HIGHLY RESOLVED NON-CONTACT ATOMIC FORCE MICROSCOPY IMAGES OF SEMICONDUCTOR SURFACES

Y. Sugimoto, M. Abe and S. Morita
Department of Electronic Engineering, Graduate School of Engineering, Osaka University
2-1 Yamada-Oka, Suita, Osaka 565-0871 JAPAN
ysugimoto@ele.eng.osaka-u.ac.jp

Non-contact atomic force microscopy (NC-AFM) is a powerful tool for the atomic level observation of various kinds of surfaces including even insulators, and it has been rapidly developed [1]. While the main observable value in the scanning tunneling microscope (STM) is a tunneling current between a tip and a surface, the main observable value in NC-AFM is a frequency shift of the cantilever oscillation induced by the presence of a force between the atoms of sample surface and atoms of tip apex. From the first observation of semiconductor surfaces using NC-AFM, the performance of NC-AFM has been improved and nowadays NC-AFM images of semiconductor surfaces with resolution beyond STM were obtained. In this contribution, we report highly resolved NC-AFM images of Sn/Si(111)-($2\sqrt{3}\times2\sqrt{3}$) surfaces and iron silicide c(4×8) surfaces.

Sn/Si(111)-($2\sqrt{3}\times2\sqrt{3}$) surface

When Sn is deposited on atomically clean Si(111)-(7×7) surface, various surface structures can be obtained depending on the initial Sn coverage and the subsequent annealing temperature. One of these surface reconstructions is the Sn/Si(111)-($2\sqrt{3}\times2\sqrt{3}$), which could be obtained by depositing about one monolayer of Sn followed by an annealing at 930K. From STM studies performed on this surface, it has been reported atomically resolved images in which four protrusions per ($2\sqrt{3}\times2\sqrt{3}$) unit cell were observed. Although various structure models based on STM images have been proposed [2-4], there is a little experimental information to provide a consistent structure model. In this contribution we show that when imaging the Sn/Si(111)-($2\sqrt{3}\times2\sqrt{3}$) surface with NC-AFM, higher resolution images than the STM ones are obtained. In our NC-AFM images of this surface more than four protrusions per unit cell are clearly and routinely obtained, as it can be seen in Figures.1. Our experimental results cannot be explained by any structure models previously proposed. We believe our NC-AFM images shed some light on this surface structure.

Iron silicide c(4×8) surface

Iron silicide films have attracted a great attention for their potential application in both optoelectronic and magnetic devices. Recently, flat and homogeneous iron silicide films, which could be used as a precursor surface for a well-controlled growth, have been produced by depositing Fe in the 1.5 ML regime and subsequent annealing at 900K [5-6]. STM measurements on these thin films indicate a voltage dependent surface periodicity in a c(4×8) for empty-state images, and in a (2×2)-like periodicity for filled-state images. Since the surface periodicity changes with the applied bias voltage the STM image contrast is expected to have a pronounced spectroscopic origin, possibly associated with the existence of Fe vacancies below every adatom of the surface and the ordering of the remaining Fe vacancies in layers below the first silicide layer [6]. Besides, the exact structure of this silicide layer has not been well determined yet since STM images could not provide information about atoms configuration underneath adatoms. If first layer atoms are observed using NC-AFM, we can contribute construction of the exact structure model of iron silicide c(4×8). Figures.2 show NC-AFM topographic images of the iron silicide surface. As it can be seen, the image appearance is similar to that of STM one. Both the (2×2) and the c(4×8) periodicities are accessible to NC-AFM. Furthermore, we can observe first layer atoms at defect site of adatom.

