O 73: Nanostructures at Surfaces: 1D and 2D Structures

Time: Wednesday 18:15–21:00 Location: Poster A

O 73.1 Wed 18:15 Poster A

Fabrication of ultrathin metallic nano-contacts for molecular electronics — •Atasi Chatterjee, Frederik Edler, Christoph Tegenkamp, and Herbert Pfnür — Leibniz Universität Hannover, Institut für Festkörperphysik, 30167, Hannover, Germany

Molecular electronics, where single molecules can be used as active electronic components, is the maximum miniaturisation of electronic devices that one can achieve by the bottom up approach. To interface single molecules with the existing macroscopic electronic devices and to understand the functionalities of the molecules, metallic nano-contacts are required. Our aim is to create flat silver nano-contacts by angle deposition, which are ultrathin (few monolayers) at the centre and robust at the ends. We use a combination of electron beam lithography on a silicon substrate, and an electro-migration process to fabricate these nano-contacts, and create nanometer separation at the centre in a controllable manner. This helps the molecules to be adsorbed on an atomic and molecular scale and makes the bonding between molecule and metallic leads better. Such laterally open contact structures together with the adsorbed molecules allow direct access to the STM tips for local control, characterisation of the gap and imaging the molecules. The final aim is to study the electrical conduction properties of single molecules inside the gap which are chemically bound to these fabricated metallic contacts.

O 73.2 Wed 18:15 Poster A

Massive Formation of Highly Oriented Metal-Acetylide Chains Investigated by Scanning Tunneling Microscopy — •Jing Liu, Qiwei Chen, and Kai Wu — BNLMS, SKLSCUSS, College of Chemistry and Molecular Engineering, Peking University, Beijing 100871, China

Terminal alkynes as novel on-surface reactions precursors have received widespread attention due to their potential in building up diverse nanostructures through different reaction routes. By tuning either the structure of precursors or the metal substrates, terminal alkynes can undergo different reaction pathways and therefore lead to distinct products. Glaser Coupling, cyclotrimerization, radical cyclization, and cross-coupling have all been reported as typical reaction methods of terminal alkynes. However, besides the reactions resulting in covalent bonded structures as mentioned above, terminal alkynes can also take part in the formation of organometallic metal-acetylides which are barely reported as on-surface reaction products of terminal alkynes. In this work, we present a massive formation of highly oriented silver-acetylide chains through the reaction between terminal alkyne and Ag adatoms. The reaction and products were investigated by both STM and DFT calculations. A highly oriented arrangement of chains as well as a perfect match between period of organometallic chains and substrate lattice were observed, and were considered as a significant factor for the stabilization of metal-acetylide chains.

O 73.3 Wed 18:15 Poster A

Investigation of nanoporous networks of para-hexaphenyl-dicarbonitrile on Au(111) with ultrahigh spatial resolution — •Leonid Solianyk[1], Juan Carlos Moreno-Lopez[1], Stefano Gottardi[1], Kathrin Müller[1], Tuan Anh Pham[1], Fei Song[1], Jun Li[1], Leticia Monjas[2], Anna Hirsch[2], and Meike Stöhr[1] — [1]Zernike Institute for Advanced Materials, University of Groningen, The Netherlands — [2]Stratingh Institute for Chemistry, University of Groningen, The Netherlands

The formation and investigation of molecular nanoarchitectures on well-defined inorganic surfaces is thought to be highly relevant for the development of future nanoelectronic devices. One way to obtain insight into the underlying interactions controlling molecular self-assembly is through ultrahigh spatial resolution on the submolecular scale.

In this work, the self-assembly of para-hexaphenyl-dicarbonitrile molecules was investigated on Au(111) with low temperature scanning tunneling microscopy (STM) and non-contact atomic force microscopy (nc-AFM) using functionalized CO tips. Two different nanoporous networks were observed for submonolayer coverages. The rhombic network stabilized by C-N...H bonds was found after molecular deposition at room temperature. Upon thermal annealing at 575K, a hexagonal network stabilized by metal-ligand interactions with native gold atoms formed. Due to the ultrahigh spatial resolution of nc-AFM, information on the intermolecular interactions could be directly obtained.

