O 61: Nanostructures at Surfaces III

Time: Wednesday 16:00–19:00 Location: WIL B321

O 61.1 Wed 16:00 WIL B321

XANES and UV-Vis measurements on Ag clusters deposited into ionic liquid — •David Engemann[1], Stefanie Roese[1], Stefanie Duffe[1], Kristina Kvashnina[2], Pieter Glatzel[2], and Heinz Hövel[1] — [1]Fakultät Physik / Delta, Technische Universität Dortmund, 44227 Dortmund — [2]European Synchrotron Radiation Facility (ESRF), 6 Rue Jules Horowitz, BP220, 38043 Grenoble

The properties of silver clusters can differ widely from that of bulk material. These differences correspond to the size of the clusters, their chemical environment and, if deposited, the supporting or embedding material. For applications of clusters for example in medicine their properties must be tuned in or for the presence of liquid environments. Deposition experiments were performed with Room Temperature Ionic Liquids (RTIL) as embedding material for clusters due to their applicability in high vacuum techniques.
Silver was vaporised by a thermal cluster source and cluster were formed by atom collisions in a super sonic expansion nozzle while expanding into a vacuum. The cluster than were deposited into 1-butyl-3-methylimidazolium hexafluorophosphat (BMIM-PF_6). This RTIL, an organic salt in liquid state, consists of a big organic cation (BMIM) and a small inorganic anion (PF_6). The asymmetry between the cation and the anion prevents the liquid from condensation at room temperature. These systems were investigated with UV-Vis measurements of the cluster plasmon extinction. Also first X-ray Absorption Near Edge Structure (XANES) spectroscopy measurements at the Ag-L_2 absorption edge were performed and will be presented.

O 61.2 Wed 16:15 WIL B321

Mass selected copper clusters on xenon and argon investigated with ultraviolet photoelectron spectroscopy (UPS) — •Christoph Schröder[1], Natalie Miroslawski[1], Paul Salmen[1], Dominik Wolter[1], Bernd von Issendorff[2], and Heinz Hövel[1] — [1]Fakultät Physik / DELTA, Technische Universität Dortmund, 44221 Dortmund, Germany — [2]Albert-Ludwigs-Universität Freiburg, Physikalisches Institut, D-79104 Freiburg

We deposit mass selected copper clusters on Cu(111), Au(111) and HOPG. To minimize the cluster surface interaction the substrates are covered with rare gas layers before softlanding the nanoparticles. These samples are measured with ultraviolet photoelectron spectroscopy (UPS) using a photon energy of hν=11.6 eV. We obtain signal in the sp-band region of the clusters which should be comparable to free beam cluster spectra [1,2] of the same clustersize, because of the low cluster surface interaction. This gives us hints about what happens to the electronic structure of clusters when they have contact to a surface. Furthermore we investigate the shift of the spectra caused by changing the substrate.

[1] O. Kostko, PhD-thesis, Albert-Ludwig-Universität Freiburg (2007).

[2] H. Häkkinen, M. Moseler, O. Kostko, N. Morgner, M. A. Hoffmann and B. v. Issendorff, Phys. Rev. Lett. **93**, 093401 (2004).

O 61.3 Wed 16:30 WIL B321

Metal and metal oxide nanoparticles generated in gas phase by pulsed DC sputtering in a reactive gas admixture — •Oleksandr Polonskyi, Amir Mohammad Ahadi, Alexander Hinz, Egle Vasiliauskaite, Thomas Strunskus, and Franz Faupel — Institute for Materials Science, Chair for Multicomponent Materials, CAU at Kiel, Kaiserstr. 2, 24143 Kiel, Germany

Metal nanoparticles have been of high scientific interest in the last decades due to their unique chemical, physical, mechanical, electrical, magnetic and optical properties. Gas aggregation cluster sources (GAS) based on the magnetron sputtering (Haberland concept) are widely utilized for fabrication of various metal nanoparticles. This work is focused on deposition of metal and metal oxide nanoparticles (Ag, TiOx, AlxOy, SiOx) by means of GAS with continuous or pulsed DC magnetron sputtering. Usually argon was used as a working gas, but in case of reactive metals (Ti, Al) a low concentration of oxygen or nitrogen was admixed, which is necessary for the cluster formation process. It was also observed that a gas aggregation cluster source based on pulsed reactive DC magnetron sputtering gives rise to a huge increase in deposition rate of nanoparticles by more than one order of magnitude compared to continuous operation (e.g., TiOx nanoparticles) [1]. The influence of the sputtering parameters and reactive gas admixing on the nanoparticles formation process was investigated. The prepared nanoparticles were characterized with regard to chemical composition, morphology and optical properties.

