HL 18: Carbon: Diamond, nanotubes and Buckyballs

Time: Monday 15:00–16:45 Location: POT 112

HL 18.1 Mon 15:00 POT 112

Calculation of the optical properties of the nitrogen-vacancy center in diamond using a configuration interaction approach — •Denis Antonov[1,2], Gabriel Bester[2], and Jörg Wrachtrup[1] — [1]3. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Max-Planck-Institut für Festkörperforschung, Heisenbergstr. 1, 70569 Stuttgart, Germany

We present calculations of the optical properties of nitrogen-vacancy (NV) centers in diamond. In particular, the negatively charged NV^- center is emerging as a promising candidate in the fields of quantum information, quantum processing and high resolution magnetometry. These applications require a precise prediction, and understanding, of the optical properties of NV^- centers including their many-body multiplet structure. We utilize a new approach, the atomic effective pseudopotential (AEP) method, which is based on the local density approximation (LDA) and an empirical correction to the quasiparticle band structure, to accurately model the NV^- center in diamond. Starting from the AEP wave functions, we calculate the many body effects using a configuration interaction approach that we adapt to the treatment of defects. We will highlight the effect of screening in the calculation of the Coulomb and exchange integrals. Our results of the optical spectrum of the isolated NV^- system, calculated on large supercells, show very good agreement with previous experimental reports, including an accurate reproduction of the experimental zero phonon line.

HL 18.2 Mon 15:15 POT 112

Low dimensional effects in surface conductive diamond — •Patrick Simon, Moritz V. Hauf, Max Seifert, Alexander W. Holleitner, Martin Stutzmann, and Jose A. Garrido — Walter Schottky Institut and Zentrum für Nanotechnologie und Nanomaterialien, Am Coulombwall 4, 85748 Garching

Hydrogen-terminated diamond exhibits a high surface conductivity in air. While theoretical models have suggested that a two-dimensional hole gas is formed shortly beneath the surface, no experimental proof has been reported yet.

In this work, we prove the low dimensional character of the surface conductive channel of hydrogen-terminated diamond. Using e-beam lithography and an oxygen plasma process we selectively oxidize the hydrogen-terminated diamond surface in order to fabricate in-plane gated field effect transistors. We demonstrate the lateral depletion of the conductive channel of devices with widths of up to 250 nm by applying a gate voltage. At liquid helium temperatures we observe a transition from the initial 2D system to a 1D system exhibiting quantized conductance. In a bias regime where the channel is almost fully closed, we observe Coulomb blockade effects characteristic of multiple islands that vary in size with the applied bias. The islands dimension exhibits a gate voltage dependence which is a direct result of the two-dimensional nature of the hole gas formed by the hydrogen-terminated surface.

HL 18.3 Mon 15:30 POT 112

Photocurrent from Hybrid Systems Based on Diamond and Bacterial Reaction Centers — •Réka Csiki, Roberta Caterino, Matthias Sachsenhauser, Philipp Niedermayr, Martin Stutzmann, Anna Cattani-Scholz, and Jose Antonio Garrido — Walter Schottky Institut, TU München, Am Coulombwall 4, 85748 Garching

Photoactive reaction centers (RCs) are protein complexes which can convert sunlight into other forms of energy with high efficiency. These proteins can generate a photocurrent under photostimulation when they are immobilized on and electrically connected to inorganic electrodes. In this contribution we show that heavily boron-doped polycrystalline diamond can be chemically modified by covalently attaching the linker molecule 6-phosphonohexanoic acid to the diamond surface, creating a suitable environment for a subsequent attachment of bacterial reaction centers. Two important mediators are involved in the natural charge transfer process of the bacterial RCs: the coenzyme Q_0 and the redox protein cytochrome c. The role of these two mediators in the photocurrent generation from photoactive RCs immobilized on functionalized diamond electrodes will be reported together with a discussion on the voltage dependence of the induced photocurrent. We demonstrated that OH-terminated diamond surfaces can be functionalized with organophosphonates and, together with the attached reaction centers, represent a suitable biohybrid system for energy harvesting.

HL 18.4 Mon 15:45 POT 112

Diamond-based platforms for long-term growth and investigations of neurons — •Alexandra Voss[1], Hongying Wei[2], Cyril Popov[1], Monika Stengl[2], and Johann Peter Reithmaier[1] — [1]Institute of Nanostructure Technologies and Analytics, University of Kassel, Germany — [2]Department Animal Physiology, University of Kassel, Germany

Due to biocompatibility, large electrochemical potential window and high chemical stability, combined with a number of superior physical properties, all types of diamond films are ideal candidates for platforms for biotechnological applications, such as multielectrode arrays (MEA) for neuronal signal derivation. In our work we investigated the suitability of the integration of diamond into the fabrication process of MEA structures. For this purpose the deposition of our ultrananocrystalline diamond (UNCD) layers was investigated on different glass types and metal layers to achieve closed uniform UNCD layers with good substrate adhesion confirmed by optical microscopy and SEM. For further investigations of transparent layer systems Eagle 2000 was chosen. Better optical quality was achieved by decreasing the UNCD layer thickness. For this purpose several diamond powder dispersions for pretreatment were evaluated to enhance the nucleation leading to shorter deposition times. This increases the transparency as confirmed by ellipsometry and transmission spectroscopy. In earlier experiments the improved adhesion of pacemaker neurons of *R. maderae* was confirmed on UNCD layers with different surface termination. This fact was used to improve the cell culture preparation technique.

