ESRF

Experiment title:

Quasi One Dimensional Metal Chains

Experiment number:

SI 110

Beamline:

ID3-BL7

Date of Experiment:

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18

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Report:

The competition between adsorbate-adsorbate and adsorbate-substrate interactions manifests itself in a rich variety of surface geometries not observed in bulk materials. By controlled epitaxial growth in ultrahigh vacuum, one dimensional (lD) and two dimensional (2D) structures maybe produced. lD systems are of particular interest because of their unique behaviour. Depending on the relative magnitude of the band width and the interatomic correlation, a 1 D system at T=0K will exhibit either a charge density wave, a spin density wave or a superconductor with singlet of triplet pairing. A weak interaction between neighboring chains will stabilise chains (quasi- lD systems) at finite temperatures. The discovery of a CDW ground state in T1 chains adsorbed on the Cu(00 1) surface [1] introduced overlayers as a new class of materials capable of displaying quasi lD behaviour. Epitaxial growth allows an unprecedented opportunity to control the coverage and thus explore the phase diagrams of such systems. So far five linear chain structures have been identified but as yet the detailed atomic structure essential for a complete understanding has not been available.

In our first beamtime on ID3-BL7 we studied the growth of T1 on Cu(001) by recording the specularly reflected intensity at the (001) anti-Bragg point. The results indicated that the growth proceeds in a Stranski-Krastanov mode but, contrary to the earlier view, we find that islanding occurs at the completion of two monolayer (ML) rather than one. This is confirmed by the profile of the (00ℓ) rod measured for a film immediately before islanding. It shows the double minima between the intense Bragg peaks characteristic of a bilayer.

In-plane and out-of-plane reflections for the C4X4 structure which occurs at θ=0.6 monolayer (ML) were measured. The preliminary analysis supports a model in which T1 chains are aligned along the <100> furrows ‘(fig. 1). It further indicates that the underlying substrate is significantly distorted with probably an extra copper row between the T1 rows producing a missing row reconstruction. Rearrangements of the Cu(00 1) surface have also been reported for alkali metal adsorption [2]. On increasing the coverage beyond 0.6 ML certain in-plane reflections were observed to split. We believe this is due to anti-phase domain boundaries which form to relieve the strain along the chains.

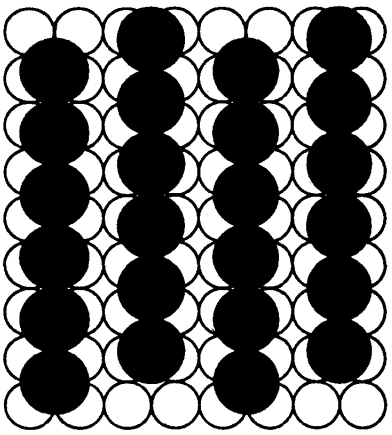

Fig. 1 A model of the C4X4 arrangement of T1 on Cu(001). The reconstruction of the substrate is not shown.

1. C. Binns, M-G. Barthès -Labrousse and C. Norris J. Phys. C: Solid State Phys. 17 (1984) 1465,
2. S. Mizuno, H. Tochihara, A. Barbieri and M. A. Van Hove, Phys. Rev. B 52 (1995) R1 1658.