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THE TEMPERATURE ENERGY GAP EVOLUTION OF $Ba_{0.6}K_{0.4}BiO_3$ BY ELECTRON TUNNELING

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We report tunneling experiments using sandwich type junctions, with superconducting bulk samples of $Ba_{0.6}K_{0.4}BiO_3$ and evaporated thin film Sn counterelectrodes. The tunneling characteristics show the energy gap feature, and structure in the d^2I/dV^2 curves. The results demonstrate that the temperature energy gap variation follows a BCS behavior. The ratio $2\Delta/k_BT_c$ is 3.75 suggesting an intermediate coupling.

1. INTRODUCTION

The discovery of the $Ba_{1-x}K_xBiO_3$, BKB, compound by Mattheiss et al. [1] brought to the field the possibility of studying a high temperature superconductor without copper, without magnetic order [2] and with a three dimensional behavior. The crystal structure of the $Ba_{0.6}K_{0.4}BiO_3$ is a cubic perovskite with corner-shared BiO_6 octahedra and Ba(K) at the cell origen.

It is well known that one of the most important probes for characterizing the superconducting state is electron tunneling spectroscopy. In this paper we report the temperature evolution of the superconducting energy gap, Δ, obtained through tunneling experiments.

2. EXPERIMENTAL AND RESULTS

The ceramic material, $Ba_{0.6}K_{0.4}BiO_3$, was prepared as reported by Hinks et al. [3]. Resistance vs Temperature measurements show an onset of the transition temperature at about 30 K, and zero resistance at 21 K. The tunnel junctions were conventional sandwich type. A pellet of high density material was encapsulated in high vacuum epoxy. When the epoxy was cured the surface of the pellet was polished and cleaned with an etching solution described by Gurvitch et al. [4]. The clean surface was left in this condition to oxidize in air for about 24 hr, after this time, the junctions were completed by evaporating a thin film strip of Sn. The junction areas were approximately 0.1×1.0 mm^2, with zero bias resistances between 20 to 100 Ω, and showed well reproducible characteristics.

The measurements of the tunnel junction conductance were performed using the conventional modulation technique and a helium cryostat. The tunnel junctions were measured at different temperatures between 4 to 300 K. The conductance vs voltage curves taken from 4 to

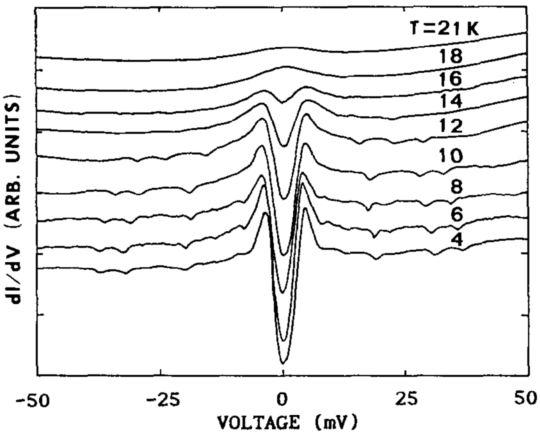

Fig. 1 *Conductance vs voltage curves (vertically shifted) of $Ba_{0.6}K_{0.4}BiO_3$-I-Sn junction at different temperature.*

21 K are shown in Fig. 1, here the temperature variation of the energy gap is observed. An anomalous behavior, is also observed in the curves taken at 18 K, 21 K and up to 77 K.

The characteristic of dI/dV vs V measured at 4 K and normalized with the characteristic at 18 K is shown in Fig. 2. The normalizing to 18 K is justified by the fact that the dI/dV characteristic at 18 K, Fig. 1, only shows the "normal" state and no evidence of the energy gap feature. In the same figure the dotted line is a theoretical curve based on a smeared density of states [5]. Using this relationship the energy gap Δ and the Γ parameter are obtained. The Γ parameter accounts for the lifetime effects [5]. The Δ value obtained with the fitting of the dI/dV curve at 4 K was 2.9 meV and Γ=1.6 meV. Taken T_c = 18 K the ratio $2\Delta/k_BT_c$ is 3.75 suggesting intermediate coupling.

