

O 33: Nanostructures at Surfaces III

Time: Tuesday 10:30–12:45

Location: H45

O 33.1 Tue 10:30 H45

Surface modification on ultra-thin sheets of molybdenum disulfide due to irradiation with highly charged ions — JOHANNES HOPSTER, •ROLAND KOZUBEK, JAKOB KRÄMER, and MARIKA SCHLEBERGER — Universität Duisburg-Essen, Duisburg, Deutschland

This presentation deals with the interaction of highly charged ions with single layer molybdenum disulfide. For this purpose MoS₂ was exfoliated on a (100)-Potassium bromide crystal and afterwards irradiated with xenon ions. Xe³⁵⁺ and Xe⁴⁰⁺ were used while the kinetic part of the energy was kept constant. By means of atomic force microscopy, pits and hillocks could be identified. The creation of hillocks was observed for both charge states and for different thicknesses of the MoS₂ layers, while their height and diameter depend on these aforementioned values. The different illustration of the defects obtained in trace and retrace scan direction in contact mode lead us to believe, that at this positions an enhanced friction exists, while the information of the topography arises from the tapping mode measurements.

The creation of pits could only be observed on single layer MoS₂ after the irradiation with Xe⁴⁰⁺. Because of the fact that the ion induced defects on KBr are quiet similar to the detected ones we deduce that these pits are formed underneath the single layer in the substrate. As a consequence, the MoS₂-Layer at this position could also be damaged and demolished.

O 33.2 Tue 10:45 H45

Novel approach to the fabrication of mixed monomolecular films and chemical patterns — •M NURUZZAMAN KHAN and MICHAEL ZHARNIKOV — Angewandte Physikalische Chemie, Universität Heidelberg, 69120 Heidelberg, Germany

Self-assembled monolayers (SAMs) provide a convenient and flexible means to control surface properties by covering surfaces with chemically uniform and densely packed monomolecular films. A versatile approach to prepare mixed SAMs and SAM-based chemical patterns on coinage metal substrates is irradiation promoted exchange reaction (IPER). The key idea of this approach is tuning the extent of the exchange reaction between a SAM covering the substrate and a potential molecular substituent by electron irradiation. As such substituents, different thiols are usually used. Here we show that not only thiols but also disulfides can serve as substituents in IPER, which extends significantly the possibilities of this approach, making it suitable for another class of commercially available compounds. Using several model disulfide compounds, we studied the outcome and kinetics of IPER in this particular case and compared them with the analogous performance of thiols. Additionally, the approach was combined with electron beam lithography and applied to the fabrication of chemical patterns which were amplified in the z-direction by surface initiated atom transfer radical polymerization.

O 33.3 Tue 11:00 H45

On the interaction of ultrathin porphyrin layers with high energy electrons — •FLORIAN VOLLNHALS, PATRICK WINTRICH, MARIE-MADELEINE WALZ, 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 interaction of energetic electrons with matter is of general interest for many fields in science and technology. In this contribution we investigate the effect of electron irradiation on monolayer and multilayer films of porphyrin derivatives adsorbed on a Ag(111) single crystal using Scanning Tunneling Microscopy (STM) and Scanning Electron Microscopy (SEM) in ultra-high vacuum (UHV). We find that the corresponding electron induced defects first of all depend on the thickness of the organic film and secondly can be used for further development to fabricate metallic nanostructures. The observed effect is closely related to the novel Electron Beam Induced Surface Activation (EBISA) technique recently explored by our group. In EBISA, an oxide surface, e.g. SiO₂, is irradiated by a focused electron beam, resulting in the chemical activation of the area, such that successively dosed Fe(CO)₅ is decomposed and forms an iron deposit. Further autocatalytic growth results in pure (>90%at.) crystalline iron nanostructures.^[1] In this contribution we expand this concept to porphyrin layers on Ag(111) as a novel means to fabricate complex nanostructures with lithographic

control. This work was supported by the DFG via grant MA 4246/1-1.
^[1] M.-M. Walz et al., *Angew. Chem. Int. Ed.* 49 (2010), 4669

O 33.4 Tue 11:15 H45

Interlayer formation of Diamond-Like Carbon Coatings on Polyethylene Plastic Material — •CHRISTIAN B. FISCHER¹,

