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Resistive Transition Broadening of Metal-Oxide Superconductors in Magnetic Fields

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A lot of publications deal with the study of resistive transitions of high-T_c superconductors in magnetic fields, and their common feature is the observation of broadening of transitions in magnetic fields.

The investigation of factors, causing that broadening of transitions, is very important now, taking into account their further technical applications.

This note reports results of measurements and calculations of the shape of superconductive transitions of Bi-Sr-Ca-Cu-O polycrystalline samples.

$Bi_4Sr_3Ca_3Cu_4O_x$ samples with 2x3x10 mm^3 dimensions were prepared by solid-state reaction.

Resistivity measurements as a function of temperature and magnetic field were performed at constant current in a standard four-probe configuration. The indium contacts had resistivity less than 0.1 Ω. Magnetic fields up to 14 T were created using a water-cooled Bitter-type magnet.

A current of density $J = 0.1$ A/cm^2 is passed along the long axis of the sample.

The typical R(T) dependences in constant magnetic fields are shown in Fig. 1 (the sample orientation is $\vec{J} \perp \vec{H}$). With increasing H the broadening of R(T) transitions increases monotonously, at the same time the onset temperature of transitions T_c^{ons} is slightly shifted. Different sample orientations ($\vec{J} \parallel \vec{H}$) demonstrate the quite analogous R(T) dependences with little smaller (about 5 %) R values at the same H values. The smallness in R(T) differences shows the absence of crystalline orientation in the investigated $Bi_4Sr_3Ca_3Cu_4O_x$ samples.

The analysis of R(T) curves in different magnetic fields shows quite a different character of resistive transition broadening in magnetic field in the upper ($R(H, T) \gtrsim 0.5 R_N$) and lower ($R(H, T) < 0.5 R_N$) transition parts. In the upper part the resistive transition broadening is proportional to the magnetic field.

The upper critical field $H_{c2}(T, \alpha)$ dependences (Fig. 2), drawn according to the $R(H, T) = \alpha R_N$ $(0.5 < \alpha < 1)$ criterion show positive curvature and a typical slope dH_{c2}/dT, increasing with α: $dH_{c2}/dT \approx 6$ T/K for $\alpha = 0.9$; $dH_{c2}/dT \approx 0.9$ T/K for $\alpha = 0.5$. In strong magnetic fields ($H > 4$ T) the lower parts ($\alpha < 0.5$) of R(T) transitions are shifted parallel to each other by the field.

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