O 42: Nanostructures at surfaces I

Time: Wednesday 10:30–13:00 Location: MA 042

O 42.1 Wed 10:30 MA 042

Synthesize and characterization of the properties of intrinsic defects in size-controlled surface ZnO nanowires by multiple spectroscopic techniques — •Kin Mun Wong[1,2], Yaoguo Fang[1,2], André Devaux[3], Liaoyong Wen[1,2], Luisa De Cola[3], and Yong Lei[1,2] — [1]Fachgebiet 3D-Nanostrukturierung, Institut für Physik & Zentrum für Mikro- und Nanotechnologien (ZIK MacroNano), Technische Universität Ilmenau, 98693 Ilmenau, Germany. — [2]Institut für Materialphysik, Westfälische Wilhelms-Universität Münster, 48149 Münster, Germany. — [3]Physikalisches Institut, Westfälische Wilhelms-Universität, 48149 Münster, Germany.

Arrays of regular and size-controlled ZnO nanowires with different length and diameter were synthesized by chemical vapour deposition and hydrothermal method. Quantitative information about the concentration of intrinsic defects such as oxygen vacancies and zinc interstitials as well as their luminescence lifetimes was obtained by a number of different spectroscopic techniques. From the correlation between the different sets of experimental data, some important relationships were observed between the concentration and spatial distribution of the intrinsic defects with regards to the size and surface to volume ratio of the ZnO nanowires. This connection between the defects and the size of the nanowires is essential for the fine tuning and optimatization of the defect related properties in ZnO nanowires. Furthermore, an analytical formula was derived for obtaining the donor concentration in the ZnO nanowires directly from the conductive atomic force microscopy measurements without prior need of depositing a metal electrode layer.

O 42.2 Wed 10:45 MA 042

Pulsed laser deposition of ZnO nanostructures for hybrid solar cells — •Sven Käbisch[1,2], Marc A. Gluba[2], Norbert H. Nickel[2], and Norbert Koch[1,2] — [1]Institut für Physik, Humboldt-Universität zu Berlin — [2]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH

Hybrid solar cells benefit from the large optical absorption cross section of organic chromophores while effective charge transport is achieved through high mobility inorganic materials. Since exciton diffusion lengths in organic materials are typically shorter than ca. 10 nm, organic/inorganic interfaces with a nanoscale interdigitation are required. Zinc oxide (ZnO) readily forms nanostructures on various substrates. Pulsed laser deposition (PLD) of ZnO nanostructures is studied in detail with respect to process parameters like laser fluence, partial pressure of the oxygen process gas, substrate temperature and type of substrate. The laser fluence and the deposition temperature determine the density of nanostructures due to the control of nucleation and diffusion of particles on the surface. The substrate type and morphology determine the shape of the nanostructures, while the deposition pressure changes their alignment. Nanostructures with optimized morphology and density are fabricated and used as electron acceptor in hybrid solar cells. A light sensitive p-n-junction is demonstrated.

O 42.3 Wed 11:00 MA 042

Structured growth of ZnO on self-assembled monolayers — •Nivedita Yumnam, Miriam Schwarz, and Veit Wagner — School of Engineering and Science, Jacobs University Bremen, Campusring 1, D-28759 Bremen (Germany)

The architecture of ZnO nanostructures grown by electrochemical deposition coupled with its enhanced light trapping mechanism can be used as a semiconductor in hybrid solar cells. We focus on the structured electrochemical growth of ZnO nanorods through self-assembled monolayers of alkanethiols adsorbed on gold. The densely packed self-assembled monolayer of alkanethiol adsorbed on gold hinders the formation of ZnO crystals. We tune the number density and the size of the ZnO nanorods by varying the adsorption time of alkanethiol monolayers on gold and the electrochemical growth time of ZnO. In order to allow for laterally structured growth of ZnO on monolayer covered gold, we employed microcontact printing of alkanethiol on gold. Depending on deposition method and parameters our results indicate a varying degree of pinholes in the self-assembled monolayer on gold. With these pinholes the ZnO rod size and the average distance between ZnO rods can be controlled. This pinhole density is correlated to the leakage current through the self-assembled monolayer of alkanethiol determined by impedance measurements.