[1] Polonskyi et al., Appl. Phys. Lett. 103, 033118 (2013)

O 61.4 Wed 16:45 WIL B321

Utilizing Dog-Boning to fabricate High-Aspect-Ratio Nanofences — •Vera Hoffmann[1], Gunther Scheunert[2], René Kullock[3], and Lukas M. Eng[1] — [1]Institut für Angewandte Photophysik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Centre for Nanostructured Media, School of Mathematics and Physics, Queen's University Belfast, Belfast BT7 1NN, United Kingdom — [3]Department of Experimental Physics 5, University of Würzburg, 97074 Würzburg, Germany

By combining electroplating, as the first thin-film technique ever in use [1], and anodized aluminum oxide (AAO), to create nanoscale templates, one can fabricate macroscopically large areas of uniform nanorod arrays [2]. In order to better exploit these arrays for sophisticated applications, e.g. catalysis or dielectric-index sensing, an additional structuring would be desirable. Previous approaches with additional top layers on the AAO prior to electroplating or the subsequent removal of nanorods with laser ablation led to fringed rims and thus limit the applicability of the resulting structures.

Here, we present a new way of structuring by utilitizing the dog-boning effect of electroplating and structured ground electrodes to deliberately fabricate nanofences – lines of free-standing high-aspect ratio nanorods [3]. We will show and explain the mechanisms behind this fabrication as well as outline future applications.

[1] L. B. Hunt, Gold Bulletin, 6, 16 (1973). [2] R. Atkinson et al. Phys. Rev. B 73, 2354021 (2006). [3] G. Scheunert, V. Hoffmann et al. J. El. Chem. Soc., 161 D26-D30 (2014), DOI:10.1149/2.024401jes

O 61.5 Wed 17:00 WIL B321

Truly monodisperse clusters on boron nitride films and self-assembled monolayers — •Fabian Knoller, Sarah Wieghold, Michael König, Friedrich Esch, and Ulrich Heiz — Technische Universität München, Catalysis Research Center, Chair of Physical Chemistry, Lichtenbergstr. 4, 85748 Garching, Germany

Matter in the non-scalable size regime displays unique, size-dependent chemical and physical properties. We study truly monodisperse supported clusters for catalytic applications, by characterizing their behavior under harsh conditions by Scanning Tunneling Microscopy (STM).
For this purpose, we soft-land size-selected PdN clusters first on epitaxial boron nitride films on Rh(111) for the study at elevated temperatures and under controlled dosage of reaction gases. It can be shown that the clusters are located at specific sites of the Moiré-structure and that these adsorption sites change upon ripening.
Second, we soft-land the clusters on self-assembled monolayers of n-dodecylthiole on Au(111) for studies in liquid ambients. Heating of the SAM sample under UHV conditions leads to long-range ordering of the film on which the PdN clusters are deposited. Their structure is conserved upon transfer into aqueous ambient (0.1M $KClO_4$) and imaging by electrochemical STM.

O 61.6 Wed 17:15 WIL B321

Structure of graphene/Ir(111) supported metal clusters — •Dirk Franz[1,2], Timm Gerber[3], Carsten Busse[3], Thomas Michely[3], Nils Blanc[4,5], Johann Coraux[4], Uta Hejral[1,2], Roman Shayduk[1], and Andreas Stierle[1,2] — [1]Deutsches Elektronen-Synchrotron DESY, D-22603 Hamburg, Germany — [2]Fachbereich Physik, Universität Hamburg, D-20355 Hamburg, Germany — [3]II. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, 50937 Köln — [4]Institut NEEL, CNRS and Universite Joseph Fourier, BP166, F-38042 Grenoble Cedex 9, France — [5]CEA-UJF, INAC, SP2M, 17 rue des Martyrs, 38054 Grenoble Cedex 9, France

It was previously shown that different 2d metal cluster arrays can been grown using the moire of graphene/Ir(111) as a template [1].

