

## TT 50: Graphene (organized by O)

Time: Tuesday 18:15–21:00

Location: Poster A

TT 50.1 Tue 18:15 Poster A

**Facile Electrochemical Transfer of Single Crystal Epitaxial Graphene from Ir(111)** — LINE KOEFOED<sup>2</sup>, ●ANTONIJA GRUBIŠIĆ ČABO<sup>1</sup>, MIKKEL KONGSFELT<sup>2</sup>, SØREN ULSTRUP<sup>1</sup>, ANDREW CASSIDY<sup>1</sup>, PATRICK R. WHELAN<sup>3</sup>, MARCO BIANCHI<sup>1</sup>, MACIEJ DENDZIK<sup>1</sup>, FILIPPO PIZZOCCHERO<sup>3</sup>, BJARKE JØRGENSEN<sup>4</sup>, PETER BØGGILD<sup>3</sup>, LIV HORNEKAER<sup>1</sup>, PHILIP HOFMANN<sup>1</sup>, STEEN U. PEDERSEN<sup>2</sup>, and KIM DAASBJERG<sup>2</sup> — <sup>1</sup>Department of Physics and Astronomy and Interdisciplinary Nanoscience Center, University of Aarhus, Ny Munkegade 120, 8000 Aarhus C, Denmark — <sup>2</sup>Department of Chemistry and Interdisciplinary Nanoscience Center, University of Aarhus, Langelandsgade 140, 8000 Aarhus C, Denmark — <sup>3</sup>Department of Micro- and Nanotechnology, Technical University of Denmark, 2800 Kongens Lyngby, Denmark — <sup>4</sup>Newtec A/S, Staermosegårdsvej 18, 5230 Odense M, Denmark

We present an electrochemical method for the transfer of large-area, high-quality single crystalline graphene from Ir(111) to SiO<sub>2</sub>/Si under ambient conditions. The method is based on intercalation of tetraoctylammonium ions between the graphene layer and the Ir surface. This simple technique allows transfer of graphene single crystals having the same size as the substrate they are grown on (diameter ≈ 8 mm). In addition, the substrate can be re-used for further growth cycles. A detailed Raman map analysis of the transferred graphene reveals that the initial characteristics and imprints left on the sheet of graphene in terms of strain and wrinkles from the growth process remain after transfer.

TT 50.2 Tue 18:15 Poster A

**The influence of the substrate roughness on the electronic properties of sidewall graphene nanoribbons** — ●JOHANNES APROJANZ, JENS BARINGHAUS, JULIA WIEGAND, MICHAEL OESTREICH, and CHRISTOPH TEGENKAMP — Institut für Festkörperphysik, Leibniz Universität Hannover, Germany

Graphene nanoribbons (GNR), epitaxially grown on the sidewalls of silicon carbide (SiC) mesa structures, have shown exceptional transport properties such as ballistic conduction within a single channel and electronic mean free paths of up to 15 μm [1]. We present a detailed study of the growth process of sidewall GNR using scanning probe and electron microscopy as well as Raman spectroscopy. Focussing on the influence of the substrate roughness, the density of terrace steps and the step height can be precisely controlled by a resistive "face-to-face" heating treatment. The local electronic properties are investigated by means of a 4-tip STM. The roughness of the SiC and of the mesa sidewalls is identified as detrimental to the electronic performance of sidewall GNR. The mean free path of the ribbons is shown to be directly dependent on the substrate terrace width. For a high density of terrace steps, a transition from ballistic to one dimensional diffusive transport is observed. In addition, Raman spectra show a selective graphene growth on the mesa sidewalls with a I(D)/I(G) ration below 0.1, which indicates high quality graphene nanostructures.

