KFM 10: Diamond and Related Dielectric Materials I

Chair: Theo Scherer (KIT Karlsruhe)

Time: Tuesday 9:30–12:00 Location: E 124

Invited Talk KFM 10.1 Tue 9:30 E 124

Exploring of the accumulation and thermal annealing of radiation defects in metal oxides via optical absorption, EPR and luminescence methods — •Aleksandr Lushchik — Institute of Physics, University of Tartu, W.Ostwald str. 1, 50411, Tartu, Estonia

High tolerance to intense radiation encourages the use of metal oxides in fission-reactor technologies and allows considering them as promising window materials for the projected fusion facilities. The functionality of optical materials is determined by the creation and accumulation of interstitial-vacancy Frenkel pairs, which are predominantly created via the elastic collisions of fast neutrons/ions with material nuclei.

The radiation damage caused by fast neutrons or ~GeV heavy ions was studied in Al2O3, MgO, MgAl2O4 crystals via optical and EPR methods. The correlations between the EPR and optical characteristics (emission/absorption bands) allowed the tracking of the creation and thermal annealing of F-type defects (an oxygen vacancy with one/two trapped electrons) in MgO, corundum and mineral spinel. The measured annealing kinetics of the F and F+ centers were modelled in terms of diffusion-controlled reactions. A number of novel EPR-active radiation defects was revealed in spinel (set of hole-type V centers) and corundum (a single oxygen interstitial; a double charged F2 dimer). The ability and limitations of the use of cathodoluminescence as a control tool of radiation damage recovery in corundum was considered.

KFM 10.2 Tue 10:00 E 124

Glovebox with a controlled atmosphere for nano-scale nuclear magnetic resonance spectroscopy — •Kseniia Volkova[1], Abhijeet Kumar[2], Karolina Schüle[3], Jens Fuhrmann[3], Kirill Bolotin[2], and Boris Naydenov[1] — [1]Department Spins in Energy Conversion and Quantum Information Science (ASPIN), Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany — [2]Department of Physics, Freie Universität Berlin, Berlin, Germany — [3]Institut für Quantenoptik, Universität Ulm, Ulm, Germany

The unique properties of nitrogen-vacancy (NV) centers in diamond allow to use them as efficient quantum sensors even at room temperature. An example application is NMR spectroscopy on nuclear spin ensembles transferred on the diamond surface using single NV centers few nanometers below the surface. The measurement sensitivity is fundamentally dependent on the spin's lifetime, which is mainly limited by NV centers' environment. In addition, diamond surface properties influence stability of shallow NV centers. We investigate few layered phosphorene flakes deposited on diamond for their possible application as a quantum simulator, but this material degrades under ambient conditions. We present a confocal microscope with a glovebox enclosure for performing NV-based NMR spectroscopy on multi-layered phosphorene.

KFM 10.3 Tue 10:20 E 124

Ambiguous Resonances in Quantum Sensing of Single Nuclear Spins — •Lucas Tsunaki, Kseniia Volkova, Anmol Singh, and Boris Naydenov — Department Spins in Energy Conversion and Quantum Information Science (ASPIN), Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Hahn-Meitner-Platz 1, 14109 Berlin, Germany

Quantum sensing is driving technology to ever increasing levels of precision and accuracy of measurements, all based on the fact that quantum states are extremely sensitive to their environment. However, this core element is also a major source of vulnerability, as quantum sensors are subject to complex interactions leading to responses that can be confused with the actual signal to be measured. In this talk, we discuss multipulse decoupling sequences in the context of NV centers in diamond, which are used to measure single nuclear spins at room temperature. Different factors that give rise to these ambiguous resonances are considered, where we compare experimental data and simulations. We also provide a graphical user interface database tool to distinguish these ambiguous resonances from actual single nuclear spins, where over 100,000 simulations can be compared with the user's experiments.

20 min. break

KFM 10.4 Tue 11:00 E 124

Fabrication steps for realization of quantum tokens — •Miriam Mendoza Delgado[1], Jan Thieme[2], Johann Peter Reithmaier[1], Kilian Singer[2], and Cyril Popov[1] — [1]Institute of Nanostructure Technologies and Analytics (INA), University of Kassel, Germany — [2]Institute of Physics, University of Kassel, Germany

Nitrogen-vacancy (NV) color centers in diamond have acquired great relevance in quantum technology, since they represent an "atom-like" solid state system with optically accessible spin properties. NVs can be implemented as single photon sources with high optical stability and quantum yield, even at room temperature. Furthermore, the coherent electron spin of NV can be used as a long lived qubit which can be applied in quantum information technology, e.g. in quantum repeaters or tokens. In order to enhance the photon collection efficiency from NVs, they should be incorporated in photonic structures, like nanopillars. The aim of the current work is the fabrication of diamond nanopillars incorporated with NVs and integrated with microwave antennas and electrodes for the realization of quantum tokens. Arrays of monocrystalline diamond nanopillars with diameters between 150 nm and 250 nm, 1 μm height and center-to-center distance of 10 μm were defined by electron beam lithography and structured subsequent by inductively coupled plasma reactive ion etching with oxygen. Different techniques are studied for the creation of NVs, which affect both their density and properties.

KFM 10.5 Tue 11:20 E 124

Optical and dielectric properties of artificial diamond — •Theo Andreas Scherer — Karlsruhe Institute of Technology (KIT-IAM-AWP), Germany

Optical and dielectric properties are key features for the application of artificial diamond as windows for nuclear fusion reactor devices in heating and current drive of the plasma and diagnostics as well. The properties of diamond are unique in the sense of extraordinary values in comparison to other dielectric crystalline materials, like sapphire, spinel, garnet or other oxide materials. The influence of defects and microstructural effects will be discussed based on vibrational bands and RAMAN experiments. Doped diamond is also considered, especially related to electric conductivity experiments. Doped diamond can be used for detector applications.

KFM 10.6 Tue 11:40 E 124

Examining atomic-scale material properties with an SnV electrometer in diamond — •Gregor Pieplow[1], Cem G. Torun[1], Joseph H. D. Munns[2], Franziska M. Herrmann[1], Andreas Thies[3], Tommaso Pregnolato[3], and Tim Schröder[1] — [1]Department of Physics, Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin, Germany — [2]PsiQuantum, 94304 California Palo Alto, USA — [3]Ferdinand-Braun-Institut, Gustav-Kirchhoff-Straße 4, 12489 Berlin, Germany

The transport of free charge carriers in solid-state materials, particularly in the presence of crystal defects, is an active area of research. Currently, existing in-situ sensing methods struggle to precisely localize single charges at the lattice scale. Our work introduces a sensor that is highly sensitive to single charges even amidst high-density background noise, common in wide-bandgap materials. We demonstrate the sensor principle using the tin-vacancy center in diamond, placed in a perturbed crystal lattice. The sensor allows us to pinpoint defect positions with high resolution, understand charge dynamics, and assess defect densities and formation yields. Importantly, this sensor aids in predicting optical performance in quantum technologies based on defect concentration, offering insights into achieving optimal optical coherence.