O 42: Poster: Nanostructures at Surfaces

Time: Tuesday 18:00–20:00 Location: P2/EG

O 42.1 Tue 18:00 P2/EG

Nanostructuring of surfaces by slow highly charged ions — •Ayman El-Said[1], Rene Heller[2], and Stefan Facsko[2] — [1]Physics Department and Interdisciplinary Research Center for Advanced Materials, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia — [2]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany

Recently, considerable research efforts were devoted to the fabrication of extremely small nanostructures of significant potential in nanophotonics and nanoelectronics applications. Slow highly charged ions (HCI), as a promising nanotechnological tool, were successfully utilized for the creation of surface nanostructures in various solids [1]. Based on both the type of the material and ion beam parameters, nanostructures of different shapes (pits, caldera-like, hillocks) and sizes were obtained [2,3]. Here, we review the research progress on HCI-induced nanostructuring and the used theoretical approaches for understanding the creation mechanisms of the observed surface structures.

[1] A.S. El-Said, R.A. Wilhelm, R. Heller, M. Sorokin, S. Facsko, F. Aumayr, Phys Rev Lett 117, 126101 (2016).

[2] F. Aumayr, S. Facsko, A. S. El-Said, C. Trautmann, and M. Schleberger, J. Phys. Condens. Matter 23, 393001 (2011).

[3] S. Facsko, R. Heller, A.S. El-Said, W. Meissl, F. Aumayr, J. Phys. condensed matter 2, 224012 (2009).

O 42.2 Tue 18:00 P2/EG

Quantum simulator to emulate lower dimensional physics and chemistry — •E. Sierda, X. Huang, D. Badrtdinov, B. Kiraly, E. J. Knol, A.M.H. Krieg, N.M.M. Aarts, G. C. Groenenboom, M. I. Katsnelson, M. Rösner, D. Wegner, and A. A. Khajetoorians — Institute for Molecules and Materials, Radboud University, Nijmegen, The Netherlands

Designing materials with tailored physical and chemical properties requires a quantitative understanding of interacting quantum systems. In order to provide predictability, a promising route is to create bottom-up platforms, where the electronic properties of individual and interacting atoms can be emulated in a tunable manner. Here, we present a quantum simulator based on patterned Cs ions embedded in a 2DEG on the surface of semiconducting InSb(110). We use this platform to emulate the structure and orbital landscape of planar organic molecules. Using STM/STS and ab initio calculations, we show that an artificial atom can be derived from localized states of patterned Cs ions. The resultant potential can be used to couple artificial atoms, leading to bonding and anti-bonding states as well as to different orbital symmetries. Based on these artificial orbitals, we emulate molecular orbitals of known organic molecules, including anti-aromatic molecules, based on various atomic structures. In a different limit where Cs atoms are much closer, this quantum simulator can also be used to probe the effect of e-e interactions. Our experimental data suggest that dense structures exhibit many-body effects which can be extended to complex quantum states based on arbitrary lattices.

O 42.3 Tue 18:00 P2/EG

Transition Metal Nanoparticles on Graphene: Influence of Temperature — •Kai Besocke, Mahboobeh Ravankhah, and Mathias Getzlaff — Institut für Angewandte Physik, Heinrich-Heine-Universität Düsseldorf

With its unique properties, such as high quality crystal structure, excellent electrical conductivity and high tensile strength, graphene is a promising substrate for fabricating nanocomposites.

In our research on supported transition metal nanoparticles we are investigating the influence of graphene as a substrate for the deposition of metallic nanoparticles and the influence of subsequent heating. In this contribution we present our results concerning the size distribution of $Fe_{0.5}Ni_{0.5}$-Nanoparticles on CVD-graphene surfaces.

The graphene surfaces are prepared on a cobalt thin film on a W(110) substrate. The particles under investigation are produced by means of Ar magnetron sputtering in a Haberland source and aggregation takes place in a He atmosphere. We analyze the behaviour of particles several nm in diameter at temperatures up to 500 °C.

Particle distributions are analyzed via STM and it will be discussed, whether the nanoparticles show different behaviour upon heating on graphene compared to other surfaces.

