O 39: 1D Metal Wires on Semiconductors II

Time: Tuesday 14:00–16:00 Location: S052

O 39.1 Tue 14:00 S052

Infrared Plasmonic Investigation of Band Filling-Induced Metal-to-Insulator Transition in Au Chains on Si(111)-5x2-Au — •Fabian Hötzel[1], Kaori Seino[2], Friedhelm Bechstedt[2], and Annemarie Pucci[1] — [1]Kirchhoff-Institut für Physik, Universität Heidelberg, Heidelberg, Deutschland — [2]Institut für Festkörpertheorie und -optik, Universität Jena, Jena, Deutschland

The investigation of infrared plasmon polaritons on the Si(111)-5x2-Au surface underlines the metallic character of the system [1] and its Kwon-Kang atomic structure model [2] with seven Au atoms per 5x2 surface unit cell. However, upon evaporating an additional 0.1 monolayer Au amount, the system undergoes a metal-to-insulator transition [3] but the 5x2 symmetry remains unchanged as proven by reflection high energy electron diffraction. This phase transition was in situ observed by means of the infrared plasmonic signal attenuation with coverage. Band-structure calculations reveal that the transition is induced by band filling of the one-dimensional half-filled band at the Fermi energy. The insulating phase represents an indirect semiconductor with a band gap of 0.29 eV. Moreover, a new surface structure model with eight Au atoms per unit cell, including the additional Au atoms, is developed for the 5x2 symmetry. By annealing the system, the plasmonic signal is recovered which shows that the phase transition is reversible. This contribution is part of the DFG Research Unit FOR 1700.

[1] Hötzel, F. et al. Nano Lett. **2015**, 15, 4155-4160.
[2] Kwon, S. G. et al. Phys. Rev. Lett. **2014**, 113, 086101.
[3] Hötzel, F. et al. J. Phys. Chem. Lett. **2015**, 6, 3615-3620.

O 39.2 Tue 14:15 S052

Optical monitoring of Ag nanostructures on Si(557) — •Sandhya Chandola[1], Eugen Speiser[1], Jochen Räthel[1], Ulrich Krieg[2], Christoph Tegenkamp[2], Herbert Pfnür[2], and Norbert Esser[1] — [1]Leibniz-Institut für Analytische Wissenschaften - ISAS - e.V., Department Berlin, Schwarzschildstraße 8, 12489 Berlin, Germany — [2]Leibniz Universität Hannover, Institut für Festkörperphysik, Appelstraße 2, 30167, Hannover, Germany

The optical response of the Si(557)-Ag surface has been studied with reflectance anisotropy spectroscopy (RAS) from 0.5 to 5 eV. Using the Si(557) surface as a template, various quasi-one dimensional (1D) Ag structures were grown and substantial differences between the structures were observed with RAS. At $\sim$ 0.3 ML of Ag, 1D chain structures were observed with STM and a large anisotropic response developed at 2.5 eV, related to the formation of Ag nanowires which are semiconducting. Further deposition up to 1.2 ML of Ag resulted in the formation of the $(\sqrt{3} \times \sqrt{3})$ phase. The anisotropy at 2.5 eV disappeared and the overall optical response showed substantial modification. Small amounts of Ag, from 0.03 ML to 0.1 ML of Ag, were then deposited on the $(\sqrt{3} \times \sqrt{3})$ surface to monitor the effects of doping on these structures. The RAS response showed a significant anisotropy towards the infrared for small amounts of doping. As RAS is only sensitive to the anisotropic optical response, which arises from stepped and facetted regions of the surface, it can be a sensitive tool to monitor the effects of excess Ag atoms concentrated at the step sites of the Si(557) surface which are supposed to be responsible for the doping mechanism.

