Q 38: Photonics II

Time: Wednesday 14:00–15:15 Location: Q-H15

Q 38.1 Wed 14:00 Q-H15

Cryogenic electro-optic modulation in titanium in-diffused lithium niobate waveguides — •Frederik Thiele[1], Felix vom Bruch[2], Julian Brockmeier[1], Maximilian Protte[1], Thomas Hummel[1], Raimund Ricken[2], Victor Quiring[2], Sebastian Lengeling[2], Harald Herrmann[2], Christof Eigner[2], Christine Silberhorn[2], and Tim J. Bartley[1] — [1]Mesoscopic Quantum Optics, Department of Physics, Paderborn University, Warburger Str. 100, 33098 Paderborn, Germany — [2]Integrated Quantum Optics, Department of Physics, Paderborn University, Warburger Str. 100, 33098 Paderborn, Germany

Lithium niobate is an important platform for integrated quantum photonics given its high second-order nonlinearity and electro-optic properties. The integration of superconducting single photon detectors offers new prospects for efficiency and scalability. In recent years frequency conversion, integrated SNSPDs and electro-optic modulation has been shown in lithium niobate at cryogenic temperatures. To combine single photon detection together with modulators, the electrooptic modulation in lithium niobate must be characterized. We show the characterization of electro-optic modulators in titanium in diffused lithium niobate waveguides at cryogenic temperatures. To do so, we realized a phase modulator, directional coupler and polarization converter below 8.5K. The decrease of the operation temperature shows an increase of the required operation voltage for all three modulators. Additionally, we give an outlook on the optimization for the cryogenic operation.

Q 38.2 Wed 14:15 Q-H15

Inverse Design of Nanophotonic Devices based on Reinforcement Learning — •Marco Butz[1], Alexander Leifhelm[1], Marlon Becker[2], Benjamin Risse[2], and Carsten Schuck[1] — [1]Institute of Physics, University of Münster, Germany — [2]Institute of Computer Science, University of Münster, Germany

Photonic integrated circuits are being employed for increasingly complex quantum optics experiments on compact and interferometrically stable chips. The integration of an ever-increasing number of circuit components poses challenging requirements on the footprint and performance of individual nanophotonic devices thus raising the need for sophisticated design algorithms. While various approaches, for instance based on direct search algorithms or analytically calculated gradients, have been demonstrated, they all suffer from drawbacks such as reliance on convex optimization methods in non-convex solution spaces or exponential runtime scaling for a linear increase in user-specified degrees of freedoms. Here we show how reinforcement learning can be applied to the nanophotonic pixel-discrete inverse design problem. Our method is capable of producing highly efficient devices with small footprints and arbitrary functionality. A distributed software architecture allows us to make efficient use of state-of-the-art high performance parallel computing resources. Multiple interfaces to the dataflow of the algorithm enable us to bias the resulting structures for realizing arbitrary design constraints. To demonstrate the broad applicability of our method, we show a wide range of devices optimized in 3D for different material platforms.

Q 38.3 Wed 14:30 Q-H15

Optimization of photonic multilayer structures to increase upconversion efficiency — •Fabian Spallek[1,2], Thomas Wellens[1,3], Stefan Buhmann[2], and Andreas Buchleitner[1] — [1]Institute of Physics, Albert-Ludwigs-University Freiburg, Germany — [2]Institute of Physics, University of Kassel, Germany — [3]Fraunhofer IAF, Freiburg, Germany

The efficiency of solar silicon solar cells can be substantially improved by widening the spectral operating window by means of upconversion materials [1]. These convert two low-energy photons into one photon with higher energy. Embedding the upconverter material in photonic dielectric nanostructures allows to influence the interplay of absorption and emission rates, energy transfer processes, local irradiance and local density of (photonic) states which in turn determines the overall efficiency.

