QUASI-1D ATOMIC-CHAINS ON VICINAL SURFACES: THE ROLE OF DEFECTS AND CONSTRICTIONS TOWARDS ELECTRONIC TRANSPORT

I. Miccoli[a], F. Edler[a], J. P. Stöckmann[a], H. Pfnür[a,b], and C. Tegenkamp [a,b]

[a] Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany
[b] Laboratorium für Nano- und Quantenengineering, Leibniz Universität Hannover, Schneiderberg 39, 30167 Hannover, Germany

Metallic atomic chains on vicinal semiconductor surfaces are prototype quasi-1D ensembles for fundamental research, such as metal to insulator phase transition or Tomonaga-Luttinger liquid behavior [1]. Despite the intense studies over the last decades on several systems, e.g. Si(111)-4x1-In, Si(557)-Au and Si(553)-Au, the effect of native defects or induced by adsorption (e.g. O_2 and H_2) on the conductance of the wires, the interwire coupling or the transition temperature, are still under debate.

Here, we present a systematic study on the transport properties of In- and Au-chains on various Si(hhk) surfaces via a multi-tip STM/SEM system. The conductivities parallel and perpendicular to the wires is quantified by the rotational four-point-probe square method [2]. Additionally, an extremely higher sensitivity towards atomic imperfections and both conductivity components was reached by a spatial constriction of the electron path [2] (Fig. 1a). In detail, the Si(111)-4x1-In system was re-analyzed with greater attention. In contrast to previous studies, we showed in agreement with DFT calculations, that the interwire coupling can be gradually tuned by O_2 adsorption [3] (Fig. 1b). Moreover, the transport properties of various Au-phases on Si(hhk) surfaces were studied. While the 0.48 ML Au on Si(553) turned out to be extremely robust and almost unaffected (up to 20 Langmuir), the 0.2 ML phase on Si(557) reacts strongly as seen by the exponential decrease and the adsorbates induce even a crossover of its conductivity components. The adsorption behavior turns out to be strongly triggered by the presence of a Si-adatom chain, which is a characteristic building block for some Au/Si(hhk) chain systems [4].

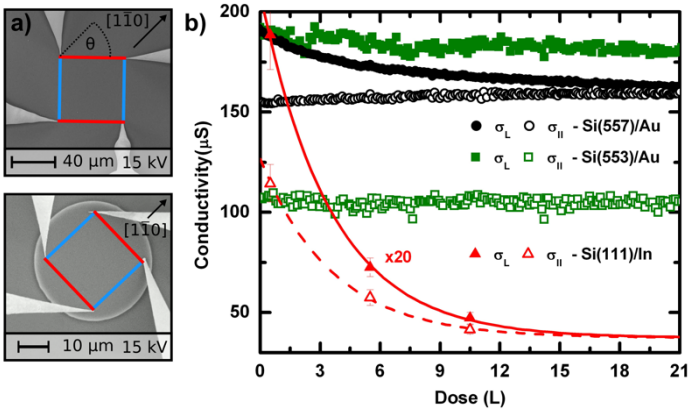

Figure 1: a) STM tips placed in square configuration on an unconfined In/Si(111) surface (above) and confined circular In/Si(111)-mesa structure (below). b) $\sigma_{||}$ and $\sigma_{\perp}$ versus O_2 dose for the Si(111)-4x1-In system, 0.48ML Au phase on Si(553) and 0.2ML Au phase on Si (557).

Keywords: Atomic-chains, metal-insulator transitions, interwire coupling, defects, lateral constrictions

[1] C. Zeng, P.R.C. Kent, T.H. Kim, A.Ping Li & H.H. Weitering, Nature Materials 7, 539 - 542 (2008).
[2] I. Miccoli, F. Edler, H. Pfnür and C. Tegenkamp, J. Phys.: Condens. Matter 27 (2015) 223201
[3] F. Edler, I. Miccoli, S. Demuth, H. Pfnür, S. Wippermann, A. Lücke, W.G. Schmidt, and C. Tegenkamp, Phys. Review B 92, 085426 (2015).
[4] J. Aulbach, S.C. Erwin, R. Claessen, and J. Schäfer , Nano Letters 16, 2698 (2016).