O 39.3 Tue 14:30 S052

Fabrication of one-dimensional arrays of magic clusters using a vicinal Si surface as a template — •Martin Franz, Julia Schmermbeck, and Mario Dähne — Technische Universität Berlin, Institut für Festkörperphysik, 10623 Berlin, Germany

Self-assembled magic clusters on surfaces are fascinating not only from a fundamental scientific point of view, they are also promising candidates to employ such zero-dimensional nano objects in future applications such as high-density memory devices or in catalysis. In the present work, magic In clusters that form on the Si(111)7 × 7 surface are used as a model system to study how the array formation affects the electronic properties and to explore the possibility to produce one-dimensional (1D) arrays of magic clusters. For this purpose, scanning tunneling microscopy and spectroscopy are empoyed. The basic properties of these clusters, such as the atomic structure and the preparation procedure, are well known. In addition, it is possible to produce perfectly ordered two-dimensional (2D) arrays of these clusters on planar Si(111)7 × 7 samples. In the present work, different electronic properties and in particular different energy gaps are observed for clusters forming in the faulted and unfaulted half unit cell of the 7 × 7 reconstruction as well as for clusters neighboring other clusters. Furthermore, the Si(557) surface, which is a vicinal surface with narrow Si(111) terraces, is used as a template resulting in the formation of two different types of 1D arrays, similar to the two types of 2D arrays that are found on the planar Si(111) surface. This work was supported by the DFG through FOR 1282 project D.

O 39.4 Tue 14:45 S052

Selective One-Dimensional Growth of an Alkyl-Sugar Functionalized Ferrocene of Graphite — •Thiruvancheril Gopakumar, Prithwidip Saha, Khushboo Yadav, Shibin Chako, and Ramesh Ramapanicker — Department of Chemistry, Indian Institute of Technology Kanpur, Kanpur 208016, India

Ferrocene molecules are interesting class of semi-conducting organometallic molecules because of their excellent redox efficiency. In addition the redox potentials may be manipulated substantially by altering functional groups attached directly to Ferrocene. Here we show, using AFM, selective one-dimensional growth of an alkyl-sugar functionalized Ferrocene molecule on graphite basal plane. The assembly is driven by formation of Ferrocene dimers. The one-dimensional growth selectivity is further enhanced by adding a keto (-C=O) group in the alkyl part of alkyl-sugar group. The growth of elongated molecular islands is only limited by terrace edges or other molecular islands and is controlled by additional inter-dimer hydrogen bonding between keto group and alkyl -C-H groups.

O 39.5 Tue 15:00 S052

Growth and electronic structure of Tb disilicide nanowires on vicinal Si(111) surfaces — •Stephan Appelfeller, Martin Franz, Christian Hassenstein, Lars Freter, Hans-Ferdinand Jirschik, and Mario Dähne — Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin

One-dimensional metals may be useful for future applications, but they are especially interesting due to their unique physical phenomena, e.g. Luttinger liquid behavior or the Peierls transition. Vicinal substrates can enable the formation of such nanowires, when thin metallic films grow exclusively on well separated, narrow terraces. $TbSi_2$ forms well ordered metallic monolayer films on planar Si(111) [1]. Here, the nanowire formation of $TbSi_2$ on various vicinal Si(111) samples was investigated. Structural information, e.g. dimensions and edge characteristics, were obtained by scanning tunneling microscopy and confirm, together with the electronic properties obtained by core-level photoemission spectroscopy, the growth of $TbSi_2$. Furthermore, the electronic dimensionality of the nanowires, which is illustrated by their Fermi surfaces, was determined using angle resolved photoemission spectroscopy.

This work was supported by the DFG (FOR1700, project E2). We kindly acknowledge the support of K. Horn and coworkers and of BESSY, where the photoemission experiments were carried out at the beamlines UE56/2 PGM-1 and PGM-2.

[1] M. Franz, J. Große, R. Kohlhaas, and M. Dähne, Surface Science **637**, 149 (2015).