TABLE 1 *Temperature variation of energy gap and Γ parameter.*

T(K)	Δ(meV)	Γ(meV)	Δ(T)/Δ(4K)	T/Tc
4	2.9	1.6	1	0.22
6	2.9	1.5	1	0.33
8	2.8	1.7	0.96	0.44
10	2.7	2.0	0.93	0.55
12	2.5	2.4	0.86	0.66
14	2.0	2.8	0.69	0.77
16	1.5	4.0	0.52	0.88

In table 1 we see the different values of the normalized energy gap, the Γ parameter and the reduced temperature, Δ and Γ were obtained using best fitting of the respectives curves shown in Fig. 1.

The Fig. 3 shows the temperature variation of the energy gap normalized to Δ(4K), the error bars indicate the uncertainty in the measurements. The continuous line is the BCS behavior.

Fig. 4 shows the d^2V/dI^2 characteristic of a tunnel junction taken at 4 K, 21K, and 77K. It is worth noting the dips, in the curve taken at 4 K, which may be related to the excitations of the superconducting state.

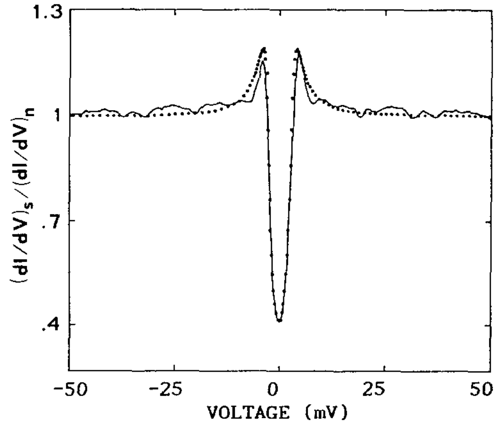

Fig. 2 *Conductance vs voltage curve taken at 4 K normalized to 18 K. The dotted curve is a smeared BCS density of states with Δ=2.9 meV and Γ=1.6 meV.*

3. CONCLUSIONS

We summarized our work as follows:

1 The energy gap value at 4 K using a smeared density of states with Γ = 1.6 meV is Δ=2.9 meV.

2 The temperature variation of the energy gap follows the BCS-like behavior.

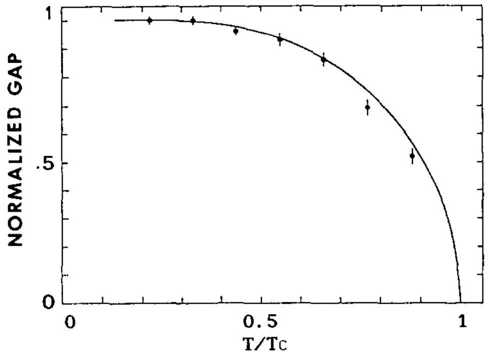

Fig. 3 *Temperature dependence of the normalized energy gap of* $Ba_{0.6}K_{0.4}BiO_3$. *The solid line is the BCS prediction.*

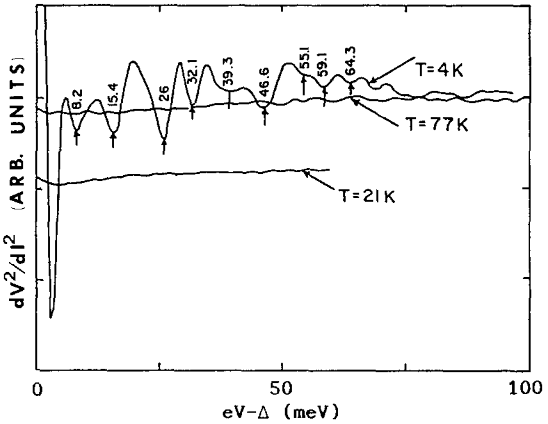

Fig. 4 *dV^2/dI^2 vs V characteristics of the tunnel junction taken at 4, 21 and 77 K.*

3 According to the ratio $2\Delta/k_BT_c$ = 3.75 the $Ba_{0.6}K_{0.4}BiO_3$ is a superconductor with intermediate coupling.

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