O 73.4 Wed 18:15 Poster A

Glancing Angle Deposition of Metal Nanostructures — •Christoph Grüner[1], Sachin K. Srivastava[2], Ibrahim Abdulhalim[2], and Bernd Rauschenbach[1] — [1]Leibniz-Institut für Oberflächenmodifizierung, Permoserstraße 15, 04318 Leipzig, Germany — [2]Ben Gurion University, Beer Sheva, 84105, Israel

Glancing angle deposition (GLAD) is an ultra high vacuum physical vapor deposition process, which utilizes the self-shadowing between growing crystallites, that appears if the substrate is highly tilted with respect to the incoming particle beam. In this configuration separated nanostructures grow, leading to a thin film with very high porosity. GLAD of different metals (Cr, Ti, Al, Ag) is investigated and the resulting nanostructures are compared between each other and with the well investigated growth of silicon nanostructures. The influence of growth temperature, surface diffusion and substrate rotation is discussed. Based on the GLAD technology, a biosensor chip for detection of a protein biomarker of endocrine disrupting compounds in aquatic environment is developed.

O 73.5 Wed 18:15 Poster A

Tb induced surface structures on Si(001) — •Stephan Appelfeller[1], Stefan Kuls[1], Paul Reiss[2], Tore Niermann[2], Michael Lehmann[2], and Mario Dähne[1] — [1]Institut für Festkörperphysik, TU Berlin, 10623 Berlin — [2]Institut für Optik und Atomare Physik, TU Berlin, 10623 Berlin

Tb, a rare earth metal, induces a large variety of surface structures on Si(001) ranging from small surface clusters containing only few atoms over wire-like structures and metallic nanowires to large islands. Such structures are interesting for applications, e.g. the clusters might be used in catalysis, but the most promising ones are the metallic nanowires with widths of only few a nm and length exceeding 1μm, which may lead to a further miniaturization of semiconductor devices by using them as interconnects.

The surface structures were grown by Tb deposition and simultaneous or subsequent annealing. *In-situ* studies using scanning tunneling microscopy and low energy electron diffraction analysing the atomic structure in detail allowed the development of structure models for all observed surface structures.

Furthermore, the metallic nanowires were overgrown with amorphous Si and their cross sections were studied by high resolution transmission electron microscopy. The nanowires stayed intact upon overgrowth, and, using moderate annealing temperatures, they could even be embedded in crystalline Si. Possible structural modifications upon overgrowth will be discussed.

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O 73.6 Wed 18:15 Poster A

Structural and electronic properties of the triangular lattice of Sn on SiC(0001) — •Florian Adler[1], Stefan Glass[1], Gang Li[2], Julian Aulbach[1], Philipp Höpfner[1], Werner Hanke[2], Jörg Schäfer[1], and Ralph Claessen[1] — [1]Physikalisches Institut and Röntgen Center for Complex Material Systems (RCCM), Universität Würzburg, Germany — [2]Institut für Theoretische Physik und Astrophysik, Universität Würzburg, Germany

Here we report on a novel two-dimensional electron system on a triangular lattice, namely the $\sqrt{3} \times \sqrt{3}$ reconstruction of Sn on SiC(0001). Using a newly developed recipe of gas phase hydrogen etching, well ordered SiC surfaces could be prepared. By evaporation of Sn and subsequent annealing, a triangular lattice of Sn on SiC(0001) with a coverage of 1/3 monolayer was realized. Both the substrate preparation and the evaporation process were monitored by low-energy electron diffraction and high-resolution scanning tunneling microscopy. While simple electron counting results in a half-filled valence band and therefore metallic behavior, first angle-resolved photoemission data shows a broad, weakly dispersing band with no spectral weight at the Fermi level, indicating Mott-Hubbard physics. The system is isostructural to the well explored Mott-insulator $\sqrt{3} \times \sqrt{3}$ Sn on Si(111), but with a 20% smaller lattice constant. Due to the increased hopping one might expect to be closer to the insulator-metal boundary of the Hubbard

model. However, the large bandgap of the substrate may also change the effective Hubbard-U due to a different substrate-related screening. Similarities and differences between both systems will be discussed.

O 73.7 Wed 18:15 Poster A

Structural and Transport Properties of Etched Silicon Nanowires — •Stefan Weidemann[1], Maximilian Kockert[1], Anna Mogilatenko[2], Klaus Rademann[3], and Saskia F. Fischer[1] — [1]Neue Materialien, Institut für Physik, Humboldt-Universität zu Berlin, D-12489 Berlin — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, D-12489, Berlin — [3]Nanostructured Materials, Institut für Chemie, Humboldt-Universität zu Berlin

Understanding thermal transport on the nanoscale is essential for the miniaturisation of electronic devices and for nanopatterned materials. Rough silicon nanowires (SiNWs) show decreased thermal conductivity [1]. Structural and thermo-electric characterization of an individual nanowire still remains a challenge.

