

TT 85: Graphene: Adsorption, Intercalation and Other Aspects (joint session DY, DS, HL, MA, O, TT, organized by O)

Time: Friday 10:30–13:00

Location: TRE Ma

TT 85.1 Fri 10:30 TRE Ma

Radiation reduced CNM formation from halogenated biphenylthiols — ●SASCHA KOCH¹, CHRISTOPH D. KAISER¹, LENA FROMMEYER¹, PATRICK STOHMANN¹, TAREK ABU-HUSEIN², ANDREAS TERFORT², and ARMIN GÖLZHÄUSER¹ — ¹Department of Physics, Universität Bielefeld, Universitätsstrasse 25, 33615 Bielefeld, Germany — ²Department of Chemistry, Goethe-Universität Frankfurt, Max-von-Laue-Straße 7, 60438 Frankfurt, Germany

Carbon Nano Membranes (CNM) are mechanical stable and homogeneous quasi 2D systems which are formed by the electron radiation induced cross linking of molecules in specific self-assembled monolayers (SAM) grown on substrates like e.g. gold or copper. Contrary to graphene, as the most popular 2D system, the CNM structural and functional properties can be tailored by the selection and composition of appropriate precursors for the SAM formation as for instance phenylthiols or naphthalenes [1,2]. Here, the study of SAMs from halogenated biphenylthiols on a Au(111) substrate is presented. These precursor molecules allow in contrast to hydrogenated biphenylthiols the cross linking of SAMs for the formation of a CNM at a highly reduced electron doses. Additionally, this specific doping of biphenyls provides an insight to the mechanisms of the formation of CNMs. [1] P. Angelova et al., ACS Nano, 2013, 7, 6489-6497 [2] A. Turchanin and A. Gölzhauser, Adv. Mat. 2016, 28 6075-6103

TT 85.2 Fri 10:45 TRE Ma

Graphene/Polymer Composite Membranes for Nano- and Ultrafiltration — ●LUKAS MADAUSS¹, JENS SCHUMACHER², OLIVER OCHEDOWSKI¹, JENS MEYER², HENNING LEBIUS³, BRIGITTE BAND-D'ETAT³, EUGENIA TOIMIL MOLARES⁴, CHRISTINA TRAUTMANN⁴, MATHIAS ULBRICHT², and MARIKA SCHLEBERGER¹ — ¹Universität Duisburg-Essen, Duisburg, Germany — ²Universität Duisburg-Essen, Essen, Germany — ³CIMAP, Caen, France — ⁴GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

Nanoporous graphene is currently investigated as a promising membrane material in which selective pores can be created depending on the requirements of the application [1]. Here, we report on the irradiation of nanoporous graphene/polymer composite membranes with swift heavy ions and consecutive track etching. The ions directly create atomic pores in the graphene lattice while cylindrical tracks consisting of damaged material are created in the polymer support. Chemical etching converts the ion tracks in the polymer into large open channels [2] without attacking the graphene layer. The graphene coverage is significantly improved by protecting graphene by a PMMA layer during the track etching process. Our method presents a facile route to create high-quality suspended graphene on a flexible polymeric membrane with pores of tunable size. The development of porous graphene/polymer composite membranes is promising for fast and selective ultrafiltration separation processes.

[1] S. P. Surwade, Nature Nanotechnology, 10, 459-464, 2015 [2] T.W. Cornelius, NIMB, 265, 553-557, 2007

TT 85.3 Fri 11:00 TRE Ma

Optically switchable hybrid graphene/carbon nanomembrane field effect transistors — ●ANTONY GEORGE, ZIAN TANG, DAVID KAISER, CHRISTOF NEUMANN, ANDREAS WINTER, and ANDREY TURCHANIN — Friedrich Schiller University Jena, Institute of Physical Chemistry, D-07743 Jena, Germany

Field effect transistors (FETs) based on 2D materials are of great interest for applications in ultrathin electronic devices and especially for sensing technology. Here we demonstrate the possibility to add an optical switchability to graphene devices by hybridizing the graphene channel with optically active azobenzene molecules. The azobenzene molecules have been incorporated to the graphene FET channel by building a van der Waals heterostructure with chemically functionalizable 1 nm thin carbon nanomembranes (CNM). Under exposure with 365 nm and 455 nm light azobenzene molecules undergo -cis and-trans molecular conformations resulting in switching of the molecular dipole. We show that these transformations triggered by external optical stimulation induces switching of the graphene FETs between two operation modes.