We have employed several surface sensitive techniques (SXRD, XRR, GISAXS, HEXRD, STM) to investigate the structure of the particles (shape, epitaxy, strain) and the coherence of the 2d lattice. SXRD and

GISAXS analysis benefits substantial from the regular arrangement of the particles and has the potential to be a possible standard technique to solve the atomic structure of ordered cluster arrays.

In particular we investigated the structure of Ir clusters in ultra high vacuum [2], Pt cluster in CO environment and alloy clusters with sequential deposition and co-deposition of Pt/Rh. A shape change of Pt/Rh clusters in an oxidizing environment has been observed.

[1] N'Diaye et al. in: Phys. Rev. Lett. 97, 215501 (2006)
[2] Franz et al. in: Phys. Rev. Lett. 110, 065503 (2013)

O 61.7 Wed 17:30 WIL B321

Ripening of truly monodisperse clusters under the STM — •Friedrich Esch[1], Yves Fukamori[1], Michael König[1], Bokwon Yoon[2], Bo Wang[1], Uzi Landman[2], and Ulrich Heiz[1] — [1]Technische Universität München, Catalysis Research Center, Chair of Physical Chemistry, Lichtenbergstr. 4, 85748 Garching, Germany — [2]School of Physics, Georgia Institute of Technology, Atlanta, Georgia 30332, USA

Matter in the non-scalable size regime displays unique, size-dependent chemical and physical properties. We study truly monodisperse supported clusters, i.e. with every cluster of same size and adsorption site and thus chemical environment. To this purpose, we soft-land size-selected Pd_N clusters on epitaxial, Moiré-structured graphene and boron nitride films.

The well-defined samples allow for studying ripening mechanisms at the atomic scale by Scanning Tunneling Microscopy (STM), by following the dynamics of individual clusters as well as the particle size distributions of ensembles of hundreds of clusters [1]. The cluster-substrate interaction determines which ripening mechanism holds, Ostwald or Smoluchowski ripening. It is shown periodically wettable substrates can be used to optimize cluster stability at elevated temperatures. Periodic wettability leads to apparent adsorption site crossovers at the ripening transition from clusters to nanoparticles.

[1] Y. Fukamori, M. König, B. Yoon, B. Wang, F. Esch, U. Heiz and U. Landman, *Fundamental Insight into the Substrate-Dependent Ripening of Monodisperse Clusters*, Chem. Cat. Chem. 5 (2013) 3330-3341

O 61.8 Wed 17:45 WIL B321

Molecule substrate registry on h-BN supported by Rh(111) — •Marcella Iannuzzi — Universität Zürich, Schweiz

Modern nano-templates based on hexagonal boron nitride or graphene grown on transition metals show potential for future applications, due to their outstanding mechanical, thermal, and electronic properties. The mismatch between the lattice constant of the sp2 overlayer and the substrate produces modulated structures, which act as nano-templates for self-assembly, electron confinement, or intercalation. We apply scanning tunneling microscopy and density functional theory to investigate the adsorption of molecules and the formation and dynamics of defects. This work focus on the site-selectivity of h-BN/Rh(111) (nanomesh) for the adsorption of hexaiodo-cyclo-hexaphenylene (I6-CHP) and H2-phthalocyanine. In both cases we observe the preferential absorption within the pore of the nanomesh and the preferential orientation with respect to the substrate. Furthermore, the significant effects on the molecular electronic properties due t the interaction with the substrate are discussed. Advanced sampling techniques and tuned analysis tools for the characterization lead to a better understanding of the interaction between the precursor molecule and the substrate, which could be exploited in the development of new structure and process, as the production of graphene derivatives on metal supported insulators.