We utilize methods from macroscopic quantum electrodynamics to calculate the influence of multilayer nanostructures on spontaneous emission and absorption rates in the upconverter. This allows us to propose specific designs optimized for upconversion efficiency [2]. Considering robustness, we take into account manufacturing errors and compare our indicators for the achievable upconversion luminescence and quantum yield of our optimized design to existing experimentally implemented [1] Bragg structures.

[1] C.L.M.Hofmann et al., Nat. Commun. 12, 14895 (2021)
[2] F.Spallek et al., J.Phys.B: At. Mol. Opt. Phys. 50, 214005 (2017)

Q 38.4 Wed 14:45 Q-H15

Probing intracavity fields of high Q-microresonators with free electrons — Jan-Wilke Henke[1,2], Arslan Sajid Raja[3], Armin Feist[1,2], Guanhao Huang[3], Germaine Arend[1,2], Yujia Yang[3], •F. Jasmin Kappert[1,2], Rui Ning Wang[3], Hugo Lourenco-Martins[1,2], Jiahe Pan[3], Junqiu Liu[3], Ofer Kfir[1,2,4], Tobias J. Kippenberg[3], and Claus Ropers[1,2] — [1]Georg-August-Universität, Göttingen, Germany — [2]Max Planck Institute of Multidisciplinary Sciences, Göttingen, Germany — [3]Swiss Federal Institute of Technology Lausanne (EPFL), Lausanne, Switzerland — [4]School of Electrical Engineering, Tel-Aviv University, Tel-Aviv, Israel

Ultrafast electron microscopes are a powerful platform for investigating confined optical modes in photon-induced near-field electron microscopy (PINEM). Mapping nanophotonic devices promises a unique access to evanescent optical fields and nonlinear phenomena.

In this work, we use free electrons to characterize the intracavity field of a high-Q Si_3N_4 microresonators, both spatially and spectrally [1]. Moreover, when altering the intracavity state, changes in the electron energy spectra signal the onset of four-wave mixing and the population of multiple optical modes in the resonator.

Future studies will explore the impact of multimode intracavity fields on the electron-light scattering, and might ultimately enable a nanoscale characterization of non-linear states like dissipative Kerr solitons by means of electron microscopy.

[1] J.-W. Henke, A. S. Raja et al., Nature, 600, 653-658, (2021)

Q 38.5 Wed 15:00 Q-H15

Correlative fluorescence and Soft X-ray-microscopy in the water window region in an integrated laboratory-based setup — •Sophia Kaleta[1], Julius Reinhard[1,2], Felix Wiesner[1], Johann Jakob Abel[1], Martin Wünsche[1,2], Jan Nathanael[1,2], Katharina Reglinski[3], Christian Franke[3], Alexander Iliou[4], Falk Hillmann[4], Christian Eggeling[3,5], Silvio Fuchs[1,2], and Gerhard Paulus[1,2] — [1]IOQ, FSU Jena, Germany — [2]Helmholtz Institute Jena, Germany — [3]IAOB, FSU Jena, Germany — [4]Leibniz-HKI, Jena, Germany — [5]Leibniz-IPHT, Jena, Germany

We present a correlative fluorescence and SXR-microscope that combines both methods in an integrated setup, which allows subsequent imaging without removing the sample. While a fluorescence microscope offers functional contrast it is not sufficient for a holistic structural characterization of the sample. This gap can be closed by the correlation with other microscopy methods, for example SXR microscopy in the water window region (2.3 to 4.4nm), which allows a high natural structural contrast in biological samples. The correlation of fluorescence and SXR microscopy has already been realized at synchrotron beam sources, but not in an integrated laboratory setup as presented here. We use a laser-produced gas plasma source, based on a gas-puff target which has also been used for other X-ray and XUV imaging methods [1]. We are able to reach 100nm half pitch resolution which has been measured using a Siemens star. Additionally, we demonstrate correlative imaging of fluorescent nanobeads and cyanobacteria.

[1] Skruszewicz, S., et al. Applied Physics B 127.4 (2021)