High-T_c superconductivity in $La_{1.8}Sr_{0.2}CuO_4$ and $Y_{1.2}Ba_{0.8}CuO_4$ systems

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Magnetic susceptibility and electrical resistance data on high-T_c superconducting La-Sr-Cu-O and Y-Ba-Cu-O compounds are presented. The superconducting onsets are 38 and 90 K for La-Sr-Cu-O and Y-Ba-Cu-O, respectively. High pressure has little influence on T_c in La-Sr-Cu-O. Preliminary data from x-ray studies are given.

During the past few months a new class of high-T_c superconducting materials, $L_{2-x}M_xCuO_4$, where L=La, M=Ba, Sr, and $x=0.2$ have been intensively studied.[1,2] Recently, spectacular experiments have shown that T_c for $Y_{1.2}Ba_{0.8}CuO_4$ is even higher than the liquid-nitrogen boiling temperature.[3] The samples were prepared by various methods: from aqueous solutions of Ba, La, and Cu nitrides[1,3] or from mixtures of $La(OH)_3$, $SrCO_3$, and CuO powders.[1,2]

We report investigations of the $La_{1.8}Sr_{0.2}CuO_4$ and $Y_{1.2}Ba_{0.8}CuO_4$ systems. The samples were prepared from the appropriate mixtures of La_2O_3, $SrCO_3$, and CuO, and of Y_2O_3, $BaCO_3$, and CuO. The purity of the starting materials was as follows: La_2O_3- 99.9%, $BaCO_3$, $SrCO_3$, and Y_2O_3-99.99%, CuO—less than 99% (unknown purity). The solid-state reaction was carried out at 900–1000 °C in air for six days. The reacted powder was then pressed into pellets and heated in oxygen and/or air for 20 h. According to x-ray analysis the samples of La-Sr-Cu-O contained 98% of the centered tetragonal $I4/mmm$ phase. The lattice constants were $a_0=3.7770\pm0.0002$ Å and $c_0=13.2309\pm0.0008$ Å.

The magnetic susceptibility χ was measured using the rf superconducting quantum interference device (SQUID) technique. A magnetic field of 5–10 G was maintained during the measurements. The resistance measurements were carried out by means of a standard dc four-probe technique, using a current density of about 0.03 A/cm^2. The resistivity was determined with an accuracy of 30% because the geometry of the samples was irregular and the packing factor was unknown. The temperature was measured with an accuracy of 0.5% with Pt and Ge thermometers. The sample densities were estimated by weighing in air and water. The determined densities were 5.8 and 4.8 g/cm^3 for La-Sr-Cu-O and Y-Ba-Cu-O, respectively, but these values could be underestimated due to the unknown packing factor.

Figure 1 shows the electrical resistivity of the La-Sr-Cu-O sample in the superconducting transition range. The resistivity starts to drop at $T_{co}=38$ K and the width of transition is about 15 K, in good agreement with results of Cava, van Dover, Batlogg, and Rietman.[2] At higher temperatures, the sample has metallic-character resistivity. The dc magnetic susceptibility measured using a SQUID magnetometer, as shown in Fig. 1, indicates that over 50% of the sample is in a superconducting phase. The superconducting-transition onset temperatures T_{co} determined from electrical and magnetical measurements are consistent with each other.

Results for a Y-Ba-Cu-O are shown in Fig. 2. We observe a wide resistive transition with the onset temperature $T_{co}=90$ K and zero resistance at temperature below 54 K. The dc magnetic susceptibility measurements exhibit the Meissner effect at temperatures up to 54 K. The magnetization measured at 4.2 K indicates that only 0.4% of the sample volume is in the superconducting state. A pronounced positive peak at 57 K suggests the existence of a strongly paramagnetic phase in the sample. We expect that our Y-Ba-Cu-O samples are composed of several phases. Attempts to determine the high-T_c phase are under way.

We report also studies of the influence of high pressure on T_{co} in the La-Sr-Cu-O system. We performed our measurements in a high-pressure Be-Cu vessel using benzine as a pressure-transmitting medium. High pressure

