The discovery of the high critical temperature (high-T_c) superconductivity in LaFeAsO_1.1-xF_x [1] has triggered intense research on iron-based superconductors [2-4]. Density functional theory calculations for iron-based superconductors predict that Fermi Surfaces (FSs) in these materials are composed of nearly cylindrical hole- and electron-like FSs at the Brillouin zone corner and center, respectively, as shown in Fig. 1(a) [5, 6]. For the emergence of iron-based superconductivity, the FSs nesting that can enhance spin frustration is the highest yet reported among iron-based superconductors that have been studied by ARPES. In order to check the characteristic FS topology for the emergence of high-T_c superconductors, we performed ARPES measurements for Ca_1.1-xLa_xFe_1.9As(O,F)_{0.06} superconductor [24].

High-quality single crystals of Ca_1.1La_0.9Fe_2As(O,F)_{0.06} were grown as described elsewhere [23]. ARPES measurements were carried out at BL-28A of the Photon Factory using circularly polarized light (h = 40-66 eV) and at BL-9A of the Hiroshima Synchrotron Radiation Center using circularly and linearly polarized light (h = 19-31 eV). The total energy resolution was set to 0.1-0.3 meV in hole-doped Ba_2K_0.8Fe_1.9As(O,F)_{0.06} surfaces were observed in situ by cleaving of crystal in a working vacuum better than 10^-9 Pa and measured at 60 K (above T_c). In Figs. 2(a) and 2(b), we show ARPES intensity plots taken along the Γ-X direction with s- and p-polarized light, respectively (h = 31 eV). We observed one hole-like band whose top is located around 30 meV below E_F (a) and two hole-like bands with crossing E_F (b) and (c). In the s-polar data along the Γ-X [Fig. 2(c)], we found that the top of the a_1g band is located around 10 meV below E_F, indicating that the a_1g band cannot form FS between the Γ and Z points. On the other hand, the a_1g and b_1g bands cross E_F at 23 eV, as seen in the s-polar data [Fig. 2(d)]. Since the position of the Fermi wave vector (k_F) of the a_1g and b_1g bands has almost no dependence [Fig. 2(h)], we find these bands form nearly two-dimensional FS around the M and A points. We observed two hole-like bands (a_1g and b_1g) as seen in Figs. 2(e) and (f). These form elliptical electron-like FSs [Fig. 2(g)], and their position shows sizeable enhancement along the k_x direction [Fig. 2(i)] indicating the elliptical shape of these FSs and the shape of the boundary in the body-centered tetragonal Brillouin zone. Figure 2(j) shows the shape of the four FSs (a_1g, b_1g, c_1g, d_1g) observed in ARPES measurements [24]. The total carrier number deduced from the volume of FSs is 0.12 ± 0.07 e/VF, which agrees with the chemical composition of 0.09 eF.

Next we discuss the implications of the present ARPES results for iron-based superconductivity. As shown in Figs. 1(b) and 1(d), all hole-like FSs in hole-doped Ba_2K_0.8Fe_1.9As(O,F)_{0.06} have nearly a two-dimensionality shape in common [19, 20]. From these results, we suggest that the two-dimensional FS topology, leading to the good FS nesting condition, is universal for high-T_c superconductors regardless of the type of dopant carrier. It supports the unconventional mechanisms for superconductivity in iron-based superconductors.

In summary, we investigated the three-dimensional electronic structure near the Fermi level of Ba_2K_0.8Fe_1.9As(O,F)_{0.06} which has a nearly two-dimensional FS topology similar to that of Ba_2KFe_2As_2, demonstrating the common identity of the electronic structure to induce high-T_c 122-type iron-based superconductors.

REFERENCES