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Superconducting gap of $PrFeAsO_{1-y}$ observed by angle-resolved photoemission spectroscopy

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1 Introduction

In the 1111-type iron-based superconductors, superconductivity is realized by electron doping through substituting F for O or Co for Fe, or introducing oxygen deficiencies [1, 2, 3]. According to previous angle-resolved photoemission spectroscopy (ARPES) studies [4, 5, 6], however, the 1111 compounds exhibit heavily hole-doped electronic structures for cleaved surfaces, which has been attributed to charge transfer because of the polar surfaces. Superconducting gaps for these surfaces have been reported recently Charnukha *et al.* [6]. They observed an edge shift around the superconducting critical temperature (T_c). However, the relationship between the surface electronic structure and the superconductivity has not been clarified yet. Therefore, more detailed knowledge about the superconducting gap at the surface is required.

In this work, we have measured the temperature dependence of the superconducting gap of the 1111 compounds using ARPES in order to understand the superconductivity at the surface.

2 Experiment

High-quality single crystals of the electron-doped superconductor $PrFeAsO_{1-y}$ (T_c = 24 K) were synthesized by the high pressure technique as described in Ref. [7]. ARPES measurements were performed at BL-28A of Photon Factory using circularly polarized light with the photon energy of 42.5 eV. A SCIENTA SES-2002 electron analyzer was used. The total energy resolution of ~ 20 meV. The crystals were cleaved *in situ* at T =8 K. The measurements were carried out in an ultrahigh vacuum of ~ 10^{-10} Torr.

3 Results and Discussion

Figure 1(a) shows a Fermi surface (FS) mapping for the $PrFeAsO_{1-y}$ at T = 8 K. One can clearly observe a large circular hole pocket and a middle-size circular hole pocket, referred to as “Outer” and “Inner”, respectively. This result is consistent with previous reports [4, 5, 6]. Figure 1(c) shows symmetrized energy distribution curves (EDCs) at the Fermi wave vector (k_F) of the “Outer” FS indicated in Fig. 1(b). One can see that an energy gap opens at low temperature. In order to quantify the energy gap, we have estimated gap depth and the gap area from the symmetrized EDCs and have plotted them in Fig. 1(c). One can clearly see an energy gap opening even above T_c. There are two possibilities for the gap opening above T_c. One is that superconductivity at the surface occurs at a higher temperature than the bulk T_c. Another possibility is that superconductivity at the surface is realized by the proximity effect of the superconducting bulk and a pseudo-gap persists up to ~80 K. To make conclusion about this issue, further investigation is required.

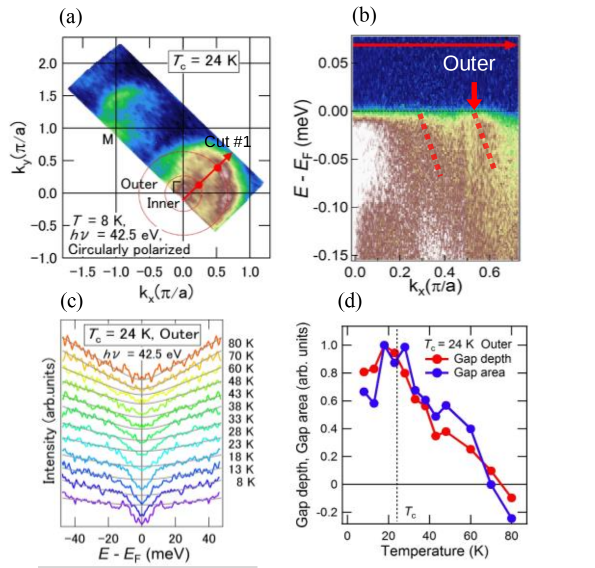

Fig. 1 ARPES results of $PrFeAsO_{1-y}$ (T_c = 24 K)

(a) Fermi surface mapping at $T = 8$ K.
(b) Energy-momentum plot along Cut #1 in Fig. 1 (a).
(c) Symmetrized EDCs at k_F of the "Outer" FS in Fig. 1 (b).
(d) Temperature dependence of the gap magnitude.

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