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Coherent and incoherent band dispersions in V 3*d* band of $SrVO_3$ 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]. $Ca_{1-x}Sr_xVO_3$ (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-28B 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 30 meV.

Results and Discussion

The E - k_x space intensity plot near E_F along the Γ - X direction in Fig. 1 shows the V 3*d* bands. The peak positions determined from both energy distribution curves (EDCs) and momentum distribution curves (MDCs) are also shown. The V $3d_{xy}$ and $3d_{zx}$ bands cross the Fermi level between the Γ and X points. For the dispersion of the coherent part, one can see clear mass renormalization compared with the LDA calculation [9]. From the experimental (-0.44 ± 0.02 eV) and calculated (-0.95 eV) occupied bandwidths, the global mass renormalization factor is estimated to be ~ 2. That is, if the LDA band dispersions are reduced by a factor of 0.5, the experimental band dispersions are well reproduced as shown in Fig. 1. This indicates that the self-energy is nearly independent of momentum and of the d_{xy}, d_{yz} or d_{zx} bands of the degenerate t_{2g} band. The kink in the band dispersion is weak and broad, if exists, but the curvature changes its sign around ~ -0.2 eV as predicted by a recent DMFT calculation [10]. As for the incoherent part located around -1.5 eV, one can see a weak but finite (~ 0.1 eV) dispersion. The intensity of the incoherent part is momentum dependent and becomes strong within the Fermi surface.

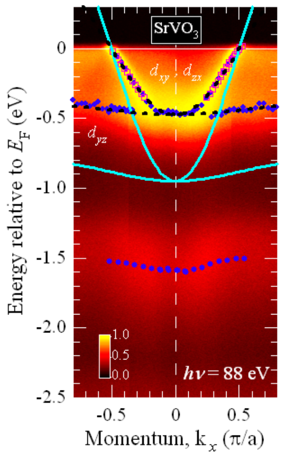

Figure 1: Energy- and momentum-dependent spectral weight near the Fermi level for $SrVO_3$. Peak positions of the EDCs and MDCs are shown by filled circles and open squares, respectively. The V 3*d* bands from the LDA calculation [9] is also shown by solid curves. Broken curves are LDA bands renormalized by a factor of 2.

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