TT 85.4 Fri 11:15 TRE Ma

Insight into the wetting of a graphene-mica slit pore with a monolayer of water — ●HU LIN, ANDRE SCHILO, RAUF KAMOKA, NIKOLAI SEVERIN, IGOR M. SOKOLOV, and JÜRGEN P. RABE — Department of Physics & IRIS Adlershof, Humboldt-Universität zu Berlin, Berlin, Germany

Graphene-mica slit pores are prepared by mechanical exfoliation of graphite onto a freshly cleaved muscovite mica surface in dry nitrogen. We followed their wetting and dewetting with water by scanning force microscopy (SFM) and Raman spectroscopy, which allows to unravel doping and strain effects upon both wetting and dewetting. SFM reveals that the wetting water layer is one monolayer thick, slightly thinner than a single layer of graphene. Raman spectra exhibit a reduction of the graphene D' peak intensity upon wetting, and a recurrence of the peak when the water layer dewets the slit pore. We attribute the D' peak to direct contact of the graphene with the ionic mica surface in dry conditions. Analyses of the 2D and G peak positions, the corresponding peak positions and the widths, imply that graphene on dry mica is charge doped and variably strained. A monolayer of water in between graphene and mica removes doping and reduces strains. This supports that in dry conditions graphene is in direct contact with the mica surface, while a complete monolayer of water wetting the slit pore decouples the graphene from the mica substrate both mechanically and electronically.

TT 85.5 Fri 11:30 TRE Ma

Substrate topography and annealing of Co/Gr/SiC(0001) investigated by means of photoemission electron microscopy — ●RICHARD HÖNIG, PHILIPP ESPETER, PETER ROESE, KARIM SHAMOUT, HERMANN KROMER, ULF BERGES, and CARSTEN WESTPHAL — Experimentelle Physik I, TU Dortmund, Otto-Hahn-Straße 4a, 44227 Dortmund, Germany

The realization of carbon electronics requires semiconducting substrates, therefore epitaxial graphene on silicon carbide is a promising candidate. Challenges with this system are the covalently bonded buffer layer impacting the electronic properties, and the limited graphene grain size depending on the preparation conditions.

Here, the so-called confinement controlled sublimation is applied to yield a high grain size. The characterization of the samples has been carried out by photoemission electron microscopy (PEEM) which combines surface sensitivity with a mesoscopic resolution and unique contrast mechanisms. Images of samples prepared under high vacuum or under inert gas conditions are presented.

In order to decouple the buffer layer as well as for tailoring the properties of this multilayer system, the intercalation of metals underneath graphene is a common method. Consequently, we will present the first attempts of cobalt intercalation.

TT 85.6 Fri 11:45 TRE Ma

Oxygen intercalation at the graphene/Ni(111) interface — ●LUCA BIGNARDI¹, PAOLO LACOVIG¹, MATTEO DALMIGLIO¹, FABRIZIO ORLANDO^{1,2}, ALIAKBAR GHAFARI^{1,3}, LUCA PETACCIA¹, ALESSANDRO BARALDI^{1,4}, ROSANNA LARCIPIRETE⁵, and SILVANO LIZZIT¹ — ¹Elettra - Sincrotrone Trieste, Trieste, Italy — ²Paul Scherrer Institut - Villigen PSI, Switzerland — ³Helmholtz-Zentrum Berlin, Berlin, Germany — ⁴Università degli Studi di Trieste, Trieste, Italy — ⁵CNR - Istituto dei Sistemi Complessi, Rome, Italy

Intercalation of atomic species at the graphene-substrate interface is an effective way to decouple graphene (GR) from the metal on which it is grown, restoring the Dirac cone and tuning the GR-substrate interaction. The intercalation of oxygen was found to be successful, independently of the extent of the graphene-metal interaction, upon a suitable choice of oxygen partial pressure and sample temperature. Herein we report on the intercalation and de-intercalation of oxygen at the strongly interacting Gr/Ni(111) interface. Synchrotron-radiation based high-resolution X-ray photoelectron spectroscopy was used to characterise the intercalation mechanism and the nature of the compounds at the interface. We observed that the intercalated oxygen efficiently decouples the GR layer quenching the hybridisation with the metal substrate. Angle-resolved photoelectron spectroscopy measurements showed the restoration of the Dirac cone band-structure.

Moreover, X-ray photoelectron diffraction added further insight into the structure of GR in the different phases of the process.

TT 85.7 Fri 12:00 TRE Ma

Graphene phonons in inelastic electron tunnelling spectroscopy — •JOHANNES HALLE¹, NICOLAS NÉEL¹, MADIS BRANDBYGE², and JÖRG KRÖGER¹ — ¹Technische Universität Ilmenau, Ilmenau, Germany — ²Technical University of Denmark, Lyngby, Denmark

Graphene on Ir(111) was intercalated by Li, Cs, and Ni. Inelastic electron tunnelling spectroscopy (IETS) unraveled remarkably strong signatures of graphene phonons for Li and Cs intercalants. For Ni-intercalated graphene, in contrast, phonon signals stayed below the detection limit of the low-temperature scanning tunnelling microscope (STM). On the basis of previously determined phonon dispersion branches the IETS features were assigned to acoustic and optical graphene phonons at the M point of the surface Brillouin zone. Additional experiments unveiled that the IETS signal increased with increasing Li coverage. Moreover, decreasing the separation between STM tip and graphene from the tunnelling to contact ranges led to a significant lowering of the phonon spectroscopic signatures. Combining these results, and comparing to transport calculations based on density functional theory, we discuss possible mechanisms that appropriately describe inelastic excitations with non-zero wave vectors via electron injection from an STM tip. Financial support by the Deutsche Forschungsgemeinschaft through Grant No. KR 2912/10-1 is acknowledged.

