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High-resolution ARPES of heavily overdoped Bi2201: evaluation of coupling parameters

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High transition-temperature (T_C) cuprate superconductors have attracted much interest since their discovery in 1986. While there have been extensive studies, there exist unsettled physical phenomena such as bad metal, density waves, magnetic fluctuations, and nematic phases [1-4]. These states are emergent from the competing charge, spin and lattice degrees of freedoms. To understand the origin of the physical properties of cuprates, it is desirable to disentangle these competing interactions and quantify each contributions.

To this end, here we focus on the Bi-based high-T_C cuprate, $(Bi,Pb)_2Sr_2CuO_{6+\delta}$ (Bi2201). The Fermi surface of Bi2201 is relatively simple because there exists a single CuO_2 plane in the unit cell. We start from the overdoped region, where the electronic state is expected to behave as the Fermi Liquid [3]. However, recently, Kurashima et al. found a ferromagnetic fluctuation close to the vanishing T_C region, and the ground state properties in this region should be investigated [3]. Previously Meevasana et al. have done angle-resolved photoemission spectroscopy (ARPES) and examined the self-energy due to the electron-electron and electron-phonon interactions especially for the heavily overdoped Bi2201 with no superconducting transition [5]. However, each contribution from the electron-phonon (or electron-boson) and electron-electron interactions as a function of hole concentration is still not clearly determined. Our purpose is, therefore, to systematically clarify the evolution of these interactions as a function of hole concentrations.

Here we have examined the electronic structure of as grown Bi2201 single crystal with T_C=6 K. We have done linear-polarization dependent ARPES experiments on BL-1 [6] to investigate the Fermi surface and energy band dispersion in the wide energy range. To examine the fine details of the electron-phonon interaction near the Fermi level, we have done high-resolution ARPES using 6.3 eV ultraviolet laser (μ-Laser ARPES machine) [7].

Figure 1(a) shows the observed Fermi surface taken at hν=90 eV at 50 K. In addition to the hole-like Fermi surface, we have observed additional Fermi surfaces moved by (π,π), which suggests antiferromagnetic fluctuation or superstructure formation. To analyze the Fermi surface shape quantitatively, we have adopted the two band tight-binding (TB) model [8]. The red lines in Fig. 1(a) show the best fit result of the TB model.

Figure 1(b) and 1(c) show the band structures along the nodal direction (cut 1) and the antinodal direction (cut 2) taken at hν=40 eV. We measured cut 1 (cut2) using p-(s-)polarization geometry taking into account the diple selectrion rule [6,9]. One can see the reduction of the group velocity near the Fermi level compared with the TB model. The deviation is assumed to derive from the self-energy due to the electron-electron interaction. We have also overlaid the LDA result [10] for Bi2201 in Fig. 1(b). One can see that the deviation of the group velocity is not so strong compared with the two band TB model.

We have also measured fine details near the Fermi level using the μ-Laser ARPES machine and have observed a clear kink structure around -90 meV. In the poster presentation, we show the self-energy due to the electron-phonon and electron-electron interactions using the two band TB model.

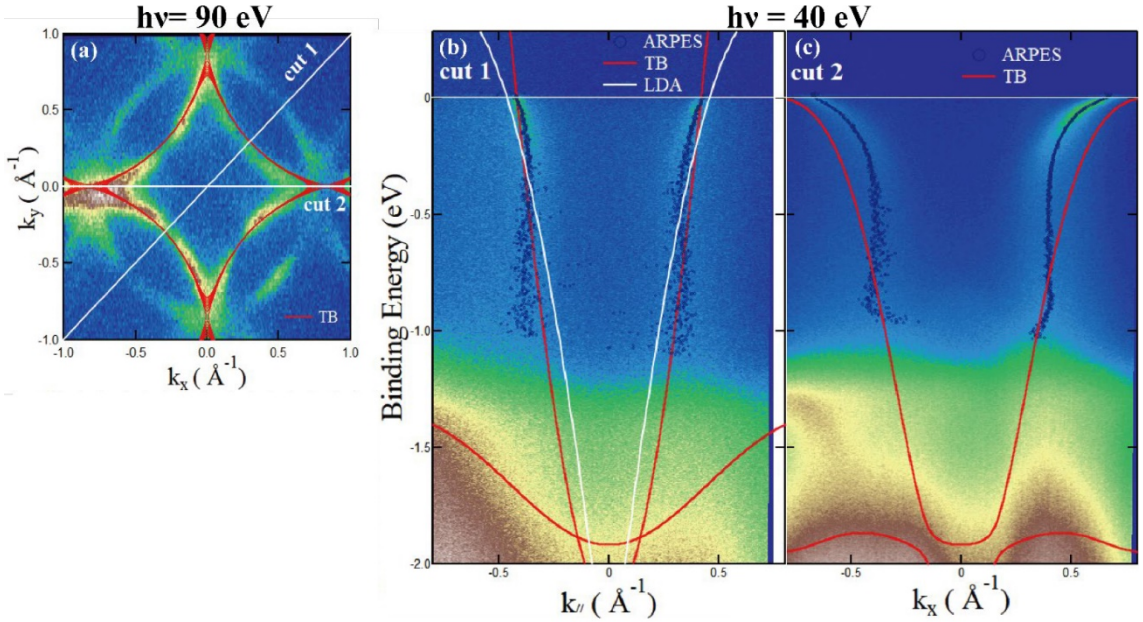

FIGURE 1. (a) Fermi surface of Bi22012 taken at hν = 90 eV at 50 K. The read lines show calculated Fermi surface using the two-band TB model. ARPES image plot along (b) the nodal direction (cut 1) and (c) the antinodal direction (cut 2) respectively taken at hν=40 eV at 25 K. Red lines in (b) and (c) show band dispersions calculated by the TB model. The white line in (b) shows a band dispersion obtained from the LDA calculation. Blue dots in (b) and (c) show the band points evaluated by the MDC analyses.

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