Surface and Interface

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Atomic arrangement and electronic structure of self-assembled Co nanoclusters fabricated on silicon surface

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Introduction

Understanding the formation mechanism and electronic/magnetic characters of self-assembled nanostructure is an important subject in the study of the development and spread of nano-technology. Especially, the nano-scale devices attract a great deal of interest in industry and surface science as the most advanced technique, such as ultrahigh density storage media, nano-catalysis and single electron transistor[1-3].

Over the past few decades, the observation of Co/Si (111) system has been carried out by scanning tunneling microscopy (STM), photoemission spectroscopy (PES) and Pseudopotantial DFT calculations methods [4-6]. It has been well known that the system has the flat-topped and 2×2 reconstructed triangular clusters by the deposition on the clean 7×7 reconstructed surface at 320°C. It was also suggested in some reports that these clusters show $CoSi_2$ structure with 7-fold Co coordination (interface) and so-called *B*-type geometry. While the Co cluster fabricated on Al nanocluster template on Si (111) surface also have the flat-topped cluster at the same substrate temperature [7], but they are seldom observed with 2×2 reconstruction. From these results, we conceive that this structure differs from $CoSi_2$ structure. What's interesting is that this Co clusters have the high perpendicular magnetic anisotropy under 40K [7]. Our purpose is to clarify the difference of the atomic structure between Co and $CoSi_2$ clusters, and the template effect of Al nanocluster phase using photoelectron diffraction experiment.

Experimental

The experiments were carried out in an ultrahigh-vacuum chamber with a base pressure of 2.0×10^{-10} mbar, using GAMMA-DATA SCIENTA SES100 at BL-18A. All of the photoelectron spectra were obtained at 100K.

Results and Discussion

Figure 1 (a) shows the Co 2p X-ray photoelectron diffraction (XPD) patterns of Co (Co-0.44ML) and $CoSi_2$ (Co-0.52ML) clusters set in the $[1\bar{1}0]$ and $[11\bar{2}]$ direction. The two peaks (22.9°, 58.0°) of $CoSi_2$ in $[11\bar{2}]$ direction are considered to be due to forward scattering of Co 2p photoelectrons by interface Co atoms between $CoSi_2$ cluster and substrate. While the Co 2p XPD pattern of the Co cluster has no conspicuous peak in the same direction. Additionally, each XPD pattern in $[1\bar{1}0]$ direction shows different features as shown by the upper two XPD patterns in Fig. 1(a). Here, we can deduce that the atomic structure of the Co cluster is not the same as that of $CoSi_2$ cluster even though these clusters are fabricated by almost the same condition and they are formed as the same triangular shape restricted 7×7 half unit cell. When Al nanocluster is formed on the Si (111) surface, it has been known that the Si rest atom in the 7×7 reconstruction surface initially bonds to a deposited Al atom [9-11]. From these results, we may say that the difference of forming process between Co and $CoSi_2$ clusters is related to the rest-atom behaviour.

Figure 1(b) shows the Al 2p photoelectron diffraction (PED) pattern of Co cluster formed on Al nanocluster surface. Here, we can find both PED patterns show no peak. This feature means that Al atom is located in the top-most on Co cluster.

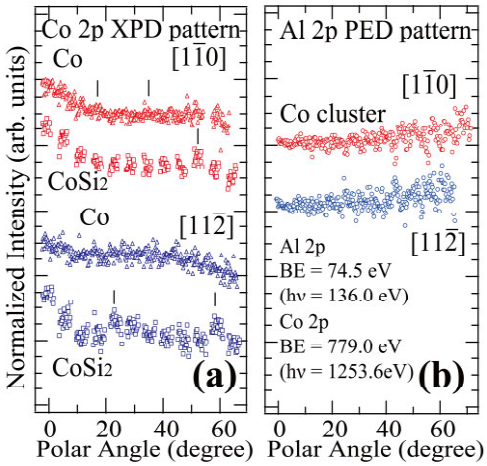

Figure1. (a) Co2p XPD patterns of Co and $CoSi_2$ clusters (MgKα source) and (b) Al 2p PED patterns of Co cluster (hν =136eV). Red and blue lines show diffraction patterns in $[1\bar{1}0]$ and $[11\bar{2}]$direction, respectively.

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