# Q 55: Nano-Optics (Single Quantum Emitters) III

Time: Thursday 14:00–15:45 Location: S SR 112 Maschb.

**Invited Talk** Q 55.1 Thu 14:00 S SR 112 Maschb.

**Color centers in diamond as novel atomic-scale sensors** — •Elke Neu — Saarland University, Faculty for Natural Sciences and Technology, Physics, 66123 Saarbrücken

Individual, luminescent defects in diamond (color centers) are stable, atomic-scale quantum systems. Nitrogen vacancy (NV) centers also represent single electronic spins which we coherently manipulate using microwave radiation while we read-out the spin state using confocal laser fluorescence microscopy. Due to their atomic size, individual NVs form nanoscopic quantum sensors e.g. for magnetic fields and optical near fields. To enable nanoscale sensing, we incorporate the centers into tip-like photonic nanostructures. These enable scanning NV centers close (< 50 nm) to a sample to record nanoscale resolution images. Simultaneously, with these structures we retrieve bright fluorescence from the centers enhancing sensitivity. The talk will summarize our work on manufacturing and optimizing such structures. We maximize fluorescence rates via numerical simulations and pave the way towards up-scaling of sensor fabrication using novel diamond materials, while treating the diamond surface aids in stabilizing the color center charge state. Finally, we present novel sensing experiments using color centers e.g. via their interaction with 2D materials.

Q 55.2 Thu 14:30 S SR 112 Maschb.

**Towards on-chip Quantum Optics experiments with color centers in nanodiamonds** — •Konstantin Fehler[1,2], Lukas Antoniuk[2], Niklas Lettner[2], Anna P. Ovvyan[3], Wolfram H.P. Pernice[3], and Alexander Kubanek[1,2] — [1]Center for Integrated Quantum Science and Technology (IQst), Ulm University, Albert-Einstein-Allee 11, D-89081 Ulm, Germany — [2]Institute for Quantum Optics, Ulm University, D-89081 Ulm — [3]Institute of Physics and Center for Nanotechnology, University of Münster, 48149 Münster, Germany

Color centers in diamond, such as the Nitrogen Vacancy ($NV^-$) and the Silicon Vacancy ($SiV^-$) Center, gained attraction through their outstanding optical and spin coherence times properties. Even on the nanoscale the diamond lattice can host these defects. Nano manipulation techniques enable deterministic positioning and reorientation of these nanodiamonds [1]. In fusion with classical integrated photonics they offer a promising platform for the realization of quantum repeaters, quantum networks and quantum simulators. We present our progress which paves the way towards on-chip quantum optics experiments.

[1] Rogers, Lachlan J., et al. "Single SiV $^-$ centers in low-strain nanodiamonds with bulk-like spectral properties and nano-manipulation capabilities." arXiv preprint arXiv:1802.03588[v4] (2018).

Q 55.3 Thu 14:45 S SR 112 Maschb.

**A Planar Optical Antenna for Color Centers in Diamond** — •Philipp Fuchs, Thomas Jung, and Christoph Becher — Universität des Saarlandes, Fakultät NT - Fachrichtung Physik, Campus E2.6, 66123 Saarbrücken

Color centers in diamond, e.g. the nitrogen (NV), silicon (SiV) or very recently the tin (SnV) vacancy center, have become very promising candidates for the implementation of stationary qubits or bright single photon sources. One of the most challenging problems when working with these defects is the low rate of collectible photoluminescence (PL) out of unstructured diamond films. Because of total internal reflection at the diamond-air-interface, this problem cannot be solved simply by using high NA objectives and the collectible PL rate is limited to a few percent of the total PL rate. Here, we present our latest progress on fabricating a planar antenna design [1] to increase the collectible PL rate by an order of magnitude compared to unstructured diamond films. The antenna design is based on a thin diamond membrane (< 200 nm), fabricated in commercially available, high purity diamond material via reactive ion etching. Combining this thin membrane with metallic layers enables the creation of tailored radiation patterns, leading to a high directivity and thereby a high collectible PL rate with only small variations for emitters at different positions or depths in the diamond film.

[1] H. Galal, M. Agio, Opt. Mater. Express 7, 1634-1646 (2017)

Q 55.4 Thu 15:00 S SR 112 Maschb.