[1] Baringhaus et al., *Nature* **506**, 349 (2014)

TT 50.3 Tue 18:15 Poster A

**Towards the growth of double-layer graphene by conversion of molecular monolayers** — ●CHRISTOF NEUMANN<sup>1</sup>, GERARDO ALGARA-SILLER<sup>2</sup>, DANIEL EMMRICH<sup>1</sup>, MARTA TRELKA<sup>1</sup>, UTE KAISER<sup>2</sup>, and ANDREY TURCHANIN<sup>1</sup> — <sup>1</sup>Faculty of Physics, University of Bielefeld, 33615 Bielefeld — <sup>2</sup>Electron Microscopy Group of Materials Science, University of Ulm, 89081 Ulm

Graphene double-layers are desired for implementation of novel electronic and optoelectronic devices as well as for applications in nanofiltration and energy storage. Despite the recent great success in production of single-layer graphene sheets, viable routes to produce graphene double-layers have not been yet established. Here, we present a molecular approach towards graphene double-layers based on the temperature-induced conversion of cross-linked self-assembled monolayers of 1,1',4',1'-terphenyl-4-thiol (TPT) on Cu(111) and polycrystalline copper foils. We characterize this transformation by complementary experimental techniques including X-ray photoelectron and Raman spectroscopy, low energy electron diffraction, helium ion and scanning tunneling microscopy. To determine the structure of suspended graphene nanomembranes we employ high resolution trans-

mission electron microscopy and selected area electron diffraction.

TT 50.4 Tue 18:15 Poster A

**Magnetotransport of epitaxial Graphene with single ion-implanted Boron, Nitrogen and Carbon atoms** — PHILIP WILLKE<sup>1</sup>, ●ANNA SINTERHAUF<sup>1</sup>, SANGEETA THAKUR<sup>3</sup>, JULIAN A. AMANI<sup>2</sup>, THOMAS KOTZOT<sup>1</sup>, STEFFEN WEIKERT<sup>2</sup>, KALOBARAN MAITI<sup>3</sup>, HANS HOFÄSS<sup>2</sup>, and MARTIN WENDEROTH<sup>1</sup> — <sup>1</sup>IV. Physikalisches Institut, Universität Göttingen, Germany — <sup>2</sup>II. Physikalisches Institut, Universität Göttingen, Germany — <sup>3</sup>Department of Condensed Matter Physics and Materials' Science, TIFR, Mumbai, India

Using magnetotransport (MR) experiments we investigate the transport properties of SiC-Graphene in combination with low-energy ion implantation. Here, we demonstrate the incorporation of single boron, nitrogen and carbon atoms for which the microscopic structure has been additionally studied by scanning tunneling microscopy [1]. The ion-implanted samples exhibit a higher resistance and a lower mobility than undoped samples. Additionally, we find a positive MR for undoped samples switching to a negative MR for doped samples at high magnetic fields, especially for <sup>11</sup>B<sup>+</sup>- and <sup>12</sup>C<sup>+</sup>-ions. We explain this behavior with the additional presence of localized scattering centers which we describe in the context of weak localization theory. This work was supported by DFG priority program 1459 "Graphene".

[1] P. Willke et al., *Appl. Phys. Lett.* **105**, 111605 (2014)

TT 50.5 Tue 18:15 Poster A

**Local properties of graphene nanoribbons with well-controlled structural variations** — ●CHRISTIAN HÄRTINGER, FABIAN QUECK, and JASCHA REPP — Institute of Experimental and Applied Physics, University of Regensburg, D-93040 Regensburg

Atomically well-defined graphene nanoribbons can be grown by bottom-up on-surface chemistry [1], which allows for a detailed analysis by scanning probe microscopy and spectroscopy methods. This synthesis can be even extended to grow graphene nanoribbon heterostructures with a local variation of doping [2]. Here, instead we implement local structural variations of a nanoribbon on an Au(111) substrate by introducing suitable precursor molecules in the synthesis process. The influences of these structural variations on the local electronic properties are studied at low temperatures of 5 K by means of scanning probe microscopy and spectroscopy.

