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Crystal orientation of silver films on silicon surfaces

Atsushi HATA[1], Koichi AKIMOTO*[1], Shinji HORII[1], Takashi EMOTO[1], Ayahiko ICHIMIYA[1], Hiroo TAJIRI[2], Toshio TAKAHASHI[2], Hiroshi SUGIYAMA[3], Xiaowei ZHANG[3], and Hiroshi KAWATA[3]

[1]Dept. of Quantum Eng., Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan
[2]Institute for Solid State Physics, University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa 277-8581, Japan
[3]Photon Factory, High Energy Accelerator Research Organization, Tsukuba 305-0801, Japan

Introduction

The effects of reconstructed structures on the preferred orientation of overlayer films have not been fully understood, while the control of the crystal orientation of overgrown films is needed in all electric devices.

The Ag-induced ($\sqrt{3}\times\sqrt{3}$)R30 structure on a Si(111) surface (called Si(111)$\sqrt{3}$-Ag for short) has been much interested by many researchers. The surface Si(111)$\sqrt{3}$-Ag structure has been explained by a honeycomb-chained-triangle (HCT) model[1,2]. Recently, the $\sqrt{3}$ structure has been reported to exist at the Ag/Si(111)$\sqrt{3}$-Ag interface[3,4]. As for Ag overlayer films on the $\sqrt{3}$ structure, some articles [3,5] has been reported on the growth mechanism and/or initial-stage structural model. However, the relation between reconstructed structures and the preferred orientation of overlayer films has not been fully understood.

Results and Discussion

The Si(111)$\sqrt{3}$-Ag surface was obtained by depositing 1ML Ag on the Si(111)7×7 surface at about 790K. After preparation of the Si(111) $\sqrt{3}$-Ag, 50ML Ag was deposited on the Si(111) $\sqrt{3}$-Ag at the substrate temperature of 50~300K. The RHEED pattern taken after the deposition of 50ML-thick Ag overlayers showed no $\sqrt{3}$ pattern. However, the Ag(50ML)/Si(111) $\sqrt{3}$-Ag showed intense $\sqrt{3}$ fractional order reflection peaks by grazing incidence X-ray diffraction measurements. This is the evidence to show that the $\sqrt{3}$ structure remains at the interface[3,4].

In order to study the crystal orientation of Ag thin films on a Si(111)$\sqrt{3}$-Ag surface, scans of X-ray measurements were made by rotating the sample about the surface normal (θ- scan). The Ag{111} plane was mainly grown on the surface[3]. In addition, the Ag 111 reflection was measured. The scan results for the sample with 50ML-Ag deposition on a $\sqrt{3}$ surface at 300K and 50K were shown in Fig. 1. In Fig. 1, a peak at θ=0° was separated in two. The separation angle was about 8°. This separation was already reported[3], but a clear explanation has not been given. In order to clarify the origin of this separation, we measured mesh scan for the sample with 50ML-Ag deposition on a $\sqrt{3}$ surface at 300K. We found streaky scattering along the [11$\bar{2}$] direction parallel to the surface as shown in Fig. 2.

The streaky scattering is thought to originate from the CTR (crystal truncation rod) scattering from a sidewall plane of the Ag {111} nanometer-scale crystals as shown in Fig. 4. The sidewall plane of the Ag {111} should be the {11$\bar{2}$} plane, because the streaky scattering was appeared along the [11$\bar{2}$] direction.

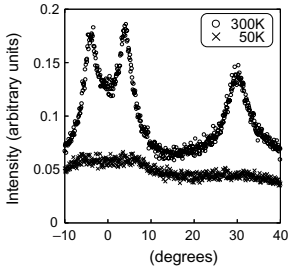

Fig.1 Intensity profiles of Ag bulk reflections for Ag/Si(111)$\sqrt{3}$-Ag for the Ag 111 reflection.

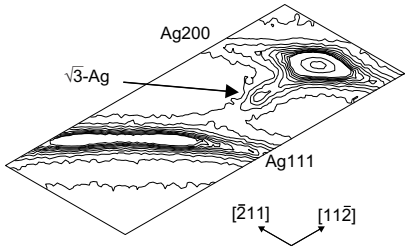

Fig. 2 Measured mesh scan for Ag/Si(111)$\sqrt{3}$-Ag.

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*akimoto@nucc.cc.nagoya-u.ac.jp