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In-situ angle-resolved photoemission study of $La_{1-x}Sr_xFeO_3$ epitaxial thin films

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Introduction

Angle-resolved photoemission spectroscopy (ARPES) is a unique and powerful experimental technique by which one can determine the band structure of a material directly. ARPES has long played a central role in studying the electronic properties of strongly correlated electron materials with a layered perovskite structure. Especially for high-T_c cuprate superconductors, ARPES has revealed important features, such as the Fermi surface topology and the strong *k*-space anisotropy of the superconducting gap [1].

In contrast, there have been few studies on transition metal oxides with a three-dimensional perovskite structure such as $La_{1-x}Sr_xFeO_3$ (LSFO) because they do not have any cleavage plane. In this work, we performed *in-situ* ARPES measurements of single-crystal thin films of LSFO. *Ex-situ* ARPES measurements were reported on thin films of $La_{0.65}Ca_{0.35}MnO_3$ and $La_{0.65}Ba_{0.35}MnO_3$ with complicated surface cleaning procedures, but nearly flat bands were observed [2]. By performing *in-situ* studies, no cleaning procedures were necessary and we succeeded in observing band dispersions in LSFO (x = 0.4).

Experimental

The LSFO thin films were fabricated in a laser MBE chamber connected to a synchrotron radiation photo-emission system at BL-1C of Photon Factory [3]. LSFO thin films were deposited on Nb-doped TiO_2-terminated $SrTiO_3$ (001) substrates [4] at 950 ^oC at an oxygen pressure of 1×10^{-4} Torr. The fabricated LSFO thin 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 150 meV. Before taking the ARPES spectra, we checked the surface cleanliness of the samples by measuring LEED patterns. 1×1 spots were clearly observed, indicating that the surface of the fabricated LSFO thin film was clean enough.

Results and Discussion

Since the clean single-crystal surfaces of LSFO thin films were confirmed, we measured their ARPES spectra. Figure 1 shows the experimental band structure of LSFO (x = 0.4) thin films obtained by ARPES measurements taken at $h\nu$ = 58 eV. In order to map the band structure, we took the second derivative of the ARPES spectra (not shown) after smoothing and plotted the intensity in gray scale in the space of wave vector and binding energy. Dark parts correspond to energy bands. This trace is almost along the X – M direction in the Brillouin zone of a cubic perovskite structure. This photon energy is in the range of the Fe 3*p* → 3*d* resonance, and therefore we could obtain the dispersion of the Fe 3*d* bands. We assigned Fe 3*d* e_g band, Fe 3*d* t_{2g} band, and O 2*p* bands. The most remarkable feature of this band structure is that the e_g band which is located in the binding energy region of about 1.3 eV shows significant dispersion while the t_{2g} band and the O 2*p* bands do not.

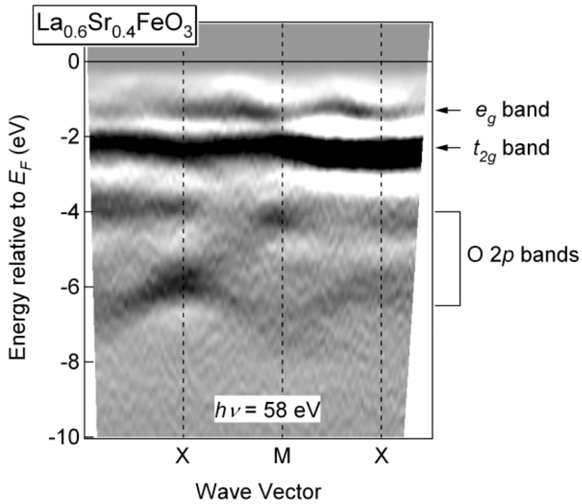

Fig. 1: Experimental band structure of LSFO (x = 0.4) obtained by ARPES measurements taken at $h\nu$ = 58 eV. Dark parts correspond to energy bands.

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