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High T_c $SmBa_2Cu_3O_{7-\delta}$ superconductors

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Abstract. The superconducting transition with onset temperature of 95 K has been confirmed in $SmBa_2Cu_3O_{7-\delta}$ system by resistivity and AC susceptibility measurements. Pressure dependence of T_{co} and T_{cf} of the title superconductor is described. The superconducting transition onset temperature and complete transition temperature increases with increase of pressure.

Keywords. Superconductivity; $SmBa_2Cu_3O_{7-\delta}$; a.c. susceptibility; pressure dependence.

1. Introduction

Since Bednorz and Muller (1986) reported the possible existence of percolative superconductivity in 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 $Ba_2YCu_3O_{7-\delta}$ crystal structure ($T_c = 70 \sim 100$ K). At present the mechanism of high T_c superconductor is a challenging problem and much work has to be done in both theoretical and experimental fields. Hence the study on the compositional and structural dependence of superconductivity is important to substantiate the mechanism of high T_c in Cu-containing oxides and to prepare new T_c materials. In an attempt to understand the problem we have studied the system $SmBa_2Cu_3O_{7-\delta}$ carefully by comparing the results of X-ray diffraction, electrical resistivity and A.C. susceptibility. Further the pressure shift of T_c for the title compound is also shown in the present work.

2. Experimental

The samples of $SmBa_2Cu_3O_{7-\delta}$ were prepared from appropriate mixtures of Sm_2O_3, BaO and CuO. The starting materials were thoroughly mixed, ground and then heated to 950°C for 12 hr in air to prepare the master materials. These materials were reground to get a fine powder and were then pressed into pellets and sintered at 950°C for 15 hr in air. The sample was slowly furnace-cooled to 200 °C for 6 hr. All samples were prepared under the same condition.

The superconductivity oxide $SmBa_2Cu_3O_{7-\delta}$ showed an X-ray diffraction pattern similar to the distorted perovskite structure. The X-ray diffraction pattern showed that the samples are principally of single phase. The lattice parameters of the title compound are as follows: $a = 3.85$ A, $b = 3.91$ A and $c = 11.81$ A. These values compare well with the values reported in the literature (Garcia-Alvarado *et al* 1987). When the sample becomes a non-superconductor the crystal structure changes from an orthorhombic to a tetragonal structure. Resistivity of the superconductor was determined from the 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 measuring electrical resistance using the four-probe technique. Kerosene was used as a 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 using a piston cylinder type press.

3. Results and discussion

The temperature dependence of electrical resistance was measured for the sample under various constant pressures of 0, 1, 2, 3 and 4 GPa. The resistance obtained at 0, 1, 2, 3 and 4 GPa are plotted in figure 1. The interesting feature in the figure is the resistance behaviour in the normal conducting state. Figure 1 reveals the following features:

(i) All resistance vs temperature curves have a slight shoulder in the transition temperature range.

(ii) The pressure shift of T_{co} and T_{cf} is very small.

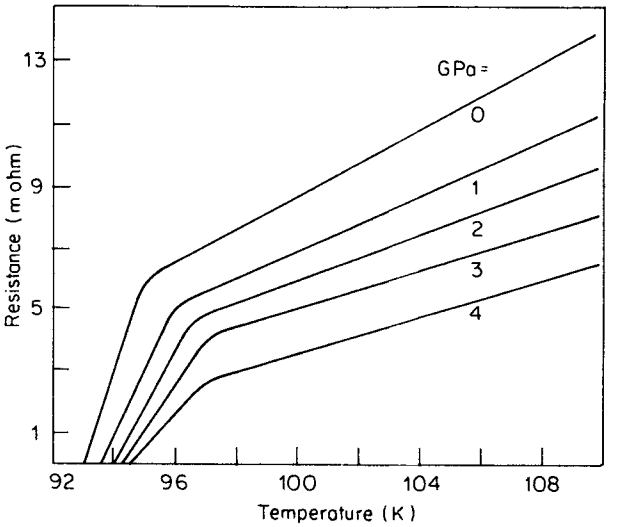

Figure 1. Electrical resistance of $SmBa_2Cu_3O_{7-\delta}$ temperature at 0, 1.0, 2.0, 3.0 and 4.0 GPa.

