Q 38: Nano-Optics (Single Quantum Emitters) II

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

Q 38.1 Wed 14:00 S SR 112 Maschb.

Towards a metrological characterization of semiconductor quantum dots for quantum radiometry in the near infrared — •Hristina Georgieva[1], Marco López[1], Beatrice Rodiek[1], Helmuth Hofer[1], Justus Christinck[1], Peter Schnauber[2], Tobias Heindel[2], Sven Rodt[2], Stephan Reitzenstein[2], and Stefan Kück[1] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Institut für Festkörperphysik, Technische Universität Berlin, Berlin, Germany

The range of possible implementations of single-photon sources in quantum information processing is rapidly growing. In order to achieve high accuracy and metrological traceability, we need reliable methods for their absolute characterization. Furthermore, single-photon emitters could be implemented as a standard source for the detection efficiency calibration of single-photon detectors. The precise measurement of small photon fluxes requires sources with high efficiency, narrow bandwidth and high single-photon purity. A promising candidate, which meets all these criteria, is an InGaAs quantum dot embedded in a deterministic photonic structure. We present measurements of the photon flux, the emission characteristics and the second-order correlation function of the InGaAs/GaAs single-photon source. The spectral filtering of the emission is realized by two bandpass filters, each having a full width at half maximum of 0.5 nm and a transmission of about 90 %. In contrast to the standard filtering method with a monochromator, our method reduces the photon losses, thus resulting in high count rates combined with high single-photon purity.

Q 38.2 Wed 14:15 S SR 112 Maschb.

Optimal Control for DNP with Quantum Defects — •Alastair Marshall[1,2] and Fedor Jelezko[1] — [1]University Ulm, Ulm, Germany — [2]NVision Imaging Technologies

The application of dynamic nuclear polarisation (DNP) techniques to systems with quantum defects is a promising way of achieving high levels of polarisation. The nitrogen vacancy centre (NV) in diamond is an excellent candidate as it can be optically polarised to a high degree at room temperature before its state is manipulated with a microwave pulse. While polarisation sequences have been designed to be robust, this is often at the expense of their efficiency. To achieve maximal polarisation transfer in as short a time as possible other techniques must be applied. We chose to apply quantum optimal control algorithms to shape the microwave pulses. A set of constraints that closely mimic our experimental setup were chosen to ensure that the shaped pulses remain realistic. Here, we hope to demonstrate pulses that have an increased robustness to errors while maintaining a high level of efficiency. In future, we hope to use these to achieve high levels of polarisation in diamond.

Reference: https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.111.067601

Q 38.3 Wed 14:30 S SR 112 Maschb.

Towards reliable, scalable scaning probe sensing using color centers in diamond — •Richard Nelz, Marie Niederländer, Lara Render, Oliver Opaluch, Michel Challier, Mariusz Radtke, Abdallah Slablab, and Elke Neu — Universität des Saarlandes, Fakultät NT - Fachrichtung Physik, Campus E2.6, 66123 Saarbrücken

The negatively charged nitrogen vacancy (NV) color center in diamond is a bright, photo-stable dipole emitter [1]. Due to its optically addressable spin states it is used for e.g. electrical and magnetic field sensing applications. In recent years, shallowly implanted NV centers in nanopillars have been introduced as scanning probes for high resolution imaging [2]. We aim to apply these probes to life science applications. However, these applications currently suffer from an insufficient control of the surface termination of the devices leading to a potentially unstable charge state of the color center as well as a poor fabrication yield. We here show routes to overcome these issues. We discuss charge state stabilization of shallow NV centers via different surface treatments, show upscaling capabilities of the nanofabrication by using novel diamond material [3] and we introduce sensing applications relevant for life sciences.

[1] Bernardi et al., Crystals **7** 124 (2017).
[2] Appel et al., Rev. Sci. Instrum. **87** 063703 (2016).
[3] Nelz et al., arXiv:1810.09350 (2018).

Q 38.4 Wed 14:45 S SR 112 Maschb.

Towards ultrafast photodynamic in quantum emitters — •Assegid M. Flatae, Haritha Kambalathmana, Stefano Lagomarsino, Florian Sledz, Lukas Hunold, and Mario Agio — Laboratory of Nano-Optics and Cμ, University of Siegen, 57072 Siegen, Germany

Controlling photophysical processes of single emitters, for example, by strong modification of the radiative decay rate, may lead to unexplored capabilities in the generation of quantum states of light.

We develop techniques for the fabrication and optical characterization of photostable quantum emitters based on the silicon-vacancy (SiV) color center in diamond [1] and semiconductor quantum dots (QDs). The SiV color center is a promising single-photon source as most of the fluorescence signal is concentrated in a narrow zero-phonon line, whereas colloidal QDs provide a rich playground to explore the photophysics.

