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In situ Photoemission Characterization of $LaFeO_3$ Thin Films Grown on $SrTiO_3$ Substrates by Laser Molecular Beam Epitaxy

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Introduction

Epitaxial multilayered heterostructures based on perovskite oxides have a great potential for future electronic device applications[1]. For realizing these devices with desired properties, it is important to control the interface and surface structure on an atomic level. In particular, it is indispensable to evaluate the diffusion or segregation of constituent atoms across the heterointerface since the physical properties of a perovskite transition metal oxide is very sensitive to its composition. In this study, we report *in-situ* photoemission characterization of $LaFeO_3$ thin films grown on wet-etched TiO_2-terminated $SrTiO_3$ (001) substrate[2] with different growth conditions and film thicknesses in order to investigate the segregation or diffusion of Sr atoms at the $LaFeO_3/SrTiO_3$ heterointerface.

Experimental

$LaFeO_3$ thin films with thickness of 20 ~ 100 ML (8 ~ 40 nm) were fabricated in a laser molecular beam epitaxy chamber connected to a synchrotron radiation photoemission system at BL-2C of the Photon Factory.[3] The $LaFeO_3$ thin films were deposited on the TiO_2-terminated $SrTiO_3$ (001) substrate at 700°C or 950°C at an oxygen pressure of 1×10^{-4}Torr.[2] During $LaFeO_3$ thin films growth, we monitored the intensity of specula spot in reflective high energy electron diffraction (RHEED) pattern by *in-situ*. According to the *in-situ* RHEED monitoring, the growth mode of $LaFeO_3$ thin film at low temperature (700°C) was layer-by-layer growth mode, while step-flow growth mode at high temperature (950°C). The fabricated $LaFeO_3$ thin films were moved into the photoemission chamber under ultra high vacquum of 1×10^{-10}Torr. The PES spectra were taken at room temperature and total total energy resolution at the photon energy of 600eV is about 200meV.

Results and Discussion

Figure 1 shows the photoemission spectra of $LaFeO_3$ thin films grown with various conditions. We observed a clear Sr 3*d* signal indicative of existence of substantial Sr atoms on the surface of $LaFeO_3$ film with thickness of 20 ML grown at high temperature. The high-resolution spectra of Sr 3*d* core level mainly consist of two components: a sharp peak at binding energy of 132.8eV and relatively broad one with an energy separation of 1.1eV. Detailed analysis of the spectra revealed that the sharp component may originate from the local formation of $La_{1-x}Sr_xFeO_3$, while the broad one emerge as a results of Sr segregation and subsequent recrystallization as Sr oxides (SrOx) on the surface. The intensity of the Sr 3*d* peak gradually decreases with increasing the film thickness and nearly disappears at 100 ML thickness. In constant, we do not observe any indication of existence of the extra Sr atoms on the surface for $LaFeO_3$ thin films grown at 700°C (layer-by-layer growth). Furthermore, even after annealing of the $LaFeO_3$ films at 950°C, the Sr atoms were not segregated on $LaFeO_3$ film surface, suggesting that Sr segregation depend on the growth mode of $LaFeO_3$ films.

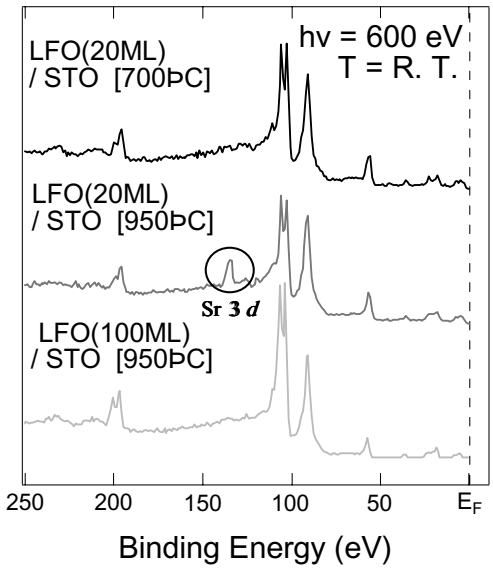

Fig. 1: Photoemission spectra of LaFeO3 thin films grown with different conditions.

References

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