# HL 59: Goup IV elements and their compounds I

Time: Wednesday 15:00–16:45 Location: H15

HL 59.1 Wed 15:00 H15

**Time-resolved electronic capture in germanium doped with hydrogen-like impurity centers** — •Nils Dessmann[1], Sergey Pavlov[2], Valery Shastin[3], Roman Zhukavin[3], Stephan Winnerl[4], Martin Mittendorff[4], and Heinz-Wilhelm Hübers[1,2] — [1]Institut für Optik und Atomare Physik, Technische Universität Berlin, Deutschland — [2]Institut für Planetenforschung, DLR, Berlin, Deutschland — [3]Institute for Physics of Microstructures, Nizhny Novgorod, Russia — [4]Helmholtz-Zentrum Dresden-Rossendorf, Deutschland

The availability of intense short-pulsed THz radiation from sources such as free electron lasers (FELs) or synchrotrons demands broadband detectors with very short response times. This triggered a renewed interest in fast germanium (Ge) detectors. The fastest operation of Ge detectors demonstrated in the THz region of the electromagnetic spectrum so far showed an about 2-ns long decay time using highly compensated neutron transmutated p-Ge:Ga:As:Sb. The short-pulse narrow-band FEL radiation allows studying impurity photoconductivity kinetics and provides information important for optimizing the speed of response of extrinsic photoconductors. The capture of free holes and electrons in Ge doped by gallium (Ga) or antimony (Sb) has been studied by a time-resolved pump-probe experiment with the FEL FELBE at the HZDR. For Ga acceptors the relaxation times decrease with increasing pump power from approximately 3 ns to 1 ns (2 ns and 1 ns for Sb donors, respectively). The results support the development of fast photoconductive detectors in the THz region of the spectrum.

HL 59.2 Wed 15:15 H15

**Photo-induced microwave emission of silicon vacancy defects in silicon carbide** — •Stefan Väth[1], Daniel Riedel[1], Hannes Kraus[1], Franziska Fuchs[1], Andreas Sperlich[1], Vladimir Dyakonov[1,2], Victor Soltamov[3], Vladimir Ilyin[4], Pavel Baranov[3], and Georgy Astakhov[1] — [1]Experimental Physics VI, Julius Maximilian University of Würzburg, 97074 Würzburg — [2]ZAE Bayern, 97074 Würzburg — [3]Ioffe Physical-Technical Institute, St. Petersburg, RU-194021 Russia — [4]Saint Petersburg Electrotechnical University, St. Petersburg, RU-194021 Russia

Silicon vacancy defects in silicon carbide are a very promising candidate for a wide range of applications in quantum information processing, photonics and magnetometry. [1]
We have reconstructed the spin structure of silicon vacancy defects using the optically detected magnetic resonance (ODMR) technique. In particular, we have observed multi-quantum spin resonances, unambiguously indicating the high-spin ground state of these defects with $S = 3/2$, terminating an ongoing discussion about a triplet or quartet ground state. This ground state is energetically split due to the crystal field even without external magnetic field, and we were able to create an inverse population using optical spin pumping. This opens intriguing perspectives for the realization of tunable microwave amplification by stimulated emission of radiation (MASER) in a solid-state system.

[1] D. Riedel et al., Physical Review Letters 109, 226402 (2012)

HL 59.3 Wed 15:30 H15

**Organophosphonate-Based PNA-Functionalization of Silicon Carbide** — •Matthias Sachsenhauser[1], Dominik Weinbrenner[1], Matthias Moritz[1], Kung-Chiang Liao[2], Jeffrey Schwartz[2], Martin Stutzmann[1], Jose Garrido[1], and Anna Cattani-Scholz[1] — [1]Walter Schottky Institut, Technische Universität München, 85748 Garching, Germany — [2]Princeton University, USA

Inorganic semiconductors combined with bio-organic systems offer the potential for the development of a wide range of novel biohybrid devices. In this context, silicon carbide (SiC) is a particularly promising substrate material because it features a high chemical stability and biocompatibility, making it ideal for biomedical and biosensing applications. However, a fundamental requirement for using SiC in biosensing applications is the ability to immobilize tailored molecular and biomolecular layers on this semiconductor's surface. Recently, we have demonstrated covalent functionalization of n-type 6H-SiC with organophosphonates. Structural and chemical properties of these monolayers were investigated through atomic force mircroscopy (AFM), X-ray photoelectron spectroscopy (XPS), contact potential difference (CPD) and Fourier-transform infrared spectroscopy (FTIR) measurements, revealing covalent bonding of the phosphonates to both (0001)- and (000-1)-oriented 6H-SiC crystal faces. Here we describe the potential of hydroxyl-terminated SAMs for the tailored biofunctionalization of (0001) 6H-SiC surfaces. In particular, we have focused our work on the covalent immobilization of peptide nucleic acid (PNA) oligonucleotides, which are receptors for DNA hybridization.