We use plasmonic nanocones [2] as optical antennas to enhance the radiative decay rate by orders of magnitudes. We explore the controlled coupling between a single quantum emitter with a single nanocone and achieved a reproducible enhancement of the radiative decay rate by two orders of magnitude. Our goal is to reach enhancements of more than three orders of magnitude, which would lead to ultrafast photodynamic and emission of nearly lifetime limited single photons at room temperature.

References: [1] S. Lagomarsino, et al. Diam. Relat. Mater. 84, 196 (2018). [2] A. M. Flatae, et al. Adv. Optical Mater. 5, 1700586 (2017).

Q 38.5 Wed 15:00 S SR 112 Maschb.

Photonic crystal cavities for efficient coupling to individual Erbium ions — •Lorenz Weiss, Andreas Gritsch, and Andreas Reiserer — Max Planck Institute of Quantum Optics, Garching, Germany

Erbium ions trapped in suited host crystals are promising candidates for large-scale quantum networks since they can combine second-long ground state spin coherence times with coherent optical transitions at telecommunication wavelengths. Unfortunately, the extremely long lifetime of the excited state (14 ms) makes it difficult to spectrally resolve and control individual ions in order to harness them for quantum networks. To overcome this challenge, we design and fabricate Photonic Crystal Cavities (PCC) on one-dimensional silicon waveguides that can then be transferred to a suited substrate material[1]. At cryogenic temperature, we thus expect to shorten the radiative lifetime of the optical transitions by more than three orders of magnitude via the Purcell effect. This will enable deterministic interactions between individual spins and single telecom photons, opening unique prospects for the realization of entanglement between spins over distances exceeding 100 km. We will present simulations and the current status of the experiment towards single-ion spectroscopy and control.

References

[1] Dibos et al., Phys. Rev. Lett. **120**, 243601 (2018)

Q 38.6 Wed 15:15 S SR 112 Maschb.

Integration of quantum emitters with SiN photonic circuits — •Philip Schrinner and Carsten Schuck — Physikalisches Institut and Center for Nanotechnology, WWU Münster, Germany

The integration of nano-scale quantum emitters with silicon nitride (SiN) waveguides is a promising approach to realize a scalable platform for quantum photonic circuits. Recent progress in embedding quantum emitters into nanophotonic devices rely on optical excitation of individual emitters with a laser via free space objectives, which lacks of scalability and has a reduced signal-to-noise ratio when characterizing waveguide-integrated emitters. Here we investigate optical excitation of emitters via nanophotonic waveguides for quantum emitters coupled to a collector waveguide. We employ scalable deposition and fabrication techniques to locate nitrogen vacancy (NV)-centers in nanodiamonds in the vicinity of feed- and collector-waveguides, which allow for optical excitation and fluorescence collection, respectively. One of our key objectives is the minimization of pump light for the efficient optical excitation of emitters to reduce auto-fluorescence from the SiN-waveguide material, which obscures the emission from NV-centers at room temperature. Based on our results with waveguide-coupled emitters we anticipate nanophotonic devices that allow for addressing large numbers of quantum emitters via a common bus waveguide while allowing for fluorescence collection into individual waveguides that serve as the input for a nanophotonic network.

Q 38.7 Wed 15:30 S SR 112 Maschb.

Accurate placement method to position single nano particles on opaque conductive structures — •Niko Nikolay[1], Nikola Sadzak[1], Alexander Dohms[1], Boaz Lubotzky[2], Hamza Abudayyeh[2], Ronen Rapaport[2], and Oliver Benson[1] — [1]AG Nanooptik & IRIS Adlershof, Humboldt Universität zu Berlin, Newtonstraße 15, D-12489 Berlin, Germany — [2]The Racah Institute of Physics, The Hebrew University of Jerusalem, Jerusalem 9190401, Israel

Photonic structures coupled to single quantum emitters are key elements for integrated quantum technologies. Up to now, a reliable method to couple theses elements is the main challenge of their fabrication. We present a method where long-range electrostatic forces between an atomic force microscope (AFM) tip carrying a nano particle hosting a single photon emitter (SPE), and the target surface are induced. This allows for positioning of SPEs on non-transparent conductive samples with sub-micrometer precision in non contact mode. The placement site can be identified with sub micrometer precision without any tip approach, eliminating the risk of a particle loss. We demonstrate the strength of the method by transferring a nanometer sized diamond containing a single nitrogen-vacancy defect to the center of a micrometer-sized silver bullseye antenna with nanometer resolution. Our approach provides a simple and reliable assembling technology for positioning single nano objects on opaque substrates with high reproducibility and precision.