SHORT COMMUNICATIONS

SUPERCONDUCTIVE BEHAVIOUR OF $Ba_2Y_{0.5}La_{0.5}Cu_3O_{7-\delta}$

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SINCE Bednorz and Muller[1] reported the possible existence of percolative superconductivity in the La–Ba–Cu–O system in the 30 K range, some new systems have been reported as high-temperature superconducting materials. Basically the currently available high T_c superconductor can be classified under two categories, viz. K_2NiF_4 type crystal structure ($T_c = 20 \sim 50$ K) and $Ba_2YCu_3O_{7-\delta}$ type crystal structure ($T_c = 70 \sim 100$ K). At present the mechanism of high T_c superconductivity is a challenging problem and much work has to be done in both theoretical and experimental fields. A study of the compositional and structural dependence of superconductivity is important to substantiate the mechanism of high T_c superconductivity in Cu-containing oxides and to prepare new high T_c materials. In an attempt to understand the problem we have studied the system $Ba_2Y_{0.5}La_{0.5}Cu_3O_{7-\delta}$ carefully by comparing the results of X-ray diffraction, electrical resistivity and AC susceptibility. The pressure shift of T_c for the compound is also shown.

Samples of $YBa_2Cu_3O_{7-\delta}$ and $LaBa_2Cu_3O_{7-\delta}$ were prepared from the appropriate mixtures of $BaCO_3Y_2O_3$, La_2O_3 and CuO. The starting materials were thoroughly mixed, ground and then heated to 900°C for 12 h in air to prepare the master materials. These materials were reground to get fine powder. The mixture of the two master materials in the requisite proportion was pressed into a disc and sintered at 900°C for 15 h in air. Then the sample was slowly furnace-cooled to 200°C over a period of 6 h. All samples were prepared under the same conditions.

The superconductor oxide with a metal ratio Y:Ba:La:Cu of 0.5:2.0:0.5:3.0 showed an X-ray diffraction pattern similar to that of the distorted perovskite structure. The X-ray diffraction pattern was used to check for the presence of secondary phases. The lattice parameters of the title compound are as follows: $a = 3.855$ Å, $b = 3.914$ Å and $c = 11.811$ Å. These values compare well with the values reported in the literature [$a = 3.848$ Å, $b = 3.899$ Å $c = 11.77$ Å (ref. 2); $(b-a)/a = 14 \times 10^{-3}$, $c = 11.72$ Å, $T_c = 94 \sim 98$ K (ref. 3)]. When $x \geqslant 0.9$ (in $Ba_2Y_{1-x}La_xCu_3O_{7-\delta}$), the crystal structure changes from orthorhombic to tetragonal; that is, samples with x in the range 0.90–0.99 are semiconductors. Resistivity of the superconductor was determined in samples cut from the disc. Pressure shift of T_c was determined by measuring the electrical resistance as a function of temperature at various pressures. Copper wires were attached to the specimen by silver paste for making electrical resistance measurements using the four-probe technique. Kerosene was used as pressure transmitting medium, which ensured hydrostatic pressure over the measuring temperature range. The specimen was immersed in kerosene with a teflon capsule. Pressure was applied by using a piston–cylinder-type press.

The temperature dependence of electrical resistance was measured under pressures of 0, 1, 2, 3 and 4 GPa. The resistance vs temperature graphs at 0, 1, 2, 3 and 4 GPa are shown in figure 1.