HL 59.4 Wed 15:45 H15

**Formation of magnetic moments induced by annealing in epitaxial graphene on SiC detected by spin precession measurements** — •Bastian Birkner[1], Daniel Pachniowski[1], Andreas Sandner[1], Markus Ostler[2], Thomas Seyller[2], Jaroslav Fabian[3], Mariusz Ciorga[1], Dieter Weiss[1], and Jonathan Eroms[1] — [1]Institute for Experimental and Applied Physics, University of Regensburg, 93040 Regensburg, Germany — [2]Lehrstuhl für Technische Physik, University of Erlangen-Nürnberg, 91058 Erlangen, Germany — [3]Institute for Theoretical Physics, University of Regensburg, 93040 Regensburg, Germany

We present results of non-local and three terminal spin precession measurements on spin injection devices fabricated on epitaxial graphene on SiC. The measurements were performed before and after an annealing step at 150 °C for 15 minutes in vacuum. The values of spin relaxation length $L_s$ and spin relaxation time $\tau_s$ obtained after annealing are reduced by a factor 2 and 4, respectively, compared to those before annealing. An apparent discrepancy between spin diffusion constant $D_s$ and charge diffusion constant $D_c$ can be resolved by investigating the temperature dependence of the effective $g$-factor, which is consistent with a model for paramagnetic magnetic moments.

HL 59.5 Wed 16:00 H15

**Growth and bubbling transfer of graphene on recyclable copper substrates** — •Simon Drieschner, Max Seifert, Lucas Hess, and José Antonio Garrido — Walter Schottky Institut, München, Deutschland

Chemical vapor deposition (CVD) is the most common method to synthesize large area high quality single layer graphene. Still, the commonly used copper foil substrate shows drawbacks in terms of surface roughness and crystal quality. We demonstrate the CVD growth of graphene in an induction heating setup, which enables the use of solid, polished copper blocks as well as copper single crystals as growth substrate. The parameter space for the growth process is explored, yielding single layer graphene of high crystal quality. A bubbling transfer method is employed to detach the graphene sheet from the copper substrate for electronic characterization. Such electrochemical transfer method allows the recycling of the catalyst substrate and a better control of the graphene crystal quality.

HL 59.6 Wed 16:15 H15

**Tubes n' Triplets - On Excitation dynamics in (6,5)-single-wall carbon nanotubes** — •Hannes Kraus[1], Florian Späth[2], Andreas Sperlich[1], Dominik Stich[2], Daniel Schilling[2], Tobias Hertel[2], and Vladimir Dyakonov[1,3] — [1]Experimental Physics VI, Julius Maximilian University of Würzburg, 97074 Würzburg — [2]Institute of Physical and Theoretical Chemistry, Julius Maximilian University of Würzburg, 97074 Würzburg — [3]ZAE Bayern, 97074 Würzburg

Carbon nanotube research is picking up pace, as this material class provides a multitude of potential applications due to its intriguing structural, electrical and optical properties. Focusing on the latter, we present spin-sensitive photoluminescence and time-correlated single photon counting (TCSPC) studies on semiconducting (6,5)-single-wall carbon nanotubes (SWNT). For the first time, we can unambiguously identify the signatures of triplet-triplet interaction in SWNTs, using optically detected magnetic resonance (ODMR). Applying a 1D diffusion model to ODMR and TCSPC experimental data yields a triplet lifetime of $(60 \pm 30)$ $\mu$s. Additionally, the triplet diffusion constant was found to be very similar to the singlet excitons', i.e. on the order of 10 $cm^2 s^{-1}$. The impact of the finding on the applications of carbon nanotubes in organic photovoltaics will be discussed.

HL 59.7 Wed 16:30 H15

**Covalent functionalization of carbon nanotubes with tetramanganese complexes** — •Robert Frielinghaus[1,5], Claire Besson[1,2,5], Anna-Katharina Saelhoff[1,5], Asmus Vierck[3], Marlou Slot[1,5], Lothar Houben[1,4,5], Janina Maultzsch[3], Paul Kögerler[1,2,5], Claus M. Schneider[1,5], and Carola Meyer[1,5] — [1]Peter Grünberg Institut, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Institut für Anorganische Chemie, RWTH Aachen, 52074 Aachen, Germany — [3]Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany — [4]Ernst Ruska Center for Microscopy and Spectroscopy with Electrons, 52425 Jülich, Germany — [5]JARA – Fundamentals of Future Information Technologies

We present first results on the covalent chemical functionalization of carbon nanotubes (CNTs) with tetramanganese coordination complexes. Raman spectra give indirect evidence of a successful reaction. It can only be achieved for tubes which contain defects with carboxylic groups. Changes in the magnetization behavior of the complexes due to the bonding to the CNTs are analyzed with temperature-dependent SQUID measurements. These results are correlated with bright and dark field high-resolution transmission electron microscopy (HR-TEM) measurements that show the repartition of the complex decoration on the CNTs. The TEM's elemental analysis capabilities, energy-dispersive X-ray and electron energy loss spectroscopy, prove the existence of Mn on the CNTs. We show that a mild oxidation, leaving the nanotubes conductive, is already sufficient for functionalization. This is important for the fabrication of transport devices.