O 73: Nanostructures at Surfaces: Metals, Oxides and Semiconductors III

Time: Wednesday 10:30–13:00 Location: REC/PHY C213

O 73.1 Wed 10:30 REC/PHY C213

Formation of GaP rotational twins at the interface to Si(111) — •Lars Winterfeld, Christian Koppka, Thomas Hannappel, and Erich Runge — Institut für Physik, Technische Universität Ilmenau, 98693 Ilmenau, Germany

We present DFT and Kinetic Monte Carlo results concerning the formation of rotational twins domains (RTDs) of GaP on Si(111). Gallium phosphate is used as a buffer layer on silicon for the growth of III-V nanowires (NWs) on top. Here, (111)-oriented substrates are commonly used, as NWs preferably grow in [111] direction and NWs vertical to the substrate are advantageous for most device architectures. Heteroepitaxial layer growth on Si(111), however, is almost always accompanied by the occurrence of RTDs, which is a crystal defect having detrimental effects on NW growth and therefore on optoelectronical properties. Recently, Koppka et al.[1] could experimentally show that adjusting the growth conditions (temperature, V/III ratio, miscut angle of the substrate, etc.) can tremendously suppress the formation of RTDs to less than 5 vol%. In this talk, we aim for an ab initio understanding of the underlying atomic mechanisms.

[1] C. Koppka et al., Crystal Growth & Design 2016 (doi: 10.1021/acs.cgd.6b00541).

O 73.2 Wed 10:45 REC/PHY C213

Glancing Angle Deposited Silver Nanostructures for Surface Enhanced Raman Scattering Based Sensors — •Christoph Grüner[1], Sachin K. Srivastava[2], Atef Shalabney[2], Ibrahim Abdulhalim[2], Mousa Abu Tier[3], and Bernd Rauschenbach[1,4] — [1]Leibniz Institute of Surface Modification, Permoserstraße 15, 04318 Leipzig, Germany — [2]Department of Electro Optic Engineering, Ben Gurion University of the Negev, Beer Sheva-84105, Israel — [3]Physics Department, Al-Quds University, Jerusalem, Palestine — [4]University Leipzig, Institute of Experimental Physics II, Linnéstr. 5, 04103 Leipzig

Fast and certain determination and quantification of environmental toxics or human blood constituents is of great interest today. Such applications require highly sensitive and specific sensors for biological agents. Self-assembled nanostructure arrays can serve as such sensors. A simple and elegant method to produce these kind of structures is Glancing Angle Deposition (GLAD). This is a physical vapor deposition process, which utilizes the self-shadowing effect that appears at highly oblique particle incidence angles. Thereby, a highly porous films consisting of thin, separated nanostructures is created. The large surface area of these films opens the opportunity to fabricate Surface Enhanced Raman Scattering (SERS) based sensors. This study is focused on growth, surface functionalization and optimization of nanostructured thin silver GLAD films on the examples of highly specific sensors for endocrine disruptors and glycated hemoglobin.

O 73.3 Wed 11:00 REC/PHY C213

Direct visualization of oxidation and reduction of FeO/Au(111) studied by time-resolved STM — •Yijia Li and Jeppe Lauritsen — Gustav Wieds Vej 14, 8000 Aarhus C

Iron oxide (FeO) is of significant interest due to its catalytical reactivity in several reactions such as CO oxidation and water-gas shift reaction, and as precursors for the formation of Fe-based Fischer Tropsch catalysts. The nature and the reaction mechanism of the active sites are fundamental questions to heterogeneous catalysis. Therefore, scanning tunneling microscopy (STM) which is capable to identify the active sites at atomic scale level is employed. Here we studied the oxidation and reduction of FeO islands on Au(111) by oxygen and hydrogen using in-situ STM measurements. It is found that the edges of FeO islands play an essential role for incorporating additional oxygen atoms and O adatoms form triangular bright features assigned to adatom defect loops. The excess O atoms are in different coordination with lattice O atoms and can be removed by molecular hydrogen dosing. On the other hand, upon hydrogen exposures FeO islands are reduced with hydroxyls formed initially on the surface and vacancy defect loops created later on. These vacancy defects can be refilled by oxygen dosing. The reversible appearance of FeO islands depending on whether it is in oxidizing or reducing atmosphere are observed dynamically by time-resolved STM movies and help to distinguish the active sites in redox reactions.