O 42.4 Wed 11:15 MA 042

Directed placement of gold nanorods using removable assembly guiding structures — •Felix Holzner[1,2], Cyrill Kuemin[1,2], Philip Paul[1,2], James L. Hedrick[3], Heiko Wolf[1], Nicholas D. Spencer[2], Urs Duerig[1], and Armin Knoll[1] — [1]IBM Research, Rueschlikon, Switzerland — [2]Laboratory of Surface Science and Technology, ETH Zurich, Switzerland — [3]IBM Research, Almaden, USA

We present a new assembly and transfer process, where we have used a temperature- sensitive, nanopatterned polymer film as a removable template to position and align gold nanorods onto an underlying target substrate with 10 nm precision [1]. Shape-matching guiding structures have been written by thermal scanning probe lithography with polyphthalaldehyde (PPA) as resist material. The patterns were written using a heated tip to decompose and evaporate the PPA locally pixel by pixel. This can be done with high speed (500000 pixels per second, 20 mm/s scan speed), high accuracy (<10 nm) and excellent control of the patterning depth [2],[3]. Capillary Assembly was used to trap gold nanorods of size 80 nm x 25 nm in the PPA shape-matching guiding structures. Measured standard deviations from the targeted orientation and position were 25.2° and 10.3 nm, respectively. Heating the sample to 215°C leads to a complete evaporation of the PPA and a transfer of the nanorods onto the underlying substrate without affecting the integrity and the placement accuracy of the nanorods.

[1] Holzner et al., Nano Letters, 2011, 11, 3957-3962 [2] Paul et al., Nanotechnology, 2011, 22, 275-306 [3] Knoll et al., Advanced Materials, 2010, 22, 3361-3365

O 42.5 Wed 11:30 MA 042

Surface optical and vibrational properties of Ge(001) at 300 K/40 K before and after Au nanowire deposition — •Jochen Räthel[1], Eugen Speiser[1], Christoph Cobet[1], Karsten Hinrichs[1], Utz Bass[2], Jean Geurts[2], 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

The interest in self organized 1-dimensional metallic nanowires on semiconductor surfaces is driven by their extraordinary electronic properties, like Luttinger liquid behaviour for Au nanowires on Ge(001) as shown recently. Therefore, the aims of our study comprise (i) the vibrational properties and the underlying surface structure and dynamics, and (ii) the anisotropic optical properties, arising from surface electronic transitions. For these purposes, we employed in-situ Raman spectroscopy as well as reflectance anisotropy spectroscopy (RAS) on self-organized Au nanowires, grown under UHV conditions on a flash-prepared Ge(001) c(4×2)/(2×1) surface. The Au chain order was identified by the expected c(8×2) LEED symmetry, with two orthogonal domain orientations. The clean Ge(001) shows surface vibration modes, whose energy values agree well with calculated mode patterns found in literature. These surface phonons vanish partly upon cooling to 40 K and completely upon Au deposition, indicating for both cases surface structure changes. RAS spectra in the range from 0.5 to 5 eV show several characteristic features before and after the Au deposition, assigned to electronic surface transitions.

O 42.6 Wed 11:45 MA 042

Structural Elements of Gold-Induced Atomic Chains on Ge(001) — •Sebastian Meyer[1], Jörg Schäfer[1], Christoph Loho[1], Christian Blumenstein[1], Simeon Sauer[2], Friedhelm Bechstedt[3], Phil Willmott[4], and Ralph Claessen[1] — [1]Physikalisches Institut, Universität Würzburg — [2]Institut für Physik, nivserität Freiburg — [3]Inst. f. Festkörpertheorie u. -optik, Universität Jena — [4]Paul Scherrer Institut, Villigen CH

Self-organized nanowires of gold on Ge(001) are outstanding among all previously reported atom chains because their electronic states are found to deviate from the common Fermi liquid picture. In contrast, the exotic many-body state of a Tomonaga-Luttinger liquid applies. Characteristic features are observed in terms of power-law suppression of the density of states towards the chemical potential in scanning tunneling spectroscopy and angle-resolved photoemission [1]. For a detailed understanding an atomistic model is highly desirable, enabling

band structure calculations within density functional theory (DFT). Thus, we have performed surface x-ray diffraction (SXRD) at the Swiss Light Source. The Patterson map resulting from in-plane scattering data yields interatomic distances which are required for structural modeling. Comparison of SXRD with recent STM data reveals essential structural building blocks which are compatible with present DFT calculations.

[1] C. Blumenstein et al., Nat. Phys. 7, 776 (2011).

O 42.7 Wed 12:00 MA 042

Pb nanowire induced facetting of Si(557) surfaces — •Sebastian Gevers[1], Thomas Weisemoeller[1], Christoph Tegenkamp[2], and Joachim Wollschläger[1] — [1]Fachbereich Physik, Universitaet Osnabrueck, Barbarastr. 7, 49069 Osnabrueck — [2]Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover

Nanowires are of fundamental interest to study electronic correlations in low-dimensional systems which cause strong deviations from simple Fermi-liquid behavior. Here, the possibility to manipulate and to characterize these structures with a variety of techniques offer a wide field for scientific research. In particular anisotropic surface transport is interesting since it directly probes inherent electronic instabilities in these low-dimensional structures.