TT 85.8 Fri 12:15 TRE Ma

Electronic transport properties of novel nanosensors based on graphene and beyond — •FRANK C. MAIER¹, GANESH SIVARAMAN¹, FABIO A.L. DE SOUZA², RODRIGO G. AMORIM³, WANDERLA L. SCOPEL², RALPH H. SCHEICHER⁴, and MARIA FYTA¹ — ¹Institute for Computational Physics, University of Stuttgart, Germany — ²Departamento de Física, Universidade Federal do Espírito Santo, Vitória/ES, Brazil — ³Universidade Federal Fluminense, Departamento de Física, Volta Redonda/RJ, Brazil — ⁴Department of Physics and Astronomy, Materials Theory, Uppsala University, Sweden

In this work, we investigate the sensing abilities of graphene based materials. Specifically, we focus on pristine graphene and on a hybrid graphene/hexagonal boron nitride monolayer. Using density functional theory based simulations together with the non-equilibrium Green's functions formalism we are able to calculate the electronic transport across these materials, which serve as a reference. At a next step we choose small molecules (such as NO₂, CO₂, H₂S, benzene derivatives, etc.) and attach these covalently and/or non-covalently on the graphene materials. We first analyze the structural and electronic properties of these modified graphene-based monolayers and the molecule specific signatures. Our aim is to predict their electronic transport properties and evaluate the change in the properties and the charge transfer with respect to the type of the attached molecule. In the end, we discuss our results in view of using graphene-based sensors

for label-free detection of molecules and binding events.

TT 85.9 Fri 12:30 TRE Ma

Switching the reactivity of graphene on Ir(111) by hydrogen intercalation. — •RICHARD BALOG¹, ANDREW CASSIDY¹, LINE KYHL¹, JAKOB JORGENSEN¹, ANTONIA CABO¹, LUCA BIGNARDI¹, PAOLO LACOVIG², SILVANO LIZZIT², PHILIP HOFMANN¹, and LIV HORNEKAER¹ — ¹Department of Physics and Astronomy and Interdisciplinary Nanoscience Center iNANO, Aarhus University, Aarhus C DK-8000, Denmark — ²Elettra-Sincrotrone Trieste S.C.p.A., S.S. 14 Km 163.5, 34149 Trieste, Italy

In this paper I will present XPS and STM data revealing the modified reactivity of graphene towards hydrogen when intercalated. First I will show that the extent of hydrogen intercalation can be monitored by the progressive downshift of C1s spectra until fully decoupled a quasi-freestanding graphene is formed on Ir(111). Secondly, I will show that this intercalation affects the reactivity of graphene towards H atoms but also vibrationally excited H₂ molecules. I will show that while graphene on Ir(111) can be functionalized upon exposure to vibrationally excited H₂, the reaction is fully suppressed in a quasi-freestanding state. Controlling the reactivity of graphene towards outer environment simply by modification of its interaction with an underlying substrate paves the way for future application of (functionalized) graphene in everyday devices.

TT 85.10 Fri 12:45 TRE Ma

Intercalation and Deintercalation of Lithium at the Ionic Liquid|Graphite(0001) Interface — •FLORIAN BUCHNER¹, JIHYUN KIM², CHRISTIANE ADLER², JOACHIM BANSMANN², and R. JÜRGEN BEHM^{1,2} — ¹Helmholtz-Institute Ulm (HIU) Electrochemical Energy Storage, D-89081 Ulm, Germany — ²Ulm University, Institute of Surface Chemistry and Catalysis, D-89069 Ulm, Germany

The intercalation and deintercalation of lithium (Li) on the graphite anode in Li-ion batteries is essential for their function. This was investigated in a model study under ultrahigh vacuum conditions as a function of temperature employing X-ray and UV photoelectron spectroscopy (XPS / UPS). After vapor deposition of metallic Li, partially charged Li^{δ+} atoms were identified on graphite(0001) at 80 K, while, they diffuse into the bulk at 300 K. Interestingly, the ionic liquid (IL) 1-butyl-1-methyl-pyrrolidinium bis-(trifluoromethylsulfonyl)amide [BMP][TFSA], which is a promising solvent/electrolyte, can be used as a probe to measure Li^{δ+} deintercalation. After adsorption of a [BMP][TFSA] (sub-)monolayer on lithiated graphite at 80 K, the sample was heated to 300 K. Both the gradual shifts of all adsorbate-related XP peaks at > 230 K and the simultaneous lowering of the work function indicate the accumulation of partially charged Li^{δ+} atoms at the IL|graphite(0001) interface. This is accompanied by a partial decomposition of the IL adlayer (LiF, Li₂S, and LiN₃, etc.), which we associate with the initial stages of the chemical formation of the electrode|electrolyte interface (EEI), which in turn is crucial for the function of batteries.