[1] Cai et al., *Nature* **466**, 470-473 (2010)

[2] Cai et al., *Nature nanotechnology* **9**, 896-900 (2014)

TT 50.6 Tue 18:15 Poster A

**Electronic and transport properties of graphene nanoribbons on Ni(111)** — ●BERNHARD KRETZ<sup>1</sup> and ARAN GARCIA-LEKUE<sup>1,2</sup> — <sup>1</sup>Donostia International Physics Center (DIPC), Paseo Manuel de Lardizabal 4, E-20018 San Sebastian, Spain — <sup>2</sup>IKERBASQUE, Basque Foundation for Science, E-48011 Bilbao, Spain

It is well known that graphene holds a great potential for electronic applications. The graphene-Ni system is an interesting case where the interaction with the ferromagnetic substrate gives rise to a number of remarkable phenomena.[1] In particular, the spin-dependent scattering of electrons at the edges of graphene islands on Ni(111) makes this system very interesting for spintronic devices.[2] Besides, the electron scattering is found to be dependent on the detailed edge structure of the graphene islands, which can exhibit unreconstructed or Stone-Wales reconstructed zigzag edge conformations.[3] In this work, we study the influence of the edge structure on the transport properties across graphene-Ni junctions. We consider graphene nanoribbons on Ni(111) with an unreconstructed and a Stone-Wales reconstructed zigzag edge, both of which are unpassivated, and we use density functional theory (DFT) calculations using the SIESTA and TransSIESTA codes.

[1]V. M. Karpan et al., *Phys. Rev. Lett.* **99**, 176602 (2007); M. Weser et al., *APL* **96**, 012504 (2010)

[2] A. Garcia-Lekue et al., *PRL* **112**, 066802 (2014)

[3] A. Garcia-Lekue et al., submitted

TT 50.7 Tue 18:15 Poster A

**Self-assembled PTCDI monolayers for band gap engi-**

**neering using organic solid/solid wetting deposition** — ●OLIVER GRETZ<sup>1,2</sup> and FRANK TRIXLER<sup>1,2,3</sup> — <sup>1</sup>Technische Universität München, School of Education, München, Germany — <sup>2</sup>Zentrum Neue Technologien, Deutsches Museum, München, Germany — <sup>3</sup>Department für Geo- und Umweltwissenschaften & Center for NanoScience, Sektion Kristallographie, Ludwig-Maximilians-Universität München, Germany

Graphene based semiconductors could be fabricated by inducing a band gap at the Dirac point in the graphene band structure. According to theoretical investigations perylene-3,4,9,10-tetra-carboxylic-diimide (PTCDI) is a promising organic semiconductor to open up a band gap in graphene by monomolecular physisorption. However the self-assembly of PTCDI monolayers on graphite could only be shown by epitaxial growth in ultra-high vacuum, yet.

Organic Solid/Solid Wetting Deposition (OSWD) is a process which enables the deposition of insoluble molecules such as organic semiconductors on substrate surfaces under ambient conditions. Here we show first results with PTCDI using OSWD, obtained via scanning tunneling microscopy, which are crucial for tuning the band structure of graphene.

TT 50.8 Tue 18:15 Poster A

**Interaction between polycrystalline copper substrate and graphene during atmospheric Chemical Vapor Deposition** — ●UMUT KAMBER, CEM KINCAL, HAKKI TUNÇ ÇİFTÇİ, BERK ZENGİN, DILEK YILDIZ, and OĞUZHAN GÜRLÜ — Istanbul Technical University, Istanbul, Turkey

