

Electronic states of SrRu_{0.9}Cr_{0.1}O₃ thin films studied by X-ray photoemission and absorption spectroscopies

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1 Introduction

Perovskite ruthenium oxide SrRuO₃ is a ferromagnetic metal with a Curie temperature of $T_C = 166$ K and widely used as an oxide electrode material. When 10% of Cr is doped into the Ru sites of the bulk SrRuO₃, T_C increases to 188 K [1]. On the other hand, the T_C values of the SrRuO₃ and SrRu_{0.9}Cr_{0.1}O₃ thin films on SrTiO₃ (001) substrates are 152 K and 165 K, respectively [2]. Thus, the effect of Cr doping on SrRuO₃ differs between bulk and thin films. This T_C enhancement is attributed to the widening of the energy bands due to the hybridization of Cr 3d_{t_{2g}} and Ru 4d_{t_{2g}} [1], but such hybridization has not been experimentally verified so far. In this study, we measured the core-level and valence band spectra of a SrRu_{0.9}Cr_{0.1}O₃ film by photoemission spectroscopy (PES) and X-ray absorption spectroscopy (XAS) to investigate the electronic states of the SrRu_{0.9}Cr_{0.1}O₃ film.

2 Experiment

Epitaxial thin films of SrRu_{0.9}Cr_{0.1}O₃ were fabricated on SrTiO₃ (001) substrates by pulsed laser deposition method. The substrate temperature and partial oxygen pressure were set to 600°C and 1×10^{-1} Torr, respectively. The typical thickness of the films was ~50 nm. Epitaxial growth of SrRu_{0.9}Cr_{0.1}O₃ films were confirmed by X-ray diffraction. T_C of the films was evaluated to be 166 K from magnetization vs. temperature measurements by a SQUID magnetometer. PES and XAS measurements were carried out at beamline 2C of the Photon Factory, KEK. The Fermi levels of the sample were referred to that of Au foil in electrical contact with the sample. The XAS spectrum was measured by the total-electron-yield method.

3 Results and Discussion

Figure 1(a) shows the Cr 2p core-level PES spectrum of the SrRu_{0.9}Cr_{0.1}O₃ film. The figure exhibits peaks at binding energies (E_b) of ~576 eV (Cr 2p_{3/2}) and ~586 eV (Cr 2p_{1/2}). The spectrum in Fig. 1(a) is similar to those of Cr₂O₃ (Cr³⁺) and CrO₂ (Cr⁴⁺) [3] as reported previously, suggesting that the Cr ions in SrRu_{0.9}Cr_{0.1}O₃ thin films are trivalent or tetravalent. Figures 1(b) and 1(c) shows the XAS spectrum near the Cr L-edge and the Cr 2p-3d resonant PES spectra, respectively, of the SrRu_{0.9}Cr_{0.1}O₃ film. The resonant PES spectra were recorded with excitation energy ranging from 573 to 588 eV and

normalized by photon flux of the incident beam. The actual incident photon energies are indicated by arrows on the Cr L-edge XAS spectrum depicted in Fig. 1(b). As seen in Fig. 1(c), the PES intensities at E_b of 1-3 eV and 6-9 eV are resonantly enhanced, indicating that the corresponding energy states are contributed by the Cr 3d orbital. By comparing the resonant PES spectra with the valence band spectra of Ca_{1-x}Sr_xRuO₃ thin films [4], we assigned the peaks located at 0-3 eV and 5-9 eV as Ru 4d_{t_{2g}}-nature states and Ru 4d-O 2p hybridized states, respectively. These results give experimental evidence that the Cr 3d_{t_{2g}} orbital is strongly hybridized with the Ru 4d_{t_{2g}} one in the SrRu_{0.9}Cr_{0.1}O₃ films.

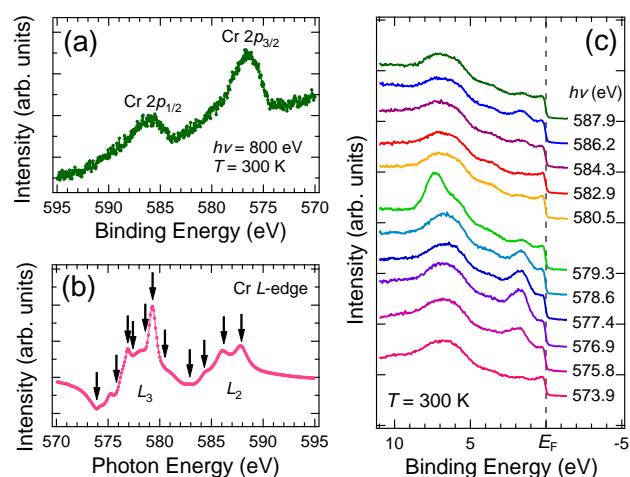


Fig. 1. (a) Cr 2p core-level PES spectrum, (b) Cr L-edge XAS spectrum, and (c) Cr 2p-3d resonant PES spectra of the SrRu_{0.9}Cr_{0.1}O₃ thin film.

References

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