In-situ angle-resolved photoemission study on La$_{1-x}$Sr$_x$MnO$_3$ thin films

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Introduction

Hole-doped perovskite manganese oxides La$_{1-x}$Sr$_x$MnO$_3$ (LSMO) have attracted much attention because of their interesting magnetic and electronic properties such as colossal magnetoresistance, half-metallicity, and metal-insulator transition. In order to clarify the origin of their physical properties, it is necessary to obtain the information on the band structures of these oxides and their changes as a function of hole concentration ($x$). In this study, we have performed in-situ angle-resolved photoemission (in-situ ARPES) study on well-ordered surfaces of LSMO ($x = 0.1, 0.2, 0.3, \text{ and } 0.4$) thin films grown epitaxially on SrTiO$_3$ (001) substrates by laser molecular beam epitaxy (laser MBE).

Experimental

The LSMO thin films were fabricated in a laser MBE chamber connected to a synchrotron radiation photoemission system at BL-1C of the Photon Factory. LSMO thin films were deposited on the TiO$_2$-terminated SrTiO$_3$ (001) substrates at 1050 ºC at the oxygen pressure of $1 \times 10^{-7}$ Torr. After cooling down below 100 ºC, the films were transferred into the photoemission chamber under the vacuum of $10^{-10}$ Torr. The PES spectra were taken with total energy resolution of about 150 meV at the photon energy of 88 eV.

Results and Discussion

Figure 1 shows the band structure of LSMO ($a$) $x = 0.1$, (b) $x = 0.2$, (c) $x = 0.3$, (d) $x = 0.4$ along the $\Gamma$–$X$ direction determined by the in-situ ARPES spectra ($h\nu = 88$ eV). As seen in Fig. 1(d), the band structures of LSMO $x = 0.4$ consist of several highly dispersive O 2$p$ derived bands at the binding energies of $2.3 - 6$ eV, almost dispersionless Mn 3$d$ bands at 2.0 eV, and an Mn 3$d_{eg}$ derived electron pocket centered at the $\Gamma$ point. We find that the energy positions of these bands monotonically shift toward higher binding energy with decreasing hole concentration in a rigid-band manner, whereas the electron pocket which is clearly observed in ferromagnetic metal LSMO $x = 0.4$ films gradually smears out with decreasing $x$, and almost disappears at ferromagnetic insulator LSMO $x = 0.1$ (Fig. 1(a)). These results suggest that the pseudogap or gap formation due to the spectral weight transfer from the near-$E_F$ region dominates the changes in electronic structure near $E_F$ of LSMO thin films with $x$.

References


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