O 22: Nanostructures at Surfaces II

Time: Monday 16:00–18:45 Location: H45

O 22.1 Mon 16:00 H45

Self-assembly of Fe cluster superlattice in metal-organic network — Marina Pivetta[1], •Giulia E. Pacchioni[1], Uta Schlickum[1,2], Johannes V. Barth[3], and Harald Brune[1] — [1]Institute of Condensed Matter Physics, École Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland — [2]Max-Planck-Institut für Festkörperforschung, D-70569 Stuttgart, Germany — [3]Physik Department E20, Technische Universität München, D-85748 Garching, Germany

We studied the self-assembly of Fe clusters and adatoms in a metal-organic honeycomb network on Cu(111) by means of low-temperature scanning tunneling microscopy. The network is formed by coordination of dicarbonitrile pentaphenyl molecules to Cu adatoms. Fe atoms landing on the metal surface are mobile and are steerd by the quantum confinement of the surface state electrons towards the center of the network hexagonal cavities. In cavities with more than one Fe atom, preferential interatomic distances are observed. Upon gentle annealing the adatoms in each hexagon aggregate into a single cluster. These clusters are again centered in the cavities and their size is discerned by their distinct apparent heights.

O 22.2 Mon 16:15 H45

Multipotent mesenchymal stem cells (MSCs) and osteoblasts (OB) on SiO2 nanopillar arrays: Effect of pillar geometry on cell adhesion, proliferation and viability — •Burcin Özdemir[1], Alfred Plettl[1], Jörg Fiedler[2], Jochen Bartholomä[2], Paul Ziemann[1], and Rolf Brenner[2] — [1]Institute of Solid State Physics — [2]Departments of Orthopedics, University of Ulm, Germany

In this contribution, we quantitatively investigate the behavior of MSCs and OB as influenced by systematically nanostructured SiO2 surfaces in order to develop optimized interfacial interactions between cells and substrate for orthopedic device design. Diblock-copolymer micelle nanolithography (BCML) is applied in combination with photochemical growth to obtain highly ordered Au nanoparticles in 2D-arrays, which, subsequently, are used as nanomasks for anisotropic reactive ion etching (RIE). Cyclic combination of photochemical growth and RIE results in well-defined hexagonally ordered SiO2 nanopillar arrays with heights up to 320 nm (maximum aspect ratio ~9:1). Ten different SiO2 nanopillar arrays combining heights of 20 and 50 nm with interpillar distances of 50, 100, 120 nm and diameters of 10, 30 nm were analyzed by high resolution scanning microscopy and immunofluorescence. Highest proliferation rate for MSC was observed on the nanopillar arrays with dimensions of 10-100-50 nm (width, distance, height). Osteogenic differentiation, however, is significantly induced by shorter pillar heights.SEM examination showed that regardless of the 3D structure of the cells, they mainly adhered to the very tops of the pillars.

O 22.3 Mon 16:30 H45

Surface-assisted organic synthesis: Hyper-benzene nanotroughs on Cu(111) — Qitang Fan[1], Cici Wang[1], Yong Han[1], Junfa Zhu[1], Julian Kuttner[2], Gerhard Hilt[2], and •J. Michael Gottfried[2] — [1]National Synchrotron Radiation Laboratory, University of Science and Technology of China — [2]Fachbereich Chemie, Philipps-Universität Marburg

The surface-assisted synthesis of organic nanostructures is a promising bottom-up approach for the functionalization of surfaces in view of applications in catalysis, sensor systems, or organic electronics. The major challenge of this approach is that most established organic reactions require a solvent and thus cannot be performed on "dry" surfaces in UHV. An exception is the Ullmann reaction, which achieves C-C coupling between haloarene molecules by means of metallic Cu and has recently been employed to prepare 1D and 2D polymers on metal single-crystal surfaces. In our combined STM/XPS study, we used specially designed bromo-terphenyl precursors in a UHV-compatible variant of the Ullmann reaction to prepare cyclo-octadeca-phenylene (hyper-benzene), a cyclic hexagonal molecule consisting of 18 phenylene units, on a Cu(111) surface. The molecules arrange in close-packed islands with a hexagonal unit cell. The inner diameter of the hyperbenzene molecules is 2.13 nm, which makes them interesting candidates for nanotroughs that can enclose metal particles or organic molecules. Besides these large hydrocarbon molecules, we will describe the growth of zigzag-shaped 1D organometallic polymers consisting of Cu-bridged oligophenylene units.