Due to its inevitable potential to be used in wide scale electronics applications, research on high quality, large area, single sheet graphene production became an intense field. For this purpose Chemical Vapor Deposition (CVD) was presented as the most efficient method. In order to obtain defect-free CVD grown graphene sheets, understanding the interaction between graphene and substrate surface is crucial. We observed that graphene can grow over different Cu facets in a continuous film, as reported earlier. Graphene films are depressed near the step-edges of the substrate and moiré patterns occur on some of the atomically flat terraces. Formation of the moiré patterns on only some of the Cu facets indicate differences between the interaction of graphene with different Cu facets. Formation of the graphene on the Cu surface clearly affects the mobility of the Cu atoms on the relevant facet at high temperature. Moreover, we observed that if the copper surfaces are covered by bulk carbon without forming graphene, copper surface crystallizes more properly than graphene covered one. Thus, we claim that formation of graphene effects the crystallization of copper surface, which generates a growth feedback affecting the quality of the graphene film grown.

TT 50.9 Tue 18:15 Poster A

**Thickness, roughness and electronic structure characterisation of graphene using soft x-ray reflection spectroscopy** — ●CHRISTINE JANSING<sup>1</sup>, HUD WAHAB<sup>2</sup>, MARC F. TESCH<sup>1,3</sup>, MARKUS GILBERT<sup>1</sup>, ANDREAS GAUPP<sup>1</sup>, ANDREY SOKOLOV<sup>3</sup>, DONG HEE SHIN<sup>4</sup>, SUK-HO CHOI<sup>4</sup>, HANS-CHRISTOPH MERTINS<sup>1</sup>, HEIKO TIMMERS<sup>2</sup>, DOMINIK LEGUT<sup>5</sup>, and PETER M. OPPENEER<sup>6</sup> — <sup>1</sup>Münster Uni. of Applied Sciences, D-48565 Steinfurt — <sup>2</sup>School of Physical, Environmental and Mathematical Sciences, Uni. of New South Wales Canberra, Canberra, Australia — <sup>3</sup>HZB, D-12489 Berlin — <sup>4</sup>Dep. of Appl. Physics, College of Appl. Science, Kyung Hee Uni., Yongin 446-701, Korea — <sup>5</sup>Nanotechnology Centre, Ostrava, Czech Republic — <sup>6</sup>Depart. of Physics, Uppsala Uni., Uppsala, Sweden

X-ray reflection spectroscopy has been performed on graphene layers supported by different substrates across the C 1s absorption edge. Results confirm that the chemical vapour deposition onto copper foil has produced graphene of monolayer coverage. Graphene, deposited under the same conditions, transferred with a PMMA carrier to other substrate materials, has been measured to be significantly thicker. The interface- and the surface-roughness of the graphene layers have been determined. Structure in the measured reflection spectra can be correlated with ab-initio electronic band structure calculations and assigned to C 1s electron excitations. For the graphene layers transferred to a SiO<sub>2</sub> substrate a feature is present that indicates excitation at an energy that is 1.8 eV less than the energy associated with the  $\pi^*$  orbital. This finding is consistent with NEXAFS observations.

TT 50.10 Tue 18:15 Poster A

**Preparation of Graphene using the confinement controlled sublimation method** — ●CORNELIS HILSCHER, ULF BERGES,

DOMINIQUE HANDSCHAK, CHRISTOPH KEUTNER, LOTHAR BROSDA, PHILIPP ESPETER, and CARSTEN WESTPHAL — Experimentelle Physik I, TU Dortmund

Graphene is one of the most promising novel materials. Due to rapid, out of equilibrium growth at 1200 °C in ultra high vacuum successful production of high quality graphene, suitable for electronic applications, still causes many problems. There are some possible solutions like using argon or an enclosure to overcome these issues.

In this work the confinement controlled sublimation method [1] will be used to grow graphene on SiC(0001)-6H. The silicon carbide (SiC) is surrounded by a graphite enclosure with a small pinhole. Thus, the sublimating silicon stays in the enclosure causing a high silicon vapor pressure during the preparation process. Accordingly, the silicon's sublimation rate is decreased significantly, which leads to a 300 °C increase of the graphene formation temperature. Hence, the growth proceeds near to thermodynamic equilibrium and the graphene layer takes much longer to form. So very homogeneous graphene is expected.

