Indium Adsorption on the Reconstructed Si(111)√3×√3 and 4×1–In Surfaces at Room and Low Temperature

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Abstract

In this work we experimentally study the In adsorption on the reconstructed Si(111)√3×√3 and 4×1–In surfaces at room and low temperature. The low energy core levels Si 2p and In 4d as well as the valence band are measured by synchrotron radiation facilities to reveal the structural and the electronic properties.

Introduction

The ability to control the morphology of atomic overlayers on surfaces, is of fundamental importance in nanotechnology. In particular, the shape, the height and the size of the grown nanostructures, affect and ultimately determine the functionality and the performance of the modern micro- and nanoelectronic devices. Therefore, one needs to know the atomistic mechanisms which determine the growth of nanostructures on surfaces, in order to finally achieve selective fabrication of specific nanoscale devices with desirable properties. In the last decade, there is a great research effort in this direction and more particularly in the development of metal/semiconductor epitaxial systems. In this work we investigate the In ultrathin film development on the reconstructed Si(111)√3×√3 and 4×1–In surfaces at room and low temperature by using synchrotron radiation facilities.

Experimental

The experiments were performed at BACH beamline in ELETTRA synchrotron radiation center in Trieste in Italy. The sample was a *p* type Si(111) single crystal of resistivity 100 Ωcm, while the indium deposition on the substrate was done in steps of successive doses (1D=10 min) by using a Knudsen cell. An average flux of ~0.07 monolayers (ML)/min was estimated throughout the experiments. Low energy electron diffraction (LEED) measurements, were also performed to monitor the In reconstructed Si(111)√3×√3 and 4×1–In surfaces. The study is mainly based on the Si 2p and In 4d photoemission spectra as well as on the valence band measurements.

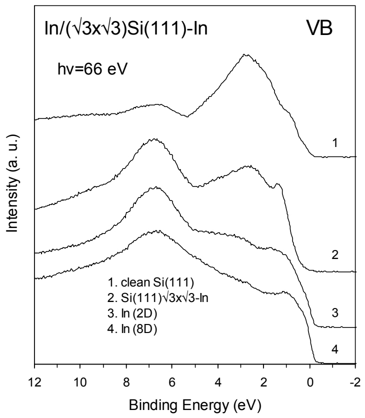

Figure 1. The valence band spectra for In adsorption on the Si(111)√3×√3-In surface.

Results and Discussion

Initially the two indium reconstructed silicon surfaces were studied for reference purposes giving consistent results with the literature [1,2]. Next, we started the In deposition on both of the reconstructed Si(111) surfaces. The results show that indium develops in the form of metallic nano-particles changing the electronic and structural properties of the reconstructed substrate. For example, the semiconducting character of the Si(111)√3×√3–In is transformed into metallic as the density of the states increases at the Fermi edge as Fig. 1 shows. The metallic character of the In particles is also indicated from the asymmetric shape of the In 4d doublet at the higher binding energy side as it is shown in Fig. 2. This asymmetry is originated by the inelastic collisions of the photoelectrons with the free electrons in the conduction band of the interface. Further investigation was carried out by performing measurements at low temperature to determine how the properties of the In/Si interface are affected by the kinetics at the nanoscale.

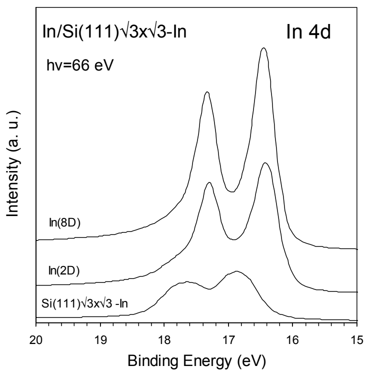

Figure 2. Indium 4d photoemission spectra for In adsorption on the Si(111)√3×√3-In surface.

Conclusions

Conclusively, as far as it concerns the room temperature experiments, it seems that the different reconstruction of the substrate does not crucially affect the structural and electronic properties of the In overlayer. The low temperature results are still under consideration.

References

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