References:

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Figures:

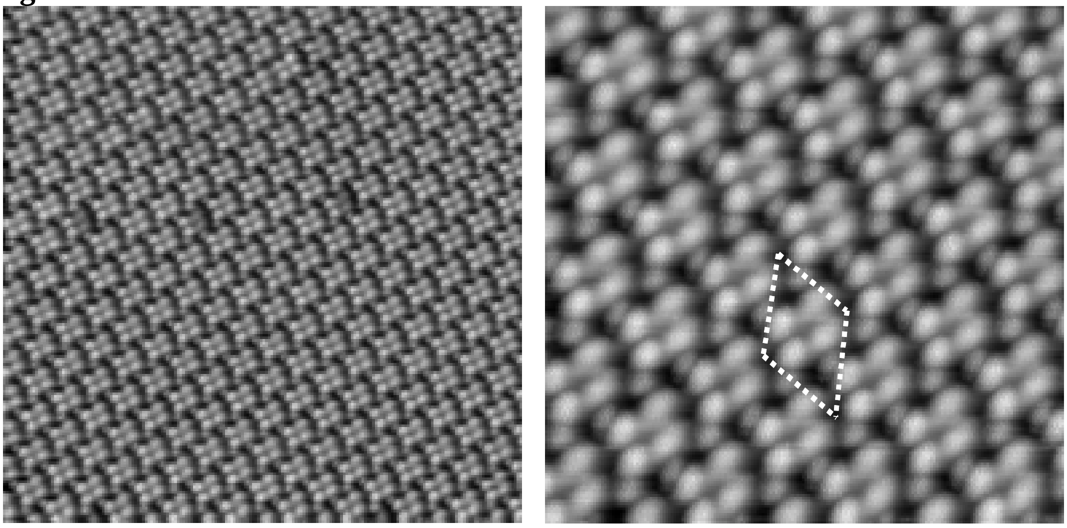

Fig. 1:
NC-AFM topography images of the Sn/Si(111)-(2√3×2√3). In the right image a unit cell of the surface is indicated for clarity. Experimental parameters: (19.4×19.4) nm^2 left and (6.4×6.4) nm^2 right, respectively.

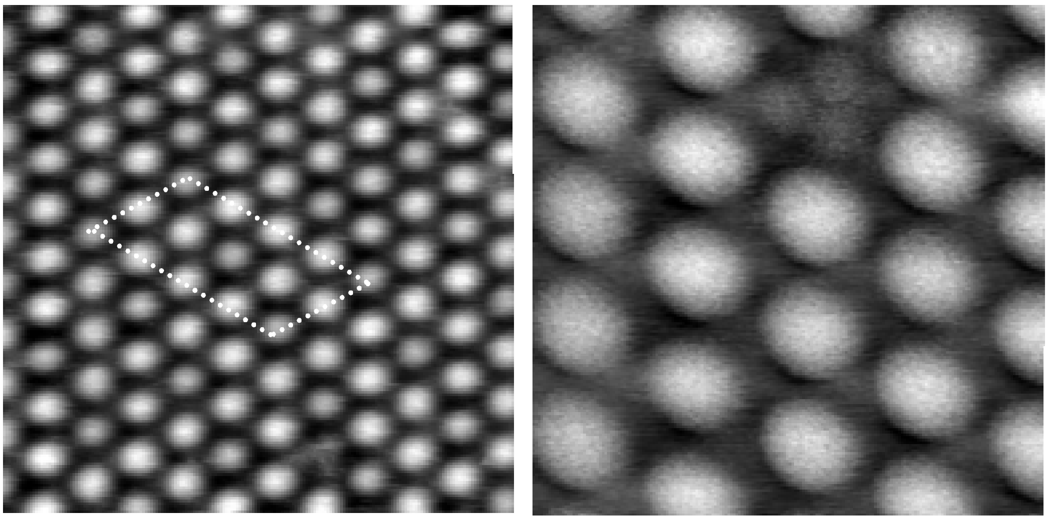

Fig. 2:
NC-AFM topographic images of the iron silicide surface showing a c(4×8) periodicity with a slight contrast between dark and bright atoms on the left, and a (2×2) periodicity on the right. In the image showing a (2×2) structure, it can be observed a vacancy in which three atoms in first layer of the iron silicide are resolved. Image sizes are (35×35)Å^2 right and (86×86)Å^2 left, respectively.