KFM 12: Diamond and Related Dielectric Materials II

Chair: Theo Scherer (KIT Karlsruhe)

Time: Wednesday 9:30–11:50 Location: EMH 025

KFM 12.1 Wed 9:30 EMH 025

Diamond-based platforms for biochemical measurements of time-resolved clock cell signaling in response to external zeitgebers and coupling factors — •Rezvaneh Ghasemitabesh[1], Daniel Merker[1], Daniela Bertinetti[2], Friedrich W. Herberg[2], and Cyril Popov[1] — [1]Institute of Nanostructure Technologies and Analytics, Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Germany — [2]Department of Biochemistry, CINSaT, University of Kassel, Germany

Nowadays, techniques for immobilization of biomolecules for biosensor fabrication have been investigated on various diamond substrates due to their exceptional properties. This study focuses on the potential application of ultrananocrystalline diamond (UNCD) films as biosensor platforms for detection of biomolecules, such as neuropeptides (e.g. pigment dispersing factor (PDF)), secreted by clock neurons. To achieve an effective biosensor, calibration tests are initially conducted. These tests involve non-covalent and covalent immobilizations of green fluorescence protein (GFP) on nanostructured UNCD films. The results of non-specific binding of GFP to O-, H- and F-terminated UNCDs demonstrate that with decreasing GFP concentration, the fluorescence intensity is decreasing. Also, the immobilizations of various nanobodies against GFP show promising initial results. The long-term goal is to immobilize PDF-binding proteins for capturing PDF released from clock neurons and detecting it using a reporter complex composed of a binding protein and a fluorescent molecule.

KFM 12.2 Wed 9:50 EMH 025

Application and design evolution of CVD diamond windows in fusion experiment devices — •Peter Spaeh — KIT, Institute for applied materials, Karlsruhe

For experimental fusion devices and also for future fusion power plants, efficient plasma heating concepts based on high frequency electromagnetic waves are essential. Electron Cyclotron Resonance Heating (ECRH) is one of these heating systems. An ECRH system generates very high power radiation at millimetre wavelength in Gyrotrons, which are basically evacuated masers. From there the millimetre waves are coupled out and guided through transmission lines into the torus chamber of the fusion reactor aiming for plasma heating or plasma stabilisation. To separate these sections from each other, radiation transparent windows are required, which enable millimetre wave passage at very low dielectrical losses, while at the same time acting as mechanical barriers to cope with pressure gradients and contamination issues. Beside window materials like sapphire, boron nitride or beryllium oxide, the most promising material for low-loss transmission and high mechanical strength under vacuum safe long pulse operation is synthetic diamond. With the continuous progress on growing diamond by CVD (chemical vapour deposition), also the applicability and the performance of CVD diamond windows in experimental fusion devices has evolved substantially. This talk gives an overview on various configurations and design evolutions of CVD diamond windows for nuclear fusion applications. Also respective design requirements, relevant design parameters and associated material properties are presented.

KFM 12.3 Wed 10:10 EMH 025

Initial characterization of MPA CVD diamond to be investigated by fracture toughness measurements — •Gaetano Aiello, Carsten Bonnekoh, Andreas Meier, Theo Scherer, Sabine Schreck, Klaus Seemann, and Dirk Strauss — Karlsruhe Institute of Technology, Institute for Applied Materials, 76021 Karlsruhe, Germany

Microwave Plasma Assisted (MPA) Chemical Vapour Deposition (CVD) optical quality polycrystalline diamond is used in shape of disks with thickness of 1 to 2 mm in window units for plasma heating and stabilization in nuclear fusion devices. Due to limited body of work in literature and the important safety role of the disks, fracture toughness measurements on this type of diamond are planned to check its resistance against crack propagation. In this work, the activities aiming to characterize the diamond samples prior to the experiments are discussed mainly with reference to X-ray diffraction, electron backscatter diffraction and loss tangent measurements. For in-depth understanding, thermal grade diamond has been also considered. It grows much faster than the optical grade and it has a greater density of microfeatures. In addition, the design and thermo-mechanical performance of a typical diamond window unit in nuclear fusion devices are presented.