O 61.9 Wed 18:00 WIL B321

Tracking of cluster island diffusion on HOPG using non-contact AFM — Mumin Koç, Gauthier Torricelli, and •Klaus von Haeften — Department of Physics and Astronomy, University of Leicester, UK

Silicon oxide nanoparticles produced by co-deposition of silicon clusters and water vapour show very weak interaction in solution [1,2]. To elucidate the microscopic origins of the weak interaction, we deposited these clusters on highly oriented pyrolytic graphite (HOPG) surfaces and investigated their dynamics using non-contact AFM. The AFM images showed that practically all clusters were agglomerated into islands of different sizes. Larger islands were predominantly immobile, whereas a number of smaller islands were found to perform random walks in a Brownian-motion type fashion. The diffusion constant was determined from the time dependence of the mean square displacement. Detailed inspection of the island dynamics revealed correlated motion of 'dimer-islands', dissociation, and independent random walks of the dimer fragments. The role of the equipartition of energy between surface, islands, clusters and the AFM tip are discussed.

[1] A. Brewer and K. von Haeften, Appl. Phys. Lett. 94, 261102 (2009). [2] G. Torricelli, A. Akraiam, and K. von Haeften, Nanotechnology 22, 315711 (2011).

O 61.10 Wed 18:15 WIL B321

Magnetic anisotropy of monolayer Co/Ir(111) and graphene/Co/Ir(111) — •Alexander B. Shick[1], Frantisek Maca[1], and Alexander I. Lichtenstein[2] — [1]Institute of Physics, Academy of Sciences of the Czech Republic, Prague, Czech Republic — [2]Institute of Theoretical Physics, University of Hamburg, Hamburg, Germany

The positive magnetic anisotropy in cobalt-intercalated graphene on Ir(111) attracts interest due to spintronics applications [1]. The magnetism, and the magnetic anisotropy energy (MAE) of monolayer Co/Ir(111) and graphene/Co/Ir(111) are studied making use of the first-principles FP-LAPW, and the magnetic torque methods, including the element-specific contributions to the MAE. We found reasonable agreement for the MAE with previous KKR-ASA calculations of monolayer Co on Ir(111) for unrelaxed structure [2]. The structure relaxation provides a substantial positive MAE enhancement, and the MAE of 0.45 meV per Co is consistent with experiment [3]. The magnetic moments and the MAE are strongly affected by presence of graphene. For the placement with one of the C atoms on the top of Co ("top" position) the MAE becomes negative. For different arrangement, with graphene in the hexagonal hollow positions over the monolayer Co ("hex"), the effect of graphene is weaker, and the MAE stays positive. The role of Coulomb correlations beyond DFT will be discussed. [1] N. Rougemaille *et al.,* Appl. Phys. Lett., **101**, 142403 (2012); [2] S. Bornemann *et al.,* Phys. Rev **B86**, 104436 (2012); [3] J.E. Bickel *et al.,* Phys. Rev **B84**, 054454 (2011).

O 61.11 Wed 18:30 WIL B321

Nanojunctions on Epitaxial Graphene — •Konrad Ullmann and Heiko B. Weber — Lehrstuhl für Angewandte Physik, FAU Erlangen-Nürnberg, Germany

We will report on the fabrication and characterization of graphene nanojunctions, created on epitaxial graphene (0001). Micrometer-sized constrictions are fabricated by electron-beam lithography. By a current driven process similar to electromigration, nanojunctions can reproducible be fabricated. The nanojunctions give access to the formation of single-molecule junctions with graphene electrodes.

O 61.12 Wed 18:45 WIL B321

Observation of 4 nm Pitch Stripe Domains Formed by Exposing Graphene to Ambient Air — •Daniel Sebastian Wastl[1], Florian Speck[2], Elisabeth Wutscher[1], Markus Ostler[3], Thomas Seyller[2,3], and Franz Josef Giessibl[1] — [1]Institut für experimentelle und angewandte Physik, Universität Regensburg, 93053 Regensburg, Germany — [2]Lehrstuhl für Technische Physik, Universität Erlangen-Nürnberg, 91058 Erlangen, Germany — [3]Institut für Physik, Technische Universität Chemnitz, 09126 Chemnitz, Germany

We study epitaxial graphene on the 6H-SiC(0001) surface under ambient conditions using frequency-modulation atomic force microscopy. We observe large terraces with a self assembled stripe structure within a highly adsorbate covered surface on top of the graphene[1]. To identify the origin of the structure, we compare the experimental data on graphene with calculations and experiments on graphite that predict the formation of a solid-gas monolayer in the solid-liquid interface of hydrophobic surfaces.

[1] Wastl et al. ACS Nano, 2013, doi: 10.1021/nn403988y