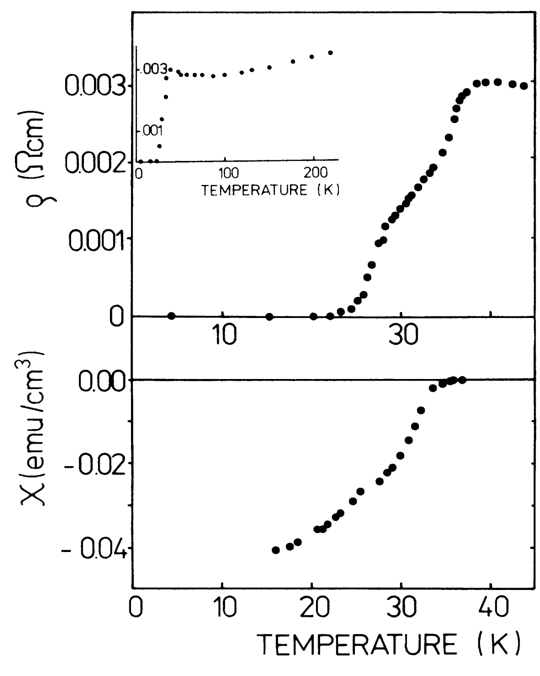

FIG. 1. The electrical resistivity of the La-Sr-Cu-O sample vs temperature in superconducting range. Inset: resistivity over a wide range of temperatures.

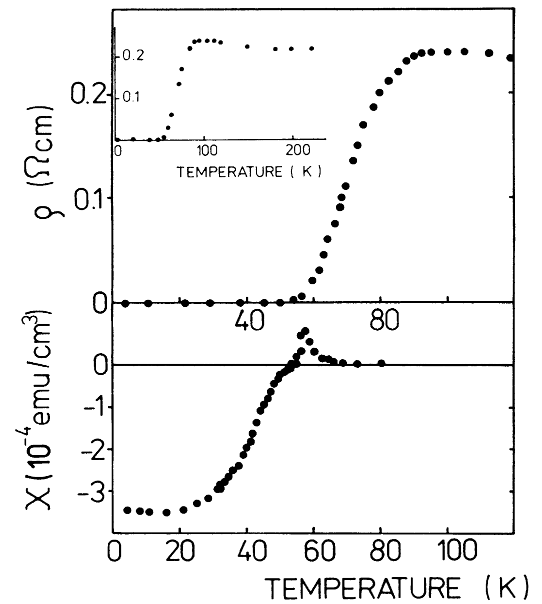

FIG. 2. The electrical resistivity and dc magnetic susceptibility of the Y-Ba-Cu-O sample vs temperature in the superconducting range. Inset: resistivity over a wide range of temperatures.

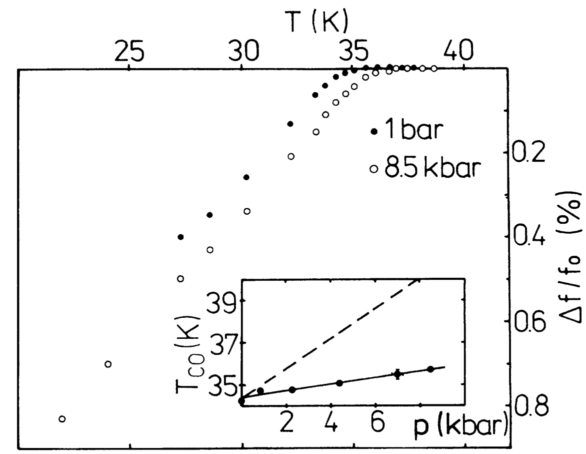

FIG. 3. The temperature dependence of the oscillator frequency ($\Delta t/f_0 \sim -\Delta\chi_{a,c}$) at different pressures. Filled circles: 1 bar, open circles: 8.5 kbar.

was applied at room temperature and measured with a superconducting lead thermometer at low temperatures. We observed the superconducting transition of the sample by measuring the frequency ratio of two *LC* oscillating circuits supplied by tunnel diodes.[4] The coils were placed in the high-pressure vessel and one of them contained the sample while the other contained a lead manometer. The relative increase in the frequency for the coil containing the sample is proportional to the decrease in the magnetic susceptibility χ of the sample.

In Fig. 3 we present the change in resonance frequency as a function of temperature for the measurements at ambient pressure and at a pressure of 8.5 kbar. The observed pressure effect on superconducting-transition onset temperature is presented in the inset in Fig. 3. The value of dT_{co}/dP calculated from these results is equal to 0.12 K/kbar. Hor *et al.*[5] have stressed that pressure has a very strong effect on superconductivity of the La-Ba-Cu-O and La-Sr-Cu-O systems in contrast to the behavior of Y-Ba-Cu-O compound. They reported the value of dT_{co}/dP $=0.9$ K/kbar for the systems containing La. Their data are represented as a dashed line in Fig. 3.

Since our value of the pressure coefficient of T_{co} is about one order of magnitude smaller, we conclude that the strong pressure effect is not a universal property of La-based compounds.

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