Since long-range ordering is required to perform transport measurements, Si(557) surfaces with high step stiffness are used as a substrate to grow arrays of crystalline Pb nanowires. Furthermore, it has been reported that the system switches from 2D to 1D conductivity which is correlated with structure phase transitions. In the present work, the surface structure and morphology of substrate and nanowires is investigated by grazing incidence x-ray diffraction (GIXRD) and spot profile low energy electron diffraction (SPALEED). It is shown that a layer by layer growth of Pb can be obtained and that refacetting of the Si(557) substrate occurs at elevated substrate temperatures. In particular we take advantage of the high precision of the GIXRD experiment to characterize the refacetting.

O 42.8 Wed 12:15 MA 042

Reconstruction of Atomic-Scale Wires on Si(553)-Au: Observation of Current-Dependent Periodicity — •S. Polei[1], I. Barke[1], P.C. Snijders[2], F.J. Himpsel[3], S.C. Erwin[4], and K.-H. Meiwes-Broer[1] — [1]Inst. für Physik, Uni Rostock, Rostock, Germany — [2]Materials Science & Technology Division, Oak Ridge Nat. Lab., Oak Ridge, Tennessee, USA — [3]Physics Dept., University of Wisconsin Madison, Madison, Wisconsin, USA — [4]Center for Computational Materials Science, Naval Research Lab., Washington, DC, USA

Quasi one-dimensional metallic chains on silicon have received considerable attention in the last few years, primarily because they possess unusual electronic properties [1]. In particular, the Au-induced reconstruction of the Si(553) surface is of great interest because recent theoretical findings predict that it has a magnetic ground state [4]. We present STM and STS measurements to investigate the nature of the phase transition to a reconstructed Si step edge at low temperature and the possible development of non-zero Si spin-polarization. Different periodicities are observed at the Si step-edge chains depending on the tunneling current. When the tunneling current is increased at 51 K the reconstruction along the chains changes gradually from 1x3 to 1x2. As a result, the STM topography has 1x6 periodicity in the transition regime. Findings are discussed in the context of a possible magnetic state [2].

[1] J. N. Crain et al., PRB 69, 125401 (2004); P. C. Snijders et al., PRL 96, 076801 (2006); I. Barke et al., PRL 97, 226405 (2006) [2] S. C. Erwin, F. J. Himpsel, Nat. Commun. 1, 58 (2010)

O 42.9 Wed 12:30 MA 042

Quasi-1D metallic Ag-wires grown on vicinal Silicon surfaces — •Christian Brand, Jędrzej Schmeidel, Christoph Tegenkamp, and Herbert Pfnür — Institut für Festkörperphysik, Leibniz Universität Hannover, Germany

A prototype system of a nearly free 2D electron gas system is the Ag-$(\sqrt{3} \times \sqrt{3})$ reconstruction on a Si(111)-(7×7) surface. Consequently, a promising route to fabricate a 1D electron gas system might be the self assembly of Ag wetting structures on uniaxial Si(557) surfaces.

The Si(557) surface consists of (111) terraces and triple steps with a periodicity of 5.73 nm. By adsorption of sub-monolayer amounts of Ag at 770 K several types of quasi-1D structures are formed, accompanied by locally varying refacetting of the surface. Besides insulating chains of monatomic width (α-, β- and γ-type) also metallic wires with $(\sqrt{3} \times \sqrt{3})$ reconstruction are formed, as deduced from our LEED- and STM/STS-study.

In many cases metallic monolayer species are decoupled electronically from the Si-surfaces by forming Schottky barriers, which limit the applicability of STS to measure the electronic structure of the wires themselves at low bias voltages. In order to contact the wires electrically, a shadow mask technique on the basis of a Si_3N_4 membrane has been developed. First results will be presented.

O 42.10 Wed 12:45 MA 042

Growth phenomena of Ge nanowires grown by MBE — •Roman Bansen, Jan Schmidtbauer, Robert Heimburger, Thomas Teubner, and Torsten Boeck — Leibniz Institute for Crystal Growth, 12489 Berlin, Germany

Advances in nanotechnology with its significantly lower material consumption and quantum effects-related new semiconductor properties have led to a renewed interest in germanium, with its advantageous properties for numerous possible applications in photovoltaics, thermoelectrics and electronics.

The presentation concentrates on growth as well as in-detail characterization of Ge nanowires with a focus on basic growth characteristics and their dependencies on surface preparation methods. The nanowires were grown by MBE on Ge substrates using the VLS mechanism with Au as catalyst metal.

A range of different surface passivations was tested for their effect on nanowire growth. The unexpected results reveal that very clean and smooth surfaces make the catalyst droplets preferentially form "in-plane" nanowires, instead of growing "conventional" (out-of-plane) nanowires. Depending on the respective types of passivation, changes of the in-plane wires' growth directions can be observed. It is possible to explain the directions with the help of SEM and TEM images for the most part, and a model will be presented for the effect itself.