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CRITICAL FIELDS OF THE HIGH T_c BiCaSrCuO COMPOUND

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Using pulsed magnetic fields up to 27 Tesla, we have measured the temperature dependence of the upper critical field for the Bi-Ca-Sr-Cu-O compound. From these measurements we infer a superconducting coherence length of the order of 1 nm. Close to T_c, the appearance of a finite resistance at very low magnetic fields as well as the small critical current density, confirm the importance of Josephson coupling in the Bi-Ca-Sr-Cu-O samples

1. INTRODUCTION

Very recently, it has been reported that BiCaSrCuO compounds may show a sharp resistance drop around 110K. The magnitude of this resistance drop strongly depends upon the details of the sample preparation. The zero resistance superconducting state is only recovered below 90K [1,2,3]. This indicates the inhomogeneous character of the material, where at least two superconducting phases with a different T_c value are present [2]. The possible existence of a superconducting phase with $T_c \simeq 110$K is also confirmed by the appearance of a partial diamagnetic respons around this temperature [1,2].

In this paper, we report on our measurements of the critical fields and current densities for the lower T_c phase [4]. Our samples with atomic ratios of Bi/Ca/Sr/Cu = 1/1/1/2 , only show weak superconducting fluctuation effects around 110K, while the superconducting transition itself occurs around 80K. Our electrical transport measurements reveal an analogous behaviour for the YBaCuO [5] and the BiCaSrCuO system. In both materials the electronic transport is limited by important inter-grain resistances, giving rise to relatively low critical current densities. The Josephson- like coupling between the grains, causes the appearance of a small, but finite resistance in a small magnetic field (~ 10 Gauss). The strong superconducting order within the superconducting grains is confirmed by the fact that the normal state resistance is only recovered at very high magnetic fields [6,7].

2. EXPERIMENTAL METHOD

The BiCaSrCuO compounds were prepared by solid state reaction at 800°C (for 5 hours) of the apppropriate amounts of Bi_2O_3, $CaCO_3$, $SrCO_3$ and CuO powders that had been mixed in atomic ratios Bi/Ca/Sr/Cu/O = 1/1/1/2 and pressed into pellets. Subsequently, the samples were annealed in a pure oxygen flow at 890°C for 20 minutes, followed by a slow furnace cooling (100°C/ hour) [4]. The four-terminal resistance of the samples has been measured by feeding the bar samples (typical dimensions 10mm x 2mm x 1mm) with a constant current. The upper critical field was determined using pulsed magnetic fields up to 27 Tesla. The high fields are generated by the discharge of a capacitor bank through a wire wound coil cooled by liquid nitrogen.

3. EXPERIMENTAL RESULTS AND DISCUSSION

Figure 1 shows a typical superconducting transition for a BiCaSrCuO sample. The transition has a width $\Delta T_c \simeq 8$K and the sample resistivity ρ becomes zero below 80K. The existence of a superconducting state is also confirmed by the important diamagnetic respons which we infer from our measurements of the rf susceptibility [4]. The strong downward curvature of the ρ(T) dependence around 110K, may indicate the appearance of superconductivity in some parts of the granular sample.

In Fig. 2 we show the temperature dependence of the upper critical field for the BiCaSrCuO system together with our previously obtained results for a typical $YBa_2Cu_3O_7$ sample. For both materials, the value of

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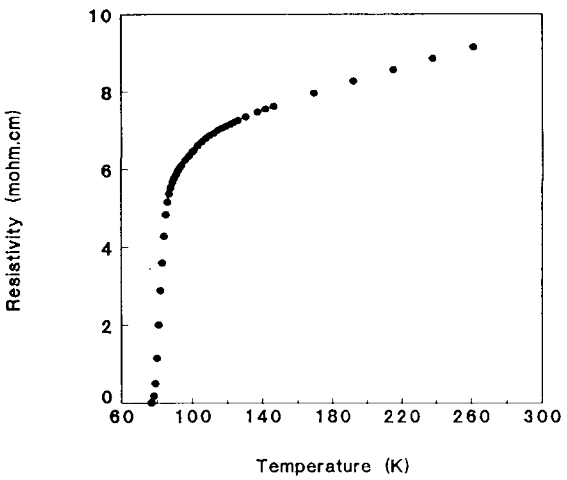

Fig. 1 Temperature dependence of the resistivity for a typical BiCaSrCuO sample

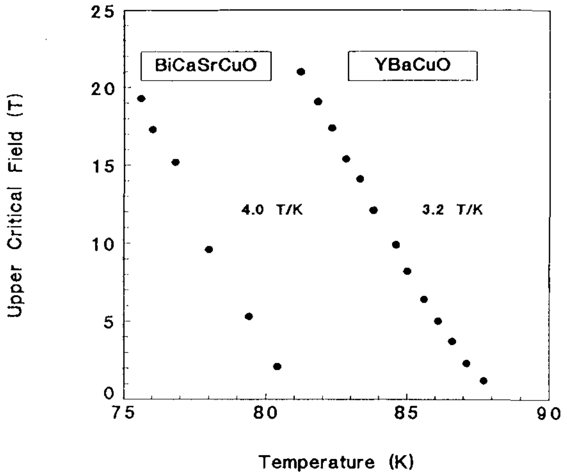

Fig. 2 Temperature dependence of the upper critical field for the BiCaSrCuO sample shown in Fig. 1 and for a typical $YBa_2Cu_3O_7$ sample

the critical field was defined as the field at which 50% of the normal state resistivity is recovered. The linear temperature dependence of the upper critical field is typical of a type II superconductor. The slopes of the critical fields are comparable for the BiCaSrCuO and YBaCuO compounds, indicating a coherence length ξ of the order of 1 nm.

Finally, we also find that close to T_c, the resistivity of the BiCaSrCuO sample shown in Fig. 1, jumps to a finite value when a small magnetic field is applied. This lower critical magnetic field can be smaller than 10 Gauss for $T/T_c > 0.99$. For $T/T_c = 0.90$, no sign of a finite resistivity is observed below 1000 Gauss. This indicates that, similar to the case of YBaCuO compounds, weak Josephson coupling between isolated superconducting grains influences the electrical transport on a macroscopic scale. Near T_c, the Josephson effects start to dominate and strongly limit the value for the critical current density. At lower temperatures, the critical current density rapidly increases and exceeds 5 A/cm^2 at $T/T_c = 0.95$.

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