O 74: Nanostructures at surfaces: Other

Time: Thursday 15:00–18:00 Location: H34

O 74.1 Thu 15:00 H34

UTAM based Surface Nano-Structuring for Functional Surfaces — •Stefan Ostendorp, Yong Lei, Christian Heckel, and Gerhard Wilde — WWU Münster, Institut für Materialphysik, Wilhel-Klemm-Straße 10, 48149 Münster, Germany

Versatile surface nano-structuring techniques with high throughput and low costs are highly desirable. The UTAM (Ultra-Thin Alumina Membrane) technique is such a method to create highly regular surface structures: nano-pores, nanodots and free-standing one-dimensional nanostructures (wires and tubes). Based on a wet-chemical anodization process of Aluminum, there is in principle no limitation to the patterning-area of the nano-structured surface. We want to present our latest results concerning this UTAM surface nano-structuring technique. Besides porous layer structures and metallic or semiconducting nano-particles and wires, we are able to create surface arrays or 3D-structures of functional molecules. All these structures have in common, that we can adjust their size and spacing within certain limitations by changing the preparation conditions for the UTAM.

Especially some functional molecules were sublimated through and along the pores of UTAMs on different substrates to obtain tubular structures. To determine the properties of these molecules, which have a wide range of possible applications e.g. in the field of opto-electronics, we use different techniques like AFM, SEM, IV-characterization or PL-spectrometry.

O 74.2 Thu 15:15 H34

Generation of Clean Iron Structures by Electron Beam Induced Deposition and Catalytic Decomposition of Iron Pentacarbonyl on Rh(110) — •Michael Schirmer, Thomas Lukasczyk, Hans-Peter Steinrück, and Hubertus Marbach — Lehrstuhl für Physikalische Chemie II and Interdisciplinary Center for Molecular Materials (ICMM), Universität Erlangen-Nürnberg, Egerlandstraße 3, D-91058 Erlangen

The fabrication of nanostructures with arbitrary shape and well defined chemical composition still is a major challenge. Our approach is the electron beam induced deposition (EBID) in which a focused electron beam induces the local decomposition of precursor molecules, resulting in the deposition of non-volatile fragments. Here, we present an EBID study with $Fe(CO)_5$, on clean and modified Rh(110) surfaces. By utilizing an ultra high vacuum (UHV) system, we achieved a very high iron purity of more than 88 %, similar to previous findings on Si(100) [1]. For Rh(110) the process strongly depends on the surface properties: On a perfect, clean Rh(110) surface iron is found on irradiated and non-irradiated surface regions, due to catalytic decomposition of the $Fe(CO)_5$. However, on a structurally non-perfect Rh(110) surface and on a Ti-precovered Rh(110) surface a high selectivity is found, i.e. Fe deposits are formed in irradiated regions only. The role of catalytic and autocatalytic growth of iron is discussed [2]. This work was supported by the DFG under grant MA 4246/1-1. [1] T. Lukasczyk, et al., Small 4(6) (2008) 841. [2] T. Lukasczyk, et al., Langmuir 25(19) (2009) 11930.

O 74.3 Thu 15:30 H34

Local Surface Activation of SiO_x by a Focused Electron Beam as a Means for Nanoscale Lithography — •Florian Vollnhals, Marie-Madeleine Walz, Michael Schirmer, Thomas Lukasczyk, Hans-Peter Steinrück, and Hubertus Marbach — Lehrstuhl für Physikalische Chemie II and Interdisciplinary Center for Molecular Materials (ICMM), Friedrich-Alexander- University Erlangen-Nuremberg, Egerlandstr. 3, 91058 Erlangen

The fabrication of arbitrarily shaped nanostructures is of key interest for industrial applications as well as for scientific research. Suitable fabrication techniques include resist-based and resist-free techniques, e.g. electron beam induced deposition (EBID).

In EBID, a precursor gas adsorbs on a substrate and is decomposed locally by a focused electron beam. Non-volatile fragments then form a deposit on the surface. It was shown that this process can yield almost pure Fe deposits (95%) from $Fe(CO)_5$ under UHV conditions [1].

