

## O 62: Graphene III

Time: Thursday 10:30–12:30

Location: H31

O 62.1 Thu 10:30 H31

**Structural properties and site specific interactions of Pt with the graphene/Ru(0001) moiré overlayer** — KERSTIN DONNER, MARTIN WILLENBOCKEL, and PETER JAKOB — Fachbereich Physik, Philipps-Universität Marburg, Germany

The growth, structure, and adsorptive properties of graphene on Ru(0001) has been investigated in detail [1]. Thereby the coherence of graphene layers on Ru(0001) over extended distances has been employed to discriminate between A and B types of Ru(0001) steps and to identify fcc as well as hcp regions of the associated moiré superstructure. We demonstrate that the individual regions of the graphene/Ru(0001) overlayer exhibit pronounced variations in interaction strengths with deposited metal atoms, recommending this substrate to serve as a template for growing periodic arrays of uniform nanoislands. In fact Pt clusters have been grown at 140–180 K and they are found to organize in a well-ordered periodic array defined by the moiré superlattice. Their preferred location within the graphene/Ru(0001) moiré unit cell is identified to be the fcc region. Pt islands are found to be structurally stable at room temperature; they may, however, exhibit some distinct frizziness which is attributed to some of the islands consisting of stable cores with one or two weakly bound Pt atoms additionally attached to them. Occasionally, pick-up or lateral displacement of Pt islands by the STM tip is observed, which can be avoided by working at tunneling resistances  $R_T > 10^9 \Omega$  and tunneling currents  $I_T < 50$  pA.

[1] K. Donner and P. Jakob, *J. Chem. Phys.* **131** (2009) 164701.

O 62.2 Thu 10:45 H31

**Atomic structure of graphene on Rh(111)** — MIKHAIL FONIN<sup>1</sup>, OLE ZANDER<sup>1</sup>, MURIEL SICOT<sup>1</sup>, SAMUEL BOUVRON<sup>1</sup>, ULRICH RÜDIGER<sup>1</sup>, YURIY S. DEDKOV<sup>2</sup>, and KARSTEN HORN<sup>2</sup> — <sup>1</sup>Fachbereich Physik, Universität Konstanz, 78457 Konstanz — <sup>2</sup>Fritz-Haber-Institut der Max-Planck-Gesellschaft, 14195 Berlin

Exceptional transport properties of graphene, a two-dimensional honeycomb lattice of sp<sup>2</sup>-bonded carbon atoms [1], recently observed on exfoliated quasi-free-standing samples make it a promising material for applications in microelectronics and sensing.

Here, we present a systematic scanning tunneling microscopy (STM) study of the atomic structure of graphene monolayer on the Rh(111) surface. Depending on the preparation conditions a multi-domain or a single domain graphene monolayer can be obtained. Atomically-resolved imaging of the graphene surface shows a moiré structure with pronounced buckling due to a strong interaction with the metal substrate. We show the most abundant moiré pattern in the multi-domain graphene which has the same structure as that in the single domain layer differs distinctly from those previously reported for graphene on Ir(111) or Ru(0001) as well as for *h*-BN nanomesh on Rh(111). Moreover, STM reveals a small rotation between graphene superstructure and metal lattices resulting in the formation of chiral domains.

This work is supported by DFG through SFB 767 (TP C5).

[1] A. K. Geim and K. S. Novoselov, *Nature Mater.* **6**, 183 (2007).

O 62.3 Thu 11:00 H31

**Bimetallic nanoclusters self-assembled on Ru(0001) supported monolayer graphene** — ALBERT K. ENGSTFELD, OTAVIO B. ALVES, PETRA M. ERNE, HARRY E. HOSTER, and R. JÜRGEN BEHM — Institute of Surface Chemistry and Catalysis, Ulm University, D-89069 Ulm, Germany

The Moiré-type nm-scale patterns of graphene monolayers on metal single crystals were recently shown to allow facile fabrication of ordered arrays of virtually monodisperse metal nanoclusters by simple metal vapour deposition in UHV [1–3]. Pt clusters formed this way on graphene/Ru(0001) have heights of 1–5 atomic layers and lateral diameters in the range 1–4 nm. In view of a potential utilization as model systems in electrocatalysis, we have tested the possibility of preparing Ru and bimetallic PtRu clusters by an analogous procedure. Based on statistically evaluated STM images, we will report on the size distributions of Ru and PtRu clusters in comparison to the properties of Pt clusters. For the bimetallic clusters, we will also elucidate the structural differences depending on whether Pt or Ru is deposited first, and we will discuss possible consequences for their (electro-)chemical properties.