**Influence of dielectric interfaces on the angular emission characteristics of nv centers in nanodiamond** — •Justus Christinck, Beatrice Rodiek, Marco López, Helmuth Hofer, Hristina Georgieva, and Stefan Kück — Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany

The development of reliable and stable single photon sources attracts more and more attention. PTB already absolutely characterized a single photon emitting NV-center in a nanodiamond using a confocal microscope setup [Rodiek, 2018]. The next step is to get a better understanding of the angular emission of a NV-center, which is localized at a dielectric interface. The dielectric interface, namely a microscope cover glass, is within the near field of the emitting dipoles, which results in refraction of evanescent waves into the cover glass and a highly directional emission of photons. We present the development of a model of the angular distribution of the emitted light. First, the orientation of the transition dipole moments of NV-centers was investigated and second, using a model of the light emission by dipoles [Lukosz, 1979], the radiation patterns of an arbitrary oriented NV-center were calculated. A theoretical back focal plane image and the collection efficiency of the setup were computed. Furthermore, we present the investigation of a sample of spin-coated nanodiamonds. The NV-centers were characterized spectroscopically and by measurement of the 2nd order correlation function in a Hanbury-Brown and Twiss interferometer. Pictures of the back focal plane of the NV-center emission were taken and were compared to the theoretical back focal plane image.

Q 55.5 Thu 15:15 S SR 112 Maschb.

**On-Chip Integration of a Single Diamond Quantum Emitter with a SiO2 Photonic Platform** — •Florian Böhm[1,2], Niko Nikolay[1,2], Christoph Pyrlik[3], Jan Schlegel[3], Andreas Thies[3], Andreas Wicht[3], and Oliver Benson[1,2] — [1]Institut für Physik, Humboldt-Universität zu Berlin, Germany — [2]IRIS Adlershof, Humboldt-Universität zu Berlin, Germany — [3]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Berlin, Germany

To realize nanophotonic devices the scalable on-chip integration of single photon emitters with single optical modes is required.

Here we present the deterministic integration of a single solid-state qubit, the nitrogen-vacancy (NV) center, with a photonic platform consisting exclusively of SiO2 grown thermally on a Si substrate. The platform stands out by its ultra-low fluorescence and the ability to produce various passive structures such as high-Q microresonators and mode-size converters.

By numerical analysis an optimal structure for the efficient coupling of a dipole emitter to the guided mode could be determined. Experimentally, the integration of a preselected NV emitter was performed with an atomic force microscope and the on-chip excitation of the quantum emitter as well as the coupling of single photons to the guided mode of the integrated structure could be demonstrated.

Our approach shows the potential of this platform as a robust nanoscale interface of on-chip photonic structures with solid-state qubits.

Q 55.6 Thu 15:30 S SR 112 Maschb.

**Robust optical polarization of nuclear spin baths using Hamiltonian engineering of nitrogen-vacancy center quantum dynamics** — •Benedikt Tratzmiller[1], Ilai Schwartz[1,2], Jochen Scheuer[3], Samuel Müller[3], Qiong Chen[1], Ish Dhand[1], Zhen-Yu Wang[1], Christoph Müller[2], Boris Naydenov[3], Fedor Jelezko[3], and Martin Plenio[1] — [1]Institut für Theoretische Physik und IQST, Albert-Einstein-Allee 11, Universität Ulm, 89081 Ulm, Germany. — [2]NVision Imaging Technologies GmbH, Albert-Einstein-Allee 11, 89081 Ulm, Germany. — [3]Institut für Quantenoptik und IQST, Universität Ulm, 89081 Ulm, Germany.

Dynamic nuclear polarization (DNP) is an important technique that uses polarization transfer from electron to nuclear spins to achieve nuclear hyperpolarization, which drastically improves the signal-to-noise ratio in various NMR applications. We present a new protocol for DNP introduced in [1], which uses short microwave pulses to achieve fast and robust polarization transfer. We theoretically derive sequences and experimentally demonstrate that they are capable of efficient polarization transfer from optically polarized NV centers in diamond to the surrounding 13C nuclear spin bath even in the presence of control

errors.

[1] Schwartz, Ilai, et al. "Robust optical polarization of nuclear spin baths using Hamiltonian engineering of nitrogen-vacancy center quantum dynamics." Science advances 4.8 (2018): eaat8978.