HL 18.5 Mon 16:00 POT 112

Unusual Hysteresis Observed in the Magnetoresistance of Multiwall Carbon Nanotubes Bundles — •Jose Barzola-Quiquia[1], Manuel Lindel[1], M. Muallem[2], Gilbert D. Nessim[2], and Pablo Esquinazi[1] — [1]Division of Superconductivity and Magnetism, Institute for Experimental Physics II, University of Leipzig, D-04103 Leipzig, Germany — [2]Department of Chemistry, Bar-Ilan University, Ramat Gan 52900, Israel

The magnetotransport properties of several hundreds of micrometer long multi-walled carbon nanotubes (MWCNT) bundles were studied. The samples were contacted with silver paste and showed ohmic behavior at temperatures above 10 K, i.e. linear current-voltage (I-V) curves. The temperature dependence of the resistance is well described by variable-range hopping mechanism for one-dimensional systems. In this temperature range the magnetoresistance is negative and can be explained using an empirical model based on spin-scattering processes that suggests the existence of magnetic order. No magnetic impurities were found by means of energy dispersive X-ray. At temperatures between 2 K and 12 K, the I-V curves showed a nonlinear behavior, indicating the existence of a potential barrier. In this temperature range and at low magnetic fields and low enough input currents the magnetoresistance changed to positive accompanied by a clear hysteresis. The hysteresis as well as the positive magnetoresistance vanished at large inputs currents. Our results indicate that at $T < 12$ K the unusual butterfly hysteresis in the magnetoresistance is directly related to the nonlinear I-V behavior and suggests superconducting.

HL 18.6 Mon 16:15 POT 112

Ultrasensitive force detection with a nanotube mechanical resonator — Joel Moser[1,2], •Johannes Güttinger[1,2], Alexander Eichler[1,2], Maria Jose Esplandiu[2], Dong E. Liu[3], and Mark I. Dykman[3] — [1]ICFO, Av. Carl Friedrich Gauss, 08860 Castelldefels, Barcelona, Spain — [2]ICN, CIN2-CSIC, Campus UAB, 08193 Barcelona, Spain — [3]Department of Physics and Astronomy, Michigan State University, Michigan 48824, USA

Since the advent of atomic force microscopy, mechanical resonators have been used to study a wide variety of phenomena, such as the dynamics of individual electron spins, persistent currents in normal metal rings, and the Casimir force. Key to these experiments is the ability to measure weak forces. Here, we present force sensing experiments with a sensitivity of 12 zN $Hz^{-1/2}$ at a temperature of 1.2 K using a res-

onator made of a carbon nanotube [1]. An ultra-sensitive method based on cross-correlated electrical noise measurements, in combination with parametric downconversion, is used to detect the low-amplitude vibrations of the nanotube induced by weak forces. The force sensitivity is quantified by applying a known capacitive force. This detection method also allows us to measure the Brownian vibrations of the nanotube down to cryogenic temperatures. Force sensing with nanotube resonators offers new opportunities for detecting and manipulating individual nuclear spins as well as for magnetometry measurements.

[1] J. Moser et.al. Nature Nanotechnology 8, 493 (2013)

HL 18.7 Mon 16:30 POT 112

Charge carrier scattering with acoustic phonons in chirality enriched carbon nanotubes — •Peter Vogel[1], Olga Dyatlova[1], Ulrike Woggon[1], Christopher Köhler[2], Ermin Malic[2], Andreas Knorr[2], Rishabh Jain[3], Kevin Tvrdy[3], and Michael Strano[3] — [1]Institut für Optik und Atomare Physik, Technical University of Berlin — [2]Institut für theoretische Physik, Technical University of Berlin — [3]Department of Chemical Engineering, Massachusetts Institute of Technology

By using two-color pump-probe measurements we investigate the carrier relaxation dynamics in (7,5) carbon nanotubes at different combinations of pump and probe energies. The sample was characterized by PLE spectroscopy and is highly chirality enriched for (7,5) tubes solved in water with 5% sodium dodecyl sulfate (SDS). For pumping resonant to the E22-transition energy (1.922 eV) and probing resonant to E11-transition energy (1.206 eV), typical multi-exponential decay behaviour occurs[1]. By fixing the pump energy at E22 of the (7,5) species and tuning the probe energy from resonant to E11 up to the band (1.563 eV), we observe an acceleration of the relaxation dynamics of the first ps-component. This result is in agreement with predicted theoretical results[2]. Density matrix formalism is applied obtaining microscopic access to time- and momentum-resolved relaxation dynamics driven by scattering with acoustic phonons.

[1] O.A. Dyatlova et al., Nano Lett. 12, 2249 (2012)
[2] C. Köhler et al., Phys. Status Solidi (b) 249, 2483 (2012)