O 22.4 Mon 16:45 H45

Stitch-free Electron Beam Lithography of Bragg Gratings and Photonic Crystals — Michael Kahl[1], •Jörg Stodolka[1], and Kevin Burcham[2] — [1]Raith GmbH, Konrad-Adenauer-Allee 8, Dortmund, 44263, Germany — [2]Raith USA, Inc., 2805 Veterans Highway, Suite 23, Ronkonkoma, NY 11779

We report on a new exposure mode for eliminating stitching errors and increasing the throughput in vector scan electron and ion beam lithography (EBL/IBL) of large-area, periodic micro and nano structures. When using the modulated beam moving stage (MBMS) exposure mode, beam movement is controlled in a way that the combination of patterning and continuous movement of a laser interferometer stage results in stitch-free, strip-shaped periodic structures.

The new mode has been used to expose 50 microns wide and 1 mm long gratings with a pitch within a 0.1nm tolerance for the target pitch across the complete grating, demonstrating that MBMS can fabricate periodic structures with virtually no stitching errors in the direction of stage motion. Furthermore, MBMS significantly increases throughput by reducing the times associated with stage motion, pattern data preparation and transfer, and beam settling times. Moreover, 2D arrays of circles or of any other patterns can be written with corresponding complex beam patterns, both as strip-shaped and area structures. The DFB laser gratings and photonic crystals presented in this report are just the first application examples, indicating the potential of MBMS for writing periodic structures for multiple applications such as plasmonic structures in sensors and nano sieves.

O 22.5 Mon 17:00 H45

Highly resolved KPFM investigations on gold and silver nano-dot arrays on silicon — •Anne-D. Müller[1], Yan Mi[2], Kin-Mun Wong[2], Falk Müller[1], and Yong Lei[2] — [1]Anfatec Instruments AG, Melanchthonstr. 28, 08606 Oelsnitz, Germany — [2]TU Ilmenau, Institute of Physics & INM (ZIK), Threedimensional Nanostructuring, 98684 Ilmenau, Germany

This contibution demonstrates highly resolved Kelvin Probe Force Microscopy (KPFM) results and EFM on ordered gold and silver quantum dot arrays deposited in a template structure on silicon. These quantum dots exhibit a one by one relation between dot spacing and dot diameter and are almost as wide as high. As the quality and quantifiablility of KPFM results usually strongly is influenced by topographical features, the KPFM investigation of such samples usually should not produce reliable results. This contribution demonstrates that due to the usage of specialized cantilevers, KPFM measurements with less than 10 nm resolution are possible on such topographically complicated samples.

O 22.6 Mon 17:15 H45

Self-Doping on Si(111)-(5x2)-Au: Confined Charge Density and Atomic Origin of Electron States — •Ingo Barke, Stefan Polei, Viola v. Oeynhausen, and Karl-Heinz Meiwes-Broer — Institut für Physik, Universität Rostock, 18051 Rostock, Germany

Using atomically precise scanning tunneling spectroscopy (STS) the concept of doping is pushed to the ultimate limit. On an array of atomic chains on Si(111)-(5x2)-Au it is shown that single doping atoms contribute their electrons to a small chain section, terminated by the very dopants themselves [1]. Such confined doping is a direct consequence of reduced dimensionality and is not observed in higher dimensions. This contribution focuses on the particular states affected by local doping on Si(111)-(5x2)-Au. Their doping-dependent energy shift and atomic origin is discussed on the basis of high-resolution STS-maps.