O 73.4 Wed 11:15 REC/PHY C213

On the autocatalytic growth and magnetic properties of Fe nanostructures fabricated via focused electron beam induced processing — •Fan Tu, Martin Drost, Florian Vollnhals, Esther Carrasco, Andreas Späth, Rainer Fink, and Hubertus Marbach — Lehrstuhl für Physikalische Chemie II, Universität Erlangen-Nürnberg, Egerlandstr. 3, D-91058, Erlangen, Germany

Electron beam induced deposition (EBID) was used in combination with autocatalytic growth (AG) processes to lithographically fabricate high purity (> 95%) Fe deposits from the precursor iron-pentacarbonyl in our UHV system [1-3]. In this paper correspondingly fabricated EBID-Fe deposits were investigated in detail by high resolution transmission electron microscopy (HRTEM) and scanning transmission X-ray microscopy (STXM). STXM operated in X-ray magnetic circular dicroism mode at the PoILux beamline (Swiss Light Source) allows in addition to the microscopic insights for a detailed magnetic characterization of the Fe structures depending on their actual shape [3]. We report on the thickness and lateral dimension dependent magnetic coercivity, the chemical nature and the atomic order of the Fe deposits.

This work was funded by the DFG through grant MA 4246/1-2, research unit FOR 1878/funCOS; and the Excellence Cluster Engineering of Advanced Materials granted to the FAU Erlangen-Nürnberg.

[1] T. Lukasczyk, et al., Small, 4 (2008) 841.
[2] H. Marbach, Appl. Phys. A., 117 (2014) 987.
[3] F. Tu, et al., Nanotechnology, 27 (2016) 355302.

O 73.5 Wed 11:30 REC/PHY C213

Nanostructured metallic films grown by glancing angle deposition on non-patterned substrates — •Susann Liedtke, Christoph Grüner, and Bernd Rauschenbach — Leibniz Institute of Surface Modification, Permoserstraße 15, 04318 Leipzig, Germany

Glancing angle deposition (GLAD) represents a simple and elegant method to fabricate nanostructured thin films. GLAD combines an oblique angle between incoming particle flux and substrates normal as well as substrate rotation to sculpture nanostructure morphology. On the one hand, the presentation addresses general underlying growth principles of such nanostructured films, for example the nucleation process, self-shadowing and competitive growth. On the other hand, the role of surface diffusion on the morphology of Al-, Ti-, Cr- and Mo-nanostructures grown on unstructured Si(100) substrates at room temperature is discussed. In fact, the selection of these metals covers a wide range of melting points from Al (660 °C) to Mo (2617 °C). Since melting point and surface diffusion are connected, a comparison between those metallic nanostructures reveals possible reasons for the significant differences obtained in growth behavior. The nanostructures are investigated by scanning electron microscopy and x-ray diffraction measurements.

O 73.6 Wed 11:45 REC/PHY C213

Grazing Incidence Small-Angle X-Ray Scattering on Small Sample Volumes Using Large Beams — •Mika Pflüger[1], Victor Soltwisch[1], Jürgen Probst[2], Frank Scholze[1], and Michael Krumrey[1] — [1]Physikalisch-Technische Bundesanstalt, Abbestraße 2-12, 10587 Berlin, Germany — [2]Helmholtz-Zentrum Berlin, Albert-Einstein-Straße 15, 12489 Berlin, Germany

Grazing Incidence Small-Angle X-Ray Scattering (GISAXS) is a versatile tool for the contactless and destruction-free investigation of nanostructured surfaces. However, due to the shallow incident angles used in GISAXS, the spotsize of X-ray beams on the sample is significantly elongated compared to the beam height. Traditionally, this has limited GISAXS measurements to long (several mm) samples. We will present GISAXS measurements of lamellar gratings in Si, with line lengths down to 4 μm. First, we present measurements of single grating targets on an otherwise empty substrate. Using a modified reciprocal-space construction of the intersection of the Ewald sphere with the grating we are able to quantitatively describe the recorded scattering patterns.

For most applications, such as metrological fields in semiconductor manufacturing, target structures are not completely isolated on the sample. We demonstrate that the scattering from the μm sized targets can be separated in reciprocal space from the scattering of the surrounding structures. The possibility to measure very small targets opens GISAXS for new applications in nanoscience and industry.

O 73.7 Wed 12:00 REC/PHY C213

The bismuth bilayer on Bi2Se3(0001) prepared by atomic hydrogen etching studied by scanning tunneling microscopy — •Vasilii Sevriuk[1], Holger Meyerheim[1], Arthur Ernst[1], Mikhail Otrokov[2], Dirk Sander[1], and Evgueni Chulkov[2] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany — [2]Donostia International Physics Center (DIPC), 20018 Donostia-San Sebastian, Spain

Scanning tunneling microscopy (STM) and spectroscopy (STS) has been used to study a Bi bilayer (BL) on Bi2Se3(0001) prepared by atomic hydrogen etching of the Bi2Se3 substrate. This Bi BL has been previously characterized by surface x-ray diffraction [1]. STM images show predominantly an atomically flat surface of the Bi BL, which almost fully covers Bi2Se3. Ten percent of the surface area are covered by depressions, and protrusions are observed on 5% of the surface. The depressions are 0.4 nm deep, and this corresponds to the thickness of the Bi BL. The lateral size of the depressions is from 5 to 10 nm. There are mainly two types of the protrusions with heights of 0.35 and 0.08 nm. We ascribe this to a second Bi BL and to Se atoms on the Bi BL surface, respectively. STS spectra shows a signature of the surface Dirac cone in the electronic structure of the Bi BL/Bi2Se3 structure at -0.2 V sample bias. STS maps reveal the presence of surface areas with different electronic structures. We analyze this data with the help of the first principles calculations.

