HL 34: Carbon: Diamond, nanotubes, Buckyballs

Time: Thursday 9:30–10:30 Location: EW 015

HL 34.1 Thu 9:30 EW 015

Tunable carrier density of two-dimensional hole gases on diamond — •Dennis Oing, Martin Geller, Nicolas Wöhrl, and Axel Lorke — University of Duisburg-Essen, 47057 Duisburg, Germany

Since diamond has a large band gap of 5.45 eV, it shows a vanishing intrinsic charge carrier density at room temperature. However, surface conductivity, induced by a two-dimensional hole gas on the surface, can be established by hydrogen termination and accumulation of an adsorbate layer.
Here, we investigate two-dimensional hole gases (2DHGs) on chemical-vapor-deposition-(CVD)-grown diamond after hydrogen plasma treatment and exposure to ambient atmosphere. The 2DHGs are characterized using temperature-dependent Hall experiments. The influence of the surface functionalization, determined by X-ray photoelectron spectroscopy (XPS), on the carrier density and mobility is evaluated. Hall measurements reveal that the carrier density is increasing from $7.6 \cdot 10^{11}\,\mathrm{cm}^{-2}$ to $1.5 \cdot 10^{13}\,\mathrm{cm}^{-2}$ with increasing amounts of oxygen adsorbed at the surface. In this range, the carrier density remains constant over a temperature range between 4.2 K and 325 K. For oxygen concentrations above 2.2 % (relative XPS signal), the charge carrier density decreases again and becomes temperature dependent. This supports a model based on oxygen-related centers that lead to the transfer of electrons from the surface to the adsorbate layer.

HL 34.2 Thu 9:45 EW 015

Buckyball spin networks controlled using qubits in diamond — •Dinesh Pinto[1,2], Domenico Paone[1], Lukas Schlipf[1], Bastian Kern[1], Markus Ternes[1], Amit Finkler[3], Jörg Wrachtrup[1,2], and Klaus Kern[1,4] — [1]Max Planck Institute for Solid State Research, D-70569 Stuttgart, Germany — [2]3. Physikalisches Institut, Universität Stuttgart, D-70569 Stuttgart, Germany — [3]Department of Biological and Chemical Physics, Weizmann Institute of Science, Rehovot 7610001, Israel — [4]Institut de Physique de la Matière Condensée, École Polytechnique Fédérale de Lausanne, CH-1015 Lausanne, Switzerland

The nitrogen vacancy (NV) center in diamond is a model single qubit. It can be optically initialized, coherently controlled and read out. However, controlling multi-qubit NV systems can be challenging as their distribution is generally stochastic. Molecular spin systems, especially $N@C_{60}$ (atomic nitrogen inside C_{60}), show great promise for quantum technologies: single endohedral nitrogen spins have long coherence times, and the scalability of fullerene networks allows for construction of complex nanoscale devices [1]. Coupling $N@C_{60}$ and single NV spins at ultra-high vacuum and cryogenic temperatures allowed us to observe the hyperfine splitting of endohedral nitrogen, which we used to implement quantum gate operations. Another possibility is the emergence of discrete time-crystalline order [2] in our disordered and strongly interacting molecular network.

1. Benjamin, S. C. *et al. J. Phys-Condens. Mat.* **18,** S867 (2006).
2. Choi, S. *et al. Nature* **543,** 221-225 (2017).

HL 34.3 Thu 10:00 EW 015

Fano effect in an ensemble of nitrogen vacancies in diamond under resonant excitation conditions — •Dion Braukmann[1], Vladimir P. Popov[2], Evan R. Glaser[3], Thomas A. Kennedy[3], Manfred Bayer[1,4], and Jörg Debus[1] — [1]Experimentelle Physik 2, Technische Universität Dortmund, 44227 Dortmund, Germany — [2]Rzhanov Institute of Semiconductor Physics, SB RAS, 630090 Novosibirsk, Russia — [3]Naval Research Laboratory, Washington, DC 20375, USA — [4]Ioffe Institute, Russian Academy of Sciences, 194021 St. Petersburg, Russia

Photoluminescence excitation (PLE) enables the observation of the Fano effect in an ensemble of nitrogen vacancy (NV) centers in diamond. We see a Fano resonance at resonant excitation of the NV center. Due to ensemble effects the impact of the resonance is not seen in the intensity of the NV zero phonon line (ZPL), but in a distinct energy shift. The ZPL intensity however shows a different resonance, which can be associated with a recharging process between neutral NV^0 and the negatively charged NV^- centers. In fact, resonant excitation of the NV^0 center at 2.156 eV leads to a strong increase in the NV^- ZPL emission at 1.946 eV. Temperature and excitation power dependent, spectrally resolved PLE measurements show, that due to effective recharging, the ZPL intensity can be increased about a factor of 25. Moreover, time resolved measurements reveal that the charge state can be selectively addressed in timescales of up to one hour.

HL 34.4 Thu 10:15 EW 015

Fully integrated quantum photonic circuit with an electroluminescent nanotube light source — •Felix Pyatkov[1,2], Svetlana Khasminskaya[1], Benjamin Flavel[1], Frank Hennrich[1], Manfred Kappes[1,3], Wolfram Pernice[4], and Ralph Krupke[1,2] — [1]Institute of Nanotechnology, Karlsruhe Institute of Technology, Germany — [2]Department of Materials and Earth Sciences, Technische Universität Darmstadt, Germany — [3]Institute of Physical Chemistry, Karlsruhe Institute of Technology, Germany — [4]Institute of Physics, University of Münster, Germany

Optically excited semiconducting carbon nanotubes (CNTs) can serve as quantum emitters operating in the telecommunication wavelength range. From the other side, dielectrophoretically deposited CNTs appear as waveguide-integrated electrically driven light sources [1]. The optical properties of such emitters can be tuned by photonic circuit design [2]. In the presented work we demonstrate non-classical properties of electroluminescent CNTs [3]. The electrically generated light efficiently couples and propagates into waveguide, and is recorded with integrated single photon detectors at cryogenic conditions. Correlation function demonstrates pronounced antibunching, which is a clear signature of non-classical nature of light. Therefore, we realized a CNT-based fully integrated photonic quantum circuit with purely electrical drive. [1] S. Khasminskaya, F. Pyatkov et. al., Advanced Materials 26, 3465 (2014). [2] F. Pyatkov, V. Fütterling et. al., Nature Photonics 10, 420 (2016). [3] S. Khasminskaya, F. Pyatkov et. al., Nature Photonics 10, 727 (2016).