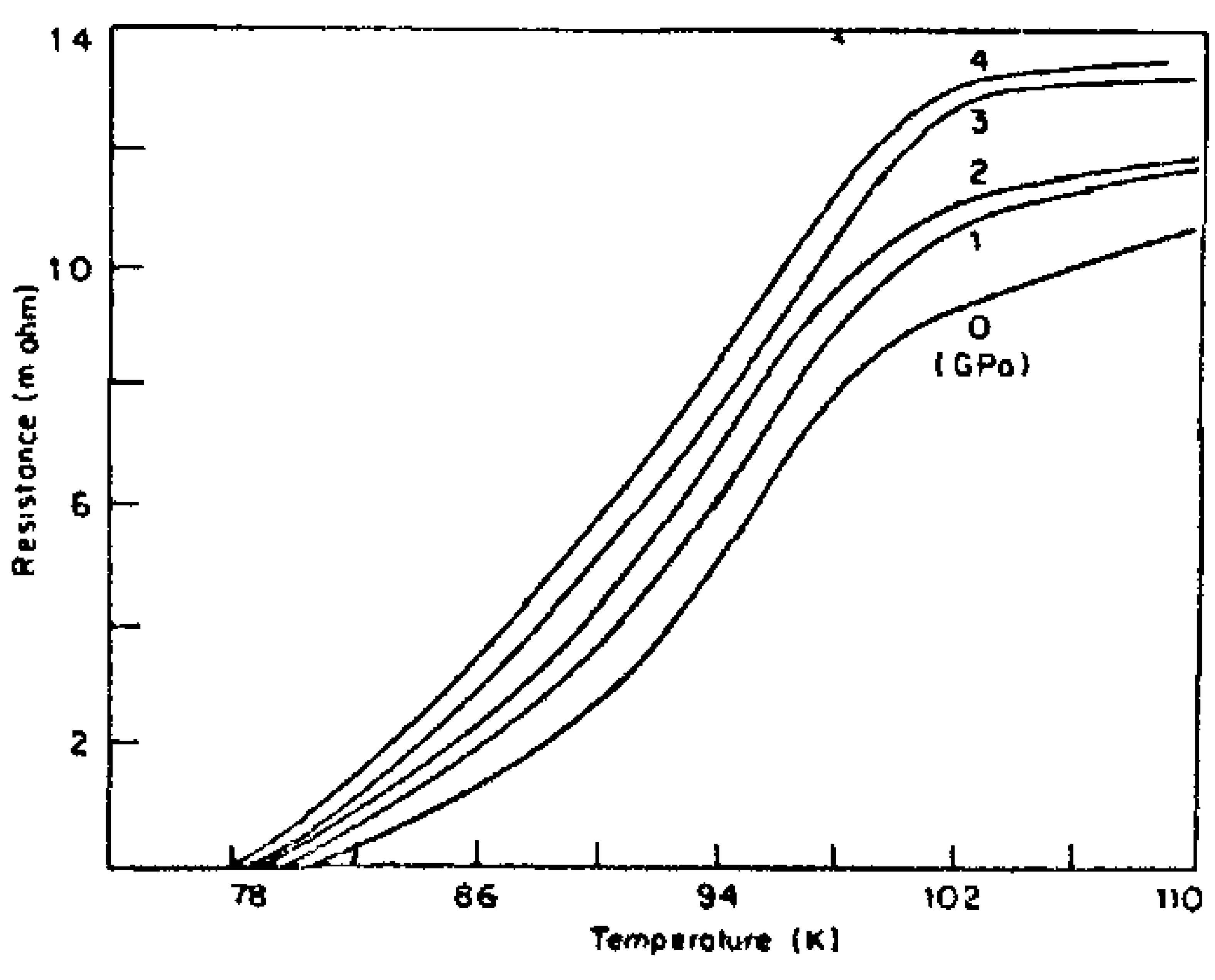

Figure 1. Electrical resistance of $Ba_2Y_{0.5}La_{0.5}Cu_3O_{7-\delta}$ vs temperature at 0, 1, 2, 3 and 4 GPa.

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The following observations are made from figure 1:

(i) All resistance vs temperature curves have a slight shoulder in the transition temperature range
(ii) The pressure shift of T_c (onset) T_{co} and T_c (final) T_{cf} is very small
(iii) The superconducting transition of the title compound terminates at 77 K at atmospheric pressure
(iv) (dR/dP) changes with increasing pressure.

The variation of transition temperature with pressure is shown in figure 2. T_{co} and T_{cf} were determined and plotted to observe the pressure dependence.

The pressure dependence of T_{co} and T_{cf} is not so large when compared with that in the La–Ba–Cu–O system. However, T_{cf} shows a maximum at 2, 3 and 4 GPa (figure 2).

The AC susceptibility down to 5 K was determined using the closed cycle refrigerator. The variation of χ_{ac} with temperature is shown in figure 3. The bulk sample exhibits a large diamagnetic signal at temperatures below 98 K. When the sample was powdered, the diamagnetic signal was reduced to 1/4 of the signal for the bulk sample at 5 K. This implies that the sample possesses superconducting phase at T=98 K only on the surface and/or given boundaries[4]. It is also interesting to note that even for a solid pellet the diamagnetic susceptibility reaches a limiting value only at 30 K though the resistivity drops to zero at 77 K.