[1] A.T. N'Diaye et al., *New J.Phys.* **11**, **2009**, 103045.

[2] Yi Pan et al., *Appl.Phys.Lett.* **95**, **2009**, 093106.

[3] K. Donner and P. Jakob, *J.Chem.Phys.* **131**, **2009**, 164701.

O 62.4 Thu 11:15 H31

**The electronic structure of graphene on Ru(0001) studied with STS** — MIKE GYAMFI, MARTA WAŚNIEWSKA, OSWALD PIETZSCH, and ROLAND WIESENDANGER — Institute of Applied Physics, University of Hamburg, Jungiusstr. 11, D-20355 Hamburg

The epitaxial monolayer graphene (MLG) on Ru(0001) displays a Moiré pattern with a strong electronic coupling with the substrate[1,2]. The unit cell of the Moiré pattern of MLG contains carbon atoms in high, low and intermediate positions. The periodic structure can produce spatial charge redistribution in the graphene and modify its electronic structure. In order to provide insight into the electronic structure of the different areas of the Moiré pattern, we performed scanning tunneling spectroscopy/microscopy at low temperatures. We observe different features in  $dI/dU$  spectra for high and low areas revealing the strong or weak bonding between graphene and the Ru substrate. The experimental results are in good agreement with previous theoretical study of graphene on Ru(0001)[3].

[1] S. Marchini et al., *Phys. Rev. B* **76**, 075429 (2007)

[2] P. Sutter et al., *NanoLett.* **9**, 2654 (2009)

[3] B. Wang et al., *Phys. Chem. Chem. Phys.* **10**, 3530 (2008)

O 62.5 Thu 11:30 H31

**Graphene on Ir(111): A tensile structure** — CARSTEN BUSSE<sup>1</sup>, PREDRAG LAZIĆ<sup>2</sup>, RABIA DJEMOUR<sup>1</sup>, JOHANN CORAUX<sup>3</sup>, TIMM GERBER<sup>1</sup>, NICOLAE ATODIRESEI<sup>2</sup>, VASILE CACIUC<sup>2</sup>, ALPHA T. N'DIAYE<sup>1</sup>, SVEN RUNTE<sup>1</sup>, STEFAN BLÜGEL<sup>3</sup>, JÖRG ZEGENHAGEN<sup>4</sup>, and THOMAS MICHELY<sup>1</sup> — <sup>1</sup>II. Physikalisches Institut, Universität zu Köln, Germany — <sup>2</sup>Institut für Festkörperforschung, Forschungszentrum Jülich, Germany — <sup>3</sup>Institut Néel / CNRS-UJF, Grenoble, France — <sup>4</sup>ESRF, Grenoble, France

Epitaxial growth on metal surfaces is an established method to produce highly ordered, extended graphene sheets. Ir(111) stands out from other substrates as the graphene grown on it is of extraordinary structural quality, shows an electronic structure almost equivalent to the one of free graphene, and can serve as a template for the growth of ordered superlattices of metal clusters.

Here we report measurements of the structure of graphene / Ir(111) based on X-ray standing waves (XSW), density functional theory (DFT) and scanning tunneling microscopy (STM). XSW reveals a bonding distance of  $(3.42 \pm 0.02)$  Å between graphene and the substrate. This height can be accurately confirmed in DFT if Van-der-Waals-interaction is taken into account. STM experiments show that due to the mismatch of graphene and Ir(111) an incommensurate moiré pattern is formed. The chemical interaction between C and Ir as determined by DFT is attractive only in some regions of the superstructure, whereas it is even repulsive for other parts. This is the reason for the significant corrugation of the graphene.

O 62.6 Thu 11:45 H31

**Nucleation and growth of nickel and cobalt nanoclusters on graphene Moiré on Rh(111)** — MURIEL SICOT<sup>1</sup>, SAMUEL BOUVRON<sup>1</sup>, OLE ZANDER<sup>1</sup>, MIKHAIL FONIN<sup>1</sup>, ULRICH RÜDIGER<sup>1</sup>, and YURIY S. DEDKOV<sup>2</sup> — <sup>1</sup>Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany — <sup>2</sup>Fritz-Haber-Institut der Max-Planck Gesellschaft, 14195 Berlin, Germany