O 42.4 Tue 18:00 P2/EG

Activity of cerium oxide thin films prepared by atomic layer deposition using custom and commercial precursors — •Yuliia Kosto[1], Carlos Morales[1], Anjana Devi[2], Karsten Henkel[1], and Jan Ingo Flege[1] — [1]Applied Physics and Semiconductor Spectroscopy, Brandenburg University of Technology Cottbus-Senftenberg, Konrad-Zuse-Strasse 1, Cottbus 03046, Germany — [2]Inorganic Materials Chemistry, Ruhr University Bochum, Universitätsstraße 150, Bochum 44801, Germany

Atomic layer deposition (ALD) allows preparation of conformal coatings with possibility to control their thickness at the submonolayer level, making it a good tool for depositing active layers on 3D structures. Our group is working on cerium oxide-based materials for hydrogen detection, which is difficult at ambient conditions due to the low sensitivity and long response time of the sensors. The cerium oxide layers prepared by ALD contain a lot of defects and provide an opportunity to overcome these complications. Thickness and morphology of the oxide films play an important role in defining the Ce3+/Ce4+ ratio, as well as the interface with the used substrate. Here, we compare cerium oxide thin films deposited by ALD techniques on SiO2 and Al2O3 substrates. The results reveal that the interface to the substrate can considerably influence the reactivity of the cerium oxide toward hydrogen and oxygen. Preparation of the oxides using two different precursors (commercial Ce(thd)4 and custom Ce(dpdmg)3) has been demonstrated to affect the redox properties of the films, their reactivity, and the reversibility.

O 42.5 Tue 18:00 P2/EG

Local work function on Graphene Nanoribbons on Au(111) — •Daniel Rothhardt[1], Tilmann Klamroth[2], Amina Kimouche[1], and Regina Hoffmann-Vogel[1] — [1]Institute of Physics and Astronomy, University of Potsdam, Karl-Liebknecht-Str. 24-25, 14476 Potsdam-Golm, Germany — [2]Institute of Chemistry, University of Potsdam, Karl-Liebknecht-Str. 24-25, 14476 Potsdam-Golm, Germany

Graphene nanoribbons (GNRs) exhibit remarkable electronic properties due to the nature of the charge carriers and local confinements [1]. The local work function difference (LCDP) was investigated using an ultra-high-vacuum non-contact mode AFM and in addition to the topography, the local differences in the contact potential were recorded using the method of Kelvin Probe Force Microscopy. A charge transfer between the GNRs and the underlying gold substrate can be detected in the LCPD images which verifies the p-doping of the GNRS [2]. We observed a modification of the work function along the edges of the GNRs, which is due to the screening of the Au(111) of electrostatic fields from the GNR. Density functional theory (DFT) calculation supports the experimental findings.

[1] A.H. Castro, Neto et al , Rev. Mod. Phys. **81** , 109 (2009)

[2] D. Rothhardt et al , arXiv:2203.06945v1 , (2022)

O 42.6 Tue 18:00 P2/EG

Spin Switching in Self-Assembled Tetramers on Ag(111) — •Sven Johannsen[1], Sascha Ossinger[2], Sascha Schüddekopf[1], Jan Grunwald[3], Alexander Hermann[4], Troels Markussen[5], Heiko Wende[4], Felix Tuczek[3], Manuel Gruber[4], and Richard Berndt[1] — [1]Institute of Experimental and Applied Physics, CAU Kiel, Germany — [2]Department of Chemistry, University of Basel, Switzerland — [3]Institute of Inorganic Chemistry, CAU Kiel, Germany — [4]Faculty of Physics and CENIDE, University of Duisburg-Essen, Germany — [5]Synopsys Denmark, Fruebjergvej 3, 2100 Copenhagen, Denmark

Spin-crossover (SCO) molecules can be switched between a low spin (LS) state and a high spin (HS) state. Adsorption to a surface can lead to a drastic change of the SCO behaviour. We present a low-temperature scanning-tunneling-microscope investigation of the switching characteristics of metal-based SCO molecules organized in tetramers on a Ag(111) surface. Via the injection of current pulses two molecules per tetramer can be reversibly switched. In addition, these molecules may be switched remotely by applying the excitation to one of the other two molecules of the tetramers. The latter molecules themselves are immutable. We induced tens of thousands of switch-

ing events using different currents and voltages and observed that the switching yields that are 2 to 3 orders of magnitude larger compared to previous results. We show that the switching is likely linked to a spin transition and also report three-state switching that involves charging of a molecule.