[1] I. Barke, S. Polei, V. von Oeynhausen, and K.-H. Meiwes-Broer, Phys. Rev. Lett, **109**, 066801 (2012).

O 22.7 Mon 17:30 H45

Structural Phase Transition on Si(553)-Au: Temperature and Tunneling Current Dependence — •Stefan Polei[1], Ingo Barke[1], Paul Snijders[2], and Karl-Heinz Meiwes-Broer[1] —

[1]Institut für Physik, Universität Rostock, Rostock, Germany — [2]Materials Science & Technology Division, Oak Ridge Nat. Lab., Oak Ridge, Tennessee, USA

Atomic chains on semiconductor surfaces have gained considerable interest in the last few years because they are a promising model system for low dimensional physics. On Si(553)-Au earlier studies revealed competing periodicities of 1x2 and 1x3 unit cells [1]. Recently, the frequently observed 1x3 structure was attributed to a spin-polarized ground state with antiferromagnetic ordering [2]. In this contribution we present Scanning Tunneling Microscopy (STM) measurements of the Si(553)-Au surface at various temperatures and tunneling conditions. The periodicity of the Si step-edge chain is found to change gradually from 1x3 to 1x2 depending on temperature and magnitude of the tunneling current. As a consequence, the STM topography shows an apparent 1x6 structure in the transition regime. A Fourier-based analysis of the observed periodicities allows the deduction of a qualitative phase diagram as a function of current and temperature.

[1] P. C. Snijders et al., PRL 96, 076801 (2006); [2] S. C. Erwin, F. J. Himpsel, Nat. Commun. 1, 58 (2010)

O 22.8 Mon 17:45 H45

Optical Anisotropy Spectroscopy of metallic Nanowires on vicinal Semiconductor Surfaces — •Jochen Räthel[1], Eugen Speiser[1], Sebastian Meyer[2], Julian Aulbach[2], Lenart Dudy[2], Jörg Schäfer[2], Daniel Lükermann[3], Ulrich Krieg[3], Christoph Tegenkamp[3], and Norbert Esser[1] — [1]Leibniz-Institut für Analytische Wissenschaften – ISAS – e.V., Albert-Einstein-Str. 9, 12489 Berlin — [2]Universität Würzburg, Physikalisches Institut, Am Hubland, 97074 Würzburg — [3]Institut für Festkörperphysik, Leibniz-Universität Hannover, Appelstraße 2, 30167 Hannover

Metals adsorbed on semiconductor surfaces allow a variety of different surface reconstructions. Among them are one-dimensional structures, often denoted as atomic quantum chains, which preferably grow on vicinal substrates. These chains host exotic electronic ground states, e.g. a charge-density wave state reported for In on Si(111) and Au on Si(553), a insulator-to-metal transition in In on Si(111) and Pb on Si(557) or the rare Tomonaga-Luttinger liquid phase in Au on Ge(001). This talk will briefly introduce these four types of wires from their optical properties as deduced from reflection anisotropy spectroscopy (RAS) of linear polarized light at normal incidence. The response gives access to optical transitions within the band structure from the IR to the UV spectral range. Combined with calculated optical spectra by ab-initio density functional theory the experimental data provide a bases for structural modeling of these complex surface reconstructions [PRL 102, 226805 (2009)].

O 22.9 Mon 18:00 H45

Evolution of microstructure and magnetic properties of amorphous FeNiP nanowire arrays upon annealing — •Nina Winkler, Martin Peterlechner, and Gerhard Wilde — Institute of Materials Physics, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm Str. 10, 48149 Münster, Germany

Amorphous soft magnetic materials are suitable for application in high frequency, high power conversion and many further research fields. In this work, the fabrication of amorphous FeNiP nanowire arrays with large aspect ratios using porous Anodic Aluminum Oxide (AAO) templates will be presented.

