O 54: Metallic Nanowires on Semiconductor Surfaces

Time: Tuesday 18:30–20:30 Location: P1C

O 54.1 Tue 18:30 P1C

Quasi-one-dimensional plasmons in Si(hhk)-Au: a crossover of dimensions — •Timo Lichtenstein[1], Zamin Mamiyev[1], Marvin Detert[1], Julian Aulbach[2], Jörg Schäfer[2], Christoph Tegenkamp[1], and Herbert Pfnür[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover — [2]Physikalisches Institut and RCCM, Universität Würzburg

For future plasmonic devices one-dimensional (1d) plasmons offer unique properties: an inherently predetermined direction, a wavelength much shorter than those of photons, and an almost linear dispersion. Au induced wires on regularly stepped Si(hhk) are a playground for quasi-1d structures. Therefore, they were prepared at coverages where the surfaces host single or double atomic gold chains parallel to the steps. This allows studying the influence of spacing and wire width. The wire quality was checked with spot profile analysis in low energy electron diffraction, in combination with an electron energy loss spectrometer providing both high energy and momentum resolution it gave access to the plasmon dispersion. Although 1d metallicity is observed, the plasmon dispersion strongly depends on two-dimensional properties: the lateral distribution of the 1d electron density within one terrace (intrawire correlation) and the spacing of the wires (interwire correlation). We obtained effective widths considerably smaller than the terrace width. A quantitative description is possible by a modified wire array plasmon model, claiming extensions of theory. Also, STM gives a modulated DOS of comparable width. Both the chain type as well as the terrace size seem to be of influence.

O 54.2 Tue 18:30 P1C

Au-chains grown on Ge(100): A detailed SPA-LEED and EELS-LEED study — •Timo Lichtenstein, Zamin Mamiyev, Christoph Tegenkamp, and Herbert Pfnür — Institut für Festkörperphysik, Leibniz Universität Hannover

Ge(100) is known as a substrate for self-organized growth of one-dimensional quantum wires by adsorption of Au, highly interesting for future plasmonic devices. In this study, the morphology has been investigated by means of spot profile analysis low energy electron diffraction. Using LEED in combination with an energy electron loss spectrometer we measured the plasmon dispersion relation with both high energy and momentum resolution. First, we systematically measured the properties on variously prepared surfaces. From G(S)- and H(S)-analyses on ex-situ chemically treated Ge-samples followed by multiple in-situ Ar^+-sputtering and high-temperature annealing cycles, we were able to obtain surfaces with a terrace width of around 100 nm and low roughness After the growth of the Au-wires, this analysis favors a giant missing row structure. For Au coverages higher than 0.7 ML low-dimensional plasmon modes appear in the loss spectra. Their dispersion relation increases linearly for parallel momentum $> 0.1\,\text{Å}^{-1}$, but deviates from the typical dispersion of a quasi-one-dimensional plasmon for $< 0.1\,\text{Å}^{-1}$. These effects are possibly attributed to the strong electronic correlations of the system due to the Luttinger-liquid-like behavior inside the wires as well as the strong coupling between. Peak widths and heights of the plasmon excitations in the loss spectra reveal a low excitation probability and very short lifetimes.

O 54.3 Tue 18:30 P1C

Tin nanowires on vicinal Si(111) surfaces — •Monika Jäger, Herbert Pfnür, and Christoph Tegenkamp — Institut für Festkörperphysik, Leibniz Universität Hannover, Germany

Si(111) surfaces covered by 0.3 ML Sn are known to form a $\sqrt{3}\times\sqrt{3}$ reconstruction and reveal a Mott transition upon cooling below 70 K [1]. This system is now confined to a wire like one-dimensional structure using vicinal Si(111) substrates and investigated by means of STM and LEED.

Adsorption of Sn at 900 K gives rise to a refacetting of the Si(557) surface into a local (223) orientation with an average spacing of 1.58 nm similar to the isoelectronic Pb/Si(557) system (e.g. [2]). This change in orientation ist compensated by wider (111) terraces exhibiting a $\sqrt{3}\times\sqrt{3}$ reconstruction. In order to improve the long-ranged ordering, Si(223) surfaces are used additionally as a substrate. On both vicinal surfaces, the (223)-orientated parts consist of $4\frac{2}{3}\times 0.332$ nm wide (111) terraces which show a 0.75 nm periodicity along the terraces. This is consistent with the $\times 2$ features seen in LEED measurements. Furthermore, the electronic structure is probed at different temperatures by STS.

[1] S. Modesti et al., PRL **98**, 126401 (2007).
[2] C. Brand et al., Nat. Comm. **6**, 8118 (2015).

O 54.4 Tue 18:30 P1C

Quantitative LEED studies on Si(111)-(5×2)-Au — •Andreas Alexander[1], Frederic Timmer[1], Joachim Wollschläger[1], Kaori Seino[2], and Friedhelm Bechstedt[2] — [1]Fachbereich Physik, Universität Osnabrück, Barbarastr. 7, 49076 Osnabrück — [2]Institut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena

The (5×2)-Au reconstruction on Si(111) has been in the focus of research for nearly 50 years now. Lately, in particular as a prototype for one-dimensional (1D) metallic chain structures. In order to understand the physical properties accompanying these 1D chains a profound knowledge of the atomic structure is needed. Historically, a plethora of atomic structures (EBH [1],AN [2],KK [3]) with varying Au coverages were discussed. More recently Shirasawa et al. [4] were able to show that Surface X-ray Diffraction experiments favor the KK-model slightly. Due to the higher surface sensitivity of Low Energy Electron Diffraction (LEED) as compared to SXRD we carried out quantitative LEED experiments in order to assess this observation.

[1] S. Erwin et al., Phys. Rev. B **80**, 155409 (2009)
[2] T. Abukawa and Y. Nishigaya, Phys. Rev. Lett. **110**, 036102 (2013)
[3] S. G. Kwon and M. H. Kang, Phys. Rev. Lett. **113**, 086101 (2014)
[4] T. Shirasawa et al., Phys. Rev. Lett. **113**, 165501 (2014)

O 54.5 Tue 18:30 P1C

Gold-induced Surfaces on Stepped Germanium: Growth and Characterization — •Tim Wagner, Julian Aulbach, Ralph Claessen, and Jörg Schäfer — Physikalisches Institut and Röntgen Center for Complex Material Systems (RCCM), Universität Würzburg

Adsorption of gold atoms on stepped Ge(hhk) surfaces leads to the formation of atomic wires via self-organization. Inspired by interesting physics such as spin chains on the step edges of similar gold-induced Si(hhk) surfaces [1], we establish recipes for the preparation of several gold-induced Ge(hhk) surfaces. Therefore, the preliminary sputter and anneal treatment of the stepped Ge(335), Ge(557) and Ge(553) substrates as well as the adsorption procedure of gold atoms provided by an electron beam evaporator have been optimized to achieve well-ordered surfaces. Due to the adsorption of gold atoms some Ge(hhk) surfaces undergo a refacetting in order to form a stable gold-induced surface. Based on scanning tunneling microscopy and low energy electron diffraction we determine the formation of surface reconstructions on the atomic scale on the Ge(hhk)-Au surfaces. In particular, we have characterized these surfaces regarding the formation of atomic wire structures, such as those formed by the Au and Ge atoms, and will present first indications for the occurence of superstructures.

[1] J. Aulbach et al., Nano Lett. 16(4) (2016).