Thermoelectric power of Y-Ba-Cu-O and Eu-Y-Ba-Cu-O

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The temperature dependence of the thermoelectric powers of the high-temperature oxide superconductors $Y_1Ba_2Cu_3O_{7-x}$ and $(Eu\text{-}Y)_1Ba_2Cu_3O_{7-x}$ is reported. The sign of the dominant carriers in the normal state is observed to be positive. Well above the superconducting transition, the magnitude of the thermoelectric power is a weakly decreasing function of temperature.

Thermoelectric power measurements can provide useful data about transport mechanisms in conducting media. Several authors have previously reported on the thermoelectric properties of the high-temperature oxide superconductors La-Ba-Cu-O (Refs. 1 and 2) and La-Sr-Cu-O.[2,3] In this paper we report similar measurements in the Y-Ba-Cu-O system.

Our samples were fabricated by solid-state synthesis procedures similar to those described in the literature.[4,5] Powders of chemically pure oxides (or barium carbonate) were mixed in the appropriate stoichiometry, heated at 1223 ± 10 K in an oxygen atmosphere, reground and reheated several times, and then pelletized before a final heating under the same conditions.

The x-ray powder-diffraction patterns of our samples are in excellent agreement with published data for single-phase material.[6] The morphology, as studied by electron microscopy, is quite complicated. The samples consist of small crystallites having typical dimensions on the order of tens of microns. Energy dispersive x-ray (EDX) studies have revealed some compositional differences between the grains themselves and the interfacial materials which separate them.[7] The measured critical currents are quite small, less than 10 A/cm^2 at 78 K.

For the thermopower measurements, the samples were clamped between copper blocks containing chromel-constantan thermocouples in electrical as well as thermal contact. A constant temperature difference was maintained between the blocks and monitored by means of the thermocouples. Voltage measurements were made between the two chromel leads, and additionally between the constantan leads. From these voltage measurements, and the known temperature difference, one could extract the thermoelectric powers of the samples relative to chromel and to constantan, respectively. The thermopowers of the latter materials, previously measured with respect to pure metallic standards in the same apparatus, were subtracted from the total to yield the thermopower of the sample alone. The resistances of the superconductive samples were measured in a second apparatus by a standard dc four-lead technique.

Figures 1(a) and 1(b) illustrate the temperature-dependent resistances and thermopowers, respectively, of two typical samples. Our resistivity data are similar to

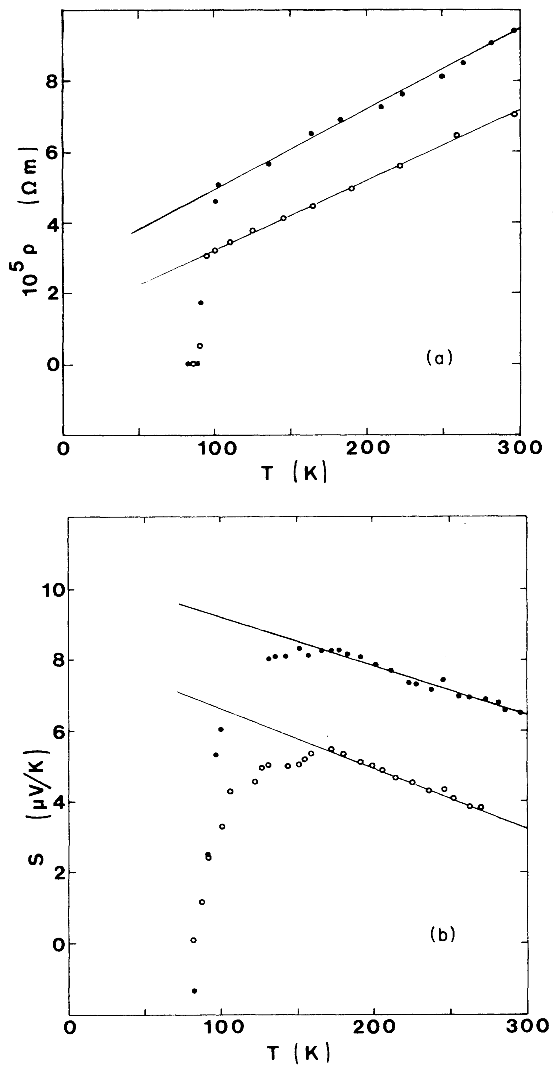

FIG. 1. (a) Electrical resistivity of $Y_1Ba_2Cu_3O_{7-x}$ (closed symbols) and of $(Eu\text{-}Y)_1Ba_2Cu_3O_{7-x}$ (open symbols) as a function of temperature. (b) Thermoelectric power as a function of temperature for the same samples as in (a). The single negative value near the transition point for the $Y_1Ba_2Cu_3O_{7-x}$ sample is probably due to a calibration offset in the measurement.

those reported by a number of other laboratories. The narrow widths of the transition are indicative of reasonably homogeneous samples. The resistivities above the transition are remarkably linear as previously observed. Since the shapes of our samples are somewhat irregular, it is difficult to accurately compute the resistivities from resistance measurements. However, our calculated values at room temperature are comparable to published results.[8]

The thermoelectric power of either sample is positive with a negative temperature coefficient in the normal state, and falls rapidly to zero at a temperature near to that of the resistive transition. This behavior is similar to that which has been observed in the La-Ba-Cu-O and La-Sr-Cu-O systems. The positive sign is indicative of hole-like conduction. As the temperature is raised above the transition, the thermoelectric power displays a broad maximum followed by a relatively slow decline. As in the lower-temperature materials, there seem to be signs of the incipient superconductivity at temperatures well above the center of the resistive transition. In contrast to the earlier materials, however, the magnitude of the maximum thermoelectric power is smaller by about a factor of 3. Above 160 K, the data are nearly linear with a negative slope. Potentially sharp features in the data, such as the superconducting transition itself, are somewhat broadened by the fact that a temperature difference of about 10 K was imposed across the sample during the measurements. This smoothing effect is quite small at high temperatures, where the thermoelectric power is slowly varying and nearly linear.

As has been pointed out previously, the observations do not conform to standard metallic behavior. Cooper *et al.* have suggested that the similar normal-state thermoelectric power of doped La_2CuO_4 compounds may be due to "correlation effects or unusual entropy carrying excitations."[2] Hundley, Zettl, Stacy, and Cohen have referred to the possibility of phonon drag to explain the same features in their data on La-Sr-Cu-O.[3] The presence of similar features at higher temperatures in the present system may point to a more intrinsic mechanism perhaps common to all of the high-temperature oxide materials.

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