O 42.7 Tue 18:00 P2/EG

Simulation of electronic transport in 2D networks — •Tim Güldenpfennig, Markus Gruschwitz, and Christoph Tegenkamp — Institut für Physik, TU Chemnitz, Reichenhainerstr. 70, 09126 Chemnitz

Interclation of atomic hydrogen into to the interface of buffer layer systems on SiC(0001) was shown to be powerful method to realize almost charge neutral quasi free monolayer graphene. This concept works also for intercalation of various metals (e.g. Pb, Sn, In) coming along with the formation of new 2D interface structures in proximity to graphene. However, defects within the buffer layer are often required for the intercalation of larger elements, thus the homogeneity of the intercalated areas depend strongly on the quality of the buffer layer and intercalation parameters. As a result, the quasi free monolayer graphene resembles a network structure rather than a homogeneous 2D phase.

In order to deduce the conductivity from our transport measurements done with a 4 point probe STM, we performed simulations. By means of COMSOL java api and the MPh library, the simulations were controlled via self-written python scripts. Next to the import of experimental data measured with high resolution SEM, own network structures were designed to study systematically the effect of anisotropy and inhomogeneities in 2D systems.

O 42.8 Tue 18:00 P2/EG

Preparation and STM study of clean Nb(111) surfaces — •Julia Goedecke[1], Maciej Bazarnik[2], and Roland Wiesendanger[1] — [1]Dept. of Physics, University of Hamburg, D-20355 Hamburg, Germany — [2]Institute of Physics, Poznan University of Technology, Piotrowo 3, 60-965 Poznan, Poland

Niobium with its highest transition temperature among all elemental superconductors has become a favorable substrate for realizing well-defined low-dimensional magnet-superconductor hybrid systems exhibiting novel types of exotic electronic states such as Majorana zero-energy modes. While a preparation procedure for obtaining atomically clean Nb(110) substrates has previously been reported, a suitable preparation method for clean Nb(111) surfaces is still lacking. Here, we report a recipe for cleaning Nb(111) surfaces based on an atomic hydrogen treatment followed by short flashes to elevated temperatures. The atomic surface structure of clean Nb(111) is investigated by high-resolution scanning tunneling microscopy (STM), revealing a surface reconstruction with a reduced atom density compared to the (111) plane of a bcc crystal.

O 42.9 Tue 18:00 P2/EG

Pulling single polar molecular wires by atomic force microscopy — •Christophe Nacci and Leonhard Grill — Institute of Chemistry, University of Graz, Graz, Austria

The frictional properties of individual nanostructures are strongly influenced by the low dimensionality and reduced size. Probing how they respond mechanically on different surfaces is essential to understand how the static and dynamic friction depend on the interplay between chemical composition and structural commensurability. Here, we report the vertical pulling of DAD molecular wires [1] off metal surfaces by non-contact atomic force microscopy (AFM), performed under ultrahigh vacuum and at low temperatures. The chemical structure of DAD polar wires is made of a regular alternation of donor (D) and acceptor (A) units. The mechanical response of single isolated molecular wires is probed by force spectroscopy. To further explore the role of structural commensurability between polymers and surface, the polar wires are also grown on ultrathin insulating NaCl films on metal surfaces.

[1] C. Nacci et al., Nature Comm. 6, 7397 (2015)

O 42.10 Tue 18:00 P2/EG

XRR Analysis of Al2O3 coated and mid-T baked niobium for future implementation in SIS-based SRF cavities — •Artem Zaidman[1,2], Getnet Kacha Deyu[2], Marc Wenskat[2], Vedran Vonk[1], Robert Zierold[3], Robert Blick[3,4], Wolfgang Hillert[2], and Andreas Stierle[1,2] — [1]Deutsches Elektronen-SynchrDeutsches Elektronen-Synchrotron DESY, Germany — [2]Institute of Experimental Physics, Universität Hamburg, Germany — [3]Center for Hybrid Nanostructures (CHyN), Universität Hamburg, Germany — [4]Materials Science and Engineering, University of Wisconsin-Madison, United States