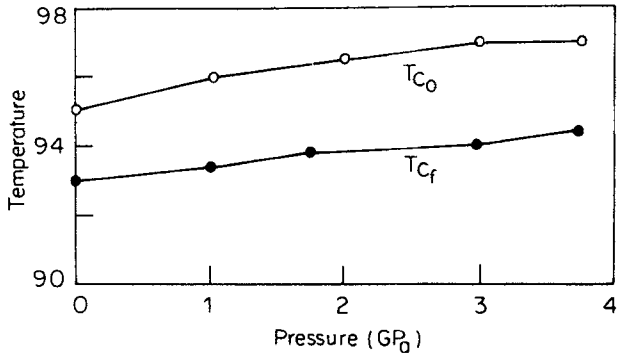

Figure 2. Pressure dependence of T_{co} and T_{cf}.

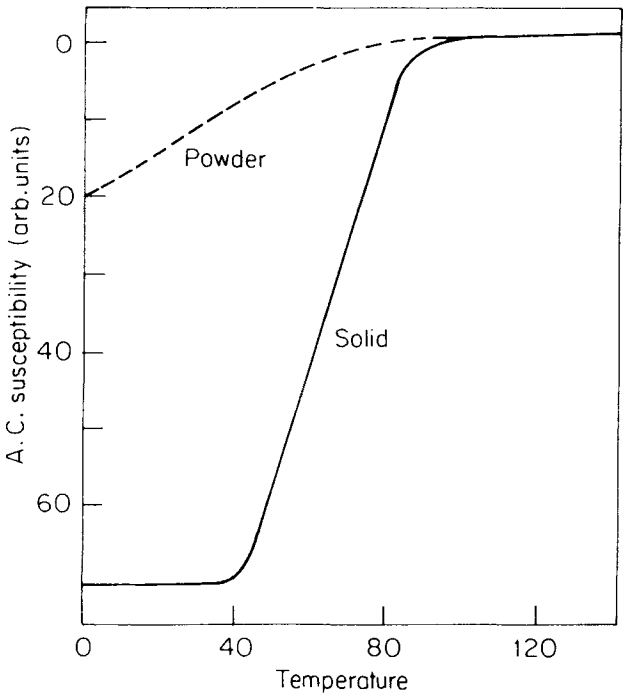

Figure 3. Variation of X_{ac} vs temperature.

(iii) The superconducting transition of the title compound terminates at 93 K at atmospheric pressure.
(iv) dR/dP changes with increasing pressure.
(v) The resistivity is smaller above T_c under pressure while T_c increases with pressure.

The variation of temperature vs pressure is shown in figure 2. T_{co} and T_{cf} points, determined to observe the pressure dependence do not show large values compared to the La–Ba–Cu–O system. However T_{cf} shows a maximum at 3 and 4 GPa.

The variation of X_{ac} vs temperature is shown in figure 3. The bulk sample exhibits a large diamagnetic signal at temperatures below 95 K. When the sample is powdered, the diamagnetic signal was reduced to 1/4 of the signal for the bulk sample at 5 K. The a.c. susceptibility down to 5 K was determined using the closed cycle refrigerator. This implies that the sample possesses a superconducting phase at $T = 95$ K only on the surface and/or given boundaries (Takabatake *et al* 1987). It is also interesting to note that even for a solid pellet the diamagnetic susceptibility reaches a limiting value only at 40 K though the resistivity drops to zero at 77 K.

The sample preparation with different compositions, sample dependence, high pressure IR and laser Raman studies are under progress.

References

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