Commissioning and characterization of the preparation chamber is still in progress and includes optimization of parameters like background pressure, heating time and heating temperature.

[1] DE HEER, W. A. et al (2011): *Large area and structured epitaxial graphene produced by confinement controlled sublimation of silicon carbide*. In: PNAS, **108**, 41, 16900–16905

TT 50.11 Tue 18:15 Poster A

**Polarization doping of graphene on silicon carbide** — SAMIR MAMMADOV<sup>1</sup>, JÜRGEN RISTEIN<sup>2</sup>, ROLAND J. KOCH<sup>1</sup>, MARKUS OSTLER<sup>1</sup>, CHRISTAIN RAIDEL<sup>1</sup>, MARTINA WANKE<sup>1</sup>, REMIGIJUS VASILIAUSKAS<sup>3</sup>, ROSITZA YAKIMOVA<sup>3</sup>, and ●THOMAS SEYLLER<sup>1</sup> — <sup>1</sup>Institut für Physik, TU Chemnitz, Reichenhainer Str. 70, D-09126 Chemnitz, Germany — <sup>2</sup>Lehrstuhl für Laserphysik, FAU Erlangen-Nürnberg, Erwin-Rommel-Str. 1, D-91058 Erlangen, Germany — <sup>3</sup>Department of Physics, Chemistry and Biology, Linköping University, SE-58183, Linköping, Sweden

Being an atomically thin layer, graphene has no bulk. Hence, the charge carrier density is influenced by its environment, especially the substrate. While epitaxial graphene on SiC(0001) is n-type doped due to charge transfer from interface states [1], quasi-freestanding graphene (QFG) on H-terminated SiC(0001) is p-type doped [2]. This was explained by the spontaneous polarization of the hexagonal SiC substrate [3]. As a test, we have carried out angle-resolved photoelectron spectroscopy of QFG on H-terminated 3C-SiC(111), 6H-SiC(0001), and 4H-SiC(0001). Using semi-insulating and n-type substrates we shed light on the contributions to the charge carrier density in QFG caused by the spontaneous polarization of the substrate, and the band alignment between the substrate and the graphene layer. In this way we provide quantitative support for the polarization doping model.

[1] S. Kopylov et al., Appl. Phys. Lett. 97 (2010) 112109. [2] F. Speck et al., Appl. Phys. Lett. 99 (2011) 122106. [3] J. Ristein et al., Phys. Rev. Lett. 108 (2012) 246104.

TT 50.12 Tue 18:15 Poster A

**Phonon Dispersion of Bilayer Graphene on 6H-SiC(0001)** — ●SINDY FRANZ, CHRISTIAN HEIDRICH, ROLAND J. KOCH, and THOMAS SEYLLER — Institut für Physik, TU Chemnitz, Reichenhainer Str. 70, D-09126 Chemnitz, Germany

Electron phonon coupling in graphene leads to characteristic changes in the phonon dispersion as well as a renormalization of the band structure. In the phonon dispersion it results in the well-known Kohn anomalies at the center of the Brillouin zone as well as the K-point. Using high-resolution electron energy loss spectroscopy (HREELS) in off-specular scattering geometry we investigate the phonon dispersion of epitaxial bilayer graphene on silicon carbide. In order to interpret our results, we compare them to previous measurements of monolayer graphene and of the buffer layer.

