論文の内容の要旨

Electronic Structure and its Relationship to Superconductivity in Iron-based and Cuprate High-T_c Superconductors Studied by Angle-resolved Photoemission Spectroscopy

(角度分解光電子分光による鉄系および銅酸化物超伝導体の電子構造とその超伝導との関連の研究**)**

氏　名　　出田　真一郎

Why the superconducting (SC) transition temperature (T_c) is so high in the high-T_c cuprates (HTSCs) and the iron-based superconductors (Fe-SCs) is still under hot debate. In order to elucidate the mechanism of superconductivity, it is crucial to study the electronic structure of the high-T_c superconductors systematically and to elucidate the origins of the microscopic physical properties. In this thesis, we have studied the electronic structure of both classes of high-T_c superconductors, HTSCs and Fe-SCs, by angle-resolved photoemission spectroscopy (ARPES) in order to investigate parameters which determine the T_c of the high-T_c superconductors.

ARPES is one of the most powerful tools to study the electronic structure of strongly correlated materials [1]. In this thesis, we have investigated the electronic structure of the HTSCs and the Fe-SCs by ARPES. We have studied the electronic structure of the tri-layer HTSC $Bi_2Sr_2Ca_2Cu_3O_{10+\delta}$ (Bi2223) which has the highest T_c among Bi-based HTSCs and the transition metal-doped $BaFe_2As_2$ (Ba122). The electronic structure and its relationship to the superconductivity in the HTSCs and the Fe-SCs are discussed.

In a previous study, we have observed two band dispersions separately corresponding to the outer and inner CuO_2 planes of Bi2223 [2]. In Chapter 4, we have performed a temperature dependent ARPES study of the superconducting (SC) gaps on the Fermi surfaces of these bands. In the SC state, the outer band shows a simple *d*-wave SC gap, while the SC gap of the inner band deviates from the simple *d*-wave form, so-called “two-gap” behavior [3-5]. We found that in the

normal state, the gap for both bands collapses near the nodal direction, causing a “Fermi arc” [6], whereas an energy gap remains open around the anti-node. We have deduced a characteristic parameter from the Fermi arc length and the SC gap, and found that this parameter is directly related to the T_c of various HTSCs. In Chapter 5, we have investigated the band renormalization effect, “kink”, in Bi2223. The band dispersion of the HTSCs shows a kink at the binding energy around - 70 meV due to coupling between the quasi-particles and boson excitations. However, in the case of Bi2223, the kink energy for the inner band shows an unusually large energy of ~ 100 meV, while that for the outer band is ~ 70 meV comparable to the other cuprates. We discuss the origin of the large kink energy for the inner band and a possible candidate for the boson mode.

The newly discovered Fe-SCs have generated great interest, and have opened up a new area in the field of superconductivity research. For electron-doped Ba122, superconductivity emerges by electron doping via partial substitution of transition-metal atoms such as Co, Ni, and Cu for Fe. In Chapters 6 and 7, we have studied the electronic structure of Co, Ni, Cu, and Zn-doped Ba122, and $BaNi_2P_2$ by ARPES. The T_c of the electron-doped Ba122 decreases in going from Co, Ni, Cu, to Zn. However, the microscopic effect of doped transition-metal atoms on the electronic structure of the iron pnictides is still highly controversial [7, 8]. In Chapter 6, in order to see whether the rigid-band behavior persists for the substitution of the various transition metals, we report an ARPES result on the Ni-, Cu-, and Zn-doped Ba122, and show the evolution of the electronic structure with the strength of impurity potential in going from Co-, Ni-, Cu-, to Zn-doped Ba122.

In Chapter 7, we have studied the electronic structure of $BaNi_2P_2$ which shows the low T_c of 2.5 K. Fermi surface shapes are completely different from the other Ba122 compounds with higher T_cs. We compare the observed Fermi surfaces with the band-structure calculation, and estimate renormalization factors of the band dispersions to discuss the electron correlation effect in $BaNi_2P_2$.

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