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In-situ photoemission study on $SrRuO_3$ epitaxial thin films grown by Laser MBE

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Introduction

$SrRuO_3$ (SRO) has attracted much attention because of potential device applications such as electrodes of oxide electronic devices [1] and normal metal layers in Josephson junction devices [2] utilizing its interesting electrical and magnetic properties [3]. The electronic structure of SRO has been intensively investigated by photoemission spectroscopy (PES) [4]. However, questions arose as to reliability of PES spectra on addressing the electronic structure of SRO; the PES spectra do not show any indication of a sharp peak at the Fermi level (E_F) responsible for itinerant ferromagnetism in SRO. This may be due to surface disorder induced by the surface preparation procedures required for previous PES measurements [4]. One of the best ways to solve this problem is to grow high-quality epitaxial thin films with well-ordered surfaces and then to measure them *in-situ* without exposing their surfaces to the air. In this study, we report *in-situ* PES and x-ray absorption spectroscopy (XAS) results on well-ordered single-crystal surfaces of high-quality SRO thin films.

Experimental

SRO thin films were grown on Nb-doped $SrTiO_3$ substrates by laser molecular beam epitaxy using a Nd:YAG laser in the frequency-tripled mode at a repetition rate of 10 Hz. Substrate temperature during film growth was maintained at 900 ^{O}C. After thin film growth, *in-situ* PES and XAS measurements were performed at the beam line BL-2C. The energy resolution is set to 150 meV at the photon energy of 600 eV. The surface morphology and film structures of the measured films are characterized by atomic force microscopy (AFM) and four-circle x-ray diffraction, respectively, confirming the high quality of measured thin films.

Results and Discussion

Figure 1 shows the PES and XAS spectra of $SrRuO_3$ thin films. The inset shows an typical AFM image of the films. Clear step and terrace structures are observed in the AFM image, showing atomically-flat surface. In sharp contrast to the previous PES results [4], the PES spectra on the well-ordered surface exhibit an existence of a sharp peak just at E_F. In comparison with a band structure calculation, the sharp peak originates from the Ru 4*d* t_{2g} states which are responsible for itinerant ferromagnetism in SRO. On the other hand, the relatively broad features in PES spectrum located around 3.5 eV and 6.7 eV are assigned to O 2*p* non-bonding states and Ru 4*d* – O 2*p* bonding states, respectively, while the structures at about –3.7 eV in XAS spectra are assigned to Ru 4*d* – O 2*p* anti-bonding states. The observation of sharp peak just at E_F strongly suggests the importance of *in-situ* PES measurements on well-ordered surfaces of transition metal oxides for revealing their intrinsic electronic structures.

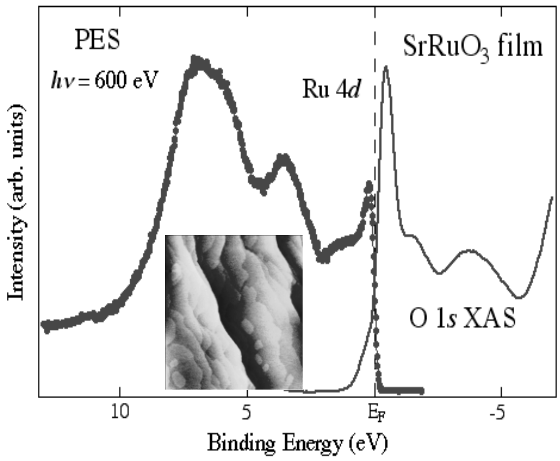

Fig.1: PES and XAS spectrum of SRO thin films. The inset shows an typical AFM image of the films.

References

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