In our study we prepare SiNWs by two-step metal-assisted chemical etching, which allows fabrication on wafer scale [2]. Doping levels range from undoped Si, resistivity $\rho > 1000$ Ωcm, to highly boron-doped Si, $\rho = 0.01$ Ωcm, and the axial crystal orientation is (100). By controlling the etching conditions and the substrate selection the NW lengths $(30 - 100\mu m)$ and surface morphology (solid, rough and porous) can be adjusted [3]. Single SiNW in the diameter range from 200 - 400 nm are investigated. Electrical conductivities and the thermovoltage are measured on a platform designed in four-point geometry with heaters.

[1] A. I. Hochbaum *et al.*, Nature 451, 163 (2008).
[2] S. Weidemann *et al.*, arxiv:1410.3763 (2014) submitted.
[3] G. Yuan *et al.*, Jour. Phy. Chem C, 116, 13767 (2012).

O 73.8 Wed 18:15 Poster A

Preparation of undoped and boron-doped silicon nanowires — •Maximilian Kockert[1], Stefan Weidemann[1], Klaus Rademann[2], and Saskia F. Fischer[1] — [1]Neue Materialien, Humboldt-Universität zu Berlin, 12489 Berlin, Germany — [2]Nanostrukturierte Materialien, Humboldt-Universität zu Berlin, 12489 Berlin, Germany

Silicon nanowires (SiNWs) are potentially efficient thermoelectric materials because of the reduced phonon contribution to the thermal conductivity and they are interesting for biochemical applications due to their big surface-to-volume ratio [1]. In this work we prepare SiNWs of undoped silicon substrates (electrical resistivity $\rho > 1400$ Ωcm) and boron-doped silicon substrates ($\rho = 0.01$ - 0.02 Ωcm) by metal-assisted chemical etching. We analyse the influence of the concentration of hydrogen peroxide, light and temperature on the wire length [2]. Scanning electron microscope investigations show that an increase of one of these etching parameters lead to longer SiNWs, when the etching time is constant. Further measurements show that after three hours of etching the wire length l of undoped SiNWs reaches $l = 75$ μm and of boron-doped $l = 43$ μm.

[1] A. Boukai *et al.*, Nature **415**, 168 (2008).
[2] S. Weidemann *et al.*, arXiv:1410.3763 (2014).

O 73.9 Wed 18:15 Poster A

Effect of electron-phonon coupling on band-structure formation: Chains of Cl-vacancies — Bruno Schuler[1], Mats Persson[2], Sami Paavilainen[3], •Niko Pavliček[1], Leo Gross[1], Gerhard Meyer[1], and Jascha Repp[4] — [1]IBM Research–Zurich, Säumerstrasse 4, 8803 Rüschlikon, Switzerland — [2]Science Research Centre, University of Liverpool, L69 3BX, United Kingdom — [3]Department of Physics, Tampere University of Technology, 33720 Tampere, Finland — [4]Institute of Experimental and Applied Physics, University of Regensburg, 93053 Regensburg, Germany

We have investigated the effects of strong electron-phonon (*e-ph*) coupling on the formation of extended electronic states of Cl divacancies and vacancy chains in a NaCl bilayer on Cu(111) with scanning tunneling spectroscopy, atomic force microscopy and a tight-binding model including linear coupling to phonon modes. Vacancy pairs and chains with different orientation and separation were created by extracting individual Cl anions with atomic precision using vertical manipulation. Symmetric and anti-symmetric vacancy states (VS) and localized interface states are shown to be formed at divacancies, in analogy with the bonding and anti-bonding orbitals of the hydrogen molecule. As expected, the level splitting increases with decreasing inter-vacancy distance. However, splitting of the VSs is significantly enlarged by level repulsion as a result of the strong *e-ph* interaction [1]. Already for chains of a few coupled vacancies we observe an emerging band structure of the defect band.

[1] J. Repp, et al., Phys. Rev. Lett. 95, 225503 (2005).

O 73.10 Wed 18:15 Poster A

Dynamic Bragg-like scattering in GISAXS from rough gratings — •Victor Soltwisch[1], Jan Wernecke[1], Anton Haase[1], Michael Krumrey[1], Juergen Probst[2], Max Schoengen[2], and Frank Scholze[1] — [1]Physikalisch-Technische Bundesanstalt — [2]Helmholz-Zentrum Berlin

The decrease in feature size down to several nm is chall enging for the given metrology toolsets. X-ray scattering with grazing incidence angles (GISAXS), close to the critical angle, is a fast and non-destructive method with a high surface sensitivity. We report the observation of dynamic scattering effects from rough structured surfaces which leads to higher ordering of the Yoneda lines.