MAGDALENA ROHRBECK¹, STEFAN WEHNER¹, MATTHIAS RICHTER², MATTHIAS STÄDTER², and DIETER SCHMEISSER² — ¹Department of Physics, University Koblenz-Landau, 56070 Koblenz, Germany — ²Department of Applied Physics and Sensors, Brandenburg University of Technology, 03046 Cottbus, Germany

The coating of materials with diamond-like carbon (DLC) is a very common way to further improve and modify surface specific properties. Although DLC is frequently used as a protective coating on several substrates, the chemical and physical properties throughout the coating process on plastics are yet sparsely investigated. Different layer thicknesses of two types of protective coatings one sp³-enriched (robust, r-type) and one with more sp²-centers (flexible, f-type) have been realized on polyethylene by PECVD. Microscopic analysis showed diverse surface topographies for the two DLC-types. NEXAFS spectroscopy revealed significant details of carbon centers in chemically different neighborhood displaying a characteristic fingerprint behavior. The appropriate explanation for the current carbon deposition process is obviously the formation of an interlayer between these unequal materials. An improved understanding of hard DLC and soft polyethylene assembly is part of the present work.

O 33.5 Tue 11:30 H45

A new route for the electroless fabrication of mesoporous silicon — •XIAOPENG LI^{1,2}, STEFAN L. SCHWEIZER², ALEXANDER SPRAFKE², and RALF B. WEHRSPÖHN^{2,3} — ¹Max-Planck Institute of Microstructure Physics, Halle D-06120, Germany — ²Martin-Luther-University Halle-Wittenberg, Germany — ³Fraunhofer Institute for Mechanics of Materials, Halle D-06120, Germany

Recently, mesoporous silicon (meso-PSi) has demonstrated considerable potential for bio-medical applications regarding biocompatibility and biodegradability, due to its large internal surface area and its mechanical stability. In photovoltaics, meso-PSi has been utilized for antireflective layers, and as sacrificial layers for layer-transfer processes. Until now, electrochemical etching (ECE) is considered as the only method to achieve controlled fabrication of meso-PSi. However, ECE is cost-inefficient on full wafer-scale, additionally, its process stability for high-throughput, in-line processes is critical on wafer-scale. Here, we present a new route for the fabrication of meso-PSi using Pt nanoparticle-assisted chemical etching (PaCE) without applying any external potential. Si wafers were firstly loaded with Pt nanoparticles (PtNPs), and then immersed in solution containing HF and H₂O₂. PtNPs drill nanopores deep into the Si substrate; meanwhile, meso-PSi is created. The obtained mesoporous silicon films show surprisingly good uniformity in which the porosity and thickness can be tuned well via adjusting the etching conditions. To qualitatively explain the observed phenomenon, we propose a new model based on the Pt-Si nano-Schottky contact.

O 33.6 Tue 11:45 H45

Emission cone narrowing of electrons in the strong field around a sharp metallic nanotip — DOOJAE PARK, BJÖRN

PIGLOSIEWICZ, SŁAWA SCHMIDT, •PETRA GROSS, and CHRISTOPH LIENAU — Ultraschnelle Nano-Optik, Institut für Physik, Universität Oldenburg, 26111 Oldenburg

When sharp, nanometer-sized metal tips are irradiated with few-cycle near-infrared laser pulses with around 1.6 μm center wavelength and few nJ energy, the strong laser field around the tip apex enables tunneling of electrons out of the tip. At these conditions, we find a pronounced strong-field acceleration of the electrons within the field gradient near the tip apex, and we observe a distinct narrowing of the emission cone angle of the fastest electrons.

We investigate the electron motion in the strong field around the nanostructure by recording angle-resolved kinetic energy spectra and using numerical simulations incorporating the curved, vectorial gradient of the oscillating laser field [1]. These studies show that the emission cone narrowing of the fastest electrons can be ascribed to the

field-induced steering of sub-cycle electrons, which escape the tip's near field within half an oscillation of the laser pulse. Our results indicate new possibilities for designing directional ultrafast electron sources.

[1] D. J. Park *et al.*, Phys. Rev. Lett., in press (2012)

O 33.7 Tue 12:00 H45

Electron motion in few-cycle laser field around metallic nanostructures — BJÖRN PIGLOSIEWICZ, SLAWA SCHMIDT, DOOJAE PARK, JAN VOGELSANG, •PETRA GROSS, and CHRISTOPH LIENAU — Ultraschnelle Nano-Optik, Institut für Physik, Universität Oldenburg, 26111 Oldenburg

Sharp metallic nanotips irradiated with few-cycle laser pulses are promising candidates as sources of highly confined electron wavepackets of short temporal duration and high spatial directivity. Specifically the strong-field regime, where electron emission by tunneling becomes dominant over multi-photon and above-threshold ionization, enables the generation of (sub-)femtosecond electron wavepackets. For sufficiently long wavelengths and short pulses, electrons are accelerated to escape the near field within one half-cycle of the laser oscillation [1,2].

