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Thickness dependence of $SrRuO_3$ epitaxial thin films studied by *in-situ* photoemission spectroscopy

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Introduction

A metallic oxide $SrRuO_3$ (SRO) with high chemical stability has a great potential for future oxides electronic device applications such as an electrode in the heteroepitaxial structures consisting of a variety of perovskite-based ferroelectric, ferromagnetic, and superconducting films [1-3]. However, the electronic and magnetic properties of the oxide films are very sensitive to the film thickness and heterointerface structure. For designing devices with desired properties, it is critically important to understand the thickness dependent physical properties of the films as well as to control the valence band discontinuity at heterointerfaces. In this study, we report the thickness dependence of *in-situ* photoemission (PES) spectra of SRO layers deposited on $SrTiO_3$ (STO) substrates.

Experimental

SRO thin films were fabricated by a laser molecular beam epitaxy on TiO_2-terminated STO substrates. A Nd:YAG laser was used for ablation in its frequency-tripled mode (λ= 355 nm) at a repetition rate of 1 Hz. During deposition, the substrate temperature was kept at 750 °C and the oxygen pressure was 1 x 10^{-3} Torr. The nominal thicknesses of the films range from 1 to 100 ML. After thin film growth, *in-situ* PES measurements were performed at the beam line BL-2C. The energy resolution is set to 150 meV at the photon energy of 600 eV.

Results and Discussion

Figure 1 shows the PES spectra of SRO thin films with varying the nominal film thickness. The PES spectra show remarkable and systematic changes as a function of SRO film thickness; (1) the PES spectra for the film thickness of 1 – 4 ML clearly exhibit the existence of an energy gap at the Fermi level (E_F), while the Ru-4*d* derived in-gap states emerge at E_F above 5 ML, indicating the occurrence of metal-insulator transition at film thickness of 4 – 5 ML. (2) The in-gap states gradually grow with increasing film thickness and finally have evolved into the Ru-4*d* sharp peak just at E_F above 15 ML, which is responsible for itinerant ferromagnetism in SRO. These results suggest that a layer of SRO more than 15 ML in thickness is necessary to obtain intrinsic properties of SRO.

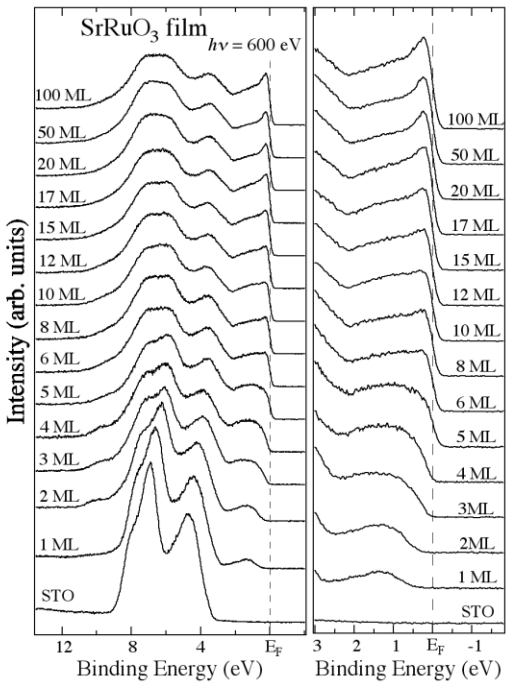

Fig.1: PES spectrum of SRO thin films

References

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