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Electrical resistivity and magnetization of $Sr_{1-x}K_xBiO_3$ superconductor in magnetic field: Observation of a reentrant superconducting resistive transition at low temperature.

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Magnetoresistance and magnetization of $Sr_{1-x}K_xBiO_3$ were both measured as functions of temperature and magnetic field. Resistivity goes to zero at T=10.1K and the overall superconducting transition behavior under applied magnetic fields is similar to that of other BiO based superconductors. Also, below T<5K we have observed the reappearance of finite resistivity with a power law temperature dependence($\rho \sim T^{-1}$); the reentrant superconducting transition of resistivity. Contrary to the Josephson weak link effect in polycrystalline samples, which gives the depression of the superconducting state with increasing electrical current or magnetic field, the superconducting state for T<5K is resumed by applying a higher current or magnetic field. Magnetic susceptibility(χ) of $Sr_{1-x}K_xBiO_3$ for T<5K also shows similar trends to that observed in transport measurements: increase of χ(paramagnetic-like behavior) at a low magnetic fields(B=50 Oe) and, the resumption of perfect diamagnetism at high fields.

1. Introduction

Since the discovery of superconductivity in the bismuth-oxide (BiO) based perovskite structure [1], many experimental studies have been carried out to investigate the superconducting properties of this system. However, in BiO based superconductors, superconducting compounds with different phases have been limited to $BaPb_{1-x}Bi_xO_3$(BPBO) and $Ba_{1-x}K_xBiO_3$ (BKBO), contrary to many homogeneous series found in CuO based superconductors.

Recently a second family of BiO based superconductor, $Sr_{1-x}K_xBiO_3$(SKBO), has been discovered[2], which would give additional clues to understanding the superconducting mechanism in BiO based superconductors.

In this work, we report the first results of magneto-transport measurement for $Sr_{1-x}K_xBiO_3$ with the observation of a re-entrant resistive transition below T~5K.

2. Experimental

The experiments have been performed on polycrystalline SKBO synthesized using a belt-type high pressure furnace. The synthesis procedure of the $Sr_{1-x}K_xBiO_3$ compound was well described in Ref. [2]. Magnetoresistivity was measured using a 7T superconducting magnet with a four probe method. DC magnetization measurements on powder sample were performed using a SQUID magnetometer at temperature between 2K and 15K.

3. Results and Discussion

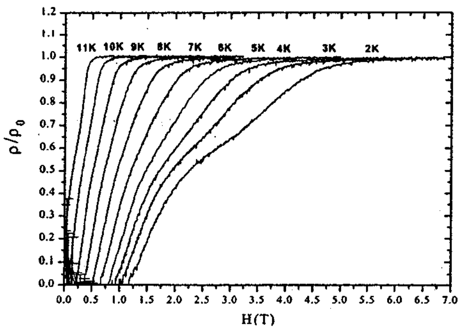

Fig. 1 Resistive transition in magnetic fields measured for different temperature on SKBO

Figure 1 shows the magnetoresistance data for different temperatures as a function of magnetic field. As the magnetic field increases, adjacent resistive transition curves remain approximately parallel, as for a BCS-type superconductor. Also, the transition region becomes broader with applied magnetic field. This significant broadening, implying a large vortex state transition region as in the case of the high Tc cuprates, looks different from the small vortex region found in BKBO single crystals[3]. This large broadening in our polycrystalline sample could be attributed to disorder, which can be surmised from the broad superconducting transition and large value of ρ(15K)/ρ(300K)~0.85. However, magneto- resistance in the normal state is not observed, indicating that disorder does not have any localization-like effect on normal carriers.

Figure 2 shows the temperature dependence of the upper critical field (H_{C2}) of SKBO. We define H_{C2} at the 10% reduction level of the resistivity during the superconducting transition. Similar to high-T_C cuprates and BKBO single crystals[4], this curve shows an upward curvature just below the transition temperature. Within the framework of the Ginzburg-Landau theory[5], we have estimated $H_{C2}(0)$ and a coherence length, $\xi(0)$, from the upper critical field slope. The slope dH_{C2}/dT is estimated from the data in the high field region because the low field upward curvature near T_c depends on sample quality[6]. The linear fit results, dH_{C2}/dT = -0.52T/K and $H_{C2}(0)$ = 5.09T, are obtained by extrapolating dH_{C2}/dT to T=0. The Ginzburg-Landau coherence length at zero temperature, $\xi(0)$, is deduced from $H_{C2}(0)$ using the relation $H_{C2}(0) = \Phi_0/2\pi\xi^2$, where Φ_0 is the flux quanta. The coherence length becomes 79.1Å. The estimated $\xi(0)$ of SKBO is comparable to that of other BiO based superconductors.