TT 50.13 Tue 18:15 Poster A

**Phonon-Plasmon-Coupling in Bilayer Graphene on 6H-SiC(0001)** — ●CHRISTIAN HEIDRICH, SINDY FRANZ, ROLAND KOCH, and THOMAS SEYLLER — Institut für Physik, TU Chemnitz, Reichenhainer Str. 70, D-09126 Chemnitz, Germany

Understanding the interaction between phonons and charge carriers of graphene is of high relevance from a fundamental as well as from an application point of view. Here we report on a study of bilayer epitaxial graphene on SiC(0001) using high resolution electron energy-loss spectroscopy (HREELS). This surface sensitive method is useful for

the investigation of phonon vibrations, plasmon excitations, and the coupling of both. It is also possible to study the dispersion of these phenomena over the whole Brillouin zone by varying the scattering geometry. Changing the primary beam energy on the other hand enables measuring those dispersion relations very close to the center of the Brillouin zone. Here we employ the latter to study the coupling of graphene's free charge carrier plasmon to phonons in the substrate as well as graphene itself in the dipole scattering regime. Using dielectric theory calculations, we simulated our measurements and the dispersion relation for the coupled phonon plasmon modes to compare with the experiment.

TT 50.14 Tue 18:15 Poster A

**Symmetry broken states of high mobility graphene on boron nitride devices suited for combined transport and STM experiments** — ●FELIX JEKAT, TJORVEN JOHNSEN, NILS FREITAG, PETER NEMES-INCZE, and MARKUS MORGENSTERN — II. Physikalisches Institut B, RWTH Aachen, Otto-Blumenthal-Straße, 52074 Aachen

Monolayer graphene is an ideal candidate to combine STM and transport measurements in the Quantum Hall regime. Such measurements require samples in which the exposed graphene surface is clean of processing residues and show high mobility. Here we present magneto-transport measurements of a monolayer graphene on boron nitride prepared by a process which fulfills the above requirements. The sample temperature is as low as 280 mK at a magnetic field of up to 10 T. The presented device shows a field effect mobility of  $50,000 \frac{\text{cm}^2}{\text{Vs}}$ . We observe full degeneracy splitting, at a magnetic field of 6 T in the zeroth and first Landau Level within the hole regime and the insulating phase in the zeroth Landau level. In the electron regime, only two fold degeneracy splitting is present. Temperature dependent measurements were conducted to determine the activation gaps of the broken symmetry states revealing gaps up to 80 K.

TT 50.15 Tue 18:15 Poster A

**Preparation of high mobility graphene samples for combined transport and STM experiments** — ●TJORVEN JOHNSEN, FELIX JEKAT, NILS FREITAG, PETER NEMES-INCZE, and MARKUS MORGENSTERN — II. Physikalisches Institut B, RWTH Aachen, Otto-Blumenthal-Straße, 52074 Aachen

Graphene on boron nitride provides the possibility to measure high mobility two dimensional electron systems by scanning tunneling microscopy. For this kind of measurement clean surfaces are crucial leading to the requirement that the exposed graphene surface has to be clean of processing residues. Adapting a dry transfer method presented by Kretinin et al. [1] for graphene transfer on boron nitride and employing shadow mask evaporation we are able to produce ultra clean graphene surfaces. A graphene flake is placed on a boron nitride flake exfoliated on SiO<sub>2</sub>/Si chip serving as the back gate. Charge carrier concentration can thus be controlled during the experiment. The graphene flake ( $30 \times 30 \mu\text{m}$ , bubble free area of  $10 \times 10 \mu\text{m}$ ) is contacted by 50 nm gold contacts defined by shadow mask evaporation. Homemade glass fibers [2] and TEM grids are utilized as shadow masks with alignment precision down to  $2 \mu\text{m}$ . Four probe transport measurements exhibit high mobility ( $50,000 \frac{\text{cm}^2}{\text{Vs}}$ ) and symmetry breaking in Quantum Hall Effect at 0.3 K. We also report on the less successful contacting by microsoldering [3].