Bulk niobium is currently the most used material for RF surfaces. A new approach proposed by Gurevich [1] suggests the use of a superconductor-insulator-superconductor structure (SIS) to achieve higher accelerating fields and reduced surface resistance beyond the thermodynamic limits of Nb. As an intermediate step to pursue this model and in coordination with a similar procedure performed on a single-cell niobium cavity, a mechanically polished two-grain-Nb sample was coated with a 36 nm Al2O3 thin film via thermal atomic layer deposition (ALD) to create an insulating layer and baked for 3h at 300°C (mid-T bake) [2]. An XRR analysis of the sample was taken at each processing step to follow the changes in the niobium native oxide thickness and composition.

[1] A. Gurevich, Appl. Phys. Lett. 88, 012511 (2006) [2] S. Posen, et al., Phys. Rev. Applied 13, 014024 (2020)

O 42.11 Tue 18:00 P2/EG

Oxidation of α-Al_2O_3(0001)-supported Pt-Rh alloy nanoparticles — •Ming-Chao Kao, Simon Chung, Thomas F. Keller, Vedran Vonk, and Andreas Stierle — Deutsches Elektronen-Synchrotron DESY, Center for x-ray and Nanoscience CXNS, Hamburg 22607, Germany

Metal oxide supported platinum-rhodium bimetallic alloy nanoparticles are widely deployed in the field of heterogeneous catalysis, where they often undergo oxidation-reduction cycles. To better understand the oxidation process, we monitored the nanoparticles in-situ by Grazing Incidence X-ray Diffraction (GIXRD) as a function of different alloy compositions. By heteroepitaxial growth, α-Al_2O_3(0001) substrate supported Pt, Rh, and Pt-Rh alloy nanoparticles were grown via molecular beam epitaxy. The samples were characterized by SEM, AFM, XRR, and GIXRD. The aim of this study is to uncover the oxide formation on the NPs as a function of oxygen partial pressure and temperature. The oxidation experiment is performed with an in-situ oxidation chamber, which enables experiments to be carried out up to an oxygen pressure of 1000 mbar at 450°C. From the in-situ XRD experiments performed at constant temperature and increasing oxygen pressure, the following phenomena are deduced: particle sintering, selective oxidation, epitaxial strain, and the formation of Rh_2O_3 bulk oxide on (111)-oriented nanoparticles. Furthermore, composition-dependent changes together with selective oxidation and epitaxial strain were observed.

O 42.12 Tue 18:00 P2/EG

Structural and magnetic properties of epitaxial iron oxide nanoislands on $SrTiO_3$ — •Steffen Tober, Mai H. Hamed, Yifan Xu, Asmaa Qdemat, Connie Bednarski-Meinke, Ulrich Rücker, Oleg Petracic, Emmanuel Kentzinger, and Thomas Brückel — Jülich Centre for Neutron Science (JCNS) and Peter Grünberg Institut (PGI), JARA-FIT, Forschungszentrum Jülich

The chemical, electronic and magnetic properties of Fe_xO_y/oxide substrate heterostructures depend on substrate interactions and the flexible chemistry of the iron oxides, resulting in conductive or insulating, ferri- or antiferromagnetic phases. The reduced geometry of $Fe_{3-\delta}O_4$ nanoislands grown by reactive molecular beam epitaxy enables further tuning of electronic and magnetic properties for applications in catalysts and magnetoelectric devices [1]. We present the structural and magnetic characterisation of $Fe_{3-\delta}O_4$ nanoislands on (001) oriented $SrTiO_3$ with mixed SrO/TiO_2 and stepped TiO_2 surface terminations by reflection high-energy electron diffraction (RHEED), grazing incidence small angle X-ray scattering (GISAXS) and SQUID magnetometry [2,3]. Our findings indicate the growth of crystalline, evenly shaped, ferrimagnetic islands. These results form the basis for further experiments probing the local electronic and magnetic structure of the nanoislands.

[1] Y. Z. Chen et al., J. Appl. Phys. 103, 07D703 (2008), [2] G. E. Sterbinsky et al., J. Vac. Sci. Technol. B 25, 1389 (2007), [3] JCNS, JLSRF, 2, A61 (2016).