SOME SUPERCONDUCTING PROPERTIES OF (BaK)BiO₃ SYSTEM

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In this paper, we will report the superconductivity of Ba_{1-x}K_xBiO₃ system for various K concentrations. A phase diagram around the composition x=0.4 will be studied systematically. It is found that the transition temperature T_c of the sample with x=0.5 is as high as 24K. DC magnetic susceptibility for this x=0.5 sample will be measured to study H_{c1} and H_{c2}. From experiments, an extremely low H_{c1}(T) curve is observed, whereas H_{c2}(T) curve is relatively high.

1. INTRODUCTION

The (BaK)BiO₃ compound was discovered in 1988(1) as a unique oxide superconductor with the absence of Cu-O layers, which play a very important roles for the rest superconducting oxide systems. The simple cubic structure also provides an interesting insight to probe the mechanism of superconductivity for oxide superconductors. There has been several works(2-4) in the study of the superconducting properties of this system. In this work, we are going to report the phase diagram concerning the superconducting and magnetic properties around samples with x=0.4. The sample (x=0.5) with the highest T_c was taken as a prototype to illustrate the critical magnetic fields for this system.

2. EXPERIMENTAL DETAILS

The samples were prepared by mixing high purity powders of BaO, K₂O, and Bi₂O₃ thoroughly. The following steps were proceeded: (1). The powders were first annealed in flowing N₂ at 700°C for 1 hour at heating rate 4°C per minute and followed by rapid quenching to room temperature. (2). The powders were then annealed in flowing O₂ at 450°C for two hours and furnace cooled to room temperature. (3). The annealed powders were pressed into pellets and repeated steps (2) and (3) once more time. It is noted that samples with x=0.65 and 0.70 seemed to melt at 700°C, so we reduced the annealing temperature from 700°C to 650°C. All above mixing and grinding steps were handled very carefully in a N₂ atmosphere plastic bag to prevent getting wet.

For samples with 0.3≤x≤0.6 in our work, powder x-ray peaks can be indexed completely by the main BaKBiO phase and confirm the single phase in this x

range. For x>0.6 samples, a quite amount of Bi₂O₃ impurity was found.

DC magnetic susceptibility and magnetic hysteresis data were obtained from a SQUID magnetometer (Quantum Design).

3. RESULTS

The electrical resistivity and dc magnetic susceptibility were measured to obtain the onset T_c's for Ba_{1-x}K_xBiO₃. The summarized results were shown in Table 1. The magnetic data for samples x=0.35 and 0.7 were absent. From the resistivity measurement, only samples with 0.4≤x≤0.6 are superconductors and the rest are semiconductors. But, from magnetic data, x=0.3 and 0.65 samples still behaved as superconductors. The ZFC magnetic moments for superconducting samples were shown in figure 1. From the experiments on the nearly single phase materials, it is observed that the abrupt decreasing in magnetic drop happened as x varied from 0.5 to 0.4. Although the drop for x=0.65 is as high

Table 1

The results on the onset superconducting transition temperatures for Ba_{1-x}K_xBiO₃ were summarized.

x	Resistivity	Magnetic susceptibility
	T _c (K)	T _c (K)
0.3	semicond.	26.8
0.35	semicond.	
0.37	semicond.	--
0.40	22.8	24.1
0.5	24.1	23.0
0.6	23.1	21.5
0.65	semicond.	21.8
0.7	semicond.	

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FIGURE 1

Dc magnetic susceptibility as a function of temperature for samples with $x=0.3$, 0.4 , 0.5 , 0.6 and 0.65 in $\text{Ba}_{1-x}\text{K}_x\text{BiO}_3$.

as $x=0.6$ sample, we may conclude that the $x=0.65$ sample contained two phases, Bi_2O_3 and the phase with the highest T_c , namely $x=0.5$, and hence possessed higher T_c than that of $x=0.6$ sample.

For advanced study, data on Table 1 were then plotted in figure 2. A linear fashion was observed with an exception of $x=0.65$ multiphase sample.

Similar to this, the linear tendency also occurs for the lattice parameter and shown in figure 3. It may be suggested that the higher T_c is caused by a larger lattice cell. Multiphase samples ($x=0.65$ and 0.7) are far away from the linear line.

Since the sample with $x=0.5$ has the highest T_c among samples in this system, it is an ideal candidate for studying the critical fields of this system. The lower critical field H_{C1} was obtained from the maximum value of the constant temperature magnetic hysteresis curve before saturated, while the upper critical field H_{C2} was determined by T_c (90% resistive height of transition) at constant magnetic field. The results were shown in figure 4 with logarithm

FIGURE 2

Composition dependence of T_c for superconducting samples in $\text{Ba}_{1-x}\text{K}_x\text{BiO}_3$.

FIGURE 3

Lattice parameter for cubic $\text{Ba}_{1-x}\text{K}_x\text{BiO}_3$.

FIGURE 4

The logarithm H_{C1} and H_{C2} for $x=0.5$ sample.

scale due to two order difference between H_{C1} and H_{C2} . An extremely low H_{C1} curve was obtained. And also in our report(5), a linear temperature dependence of H_{C2} in $(1-T/T_c)$, which has been predicted in the GL theory of superconductivity, was found at T near T_c .

4. SUMMARY

In summary, single phase superconductor may be found in samples with $0.3 \leq x \leq 0.6$. The higher the T_c is, the smaller the transition drop and lattice constant are. $H_{C2}(T)$ is about two order higher than $H_{C1}(T)$.

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