

## Doping dependence of the photoemission spectra of $\text{La}_{1-x}\text{Sr}_x\text{FeO}_3$ epitaxial thin films

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### Introduction

Since the discovery of high- $T_c$  superconductivity in the cuprates, great interest has revived in perovskite-type transition-metal oxides because of their intriguing properties, such as metal-insulator transition (MIT), colossal magnetoresistance (CMR), and ordering of spin, charge, and orbitals [1].  $\text{La}_{1-x}\text{Sr}_x\text{FeO}_3$  (LSFO) has attracted much interest because it undergoes a charge disproportionation around  $x = 0.67$  [2]. The central question about this system is how the electronic structure evolves from the charge-transfer-type insulator  $\text{LaFeO}_3$  to the oxygen-hole metal  $\text{SrFeO}_3$ . To answer this question, we have performed *in-situ* photoemission spectroscopy (PES) and x-ray absorption spectroscopy (XAS) measurements of epitaxial thin films of LSFO ( $x = 0, 0.2, 0.4, 0.67$ ). A systematic x-ray photoemission study of scraped bulk LSFO samples has been reported by Chainani *et al.* [3]. Structures in the valence band, however, were not clearly resolved partly because of the limited energy resolution ( $\sim 0.8$  eV). In this study, we have succeeded in obtaining bulk-sensitive high-quality spectra by using soft x-ray [4] and atomically flat surfaces of the thin films.

### Experimental

The LSFO thin films were fabricated in a laser MBE chamber connected to a synchrotron radiation photoemission system at BL-2C of Photon Factory [5]. LSFO thin films were deposited on Nb-doped  $\text{TiO}_2$ -terminated  $\text{SrTiO}_3$  (001) substrates [6] at 950 °C at an oxygen pressure of  $1 \times 10^{-4}$  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 200 meV at the photon energy of 600 eV.

### Results and Discussion

Figure 1 shows the doping dependence of the combined valence-band PES and the O 1s XAS spectra. In the PES spectra, one can observe three main structures A ( $e_g$  band), B ( $t_{2g}$  band), and C (Fe 3d - O 2p bonding states) and the satellite. A gap (absence of finite DOS at  $E_F$ ) or a pseudogap (depression of DOS at  $E_F$ ) was seen for all

values of  $x$ , which is considered to be a natural consequence of the wide insulating region of the LSFO phase diagram [7]. Structures A-C move toward  $E_F$  upon hole-doping. In addition, structure A becomes weaker with increasing  $x$ , indicating that holes are doped into the  $e_g$  band. In the XAS spectra, the empty Fe 3d states are split into two peaks, D and E, due to the  $e_g - t_{2g}$  crystal-field splitting. A new peak F grows within the band gap upon hole-doping. These results indicate that spectral weight is transferred from structure A below  $E_F$  to structure F above  $E_F$ , and the band gap is filled by the new spectral weight F as holes are doped. This spectral weight transfer with hole-doping is highly non-rigid-band-like.

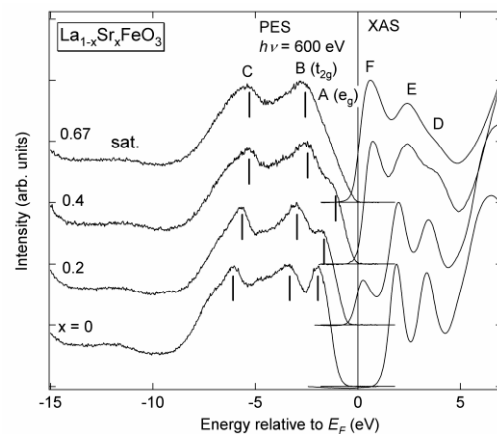


Fig. 1: Combined PES and XAS spectra of LSFO epitaxial thin films

### References

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