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Doping evolution of the electronic structure in the single-layer cuprate $Bi_2Sr_{2-x}La_xCuO_{6+\delta}$: Comparison with other single-layer cuprates

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Introduction

How the electronic structure of the antiferromagnetic insulator evolves into that of the superconductor with hole doping in the high-T_c cuprates has been a major and fundamental issue in condensed-matter physics. In this study, we have performed ARPES study on single-layer cuprate system $Bi_2Sr_{2-x}La_xCuO_{6+\delta}$ (La-Bi2201)[1] and compared the result with another single-layer cuprates $La_{2-x}Sr_xCuO_4$ (LSCO)[2,3].

Experiment

ARPES measurements were performed at beamline 28A of High Energy Accelerator Research Organization-Photon Factory (KEK-PF), using a SCIENTA SES-2002 analyzer with the total energy resolution of ~25 meV and the angular resolution of 0.3°. Measurements were performed with the photon energy $h\nu$ =55 eV and the circular polarization. The sample temperature was ~15 K. Samples were cleaved *in situ* under an ultrahigh vacuum of 10^{-10} Torr.

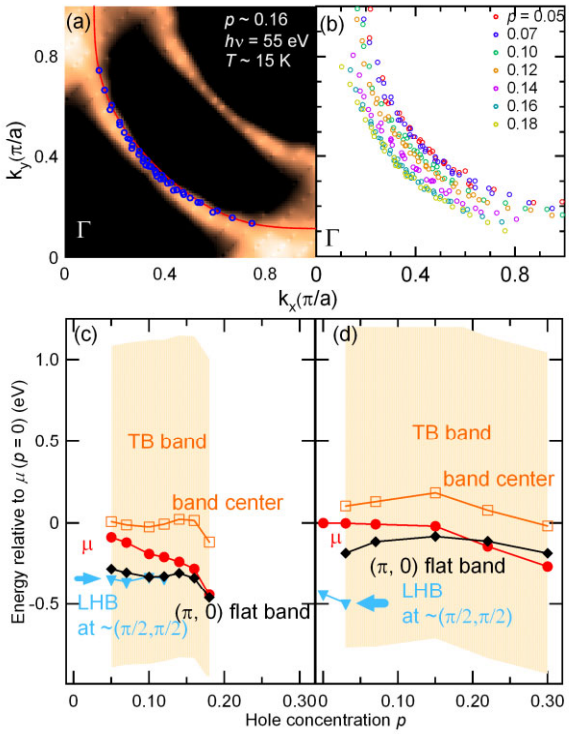

FIG. 1: Doping dependence of the electronic structure in Bi2201 (a) Fermi surface intensity plot for La-Bi2201 (p = 0.16). (b) Doping dependence of the k_F positions, i.e., of the (underlying) Fermi surface. (c) and (d) Doping dependence of the electronic structure. LSCO are taken from Refs. 2 and 3. The energy range of the TB band dispersion is shown by the orange region.

Results and discussion

Fig. 1(a) shows the Fermi surface intensity plot for La-Bi2201 (p = 0.16). We have determined the Fermi surface shape for various doping level from the momentum distribution curves (MDC's), one can see the Fermi surface evolves with doping systematically. We have evaluated the Fermi surface shape by using the two-dimensional single-band TB model. In Fig 1(c) and (d), we compare the entire doping evolution of the electronic structure with that of LSCO[2,3] using TB fitting results and chemical potential shifts determined from core-level photoemission measurements. Here, the chemical potential (μ), the band center, the, flat band position, and the top of the LHB at (π/2, π/2) are plotted relative to the chemical potential at p=0. The range of the TB band is also shown by the shaded area. For Bi2201, all quantities except for μ are relatively unchanged with doping until p~0.16 and only μ moves downward with hole doping, that is, the typical rigid-band-like shift is realized. On the other hand, in the underdoped LSCO, μ is pinned, while the other band energy positions change with doping. In the overdoped region, the evolution becomes rather close to rigid-band-like. Although there are differences how the dispersion appears with hole doping to the Mott insulator between Bi2201 and LSCO, the metallic dispersion appears with hole doping, and the band is filled with hole doping in Bi2201, similar to LSCO. The present results indicate that the similar mechanism can be applied to the doping evolution of the dispersion in Bi2201, while the spectral weight is strongly suppressed with underdoping in Bi2201 compared to that for LSCO.

References

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