Our recent results expand the EBID concept. If the focused electron beam is used to locally irradiate a thin (300nm, commercial) or an ultra thin (few nm) SiO_x layer on Si(100) without offering any precursor gas, the exposed areas can later be "developed" by dosing $Fe(CO)_5$. The resulting formation of Fe deposits is attributed to electron induced activation of the surface and enhanced by autocatalytic growth of iron in the presence of $Fe(CO)_5$.

This work was supported by the DFG through grant MA 4246/1-1. [1] T. Lukasczyk et al., Small, 4 (6) (2008) 841

O 74.4 Thu 15:45 H34

Surface Nano-Patterning in Realizing Diverse Functional Surface Nanostructures with High Structural Regularity — •Yong Lei, Stefan Ostendorp, Nina Winkler, Peter Hess, Christian Heckel, and Gerhard Wilde — Institute of Materials Physics and Center for Nanotechnology, University of Muenster, Wilhelm-Klemm-Str. 10, D-48149 Muenster, Germany

Here we want to show you the results in our group concerning the surface nano-structuring using UTAM (ultra-thin alumina mask) surface nano-patterning technique. UTAM technique is an emerging approach in fabricating ordered arrays of different surface nanostructures. Besides nanodots and nanoholes, three-dimensional surface nano-patterns (mainly free-standing one-dimensional nanostructures of metals and semiconductors) can be prepared using electrochemical processes and CVD processes. Moreover, functional molecular surface patterns are realized based on the UTAM-prepared pre-patterns on substrates. The structural parameters (size, spacing, and shape) of all these UTAM-fabricated surface nanostructures can be adjusted by controlling the structural parameters of the UTAMs, which consequently results in the tenable properties of the UTAM-synthesized surface patterns. Different applications in optical, sensing, and electronic devices will be presented based on the advantageous features of the UTAM surface patterning technique, including the tuneable structural parameters and properties, large pattern area and high throughput of surface nanostructures, and low equipment costs.

O 74.5 Thu 16:00 H34

Magnetotransport in anisotropic Pb-films and monolayers — •Daniel Lükermann, Christoph Tegenkamp, and Herbert Pfnür — Uni Hannover, Inst. für Festkörperphysik, Abt. ATMOS

Pb chain structures with strong anisotropic conductance are formed by adsorption of Pb monolayers (ML) on Si(557). In the case of 1.3 ML, even 1D transport is found along the wire's direction. The perpendicular direction shows localization due to perfect Fermi nesting for the (223) facet orientation. Above 78 K thermal activation annihilates this phase and a refactting transition switches the system back into an anisotropic transport regime.

In order to learn more about the scattering mechanisms magnetotransport measurements have been performed and analysed using the fromalism by Hikami, which allows to deduce inelastic(τ_i), elastic (τ_0) and spin–orbit (τ_{so}) scattering times . While for multilayers weak localization, i.e. increase of the resistance by contructive interference of elastically backscattered electrons, has been found, the ML phases show weak anti localization. Contrary to the Pb multilayers, spin-orbit coupling is essential for the ML phases. The anisotropy seen by conductivity measurements is nicely reflected by elastic and spin–orbit scattering rates. Interestingly, for 1.3 ML, a strong increase by three orders of magnitude in τ_{so} is seen in the parallel direction. As judged from ARPES one of the two split-off bands is nested by the modulation of the wires, while the other crosses the Fermi energy, responsible for the high conductance. This would suggest that spin-flip processes are strongly suppressed, in agreement with the magnetotransport data.

O 74.6 Thu 16:15 H34

Studies of Growth of Epicuticular Wax (nonacosan-10-ol) on Model Surfaces by Atomic Force Microscopy (MAC mode) — •Sujit Kumar Dora[1], Adrian Niemietz[2], Kerstin Koch[2], Wilhelm Barthlott[2], and Klaus Wandelt[1] — [1]Institute for Physical and Theoretical Chemistry, University of Bonn, Germany. — [2]Nees Institute for Biodiversity of Plants , University of Bonn, Germany.