Here, we study for the first time the effect of the carrier envelope phase of few cycle laser pulses on the motion of electrons emitted from metallic nanostructures by strong-field tunneling. Sharp gold tips are illuminated with CEP-stable few-cycle near-IR pulses at $1.5 \mu\text{m}$ and the kinetic energy spectra of the emitted electrons are recorded. We observe pronounced modifications of the photoelectron spectra when varying the CEP phase. Our results, explained within a modified Simpleman model, shed new light on the light-driven motion of electrons in the near field of metallic nanostructures on sub-femtosecond time scales.

[1] G. Herink *et al.*, Nature **483**, 190 [2012]

[2] D. J. Park *et al.*, Phys. Rev. Lett., in press (2012)

O 33.8 Tue 12:15 H45

DNA-Modulated Heterogeneous Nucleation and Growth of Functional Silver Nanoparticles on AgCl Particle Surface — •GUOQING WANG¹, HIDEYUKI MITOMO², YASUTAKA MATSUO^{2,3}, KENICHI NIKURA^{2,3}, and KUNIHARU IJIRO^{2,3} — ¹Graduate School of Chemical Sciences and Engineering, Hokkaido University, N13W8, Sapporo 060-8628, Japan — ²Research Institute for Electronic Science, Hokkaido University, N21W10, Sapporo 001-0021, Japan — ³JST-CREST, Sanban-cho 5, Chiyoda-Ku, Tokyo 102-0075, Japan

Photocovernsion of AgX (X = Cl, Br, I) to functional silver nanoparticle (AgNPs) is of both scientific curiosity and technological importance. Here we show that AgCl can be photoconverted to AgNPs within minutes via photoreduction in the presence of DNA. Our mechanistic studies reveal that the heterogeneous nucleation and growth of AgNPs on AgCl correlates well with the thermodynamic explanation in terms of a reduced interfacial energy barrier, and DNA serving as a template plays an essential role in controlling the morphology and size of the AgNPs. The resultant AgNPs are observed to be biofunctionalized, and exhibit photostable luminescence and DNA-specific surface-enhance Raman scattering (SERS) signature, allowing for DNA-directed recognition and dual-modal cell imaging. Furthermore, DNA-encapsulated Ag/AgCl nanostructures can be obtained through a short-term photoreduction. Their uses in plasmonic photocatalysis are demonstrated.

O 33.9 Tue 12:30 H45

Scanning probe microscopy and spectroscopy of nanodiamonds under illumination. — •RÉMY PAWLAK¹, THILO GLATZEL¹, SHIGEKI KAWAI¹, SWEETLANA FREMY¹, LOÏC SCHMIDLIN², VINCENT PICHOT², DENIS SPIETZEL², and ERNST MEYER¹ — ¹Department of Physics, University of Basel, Klingelbergstrasse 82, 4056 Basel, Switzerland. — ²Nanomatériaux pour des Systèmes Sous Sollicitations Extrêmes (NS3E) UMR 3208 ISL/CNRS Institut franco-allemand de recherches de Saint-Louis (ISL), 5 rue du Général Cassagnou, 68300 Saint-Louis, France.

Nanodiamonds (ND) are carbon particles with size from 2 to few tens of nanometers which already have broad applications in polishing materials, lubricants as well as applications in biomedical imaging. More recently, the accurate control of the doping of the nanodiamond structure with atomic defects, such as Nitrogen-Vacancy centers (NV-1), having optical and spin properties gives to this material an exceptional candidate for photonic devices and quantum information processing and computing. Here, we combine scanning probe microscopy imaging and spectroscopy to investigate at the atomic scale single nanodiamonds/HOPG. Under illumination with wavelengths of 400 nm and 470 nm, a modulation of the electronic band gap as well as the contact potential difference (CPD) between tip and sample is observed compared to the dark condition, whereas no relevant variation is obtained for wavelengths superior to 590 nm. This effect is a direct evidence of the light-induced charges arising from the NV centers of nanodiamonds.