Doping evolution of the electronic structure in the single-layer cuprate Bi$_2$Sr$_{2-x}$La$_x$CuO$_{6+\delta}$: Comparison with other single-layer cuprates

Makoto HASHIMOTO$^1$, Teppei YOSHIDA$^1$, Atsushi FUJIMORI$^1$, Masato KUBOTA$^2$, Kanta ONO$^2$, Dong-Hui LU$^3$, Zhi-Xun SHEN$^3$, Simpei ONO$^4$, Yoichi ANDO$^4$

$^1$Department of Physics, The University of Tokyo, Bunkyo-ku, Tokyo 113-0033, Japan
$^2$KEK-PF, Tsukuba, Ibaraki 305-0801, Japan
$^3$Department of Physics, Applied Physics, and Stanford Synchrotron Radiation Laboratory, Stanford University, Stanford, California 94305, USA
$^4$Central Research Institute of Electric Power Industry, Komae, Tokyo 201-8511, Japan
$^5$Institute of Scientific and Industrial Research, Osaka University, Ibaraki, Osaka 567-0047, Japan

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$_2$Sr$_{2-x}$La$_x$CuO$_{6+\delta}$ (La-Bi2201) and compared the result with another single-layer cuprates La$_{2-x}$Sr$_x$CuO$_4$ (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.

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 ($\mu$), the band center, the, flat band position, and the top of the LHB at ($\pi/2$, $\pi/2$) 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 $\mu$ are relatively unchanged with doping until $p=0.16$ and only $\mu$ moves downward with hole doping, that is, the typical rigid-band-like shift is realized. On the other hand, in the underdoped LSCO, $\mu$ 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

*MHashimoto@lbl.gov