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Spectral weight transfer in $Ca_{1-x}Sr_xRuO_3$ studied using epitaxial thin films

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Introduction

Metal-insulator transition has been extensively studied because of its fundamental importance as well as its close relationship to interesting phenomena such as high-temperature superconductivity in cuprates and colossal magnetoresistance in manganites [1]. Broadly speaking, metal-insulator transition occurs in two ways. One is bandwidth control, and the other is filling control. In bandwidth control, the bandwidth and hence electron correlation strength is changed by modifying the lattice parameter or the bond angle while essentially maintaining the original lattice structure. An example of bandwidth control is the modification of the radius of the *A* site ions in perovskite-type ABO_3 compounds.

Despite of their more extended 4*d* orbitals than the transition-metal 3*d* orbitals, ruthenates have been recently found to show various correlation effects. Previously photoemission study of $SrRuO_3$ polycrystalline have revealed that the effect of electron correlation is substantial in the Ru 4*d* t_{2g} band [2, 3].

In this work we have measured soft x-ray photoemission (PES) and absorption (XAS) spectra of the bandwidth control system $Ca_{1-x}Sr_xRuO_3$ (CSRO) using high-quality epitaxially grown thin films.

Experimental

CSRO thin films were fabricated in a laser MBE chamber connected to a synchrotron radiation photo-emission system at BL-2C of Photon Factory [4]. The films were deposited on Nb-doped TiO_2-terminated $SrTiO_3$ (001) substrates [5] at 900 ^oC at an oxygen pressure of 0.1 Torr. The fabricated CSRO films were transferred into the photoemission chamber under an ultrahigh vacuum of 10^{-10} Torr. The PES spectra were taken at room temperature with the total energy resolution of about 200 meV at the photon energy of 600 eV.

Results and Discussion

Figure 1 shows the valence-band spectra taken at hν = 600 eV and the O 1*s* XAS spectra. As shown in the previous work [2, 3], the band between ~ 5 eV to ~ -2 eV is mainly composed of Ru 4*d* character and that between ~ -2 eV to ~ -10 eV is mainly of O 2*p* character. For PES, the emission within ~ 1 eV of E_F with a sharp Fermi edge and the broad band centered at ~ -1.2 eV peak are due to the coherent (the quasiparticle band near E_F) and incoherent parts (the remnant of the lower Hubbard band) of the spectral function, respectively.

For O 1*s* XAS, two peaks are similarly seen, which we attribute to the coherent and incoherent parts. Both in PES and XAS, as one decreases x, that is, as one decreases the bandwidth, one can see that spectral weight transfer occurs from the coherent part to the incoherent part. In XAS, spectral weight transfer is relatively small. In order to quantitatively interpret XAS spectra effects of core-hole potential have to be taken into account..The present observation is consistent with the behaviour, as predicted by dynamical mean-field theory [6].

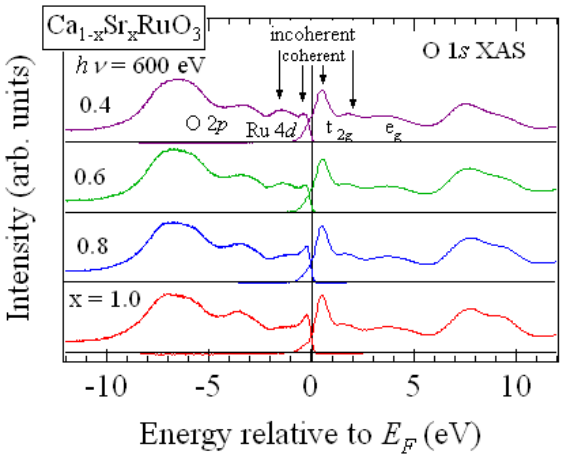

Fig. 1: Valence band PES and O 1s XAS spectra of CSRO epitaxial thin films.

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