizing optical components to control ion species in quantum computation is a vital turning point. Integrating routing and focusing elements into the chip architecture can substantially suppress environmental distortions and boost scalability. We investigated integrated waveguides and grating couplers to produce a linearly polarised Gaussian beam with a predefined emission angle, focus height and the size of the beam at this position. The studies were carried out using Lumerical FDTD simulation software and a subsequent post-processing routine. To address the different wavelengths required for the entire operation of the ion-based QCs, we have evaluated the capabilities and performance of our structures by taking advantage of the two most promising material platforms: Si3N4 and AlN. Our results can help overcome current limitations toward the multi-ion quantum system.