The development of advanced routes to fabricate highly-ordered monodispersed metallic nanostructures is one of the key challenges in nanotechnology. One of the promising ways to produce arrays of monodispersed nanoclusters (NCs) is to use a bottom-up approach where self-organization growth phenomena on template substrates are used. In this work, we use a graphene Moiré grown on Rh(111) as a template. The possibility to create arrays of magnetic clusters on this graphene Moiré is investigated by means of scanning tunneling microscopy. Regularly sized Ni and Co NCs have been grown. We determine that the initial growth of Co and Ni at 150 K leads to preferential nucleation of monodispersed NCs at specific sites of the Moiré superstructure. The NCs exhibit a typical diameter of about 3 nm and are 4 monolayers high. However, a defined long-range ordering of

NCs with increasing coverage is not observed. These results suggest that the graphene nanomesh on Rh(111) is suitable for the growth of low density superlattices only. Room temperature growth of Co shows the same behaviour than at 150 K whereas Ni forms large triangular-shaped nanoislands which are well-matched to the Moiré registry. This work was supported by DFG through SFB 767 (TP C5).

O 62.7 Thu 12:00 H31

**graphene monolayer on Ru(0001) as a good template for metal deposition** — •BIN WANG and MARIE-LAURE BOCQUET — Université de Lyon, Laboratoire de Chimie, Ecole Normale Supérieure de Lyon, CNRS, F69007 Lyon, France

Perfectly ordered graphene overlayers can be easily obtained on Ru(0001) surface and display a moiré pattern with large periodicities resulting from the mismatch between graphene and Ru lattices [1-2]. In previous works using DFT calculations, we have unveiled that the graphene overlayer displayed periodic ripples of 1.5 Å amplitude, alternating chemical and physical distances with Ru [3-6].

Here we show by an extensive screening over different substrates (Ir and Rh) and a related organic network (h-BN) the uniqueness of the C/Ru interface in terms of local graphitic morphology and reactivity. Next we explore the adsorption properties of several adatoms like Transition Metal atoms (Ru, Pt, Au) and find an enhanced reactivity of the graphene area chemically interacting with the Ru substrate [7]. Consequently, it makes epitaxial graphene a promising template for material science and catalysis.

[1] S. Marchini et al, Phys. Rev. B. 76, 075429 (2007)

[2] J. Wintterlin et al, Surface Science, 603, 1841 (2009)

[3] B. Wang et al, Phys. Chem. Chem. Phys. 10, 3530 (2008)

[4] B. Wang et al, Phys. Rev. Lett. 101, 099703 (2008)

[5] W. Moritz et al, submitted (2009)

[6] T. Brugger et al, Phys. Rev. B 79, 045407 (2009)

[7] B. Wang et al, submitted (2009).

O 62.8 Thu 12:15 H31

**In situ monitoring of graphene growth on Ru(0001) by STM: new growth mode leading to extremely well ordered graphene** — •SEBASTIAN DÄNHARDT<sup>1</sup>, SEBASTIAN GÜNTHER<sup>1</sup>, JOOST WINTTERLIN<sup>1</sup>, and STEFAN SCHMITT<sup>2</sup> — <sup>1</sup>Department Chemie, Universität München, Butenandtstr. 11, 81377 München, Germany — <sup>2</sup>SPECS GmbH, Voltastr. 5, 13355 Berlin, Germany

We present the results of an in situ study of graphene growth using a novel high temperature STM (SPECS STM 150 Aarhus HT). Graphene was grown by chemical vapor deposition of ethylene on Ru(0001) at temperatures between 380 and 780 °C while STM images were recorded. Three different growth modes were observed. At relatively low temperatures fractal structures form consisting of triangular units. At temperatures between 500 and 680 °C and at ethylene pressures of  $\sim 1 \cdot 10^{-8}$  mbar graphene grows in a "downhill" fashion as found before by LEEM [E. Loginova, N. C. Bartelt, P.J. Feibelman, K.F. McCarty, New Journal of Physics 11 (2009) 063046]. At temperatures above 750 °C a new growth mode was observed. This mode is connected with massive etching of ruthenium step edges, while coherent, defect free graphene islands of micrometer size grow. Because the graphene islands are restricted to single terraces of the Ru substrate, the step structure of the Ru completely rearranges, and step bunches of up to 10 monoatomic step heights are formed. In this way, by applying the correct growth conditions, flat, defect-free graphene films can be grown on single terraces. The findings may lead to a massive improvement of graphene preparation via the "metal route".