Plant surfaces are often covered by crystalline self-assembled waxes forming hydrophobic microstructured surfaces. Out of the vast variety of wax morphologies found on plant surfaces, nonacosan-10-ol wax tubules are considered as one of the most important type, found on the leaf surface of lotus (Nelumbo nucifera) and are responsible for the fa-

mous self-cleaning phenomena known as "Lotus-effect". The formation of a hydrophobic nanostructure of nonacosanol tubules on lotus leaves is responsible for its superhydrophobicity. In this contribution we describe and discuss the results of the effect of various factors e.g., concentration, presence of water, salt etc. on the growth of wax tubules on various model substrates like HOPG, Mica, Glassy Carbon and Glass as obtained by atomic force microscopy (MAC mode). The rate of tubule formation is faster on nonpolar substrates e.g., HOPG, Glassy Carbon in comparison to polar substrates e.g., Mica, Glass. Only on HOPG tubules were standing perpendicular to the substrate surface. Whereas water considerably increases the growth rate, salts and different concentrations have no effect on growth. In our investigation we developed a systematic approach to understand the different factors affecting the growth of nonacosanol tubules on model substrates.

O 74.7 Thu 16:30 H34

Spatially modulated differential conductance in nm narrow Cu channels between and on Co islands — •Safia Ouazi, Yasmine Nahas, Marco Corbetta, Hirofumi Oka, Dirk Sander, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle (Saale), Germany

Electron scattering off step edges and due to confinement in nanostructures leads to interference effects which induce a spatially modulated local density of states [1]. We measure maps of the differential conductance dI/dV on Cu(111) in a 7 nm narrow channel between Co islands by scanning tunneling microscopy and spectroscopy at 8 K. We observe a spatially modulated dI/dV signal in the channel, and also on the adjacent Co islands. We extract the energy and position dependence of the modulation pattern. The electron energy dispersion is discrete in the wave vector k. Our results are well described by a quantization rule for k, which identifies the channel width and the island height as the decisive length scales. The role of structural relaxation and electronic rim states for electron confinement in channels and islands is discussed.

O 74.8 Thu 16:45 H34

Contrast inversion of the h-BN nanomesh on Rh(111) investigated by nc-AFM and KPFM — •Markus Langer[1], Sascha Koch[1], Shigeki Kawai[1], Bartosz Such[1], Jorge Lobo-Checa[3], Thomas Brugger[2], Thomas Greber[2], Juerg Osterwalder[2], Ernst Meyer[1], and Thilo Glatzel[1] — [1]Department of Physics, University of Basel, Klingelbergstr. 82, 4056 Basel, Switzerland — [2]Physik-Institut, Universität Zürich, Winterthurerstrasse 190, 8057 Zürich, Switzerland — [3]Centre d'Investigaci'o en Nanoci'encia i Nanotecnologia, CIN2 (CSIC-ICN), Esfera UAB, Campus de Bellaterra, 08193-Barcelona, Spain

Boron-Nitride forms a highly regular, hexagonal, corrugated monolayer (h-BN nanomesh) on a Rhodium(111) substrate [1,2]. High resolution measurements by non contact atomic force microscopy (nc-AFM) as well as the analysis of the electronic structure by Kelvin probe force microscopy (KPFM) will be shown. A contrast inversion of the topography and the local contact potential difference was observed frequently and will be discussed. Two possible scenarios based on a local deformation of the tip apex or of the nanomesh will be presented and are compared to existing theoretical and experimental work.

[1] S. Berner et al., Angewandte Chemie, Int. Edition 46, 5115 (2007).

[2] R. Laskowski et al., Phys. Rev. Lett. 98, 106802 (2007).

O 74.9 Thu 17:00 H34

Transport properties of single atom and single molecule junctions — •Guillaume Schull — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, D-24098 Kiel, Germany — Institut de Physique et de Chimie de Strasbourg, Université Louis Pasteur, CNRS UMR 7504, 67034 Strasbourg, France.

The study of the current passing through single atoms or molecules has revealed fascinating phenomena such as the observation of a quantization of the conductance or a reduction of the shot noise at single atom contacts... A next step is to determine how transport properties of atoms and molecules are influenced by the contacts geometry. We used a scanning tunneling microscope (STM) which provides a way to precisely localize and characterize the structures of interest before probing their transport properties. First, I will focus on the transport properties of single C60 molecules and show how atomic scale variations of the molecule-metal interfaces influence the junction conductance. Using a STM tip with a C60 attached at the apex, the transport properties of a suspended chain made of two C60 have been probed. Here, the molecule-molecule interface is revealed to be the limiting factor to the contact conductance. Finally, I will show that specific inelastic contributions to the current (under tunnelling and contact conditions) can be probed by studying the light emitted at the STM junction.

