Tunneling Studies of Electronic State in High T_c Bi(2212)-System

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Abstract

The tunnel conductance *G(V)* was measured for the planar junction fabricated on the cleaved face (001) of $Bi_2Sr_2CaY_xCu_{1.97}Zn_{0.03}O_{8+y}$ (BSCYCZO) at various temperatures. When a temperature T decreases, the pseudo-gap (PG) opens at 194 K for $x = 0$ and at 238 K for $x = 0.03$, and the superconducting gap (SG) opens at 83 K for $x = 0$ and at 64 K for $x = 0.03$. The SG peak was highly symmetric around zero bias both for $x = 0$ and $x = 0.03$. While, the PG peak was highly symmetric around zero bias for $x = 0$ across 194 K but was strongly suppressed in negative bias for $x = 0.03$ below $T_c = 64$ K. Furthermore, the PG and SG were observed to coexist at a temperature between T_c and 4.2 K for $x = 0$ and $x = 0.03$. This suggests that the PG is not the precursor for superconducting transition.

Key words: Tunneling; BSCCO; superconductivity

1. Introduction

The pairing force of high T_c cuprate has not been unclear and is in growing interest. Recently it has been made clear from many experiments [1] that when T decreases, the PG opens and then the SG opens, and at superconducting transition temperature T_c the PG peak is continuously replaced by the SG peak. Many scientists believe that the PG is the precursor for superconducting state. If so, the origin of PG is same as the one of the SG. On the other hand, the experimental results in the mesa-junction tunnel [2] and the magneto-resistance along *c*-axis [3] contradict with the precursor model. As far, these two experimental results can not be enough evidence to refuse the precursor model, because the characteristic of mesa junction is affected by joule heating in the junction and the magneto-resistance measurement does not give direct information for PG and SG. In the present experiment, to elucidate the relation between PG and SG, the tunneling measurement was performed for the planar junction Ag-SiO-BSCYCZO at various T.

2. Experiment and Discussion

The Ag-SiO-BSCYCZO planar junction was fabricated by successively depositing SiO and then Ag onto the cleaved face of BSCYCZO in a vacuum. The tunnel conductance *G(V)* was measured by the standard voltage modulation method. The current across junction was less than 0.5 mA/mm^2 and was too low to affect the *G(V)*. As seen in Fig. 1, for $x = 0$ the PG opens at 194 K with decreasing T and the SG opens at 83 K. The value of PG below 83 K is 27 meV and free from T. While, the value of SG increases with decreasing T and arrives at 42 meV at 4.2 K. These values are in good agreement with other experiment [1]. The *G(V)* characteristic is highly symmetric respect to zero bias V = 0 in whole temperature region. Obeying to the precursor model, only SG peak must be observable below T_c, because the PG peak is followed by the SG peak lower T_c. However, the SG peak is clearly found to exist with the PG peak below 70 K. This apparently contradicts with the precursor model [4].

The *G(V)* characteristic for $x = 0.03$ is shown in Fig. 2. When T decreases, the PG opens at 238 K and then the SG opens at 64 K. The value of PG decreases

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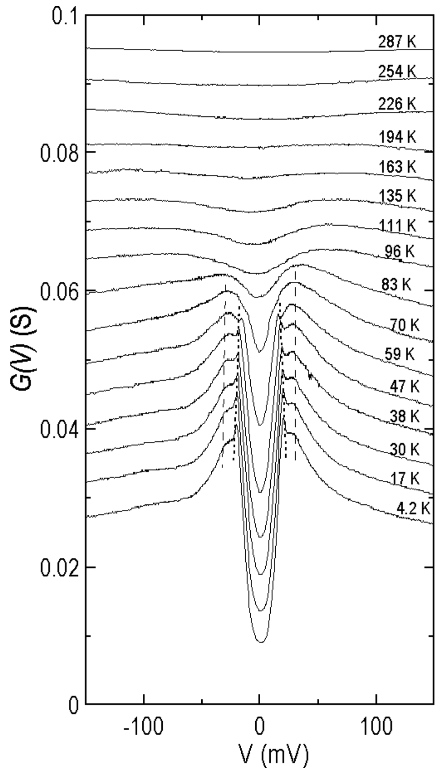

Fig. 1. The $G(V)$ characteristic for $x = 0$. The position of PG peak is shown by a dashed line and the one of SG peak by a dotted line. When T decreases, PG opens at 194 K and SG opens at 83 K. Below 83 K PG coexists with SG. PG peak and SG peak is highly symmetric around V = 0 in whole temperature region.

with decreasing T and results in 50 meV at 64 K and then keeps a constant value of 50 meV below 64 K. The PG peak is highly symmetric regard to V = 0 above 64 K but is remarkably depressed in negative bias (the hole excitation band) in comparison with positive bias (the electron excitation band) below 64 K. On the other hand the SG peak is symmetric regard to V = 0. When T decreases, the value of SG moderately and then slightly increases and arrives at 33 meV at 4.2 K. Below 64 K the SG peak apparently exists with the PG peak as seen in $x = 0$. The addition of excess Y distracts the symmetry of the PG peak around V = 0 without destroying the symmetry of SG peak. This is also suggests that the origin of SG is different from the one of PG.

In the present experiment, it was found that the PG coexists with the SG and the addition of excess Y brings the different destruction of symmetry between PG and SG peaks. This supports that the origin of SG is different from the one of PG.

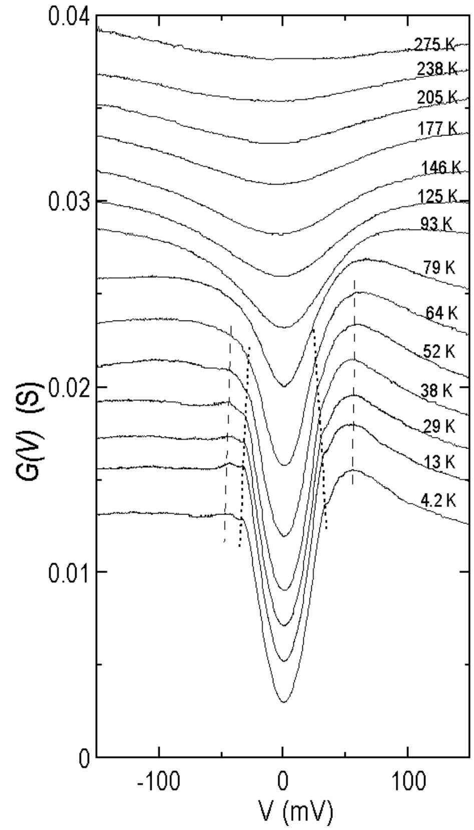

Fig. 2. The $G(V)$ characteristic for $x = 0.03$. The position of PG is shown by a dashed line and the one of SG by a dotted line. When T decreases, PG opens at 238 K and SG opens at 64 K. Below 64 K PG coexists with SG. PG peak is symmetric below 64 K. While, SG is symmetric down to 4.2 K.

References

[1] T. Nakano, N. Momono, M. Oda and M. Ido, J. Phys. Soc. Jpn. **67** (1998) 2622.

[2] V. M. Krasnov, A. yurgens, D. Winkler, P. Delsing and T.Claeson, Phys. Rev. Lett. **84** (2000) 5860.

[3] T. Shibauchi, L. Krusin-Elbaum, Ming Li, M. P. Maley and P. H. Kes, Phys. Rev. Lett. **86** (2001) 5763.

[4] Y. Yanase and K. Yamada, J. Phys. Soc. Jpn. **68** (1999) 2999.