20 min. break

KFM 12.4 Wed 10:50 EMH 025

Diamond dielectric characterization with superconducting LC micro-resonators — •Francesco Mazzocchi, Dirk Strauss, and Theo Scherer — Karlsruhe Institute of Technology, IAM-AWP, Hermann Von Helmholtz Platz 1, 76344, Eggenstein Leopoldshafen

The development of high optical quality, ultra-low losses single crystal diamond windows is paramount for the realization of future nuclear fusion facilities like DEMO, given the foresaw increase in power of microwave ECRH systems. Precise determination of the dielectric characteristics (ϵr and tanδ) of these innovative materials have so far relied on techniques involving Fabry-Perot microwave open resonators in various configurations. High Q, superconducting thin film resonators can be effectively used to determine dielectric characteristics of extremely low losses materials like single- and poly-crystalline diamond. Their extremely high-quality factors allow for a substantial increase in resolution in the determination of these parameters when compared to state-of-the-art Fabry Perot open resonators. We hereby report the simulation study that lead to the final design of the devices and the first characterization measurements performed on a prototype resonator patterned on a single crystalline diamond substrate.

KFM 12.5 Wed 11:10 EMH 025

Optimizations of Single-Crystal Diamond Surfaces for Implantation, Membranes and Nanophotonic Structures — •Lukas Wolfram, Julia Heupel, Johann Peter Reithmaier, and Cyril Popov — Institute of Nanostructure Technologies and Analytics (INA), University of Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

Due to its exceptional physical and chemical characteristics, single-crystal diamond (SCD) is a promising material for the fabrication of high-quality photonic devices and for envisioned applications in quantum information technologies (QIT). The preparation of smooth and defect-free surfaces is important to yield optimal optical properties and reduce losses by e.g. scattering. Here, a solution to remove defects originating from polishing or etching procedures (e.g. grooves and pits) is presented, while avoiding the micro masking effect during the inductive coupled plasma reactive ion etching (ICP-RIE) process. Thereby, we achieved surface roughness down to 0.2 nm using optimized Ar/Cl_2 etching recipes. The planarized diamonds are then used, as it will be shown in the talk, for structuring membranes (thickness between 5000-500 nm), nanophotonic devices or preparing implantation masks with hole sizes down to 40 nm.

KFM 12.6 Wed 11:30 EMH 025

Energy dissipation on magic angle twisted bilayer graphene — •Marcin Kisiel[1], Alexina Ollier[1], Urs Gysin[1], Martino Poggio[1], Xiaobo Lu[2], Dmitri Efetov[3], and Ernst Meyer[1] — [1]Department of Physics, University of Basel, Klingelbergstrasse 82, CH-4056 Basel, Switzerland — [2]International Center for Quantum Materials, Collaborative Innovation Center of Quantum Matter, Peking University, 100871, Beijing, China — [3]Department of Physics, Ludwig-Maximilians-University München, Geschwister- Scholl-Platz 1, 80539 München, Germany

While traditional Joule dissipation omnipresent in today's electronic devices is well understood, the energy loss of the strongly interacting electron systems remains largely unexplored. Twisted bilayer graphene (tBLG) is a host of interaction-driven correlated insulating phases, when the relative rotation is close to the magic angle (1.08deg). Here, we report on low temperature (5K) nanomechanical energy dissipation of tBLG measured by sharp tip of the pendulum atomic force microscope (pAFM). Ultrasensitive cantilever tip acting as an oscillating gate over the quantum device shows dissipation peaks attributed to different fractional filling of the flat energy bands. pAFM provides exquisite spatial resolution and thus allows to determine the twist angle distribution of tBLG. Application of magnetic fields provoked strong oscillations of the dissipation signal at 3/4 band filling, which we identified as familiar to Aharonov- Bohm oscillations arising from wavefunction interference present between domains of different doping.