Abstract

Low-dimensional antimony nanostructures on anisotropic silicon surfaces

Marek Dachniewicz

Despite the theoretically predicted new and unusual properties, one-dimensional nanostructures are still little studied experimentally. In particular, results on antimony nanostructures are lacking, which is mainly due to the molecular rather than atomic nature of Sb sublimation.

This dissertation presents the results of Ultra-High Vacuum (UHV) studies of antimony nanostructures on selected anisotropic silicon surfaces modified with Sb, Au and Pb adsorbates. High surface sensitivity methods in the form of Scanning Tunneling Spectroscopy (STS), Scanning Tunneling Microscopy (STS), Reflection High-Energy Electron Diffraction (RHEED) and Angle-Resolved Photoemission Spectroscopy (ARPES) were used. Experimental studies were confronted with calculations according to Density Functional Theory (DFT).

Investigations of Sb structures on Si(110) surface with (3x2)Sb reconstruction showed that antimony deposition on the substrate kept at room temperature leads to amorphous structures. Heating of such a sample at temperatures above 300°C causes recrystallization of antimony in the form of Sb(111) islands.

It was found that on the Si(110) substrate with reconstruction induced by Pb atoms, a significant reduction of the temperature needed for dissociation of Sb tetramers occurs. The results indicate that, for this surface, annealing at temperatures above 100°C leads to quasi-one-dimensional regions of the surface modified by the incorporation of Sb atoms into the structure of the Si(110) substrate.

Antimony on Si(553) with Au chains forms quasi-one-dimensional structures made of Sb molecules at room temperature. Annealing the Si(553) sample with deposited gold and antimony at about 600°C leads to surface reorganisation and the formation of alternating Si(111) and Si(221) facets with a regular arrangement of terraces.

The most important result of the work concerns the structures formed by the deposition of Sb onto the Si(553) surface with Pb nanoribbons. The presence of Pb atoms on the surface, acting as surfactant, causes dissociation of Sb molecules already at room temperature. Antimony was found to displace some Pb atoms from the nanoribbon structure. These atoms diffuse across the surface and accumulate as highly dispersed quasi-hexagonal islands. As a result, pairs of monoatomic chains of Pb and Sb atoms are formed on each terrace, whose periodicity is equal to the substrate lattice constant in the direction $[\,\bar{1}\,10\,]$. Both DFT calculations of the electron structure and ARPES measurements indicated that the chain of Sb atoms is metallic and is electronically isolated from the substrate.

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Dachniewicz