HL 24: Carbon-based Nanostructures

Time: Tuesday 9:30–12:00 Location: H14

HL 24.1 Tue 9:30 H14

High-frequency optically detected magnetic resonance of nitrogen-related centers in diamond — •Dion Braukmann[1], Jörg Debus[1], Vitalii Yu. Ivanov[2], Dariya Savchenko[3], Dmitri R. Yakovlev[1,4], Marek Godlewski[2], and Manfred Bayer[1,4] — [1]Experimentelle Physik 2, Technische Universität Dortmund, 44227 Dortmund, Germany — [2]Institute of Physics, Polish Academy of Sciences, 02668 Warsaw, Poland — [3]Institute of Physics, AS CR, 18221 Prague, Czech Republic — [4]Ioffe Institute, Russian Academy of Sciences, 194021 St. Petersburg, Russia

Impurities in diamond have been studied in recent years on account of possible applications in quantum information processing, spin-electronics and, e.g., biophotonics. The most promising impurity is the negatively charged nitrogen-vacancy (NV^-) center. Particular focus has been drawn on its optical and magnetic properties. The majority of studies neglects however the interplay between the NV^- center and other, mainly nitrogen-related, impurities giving rise to extraordinary changes in the magneto-optical characteristics.
In that context, we report on spectrally resolved optically detected magnetic resonance of nitrogen-related centers in diamond crystals. The application of microwaves with 65 GHz and low power allows us to reveal resonant microwave amplification.

HL 24.2 Tue 9:45 H14

Electronic transport properties of diamondoids within a gold nanojunction — Bibek Adhikari, •Ganesh Sivaraman, and Maria Fyta — Institute for Computational Physics , University of Stuttgart, Germany

Diamondoids are tiny hydrogen terminated diamond-like cages with tunable optoelectronic properties. These nanometer sized nanostructures, as well as their derivatives have been proposed as potential candidates for molecular electronics. For such an application, it is essential for diamondoids, when placed between electrodes, to facilitate electronic transport. In this work, we aim to shed light to this direction and reveal the electronic transport properties of diamondoids in a Au(111) nanojunction. The diamondoids need to be modified on either ends with functional groups in order to efficiently attach on the gold electrodes. Accordingly, the diamondoids will be attached through functional units to Au(111) electrodes. We will begin with diamantane and continue up to tetramantane. Two functional groups are chosen for grafting the diamondoid on the gold electrodes of the break junction: (a) a thiol group, and (b) a carbene molecule. Our work is based on quantum-mechanical simulations within the density functional theory (DFT) approach. The quantum transport calculations are carried out using the DFT approach together with the non-equilibrium Greens functions formalism. The electronic and transport properties of the gold electrodes including the functionalized diamondoids are presented based on this approach. Our results are highly relevant to molecular electronics and sensing devices.

HL 24.3 Tue 10:00 H14

Picosecond photocurrents in single-walled carbon nanotubes — •Maximilian Engl, Christoph Karnetzky, and Alexander W. Holleitner — Walter-Schottky-Institute and Physics-Department, Technical University of Munich, Germany

The exciton dynamics in carbon nanotubes are typically detected in a time-resolved way by optical techniques such as the transient absorption technique and the time-resolved photoluminescence spectroscopy. Both methods focus mainly on the dynamics of localized charge carriers within the carbon nanotubes. Many questions remain concerning the separation and the transport of photogenerated charge carriers to source and drain leads in an optoelectronic device structure. We address these questions by an ultrafast photocurrent spectroscopy, which is based on an on-chip THz time domain spectroscopy [1]. We find a combination of an optically induced ultrafast displacement current and interband charge-carrier recombination processes to dominate the ultrafast photocurrent of the single-walled carbon nanotubes [2]. We further discuss inter-subband relaxation processes after the optical excitation [3].

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[1] L. Prechtel et al., Nature Communications, 3, 646, (2012).
[2] L. Prechtel et al., Nano Letters, 10, 1021, (2011).
[3] C. Karnetzky et al. (2016).

HL 24.4 Tue 10:15 H14

Do clathrate structures exist at carbon? — •Conrad Schuster and Miguel Marques — Martin-Luther-Universität Halle-Wittenberg

For doped carbon clathrates many interesting properties have been proposed like super conductivity, super hardness or application as a semiconductor. Although this interest and the ability of silicon to form clathrate structures, no such material could have been produced yet.

Via DFT calculations with DFTB+ and VASP and minima hopping code we performed ab initio calculations on the stability of clathrates of carbon to show why they could not be found in experiments yet.

