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In situ angle-resolved photoemission study of strain-controlled $La_{0.6}Sr_{0.4}MnO_3$ thin films

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Introduction

Perovskite type manganese oxides $La_{1-x}Sr_xMnO_3$ show a variety of spin-charge coupled properties, such as colossal magnetoresistance, half-metallicity, and metal-insulator transition [1]. Extensive studies have demonstrated that physical properties of these manganese oxides can be controlled by epitaxial strain [2]. However, little is known on the effects of epitaxial strain on the electronic structure of these films. In this study, we have performed *in situ* angle-resolved photoemission spectroscopy (ARPES) of $La_{0.6}Sr_{0.4}MnO_3$ (LSMO) thin films deposited on $SrTiO_3$ (STO) and $LaAlO_3$ (LAO) substrates to investigate the changes in the electronic structure of LSMO thin films.

Experiment

The strain-controlled LSMO has been epitaxially grown on STO and LAO substrates in a laser MBE chamber connected to a synchrotron radiation ARPES system at BL-1C of the Photon Factory, KEK [3]. The film thickness was estimated to be 40 nm by monitoring the intensity of the specular spot in reflection high-energy electron diffraction (RHEED) patterns. The coherent growth of these films was confirmed by the four-circle X-ray diffraction measurements. The ARPES spectra were taken with total energy resolution of about 150 meV at the photon energy of 88 eV. The angular resolution was set at about 0.5° in the angle-resolved mode.

Results and Discussion

Figure 1 shows the band structures of (a) LSMO/STO and (b) LSMO/LAO along the Γ–X direction determined by *in situ* ARPES spectra ($h\nu$ = 88 eV). LSMO/STO with lattice mismatch of +1 % is a ferromagnetic metal (FM), while LSMO/LAO with that of −2 % is an antiferromagnetic insulator (AI). Dark parts correspond to the energy bands. In the band structure of FM LSMO/STO, the electron pocket centered at the Γ point is clearly seen near the Fermi level, which is assigned to the Mn $3de_g$ majority band responsible for the half-metallic nature of LSMO. On the other hand, the electron pocket disappears in the band structure of AI LSMO/LAO, reflecting the strain-induced metal-insulator transition in LSMO. The result suggests that a gap formation due to the spectral weight transfer from the coherent part to the incoherent part is responsible for the strain-induced metal-insulator transition in the strain-controlled LSMO.

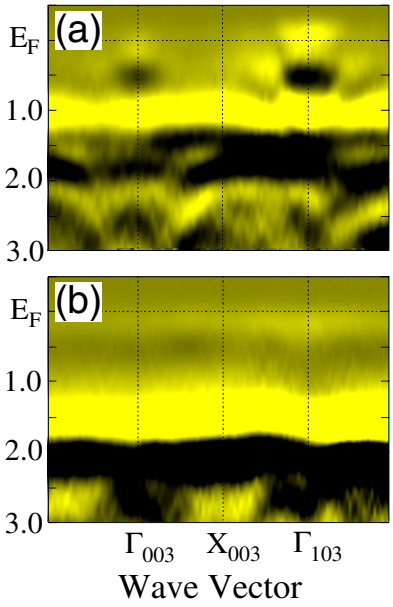

Figure 1: The band structures of (a) LSMO/STO and (b) LSMO/LAO along the Γ–X direction determined by *in situ* ARPES spectra ($h\nu$ = 88 eV).

References

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