- [1]A. V. Kretinin et al., NanoLett.14, 3270 (2014)
- [2]N. Staley et al., Appl. Phys. Lett. 90, 143518 (2007)
- [3]V. Geringer et al., Appl. Phys. Lett. 96, 082114 (2010)

TT 50.16 Tue 18:15 Poster A

**Polarization-dependent radiation patterns of Raman scattering from Graphene** — ●HARALD BUDDE, NICOLAS COCA LOPEZ, XIAN SHI, and ACHIM HARTSCHUH — Department Chemie and CeNS, LMU München, Germany

Raman Scattering Spectroscopy is a powerful technique for studying graphene and other sp<sup>2</sup> carbon materials [1]. We combined Raman Spectroscopy with back focal plane (BFP) imaging, a method used to visualize the angular distribution of emitted or scattered light. As an example BFP imaging allows to determine the orientation of single dipolar emitters [2, 3].

Graphene's Raman radiation pattern can be described as the incoherent sum of two orthogonal point dipole emitters despite its extended two-dimensional structure. Parameter-free model calculations using previously reported Raman polarization data are in excellent agreement with the observed radiation patterns of both G and 2D band.

We show that the observed polarization ratio of the 2D band and the 2D/G intensity ratio depend on the numerical aperture of the microscope objective used. Finally, the detection efficiency in microscopic Raman measurements is extracted from calculated patterns and is in agreement with the experimental data.

- [1] A. Ferrari, D. Basko, Nat. Nanotech. 8, 235-246, 2013.
- [2] M. Lieb, J. Zavislan, L. Novotny, J. Opt. Soc. Am. B 21, 1210-1215, 2004.
- [3] N. Hartmann, G. Piredda, J. Berthelot, G. Colas des Francs, A. Bouhelier, A. Hartschuh, Nano Lett. 12, 177-181, 2012.

TT 50.17 Tue 18:15 Poster A

**Innovative protocols for the epitaxial growth of graphene and boron nitride on Ag(111)** — ●MANUELA GARNICA, FELIX BISCHOFF, YUANQIN HE, JACOB DUCKE, MARTIN SCHWARZ, JOHANNES V. BARTH, and WILLI AUWÄRTER — Physik Department E20, Technische Universität München, Germany.

In recent years, the research of graphene and other 2D materials has spurred tremendous expectations for potential technological applications. In particular, the chemical vapour deposition (CVD) technique has been shown to be an effective method to grow large-areas of graphene and h-BN on highly reactive metals [1]. However, the low reactivity of noble metals makes the synthesis of 2D materials using the standard CVD techniques cumbersome [2]. In this work, we explore different growth methods of graphene and h-BN layers on Ag(111) substrates. We combine novel and well-established protocols like CVD, E-Beam evaporation or ion gun assisted deposition. The characterization of the structural properties of these layers was achieved by atomic-scale scanning probe microscopy (STM/AFM). We report the observation of different domain length, edges and defects for the resulting layers. Furthermore, we explore with subnanometer resolution the electronic properties and local surface potential of the layers by means of scanning tunneling spectroscopy.

- [1] M. Batzill, Surf. Sci. Rep. 67 (2012), p. 83
- [2] B. Kiraly et al. Nat. Commun. 4 (2013) 2804; F. Müller et al. Phys. Rev. B 82, (2010) p. 113406; Martinez-Galera et al, Nano Lett 11, (2011) p3576

TT 50.18 Tue 18:15 Poster A

**Transition of image-potential states from free-standing graphene to the graphene/metal interface** — ●NICO ARMBRUST, JENS GÜDDE, and ULRICH HÖFER — Fachbereich Physik und Zentrum für Materialwissenschaften, Philipps-Universität, D-35032 Marburg

We present a theoretical study of the formation of image-potential states on a graphene layer at varying distance to a metal surface. For this purpose we have constructed an analytical one-dimensional model-potential on the basis of the two-band model for the metal and a parametrized potential that reproduces the double Rydberg-like series of even and odd image-potential states of free-standing graphene. This enables us to calculate energies and wavefunctions of the combined system for arbitrary distances between graphene and the metal surface by solving the one-dimensional Schrödinger-equation numerically. For large distances, the image-potential states are typically located at the graphene sheet since its work function is lower than that of most metals. We show, how this double series of free-standing graphene evolves into a single series of the semi-infinite graphene/metal system when a flat graphene layer approaches the metal surface. Our model can quantitatively reproduce experimental data on graphene/Ir(111) and graphene/Ru(0001) which strongly differ in the interaction strength and therefore the binding distance. In particular, the model can explain the different binding energy and lifetime of the first ( $n = 1$ ) image-potential state in the valley and hill areas of the moiré superlattice of graphene/Ru(0001).