30 min. Coffee Break

HL 24.5 Tue 11:00 H14

Magnetotransport properties of a disordered graphite microwire produced by He^+ bombardment and embedded in a diamond crystal — •Jose Barzola-Quiquia[1], Tobias Lühmann[2], Ralf Wunderlich[1], Mahsa Zoraghi[1], Jan Meijer[1], and Pablo Esquinazi[1] — [1]Institute for Experimental Physics II, University of Leipzig, 04103 Leipzig, Germany — [2]Institute for Medicine Physics and Biophysics, University of Leipzig, 04107 Leipzig, Germany

We have investigated the magnetotransport properties of a graphite-like microwire (GLM) embedded in a diamond crystal in the temperature range of 2 K to 300 K and magnetic field to ± 8 T. The GLM was produced at ≈ 3 μm below the surface of a diamond crystal through the implantation of He^+ ions of 1.8 MeV energy using a microbeam. The initial wire was amorphous and was crystallised after heat treatment at $T \approx 1475$ K. After a first annealing treatment the electrical transport at low temperatures is well described by a fluctuation-induced tunneling conductance model. The tunneling process occurs between the partially graphitized grains separated by nearly insulating thin amorphous regions. After a second annealing the transport mechanism changes to variable range hopping conduction. A finite magnetoresistance (MR) was observed at temperatures $T < 250$ K, which can be well described by a semi-empirical model that takes into account a spin dependent scattering process. The magnetic properties indicate the existence of magnetic order in the GLM. The appearance of the graphitic structure after annealing treatment was confirmed by confocal Raman spectroscopy.

HL 24.6 Tue 11:15 H14

States of antiferromagnetic molecules detected with a carbon nanotube quantum dot — •Christian Lurz[1], Michael Schnee[1], Robert Frielinghaus[1], Claire Besson[1,2,3], Paul Kögerler[1,3], Claus M. Schneider[1,4], and Carola Meyer[1,5] — [1]Peter Grünberg Institut, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Department of Chemistry, The George Washington University, Washington, DC 20052, United States — [3]Institut für Anorganische Chemie, RWTH Aachen, 52074 Aachen, Germany — [4]Fakultät für Physik, Universität Duisburg-Essen, 47057 Duisburg, Germany — [5]Department of Physics, Universität Osnabrück, 49069 Osnabrück, Germany

Some of the most outstanding properties of carbon nanotubes (CNTs) are displayed in their sensitiveness towards changes in the environment and their spin-dependent conductivity. Thus, they are ideal devices to investigate the states of antiferromagnetic molecules via electronic transport experiments on functionalized CNTs. In this work, we present experimental data on quantum transport through CNTs covalently functionalized with antiferromagnetic tetramanganese coordination complexes. The experiments reveal a random telegraph signal (RTS), which is presumably caused by interactions between electron spin and the antiferromagnetic spin system. Furthermore, the statistics of the RTS indicate the relevant time and energy scales for transitions in this regime.

HL 24.7 Tue 11:30 H14

Effects of driving in carbon nanotube quantum dots —

•Patrick Haughian — Université du Luxembourg

The field of nanomechanics has been seen to provide a toolbox to investigate non-classical states of matter. In particular, past work has explored the interplay between photonic and vibronic degrees of freedom in engineering interesting photon states. More recently, the transport properties of quantum dots with additional electron-vibron interaction have been investigated. The case of strong interaction features significant suppression of the conductance through those systems in what is known as Franck-Condon blockade.

Our present efforts consist of analyzing such an electromechanical system, making use of theoretical techniques familiar from the treatment of optomechanical settings. Here, we want to profit from recent developments in engineering carbon nanotubes as quantum dots to control the parameters of the system. This undertaking provides a novel interface between electronic and vibronic systems, allowing us to exhibit non-classical vibron states, with possible uses in measurement setups and in exploring the quantum behavior of macroscopic systems.

HL 24.8 Tue 11:45 H14

A Fully Tuneable Fabry-Perot Microcavity for Diamond-Based Photonics — •Daniel Riedel, Brendan Shields, Sebastian Starosielec, Patrick Maletinsky, and Richard J. Warburton — Department of Physics University of Basel, Basel, Switzerland

Coupling between solid-state quantum emitters and photonic channels is a critical challenge for many applications in quantum sciences. A key requirement is a high fluence of indistinguishable photons, the generation of which requires photonic engineering and high quality, solid-state hosts. Here, we present an approach to this problem in the form of a fully tuneable Fabry-Perot micro cavity. The goal is to enhance the emission rate and zero-phonon line (ZPL) collection efficiency of nitrogen vacancy (NV) centers in diamond. At the core of the device, there is a high-quality, nano-fabricated, single-crystalline diamond membrane, bonded to a highly reflective Bragg mirror; the cavity is completed by a second, concave mirror. As a result, we achieve full spectral and spatial tunability and freedom in selecting NVs with favourable emission properties. We present first results showing how the finesse, limited to a few thousand by the reflectivity of the mirrors, is not degraded by the presence of the diamond membrane, and that the linewidth of the NV centers in the membrane can be sub-GHz. Our experimentally determined key device characteristics suggest that a 100-fold Purcell enhancement of the ZPL can be achieved in the future. Our results may thereby pave the way for highly efficient NV entanglement generation and ultraprecise quantum metrology applications.