SYDD 1: Defect centers in diamond for applications in quantum optics and nanophotonics I

Zeit: Freitag 10:30–12:30 Raum: Audi-B

Hauptvortrag SYDD 1.1 Fr 10:30 Audi-B

Manipulation and nanopositioning of single NV centers — •Ronald Hanson — Kavli Institute of Nanoscience, Delft University of Technology

Nitrogen-Vacancy (NV) defect centers in diamond are a promising system for spin-based applications in quantum information and communication. Here we present our recent results towards understanding and manipulating single NV spins, as well as controlling the position of individual NV centers with high precision. Although the NV center is studied intensively, there remain significant challenges in understanding its excited-state structure. We use single-spin resonant spectroscopy to observe the excited-state spin levels over a broad range of magnetic fields, yielding a direct measurement of the zero-field splitting, g-factor, transverse anisotropy splitting and hyperfine coupling in the orbital excited state [1]. Second, we study and manipulate the NV spin coherence time. By tuning the NV spin*s environment we find strikingly different behavior [2], leading to important insights into decoherence. Measurements as a function of temperature show that polarization of the spins in the environment fully eliminates their decohering effect [3]. Finally, we will present our first results towards controllably selecting, picking up, moving and positioning single NV centers with ∼10 nm precision.

[1] G. D. Fuchs et al., Phys. Rev. Lett. **101**, 117601 (2008)
[2] R. Hanson et al., Science **320**, 352 (2008)
[3] S. Takahashi et al., Phys. Rev. Lett. **101**, 047601 (2008)

Hauptvortrag SYDD 1.2 Fr 11:00 Audi-B

Fabrication strategies for diamond based quantum devices — •Steven Prawer — University of Melbourne, School of Physics, Parkville, Victoria, 3010, Australia

We aim to unlock the enormous potential of the weird quantum world for a new generation of information processing devices which address important and unsolved problems in secure communications, high performance computing, data storage, simulation and imaging. Surprisingly, single crystal diamond, long known for its allure as a gemstone, displays unique quantum properties and these make it ideal for the fabrication of critical components which will be the building blocks of this new quantum technology. Indeed diamond is an ideal material for use in the fabrication of (i) single photon sources for quantum communications, (ii) photonic platforms for the investigation of quantum entanglement in solid state systems (iii) optical regenerators and non-linear quantum gates and (iv) room temperature photonic based magnetometers.

But the same properties that make diamond so attractive for these applications also make it very hard to fabricate into devices. In this talk, I will describe the methods we have developed for fabricating diamond nanocrystals with desired properties and sculpting mirrors, waveguides and cavities directly into single crystal diamond by using a combination of implantation, focused ion beam milling and electrochemical etching.

The first devices based on these technologies are entering the market for applications in ultrasecure communications. But the future holds even more exciting prospects for diamond devices in quantum computing and nanoscale imaging of biological processes in real time.

Hauptvortrag SYDD 1.3 Fr 11:30 Audi-B

Controlling nonclassical emission of light in diamond — •H. Weinfurter[1], J. Bahe[1], C.L. Wang[1], X.Q. Zhou[2], T. Kippenberg[2], A. Stiebeiner[3], A. Rauschenbeutel[3], and J. Meijer[4] — [1]L.-M. Universität München, Sektion Physik, Schellingstr. 4/III, D-80799 München — [2]Max-Planck-Institut f. Quantenoptik, Hans-Kopfermann.Str. 1, D-85748 Garching — [3]Universität Mainz, Staudingerweg 7, D-55128 Mainz — [4]Ruhr-Universität Bochum, Universitätsstr. 150, D-44801 Bochum

The development of reliable devices to generate single photons is crucial for applications in quantum cryptography, as well as for fundamental quantum optics experiments. But the quality and yield of colour center based sources is intrinsically limited by broad bandwidth, shelving states, or the high index of refraction of diamond. Here we report on several attempts to improve the performance, like doping of diamond to control the charge state of single SiV centers, usage of solid immersion lenses, and coupling defects in nano crystals to the evanescent field of microdisk cavities or of tapered fibers.

SYDD 1.4 Fr 12:00 Audi-B

Towards optical interfaces for color centers in diamond — Roland Albrecht, Janine Riedrich-Moeller, Elke Neu, David Steinmetz, Christian Hepp, and •Christoph Becher — Fachrichtung 7.3 (Technische Physik), Universität des Saarlandes, Campus E 2.6, 66123 Saarbrücken

In recent years color centers in diamond have attracted significant interest for applications in quantum information. For many of these applications, e.g. quantum networks, it is essential to couple single color centers to a cavity mode with high quality-factor Q and small modal volume in order to coherently manipulate, readout and transfer the center's quantum state. We follow two different routes towards realization of such optical interfaces: coupling to microcavities based on fiber mirrors or microcavities defined within diamond-based photonic crystals (PhC). The fiber based Fabry-Perot cavities consist of a flat mirror onto which diamond nanocrystals are deposited by spin coating and a fiber mirror where a concave impression has been produced on the fiber facet by laser machining. We demonstrate cavities with lengths of a few microns and finesse of about 300, sufficient for observing modified spontaneous emission. In addition, we present optimized designs based on Fourier- and real space analysis of PhC defect cavity structures. By careful variation of the field envelope, vertically radiated power can be suppressed and the Q-factor can be improved significantly up to $Q \approx 320000$ at a modal volume of $V = 0.35(\lambda/n)^3$. We discuss routes for fabrication of diamond-based PhC cavities.

SYDD 1.5 Fr 12:15 Audi-B

Imaging magnetometry using single spins in diamond — •Gopalakrishnan Balasubramanian, Julia Tisler, Roman Kolesov, Fedor Jelezko, and Joerg Wrachtrup — 3. Physikalisches Institute, Universitaet Stuttgart, Germany

Single Nitrogen-Vacancy color centers in diamond are gaining popularity because of its exceptional optical and spin properties. The single spin of the defect can be manipulated optically, providing a efficient way to entangle single electron spins and couple nuclear spins qubits in diamond. Long spin coherence time of these single defects finds application as sensitive magnetic field probes. Using engineered diamond we can achieve ultrahigh sensitivity using which we will be able to detect a single external electron or nuclear spin.[1] Controlled creation of these color centers inside nanodiamonds offers diverse applications. By attaching these single spins to the tip of a scanning probe, we were able to perform sensitive scanning probe magnetometry at nanoscale.[2] Improving this device by using quantum grade diamond and synchronized NMR pulse sequences we would have the ability to perform nanoscale NMR/MRI of single molecules.

[1] Maze, J. R. et al. Nanoscale magnetic sensing with an individual electronic spin in diamond. Nature 455, 644-647(2008).

[2] Balasubramanian, G. et al. Nanoscale imaging magnetometry with diamond spins under ambient conditions. Nature 455, 648-651(2008).