O 39.6 Tue 15:15 S052

Strain induced quasi one-dimensional rare earth silicides structures on Si(111) — •Frederic Timmer[1], Robert Oelke[1], Martin Franz[2], Stephan Appelfeller[2], Mario Dähne[2], and Joachim Wollschläger[1] — [1]Fachbereich Physik, Universität Osnabrück, Barbarastr. 7, 49076 Osnabrück, Germany — [2]Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

Rare earth elements (REE) covered silicon surfaces have been in the focus of research for more than 30 years due to their unique properties. For instance, thin REE-silicide films on n-type Si(111) possess very low Schottky-barriers in conjunction with an abrupt surface making them interesting as ohmic contacts. Furthermore REE-nanowires might be applicable as interconnects in future nanodevices or as plasmonic waveguides due to their quasi one-dimensional structure.
Here, we report on a $\left(2\sqrt{3} \times \sqrt{3}\right)$ R30° reconstruction for REE cov-

erages exceeding 1 ML which is therefore related to the well-known $\left(\sqrt{3} \times \sqrt{3}\right)$ R30° reconstruction. We characterize the structure of the silicide films by means of Low Energy Electron Diffraction (LEED) including Spot Profile Analysis (SPA-LEED) and Scanning Tunneling Microscopy (STM). The stoichiometry of the films and their growth mode is studied by Auger Electron Spectroscopy (AES). Combining experimental results, we develop a complex model for the reconstructed surface including formation of quasi one-dimensional structures, due to striped domains.

O 39.7 Tue 15:30 S052

Local transport measurements on terbium-silicide nanowires — •Frederik Edler[1], Ilio Miccoli[1], Herbert Pfnür[1], Stephan Appelfeller[2], Mario Dähne[2], Simone Sanna[3], Wolf G. Schmidt[3], and Christoph Tegenkamp[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover — [2]Institut für Festkörperphysik, TU Berlin, 10623 Berlin — [3]Lehrstuhl für Theoretische Physik, Universität Paderborn, 33098 Paderborn

Metal silicide wires play an important role in electronics as ohmic contacts and gate electrodes due to their very low resistivity. Rare-earth (RE) metals (eg. Tb, Dy, Er, Y) can be used to grow long, extremely thin nanowires because of uniaxial lattice matching with Si which could be used for additional downscaling of Si based technology.
The transport properties of Tb silicide wires have been studied via 4-tip STM/SEM system. The SEM allows a fast characterization of sample quality and precise positioning of feedback controlled STM tips, enabling gentle contacts and transport measurements on a nm-scale. Moreover, the STM was used to correlate the surface morphology of nanowires with transport findings.
Our measurements reveal three types of metallic wires mainly depending on the growth parameters. Further analysis shows that the resistivity is strongly depending on the height of wires, which is increased for small heights. The data can be perfectly described by a theoretical model taking into account the surface roughness and lateral surface correlation. STS reveals that the wires are electronically decoupled from the Si substrate in agreement with recent DFT calculations.

O 39.8 Tue 15:45 S052

Capping of rare earth silicide nanowires on Si(001) — •Stephan Appelfeller[1], Martin Franz[1], Milan Kubicki[1], Paul Reiss[2], Tore Niermann[2], Markus Andreas Schubert[3], 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 — [3]IHP - Leibniz-Institut für innovative Mikroelektronik, 15236 Frankfurt (Oder)

Rare earth silicide nanowires are promising candidates for the use of one-dimensional metals in future applications, but they are not stable under ambient conditions. Thus, a protective layer is needed. Here, the capping of Tb and Dy silicide nanowires grown on Si(001) by Si overlayers was studied using scanning tunneling microscopy and cross-sectional high-resolution transmission electron microscopy, also with energy dispersive X-ray analysis. Amorphous Si films deposited at room temperature allow an even capping, while the nanowires maintain their original structural properties. Subsequent recrystallization by thermal annealing leads to more compact nanowire structures and to troughs in the Si layer above the nanowires, which may even reach down to the nanowires in the case of thin Si films, as well as to V-shaped stacking faults forming along {111} lattice planes. This behavior is most probably related to strain due to the lattice mismatch between the Si overlayer and the nanowires.

This work was supported by the DFG (FOR1700, project E2).