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Angle-resolved photoemission study of $SrVO_3$ thin films

Masaru TAKIZAWA*[1], Makoto MINOHARA[1], Hiroshi KUMIGASHIRA[1], Daisuke TOYOTA[1], Koji MAEKAWA[1], Hiroki WADATI[1], Teppei YOSHIDA[1], Atsushi FUJIMORI[1], Masaharu OSHIMA[1], Mikk LIPPMAA[2], Masashi KAWASAKI[3], and Hideomi KOINUMA[1]
[1]Univ. of Tokyo, Honogo, Bunkyo-ku, Tokyo 113-0033, Japan
[2]ISSP, Kashiwa, Chiba 277-8561, Japan
[3]Tohoku Univ., Sendai, Miyagi 980-8577, Japan

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]. $Ca_{1-x}Sr_xVO_3$ (CSVO) is a typical bandwidth control system but remains metallic in the entire x range. With Ca doping, ultra-violet photoemission spectra of CSVO showed spectral weight transfer from the coherent part to the incoherent part [2], while using high photon energies there were no spectral weight transfer [3]. Therefore, it is now well known that the surface electronic states are different from the bulk ones. Many studies were devoted to investigate the real "bulk" electronic states [4-6], but the problem remains highly controversial and further studies are strongly required. In the present work, we have fabricated a $SrVO_3$ (SVO) thin film and studied its electronic structure in detail by angle-resolved photoemission spectroscopy (ARPES).

Experiment

A SVO thin film was fabricated in a laser MBE chamber connected to a synchrotron radiation ARPES system at BL-1C of Photon Factory [7]. The films were deposited on Nb-doped TiO_2-terminated $SrTiO_3$ (001) substrates [8] at 900 °C at an ultra high vacuum of ~10^{-9} Torr. The fabricated SVO thin film was transferred into the photoemission chamber under an ultrahigh vacuum of 10^{-10} Torr. The ARPES spectra were taken at 20 K with the total energy resolution of 60 and 150 meV near Fermi level and in the valence-band region, respectively.

Results and Discussion

The ARPES spectra taken at 88 eV are shown in Fig. 1 (a) and (b). Using the photon energy of 88 eV, one can trace momenta along the Γ (0,0,0) – X (π,0,0) line. The bands between -10 eV to -3 eV are mainly composed of O 2*p* states and those between -3 eV to the Fermi level (E_F) mainly of V 3*d* states. There were clear dispersions both in the O 2*p* and V 3*d* bands as shown in Fig. 1 (a). In the V 3*d* band [Fig. 1 (b)], there were two features: the coherent part (the quasiparticle band crossing E_F) and the incoherent part (the remnant of the lower Hubbard band). The intensity ratio of the coherent part to the incoherent part was similar to that of the bulk spectra reported in Refs. [3, 5]. This fact indicates that the contribution of surface states is negligibly small in the V 3*d* states for SVO thin films.

From the dispersion of the coherent part near E_F, we estimated the mass renormalization factor to be about 2.0 in comparison with LDA calculation. This value was consistent with the results for bulk SVO samples [6, 9]. In the incoherent part located around -1.5 eV, one can see a weak but finite dispersion.

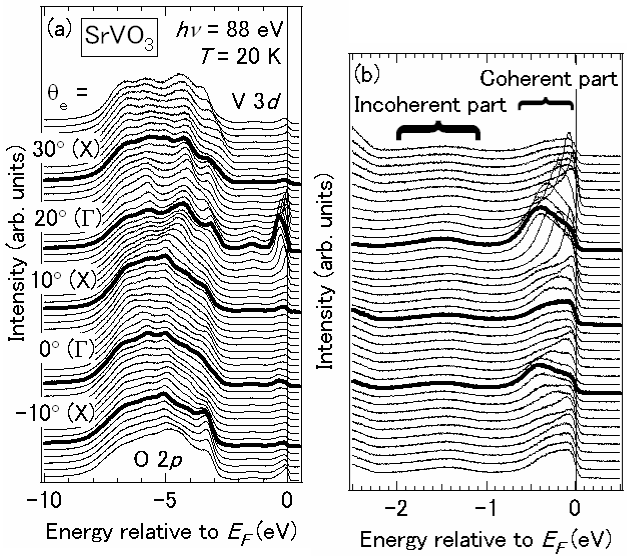

Figure 1: ARPES spectra of SVO thin films in the entire valence-band region (a) and near the Fermi level (b).

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* takizawa@wyvern.phys.s.u-tokyo.ac.jp