The AAO template exhibits high hexagonal regularity of cylindrical pores which are perpendicularly arranged with respect to the Al substrate plane. The pore diameters used for the fabrication are 20 nm to 250 nm with lengths up to 40 μm. FeNiP nanowire arrays are prepared by filling the AAO pores via electrodeposition using a potential pulse sequence. The electrodeposition parameters are analyzed via cyclic voltammetry. The structure of the nanowire arrays has been characterized by scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The magnetic properties of the nanowire arrays have been investigated by Vibrating Sample Magnetometer (VSM) measurements.

Fully amorphous FeNiP nanowires were obtained. Upon in-situ annealing in the TEM, long range diffusion leading to crystallization was observed, which naturally also triggered changes of the magnetic properties.

O 22.10 Mon 18:15 H45

Growth and properties of thin Bismuth films on vicinal Silicon substrates — •Christian Brand, Daniel Lükermann, Saddam Banyoudeh, Dennis Laube, Christoph Tegenkamp, and Herbert Pfnür — Institut für Festkörperphysik, Leibniz Universität Hannover, Germany

The semimetal Bismuth has recently come back into the focus of research due to its particular electronic properties. Low carrier concentrations in combination with small effective masses but high surface conductivity and a large Rashba splitting reveal thin Bismuth films as interesting object. Growth experiments of vicinal Bismuth films, which are expected to reveal topologically non-trivial edge states, were not performed so far. In the present work we studied the growth of ultrathin Bismuth films on vicinal Si(557) substrates by means of *SPA-LEED* and *STM/STS*. (Sub-)Monolayer (ML) thin films as wetting-layer structures with $(\sqrt{3} \times \sqrt{3})$ reconstruction strongly influence the orientation and electronic properties of thicker Bismuth films (40 bilayers) grown on the substrate. Refacetting of the (557) surface occurs at low Bismuth coverages (and high temperatures) introducing (113) and (335) facets on the α-phase (1/3 ML), while (113) and (3 3 10) facets are formed on the so called γ-phase (2/3 ML). Only on the β-phase (1 ML) the initial step structure is preserved. In particular, stepped Bi(110) films with varying, but oriented rotational domains can be grown, while stepped and rotationally disordered Bi(111) films only grow on the α-phase. The steps have been characterized by first DC- and magneto-transport measurements.

O 22.11 Mon 18:30 H45

Investigation of the doping profile of Zn-doped GaAs nanowires by a multitip STM — •Matthias Steidl[1,4], Weihong Zhao[1,4], Werner Prost[2], Stefan Korte[3], Bert Voigtländer[3], Peter Kleinschmidt[5,4], and Thomas Hannappel[1,4,5] — [1]Institut für Physik, Fachgebiet Photovoltaik, TU Ilmenau, D-98684 Ilmenau — [2]Lehrstuhl für Halbleitertechnik/Halbleitertechnologie, Universität Duisburg-Essen, D-47048 Duisburg — [3]Peter Grünberg Institut (PGI-3), Forschungszentrum Jülich, D-52425 Jülich, Germany — [4]Helmholtz-Zentrum Berlin, Institut Solare Brennstoffe und Energiespeichermaterialien, D-14109 Berlin — [5]CiS Forschungsinstitut für Mikrosensorik und Photovoltaik, D-99099 Erfurt

III-V semiconductor nanowires (NWs) are promising building blocks for novel semiconductor devices in future electronic and opto-electronic applications such as solar cells. In this context a homogeneous distribution of the dopant over the whole NW is of great importance. We have grown p-type Zn-doped GaAs-NWs on GaP(111)B using the Au-assisted vapor-liquid-solid growth mode in a metal-organic vapor phase apparatus. Prior to the actual growth, diethylzinc as Zn precursor source is offered for several minutes, so that the Au-particle is saturated with Zn and the NW is doped from beginning of the growth. For electrical characterization these free-standing NWs were contacted using a multitip STM allowing us to measure the resistivity via four-point probe measurements over nearly the complete length of a NW. These measurements reveal a constant resistivity after 1.5 μm NW growth, while it is significantly increasing towards the NW bottom.