1.3 Nanoacoustics

The current research activities of the Nanoacoustics group concentrate on the fabrication of individual nanostructures and their characterization by low-temperature scanning tunneling microscopy and spectroscopy (LT-STM/STS). Systems of interest include structures with predefined size, geometry, and chemical composition consisting of only a small number of atoms and/or molecules and range down to single atoms and molecules interacting with their solid-state environment. The major objective is to explore new functionalities involving switching and conduction processes, electronic quantization effects, as well as magnetic behavior on the level of atomic-scale structures.

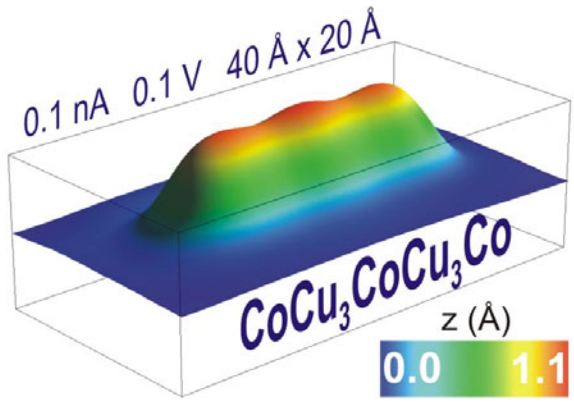

Fig. 1. Contour plot of the constant-current STM topograph obtained for a close-packed $CoCu_3CoCu_3Co$ chain with a Co atom located at each chain end and in the center of the structure. All atoms reside on adjacent face-centered cubic lattice sites of the Cu(111) surface at an interatomic distance of 2.55 Å.

The studies of close-packed Co-Cu chains engineered by atom manipulation on a Cu(111) surface have been continued [J. Lagoute *et al.*, Phys. Rev. Lett. **98**, 146804 (2007)]. Utilizing single Cu and Co adatoms as building blocks, monatomic chains of various size and composition can be assembled and imaged with chemical resolution (see for example the STM topograph of a 9-atomic $CoCu_3CoCu_3Co$ chain shown in Fig. 1). Local spectroscopy of the electron density of states along with a tight-binding analysis reveal significant interatomic Co-Cu coupling and the formation of confined quantum states delocalized along the entire heteroatomic chain. These findings indicate that Co-Cu chains constitute a promising model system for future spin-polarized STS investigations to explore the effect of local magnetic moments incorporated into a nonmagnetic host structure.

In order to test the performance of our LT-STM instruments, the electronic structure of native Ag/Ag(111) dimers was studied. In this specific system, the two adatoms of the dimer can be stabilized at will not only on adjacent lattice sites, but also on next-nearest neighbor sites or at successively larger distance. In the STS measurement, this circumstance permits to discriminate between direct interatomic coupling and substrate-mediated coupling in the case of bonding and antibonding state formation. Furthermore, in collaboration with external partners from NTT Basic Research Laboratories (Atsugi, Japan), the possibilities to manipulate single In adatoms on the InAs(111)A surface are currently investigated in order to extend the concept of atom manipulation to semiconductor-based systems.

Apart from the research topic of atom manipulation and atomic-scale quantum structures, single-molecule spectroscopy studies with the emphasis on elementary excitations of adsorbed molecules induced by inelastic electron tunneling have also been performed. The goal is to realize prototype functionalities of individual organic molecules linked to semiconductor surfaces such as reversible conformational switching behavior or radiative decay of electronic excitations. As an example, 1,5-cyclooctadiene (COD) molecules on the Si(001) surface have been investigated. As a free molecule, the 8-carbon cyclic alkene COD exists in two degenerate ground state conformations of chiral symmetry known as the 'twisted-boat' form. In the adsorbed form, we find that this conformational bistability gives rise to a binary tunneling current response reminiscent to telegraph noise when the STM tip is positioned over the adsorbed molecule. The present system serves as an example of single-molecule bistability, which can be triggered and controlled by the vertical charge transport.