The interesting feature in figure 1 is the resistance behaviour in the normal conducting state. The transition temperature changes with increasing pressure. The positive sign of (dR/dT) at low pressures becomes negative at a certain pressure between 1 GPa and 2 GPa. T_{co} shows a faint maximum around 1 GPa as a whole. This maximum corresponds to the pressure at which the sign (dR/dT) in the normal state changes from positive to negative as mentioned earlier. Similar behaviour was also noticed by Akahama *et al.*[5]

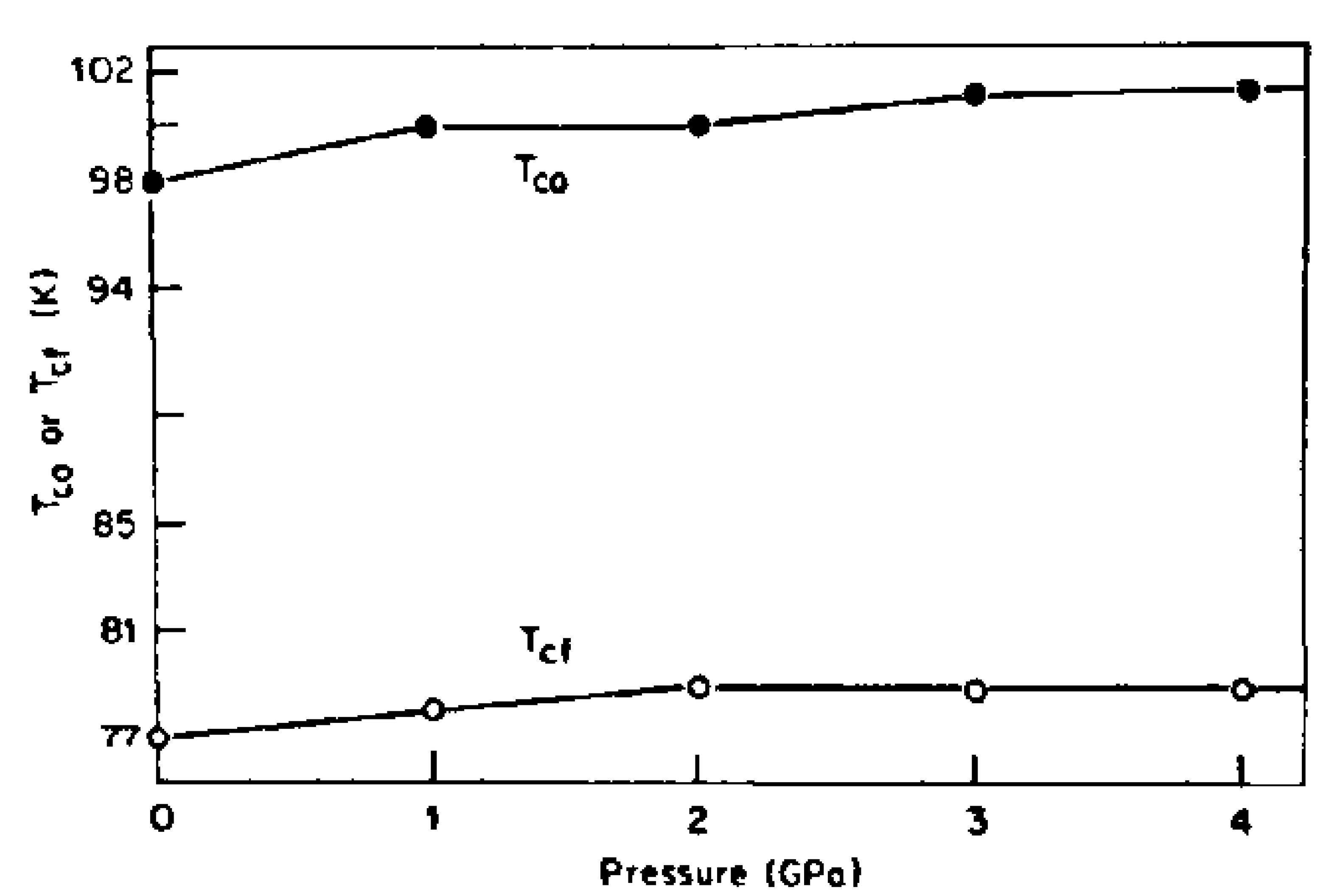

Figure 2. Pressure dependence of T_{co} and T_{cf} for $Ba_2Y_{0.5}La_{0.5}Cu_3O_{7-\delta}$.

