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Friction of Ag/Si (111) studied by synchrotron X-ray diffraction

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Introduction

Friction coefficient of Ag deposited on Si(111) surface is very low. And tribological properties of thin Ag films deposited on the Si(111) 7×7 surface and on the Si(111) √3×√3-Ag surface have been reported[1]. Furthermore, changing crystal orientation of Ag due to friction has been reported[2]. However, the reason of friction coefficient lowering is unknown. If this phenomenon is clarified, it makes the friction mechanism cleared up. We used X-ray diffraction for investigation of crystal orientation changes of Ag thin films, and extremely asymmetric X-ray diffraction technique for investigation of strain on the Si interface.

Experiment

Fabrication of samples.

Samples were fabricated in ultrahigh vacuum apparatus. After preparation of the Ag-induced Si(111) √3×√3-Ag surface by depositing 1 ML Ag on the Si(111) 7×7 clean surface. √3×√3 reconstructure and 7×7 clean surface were checked by RHEED. 5-nm-thick and 2.5-nm-thick Ag film was deposited on the surface. The friction experiments were carried out using a diamond pin-on-plate type tribometer just after the Ag deposition in the same UHV chamber. Samples were rubbed by normal load 250mN. Samples have rubbed area and non-rubbed area on the same plane.

X-ray diffraction experiments.

The crystal orientation of 5-nm-thick Ag films on the Si(111) √3×√3-Ag surface was studied using X-ray diffraction with synchrotron radiation in BL-4C,9C. The X-rays were monochromatized at 0.11 nm.We observed Ag111 and Ag200 reflection from each area.

Moreover, Si substrate strain was studied by an extremely asymmetric X-ray diffraction technique using synchrotron radiation at BL-15C. In this experiment, 2.5-nm-thick Ag film on the Si(111) √3×√3-Ag surface sample was observed by monochromatized beam at 0.16nm. We observed Si113 reflection from each area.

Results and discussion

The intensity of Ag111 reflection from rubbed area was stronger than non-rubbed area as shown in Fig 1. On the contrary, The intensity of Ag200 reflection from rubbed area was weaker than non-rubbed area as shown in Fig 2. These results indicate that Ag{100}grains disapear and Ag{111}grains are built moreover according to rubbing the surface. Next, we wrote the results of the extremely asymmetric X-ray diffraction experiments. We found that the shape of Si113 reflection rocking curve from two areas were different. The intensity of the reflection from rubbed area is larger than it comes from non-rubbed area when the incident angle is a little higher than peak. By comparing these results to the result of simulation, we conclude that difference of the peak shape comes from compressive strain on rubbed area.

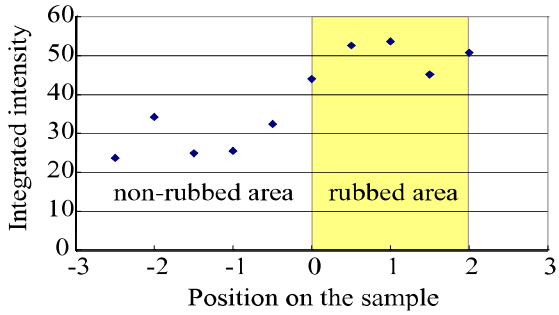

Fig.1 Intensities of Ag111 reflection

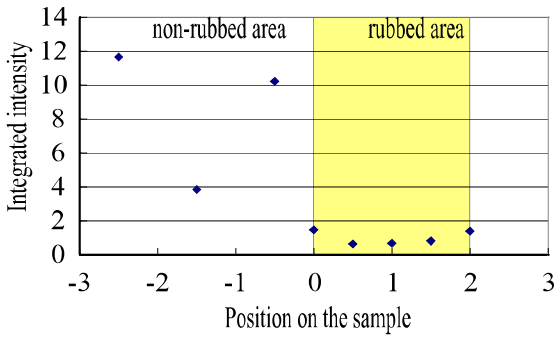

Fig.2 Intensities of Ag200 reflection

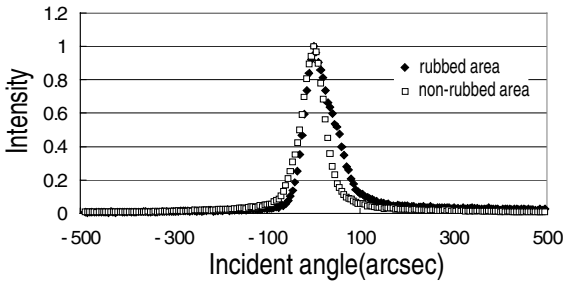

Fig3.Rocking curves of Si113 reflection

References

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