TT 50.19 Tue 18:15 Poster A

**Structural defects on swift heavy ion irradiated graphitic surfaces** — ●CEM KINCAL<sup>1</sup>, DILEK YILDIZ<sup>1</sup>, DENİZ AŞAN ACAR<sup>1</sup>, CLARA GRYGIEL<sup>2</sup>, CORNELIS J. VAN DER BEEK<sup>3</sup>, and OĞUZHAN GÜRLÜ<sup>1</sup> — <sup>1</sup>Istanbul Technical University, Istanbul, Turkey — <sup>2</sup>Université de Caen, Caen, France — <sup>3</sup>Ecole Polytechnique, Palaiseau, France

Hillock like structures on Highly Oriented Pyrolytic Graphite (HOPG) surfaces due to perpendicular swift heavy ion (SHI) irradiation were previously reported. Our results showed that structures that form on HOPG surfaces due to uranium SHI irradiation in perpendicular geometry have a variety of shapes and sizes rather than just being hillock like. Most of such defects were observed to be distributed on a line rather than being localized to a single point. On the other

hand, SHI irradiation of moiré zones on HOPG surfaces under grazing incidence did neither show destruction of the graphene layer generating the moiré pattern, nor any unzipping of the graphene as shown to happen on SHI irradiation of graphene crystals on dielectric substrates. Rather the defects forming as a result of grazing incidence irradiation were comet like both on pristine HOPG samples as well as on moiré domains. Moreover, our irradiation experiments on different graphitic samples showed variations in the structures of the induced defects on the surfaces depending on the crystal quality. Comparison of perpendicular irradiation defects on HOPG terraces to the ones on the moiré domains showed considerable differences.

TT 50.20 Tue 18:15 Poster A

**Water chemistry beneath graphene: Formation and breathing of a super-dense OH-H<sub>2</sub>O phase under graphene** — ELIN GRÅNÄS<sup>1</sup>, •ULRIKE A. SCHRÖDER<sup>2</sup>, MOHAMMAD A. ARMAN<sup>1</sup>, MIE ANDERSEN<sup>3</sup>, TIMM GERBER<sup>2</sup>, KARINA SCHULTE<sup>4</sup>, JESPER N. ANDERSEN<sup>1,4</sup>, THOMAS MICHELY<sup>2</sup>, BJØRK HAMMER<sup>3</sup>, and JAN KNUDSEN<sup>1,4</sup> — <sup>1</sup>Division of Synchrotron Radiation Research, Lund

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Placing catalysts in confined environments, e.g. carbon nanotubes, is a powerful method to modify their activity or selectivity. Unfortunately, atomic level understanding of the confinement effects is hindered by the complexity of these materials.

We use Ir(111)-supported graphene (Gr) flakes to study room temperature reduction of atomic oxygen in a confined 2D nano-reactor with X-ray photoelectron spectroscopy and scanning tunneling microscopy. The Gr cover can be used to trap OH-H<sub>2</sub>O phases that otherwise would desorb directly. Our study of these Gr-stabilized phases and their response to oxygen and hydrogen exposure reveals 2D breathing of a O-OH-H<sub>2</sub>O phase as O-atoms are dissolved into the structure (expansion) and subsequently converted to OH and H<sub>2</sub>O (contraction). Using density functional theory calculations combined with a genetic search algorithm, the structure and stability of the trapped OH-H<sub>2</sub>O structures were determined.