O 73.8 Wed 12:15 REC/PHY C213

Donor-acceptor-donor molecules for on-surface polymerization — •Dmitry Skidin[1], Frank Eisenhut[1], Justus Krüger[1], Tim Erdmann[2,3], Anton Kiriy[2,3], Brigitte Voit[2,3], Francesca Moresco[1,2], and Gianaurelio Cuniberti[1,2] — [1]Institute for Materials Science and Max Bergmann Center of Biomaterials, TU Dresden, 01062 Dresden, Germany — [2]Center for Advancing Electronics Dresden, TU Dresden, 01062 Dresden, Germany — [3]Leibniz-Institut für Polymerforschung Dresden e. V., 01069 Dresden, Germany

One of the main tasks of the modern molecular electronics is the formation of supramolecular functional units for the circuitry at nanoscale. In this regard flexible molecular wires with finite band gap and high conductivity are of essential importance. Therefore, the molecules with alternating donor and acceptor units are perspective precursors for the formation of such wires. [1]

We employ conjugated diketopyrrolopyrrole-based molecules of the donor-acceptor-donor type to grow organic polymers on the surface. After the deposition of individual brominated monomers on Au(111) surface the sample is annealed to promote polymerization via Ullmann coupling. Structural and electronic properties of the stabilized molecular wires can be studied using low-temperature scanning tunneling microscopy and spectroscopy. STM lifting experiments are performed to investigate the conductance of the wires.

References:
1. C. Nacci, F. Ample, D. Bleger, S. Hecht, C. Joachim and L. Grill, Nat. Commun., 2015, 6, 7397.

O 73.9 Wed 12:30 REC/PHY C213

Formation of CuO_2 chains embedded into the Ir(100) surface — •Lutz Hammer[1], Pascal Ferstl[1], Alexander Schneider[1], Florian Mittendorfer[2], and Josef Redinger[2] — [1]Solid State Physics, FAU Erlangen-Nürnberg — [2]Applied Physics, TU Wien

We have investigated the oxidation of submonolayer deposits of copper on an Ir(100) surface by means of STM, quantitative LEED and DFT. Postoxidation of Cu deposits of 0.25 ML or less at temperatures around 800 K leads to the formation of regularly spaced, monatomic wires of twofold oxygen-coordinated Cu atoms. The Cu wires substitute Ir rows of the (100) terraces but are laterally shifted by half a surface unit vector with respect to the Ir positions and lifted up by 0.3 Å for steric reasons. They are flanked at both sides by rows of oxygen atoms being coordinated to one Cu and two Ir atoms each. Between the Cu oxide wires the Ir(100)2×1-O superstructure develops in narrow stripes leading to a combined surface periodicity of $n \times 2$ (or c($2n \times 2$)) with n = 4, 5, 6 ... depending on the initial Cu coverage. CuO_2 chains closer than fourfold Ir distance are not found which points towards a stabilization of the structure by the intermediate 2×1-O phase. Structural parameters derived from a LEED intensity analysis ($R_P = 0.09$) of the most dense phase (n = 4) coincide within a few picometers with the predictions of corresponding DFT model calculations.

O 73.10 Wed 12:45 REC/PHY C213

Formation of dendritic and point-like silicon-oxide clusters during Chemical Vapor Deposition growth of graphene on copper foils — •Umut Kamber, Cem Kincal, and Oğuzhan Gürlü — Istanbul Technical University, Istanbul, Turkey

Chemical Vapor Deposition (CVD) is a widely employed method to produce large area graphene on metal surfaces. It has been known since the first CVD growth of graphene on copper foils in a quartz tube that some droplet like silicon-oxide contaminants appear on the surfaces. Therefore, optimizing the CVD process for defect free graphene is one of the most intensely studied subtopic in graphene research. We performed systematic experiments by changing CVD conditions to control the shapes and sizes of silicon-oxide particles. We developed a methodology to generate different shapes and sizes of nano scale fractal structures on both graphene/Cu system as well as on bare Cu foils. Parameters most effective on the number of impurities and the formation of fractals were determined to be hydrogen flow during annealing, annealing time and the amount of methane dosing. Lateral Force Microscopy (LFM) measurements were performed in order to investigate whether these particles formed at the graphene/Cu interface or on the graphene layer.