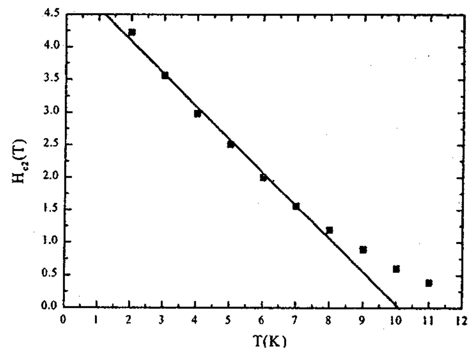

Fig. 2 Upper critical field phase diagram of SKBO obtained from resistivity measurements. The solid line is a linear fit to high-field data.

The interesting thing to point out is an observation of a reentrant resistive transition to the normal state below T~5K in our sample (Fig. 3). The reentrant superconducting−normal transition in the resistivity measurement at low temperatures ($T<T_{Conset}$) has been reported in

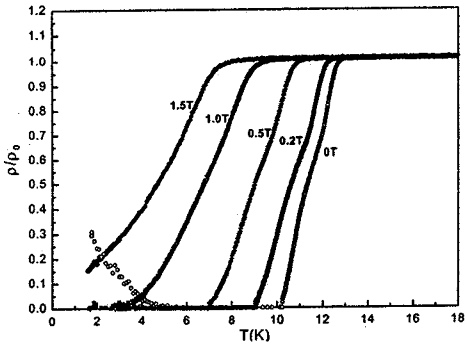

Fig. 3. Resistive transition curves as function of temperature in various magnetic fields for SKBO

other polycrystalline BiO based superconductors, $BaPb_{0.75}Bi_{0.25}O_3$ (BPBO)[7] and $Ba_{0.6}K_{0.4}BiO_3$ (BKBO)[8]. In those reports, the observed reentrant resistive tail increases with either increasing measurement current (I) or external magnetic field (H) and further increase of I or H, causes the breakdown of the superconducting phase. This behavior was well explained by the Josephson weak links effect, as follows. In a granular superconductor, the presence of insulating layers between superconducting grains can be modelled by the S-I-S Josephson junction. The increase of the normal tunnelling resistance at such a barrier at low temperatures can result in a decoupling

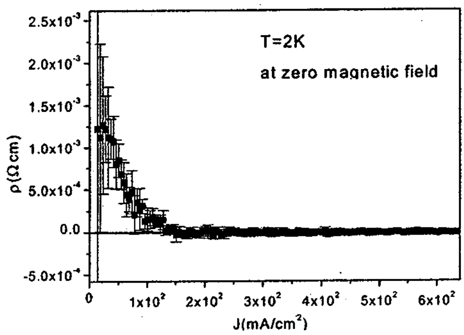

Fig. 4. Resistivity vs current for SKBO

between superconducting grains and disruption of the supercurrent[9].

However, the reentrant resistive transition of SKBO we have observed at low temperatures is different from those observed in BPBO[7] and BKBO[9]. By increasing I or applied H, the reentrant resistivity is suppressed. In other words, superconductivity of the sample is recovered(see Fig. 3 and 4).

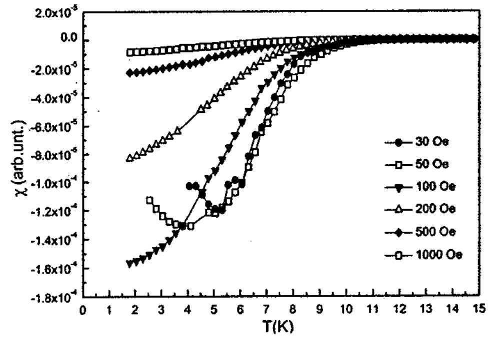

Fig. 5. Zero-field-cooled DC magnetic susceptibility of SKBO for various magnetic fields

Figure 5 shows the zero-field-cooled(ZFC) DC magnetic susceptibility of SKBO. The normal diamagnetic signal is seen down to H=100 Oe with a rounding of the superconducting transition, confirming the granularity of our sample. However, at H=50 Oe, a gradual decrease of the diamagnetic signal - the paramagnetic effect - is observed below T~4.5K. Further decrease of H (H=30 Oe) shifts the temperature where the paramagnetic effect appears slightly lower to 5K.

Interestingly, by comparing the magnetic susceptibility data with the magneto-transport data, we found that the temperature where the first paramagnetic effect is observed under the highest magnetic field(H=50 Oe) almost coincides with the starting temperature of the reenetrant resistive transition. This implies that the observed anomalous behaviors in both transport and magnetic susceptibility measurements might have the same origin.

4. Conclusion

Magnetoresistance measurements have been performed for polycrystalline $Sr_{1-x}K_xBiO_3$. The resistive superconduction transition shifts to lower temperatures with increasing magnetic field. An upper critical field of $H_{C2}(0)=5.09T$ and a coherence length of $\xi(0)=79Å$ are estimated. The reentrant superconducting transition for resistivity, which appears contrary to the Josephson weak link effect in polycrystalline samples, is observed in polycrystalline $Sr_{1-x}K_xBiO_3$. Also, this behavior might be related to the observed paramagnetic effect in ZFC magnetic susceptibility of SKBO. Detailed analyses on the reentrant superconducting transition of SKBO are underway.

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