These works were performed in collaboration with Thomas Frederiksen, Michael Becker, Nicolas Néel, Peter Johansson, Mads Brandbyge and Richard Berndt.

O 74.10 Thu 17:15 H34

Excitonic luminescence of pentacene nanocrystals induced by STM — •Klaus Kuhnke[1], Alexander Kabakchiev[1], Theresa Lutz[1], and Klaus Kern[1,2] — [1]Max-Planck Institut für Festkörperforschung, D-70569 Stuttgart — [2]Institut de physique de la matiere condensee, EPFL, CH-1015 Lausanne

The local injection of charge carriers by scanning tunneling microscopy (STM) can be employed to excite luminescence from nanostructures. We study the luminescene of pentacene nanocrystals grown on a thin insulating KCl layer on different metals. The observed electroluminescence spectrum at liquid He temperature exhibits up to 3 features and is dominated by the emission of the self-trapped singlet exciton at 1.60 eV. It compares well to low temperature spectra reported for photoluminescence on macroscopic single crystals. We find the onset bias of light emission at 1.8 eV - close to the energy of the free exciton and still below the transport gap in bulk pentacene. The charge injection conditions for luminescence involve a high electric field between STM tip and metallic substrate. The field results in a Stark shift of the dominating emission line of about 20meV. This strong shift may indicate a charge-transfer (CT) contribution to the Frenkel exciton.

O 74.11 Thu 17:30 H34

Theoretical investigation of the switching mechanism in a single-molecule memory unit — •Felix Hanke and Mats Persson — University of Liverpool, Liverpool, United Kingdom

The storage and retrieval of information at the sub-nanometer scale is one of the outstanding challenges in nanoelectronics. It was recently proposed that the molecular switch naphthalocyanine can be controlled using scanning-tunneling microscopy (STM) [1] when it is adsorbed on a thin layer of NaCl. The on/off state of naphthalocyanine is determined by the orientation of two central hydrogen atoms, which changes with the application of a high STM voltage, while a low voltage allows to read out the molecular state. Despite the wealth of available experimental information, the electronic processes responsible for the STM-induced configurational changes in naphthalocyanine are poorly understood theoretically. This project aims to explain the switching property based on density functional theory. From the adsorption geometry on the NaCl surface, the reaction path for the switching pathway is computed. This result leads to a detailed investigation of the molecular orbitals responsible for the tunneling-induced motion of the central hydrogen atoms. In particular, the evolution of the lowest two unoccupied and nearly degenerate molecular orbitals is shown to be an important piece in the puzzle. Finally, a model is developed to take into account the electron-induced motion of naphthalocyanine along its switching pathway. - [1] P. Liljeroth *et al.*, Science **317**, 1203 (2007)

O 74.12 Thu 17:45 H34

Nanocones and Nanowires Analysed with Scanning Auger Microscopy. — •Andrey Lyapin[1], Stefan Reichlmaier[1], Denis Paul[2], John Hammond[2], and Sakar Raman[2] — [1]Physical Electronics GmbH, Ismaning, Germany — [2]Physical Electronics, Chanhassen, USA

The increased interest in nanotechnological material, such as nanocone, nanorods and nanowires, has pushed the development of analytical techniques to determine the growth mechanisms of these nanostructures. Scanning electron beam techniques, including Scanning Auger Microscopy, have provided valuable imaging and elemental characterization tools for these structures with a spatial resolution better than 10 nm. Using the combination of high energy resolution chemical state spectroscopy and imaging of the Scanning Auger Microscopy allows to obtain quantitative elemental results on the different parts of the nanocone and nanowire as well as the imaging of different chemical states and depth profiling. In this talk we present results of the Auger analysis of the nanocones and nanowires which provide further insights into the growth mechanisms of these nanostructures.