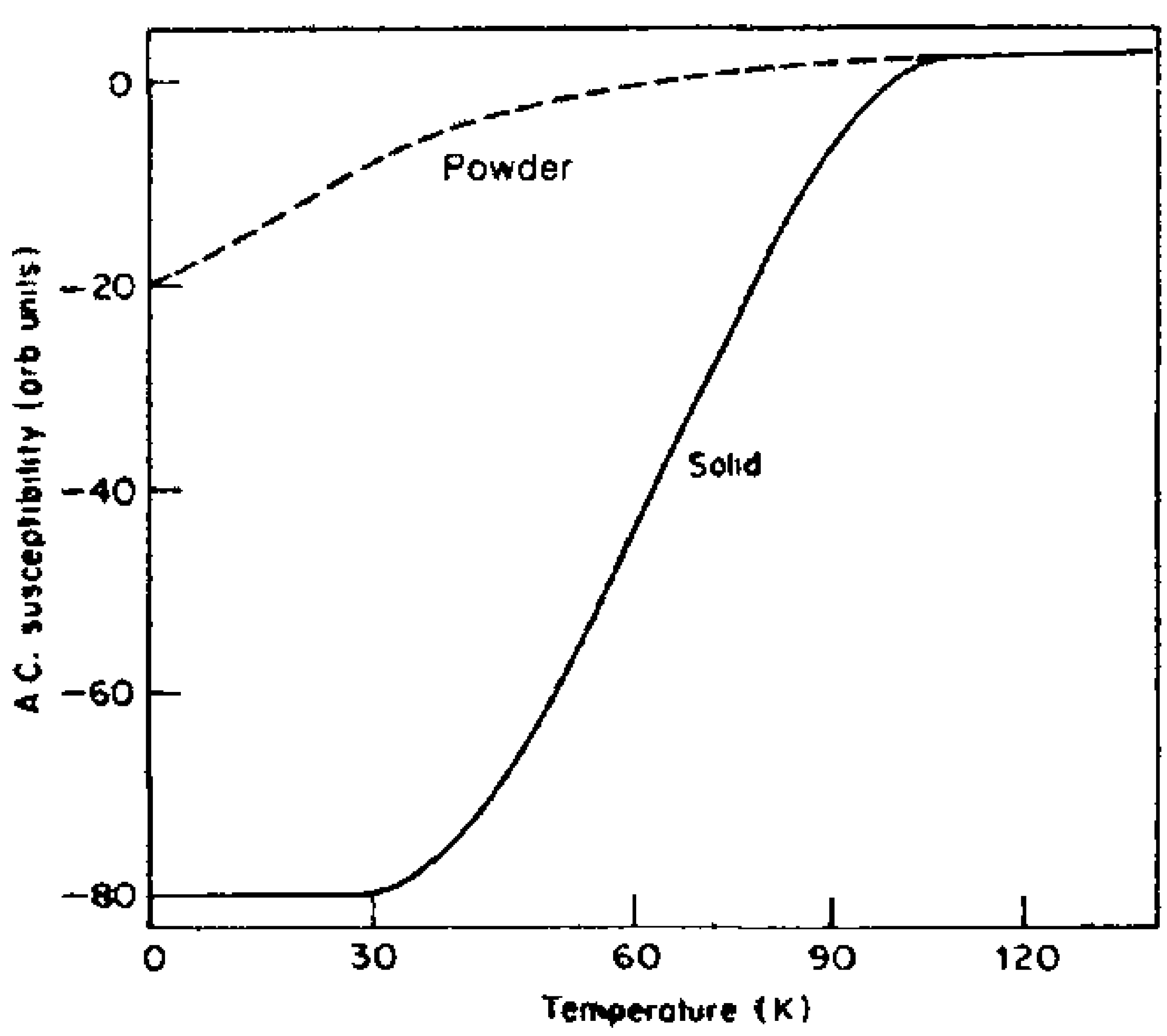

Figure 3. Variation of χ_{ac} with temperature for $Ba_2Y_{0.5}La_{0.5}Cu_3O_{7-\delta}$.

Preparation of samples with different compositions and high pressure studies are in progress.

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WHY HAS URANUS TOPPLED OVER?

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URANUS is unique among the planets in the solar system because its spin axis lies in its orbital plane. Whereas the spin axes of the neighbouring Saturn and Neptune show a tilt of 27° and 29° from the normal to their orbital planes (similar to the case of