Low-energy ARPES study of novel multi-band superconductors at HiSOR

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For understanding the mechanism of novel high-Tc superconductivity, the resolution of multiple sheets of Fermi surfaces is important issue. In bilayer cuprates, which are empirically known to have higher Tc than single-layered systems, two sheets of Fermi surfaces are present in close proximity due to small hybridization between two adjacent CuO_2 layers. In iron-based superconductors, all of five Fe 3d orbitals are responsible for low-energy electronic states, and more than three sheets of Fermi surfaces have been observed so far.

Using low-energy synchrotron radiation as the excitation photons of angle-resolved photoemission (ARPES), in general, the momentum- and energy-resolution become higher, the probing depth increases, and the perpendicular-momentum selectivity increases.

Bilayer cuprate, $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi2212), has been studied by low-energy ARPES. We have found that the spectral-intensity ratio of a bonding band to an antibonding band drastically changes from 0% to 70% as a function of excitation photon energy due to the effect of transiiton matrix elements, and thus resolved the quasiparticle properties of two bilayer states. The nodal scattering rate is higer for antibonding band than for the bonding band in superconducting phase, indicating that the quasiparticles are scatterred by the inhomogeneity of the potential from out-of-plane dopant oxygens. The magnitude of the superconducting gap is almost identical between the bonding and antibonding bands as shown in Fig. 1. With decreasing hole concentration, near-nodal superconducting gap region shrinks in momentum space for both of the bilayer bands. The width of bilayer splitting is narrower for the underdoped sample, showing the increase in two-dimensionality of electronic structure. This result is consistent with transport experiments.

Iron-based system, $BaFe_2As_2$ has been studied by a combination of low-energy ARPES at BL9A and polarization-dependent ARPES at BL1 in HiSOR. The orbital characters of low-energy bands have been determined from perpendicular-momentum dependence and polarization dependence. As shown in Fig. 2, the inner Fermi surface around Γ–Z axis shows strong dispersion in k_z direction, so that the Fermi-surface nesting is weak for the undoped material. Our results show that the top of this hole pocket comes down below the Fermi level at k_z=0, and that even- and odd-parity bands are degenerate at Γ point. Therefore, the inner Fermi surface is attributed to d_{xz} and d_{yz} orbitals.

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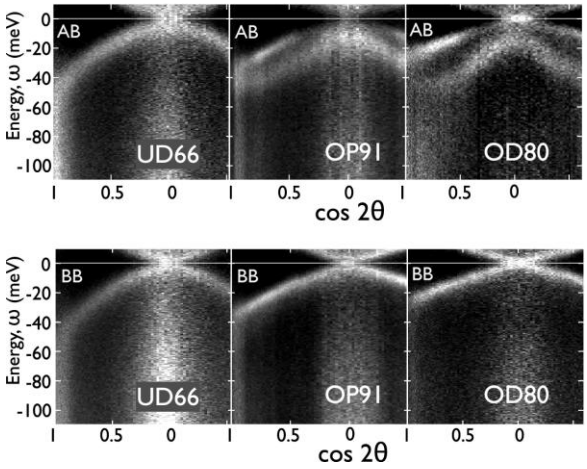

Fig. 1. ARPES spectral image taken along the antibonding-band (AB) and bonding-band (BB) Fermi surfaces of $Bi_2Sr_2CaCu_2O_{8+\delta}$ in superconducting phase (T = 10 K).

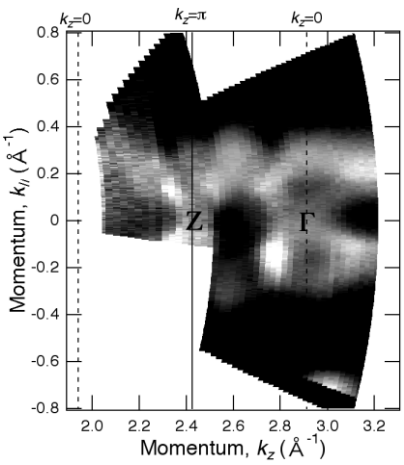

Fig. 2. ARPES spectral image taken along Γ–Z axis, a direction perpendicular to surface, for $BaFe_2As_2$.