Electrical Resistivity and Magnetic Susceptibility of 10% Pr-Doped $YBa_2Cu_3O_{7-X}$ At High Temperatures

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A reversible transition was observed at around 650°C in both dc electrical resistivity (ρ) and dc magnetic susceptibility (χ) measurements. The transition was characterized by a shoulder-like increment in the p-T curve and a sudden change in the temperature gradient of χ, which is interpreted as the orthorhombic-to-tetragonal transition.

Keywords: Electrical resistivity, magnetic susceptibility, phase transition.

1. INTRODUCTION

The subsequent discovery of high T_c oxide $YBa_2Cu_3O_{7-X}$ (T_c ~ 90 K), has stimulated into the research work aimed at its identification and characterization. It is well established that there exist two types of $YBa_2Cu_3O_{7-X}$; one has an orthorhombic structure and the other a tetragonal structure. The former is a superconductor with T_c ~ 90 K, whereas the latter is not. High temperature X-ray and neutron diffraction studies in air revealed that a transition between the orthorhombic and the tetragonal phases takes place at about 650°C, however, there are great variations in observed transition temperatures; T_t = 670°C, 640°C and 750°C. To resolve this problem, the authors carried out high temperature measurements of dc electrical resistivity and dc magnetic susceptibility.

2. EXPERIMENTAL

Sample used for measurements were prepared by solid state reaction using Y_2O_3, $BaCO_3$, Pr_6O_{11} and CuO were mixed in stoichiometric quantities. Mixtures were pressed into pellets of 10 mm diameter, placed in an alumina boat, and heated in air at 800°C for 48 hr. Reactants were reground and sintered at 930°C for 24 h. The treatment of grinding and sintering was repeated, and the pellets were then cooled down to room temperature at a rate of 1°C/min. Specimens obtained were identified by powder X-ray diffraction method. High-temperature resistivity measurements were carried out in air at up to 9000°C employing an ordinary dc four-probe method. Platinum leads were contracted to a simple disk sandwiched between baked pyroohyllite. The entire setup was heated inside an electric furnace. Heating and cooling rate was 2.5°C/min.

3. RESULTS AND DISCUSSION

Figure 1 gives the temperature dependence of an electrical resistivity (ρ) of Pr-doped $YBa_2Cu_3O_{7-X}$. In the heating process ρ shows a normal metallic conductivity from room temperature to about 300°C. In the range between 300 and 480°C, ρ has a broad peak centered at about 370°C. Above 500°C ρ increases more sharply with temperature untill 900"C. In this temperature range, however, one can recognize a very weak but district shoulder-like peak at 650°C. It is also noteworthy that there is an inflection point of the ρ - T curve at about 850°C; the differential increment of ρ, *d* ρ*/dT* has a maximum at this point.

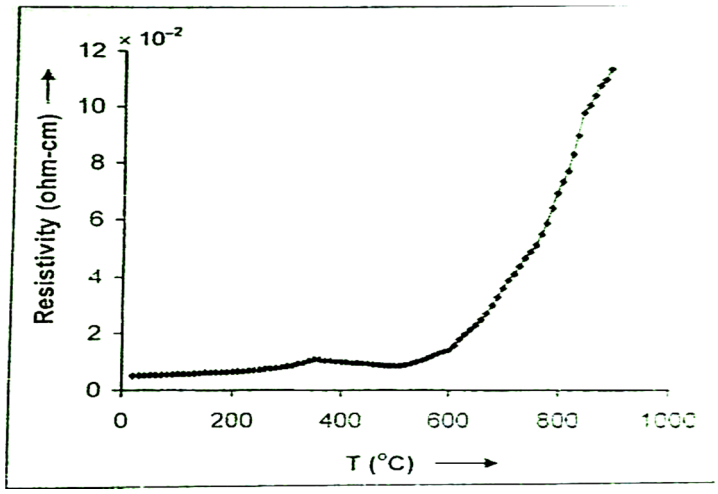

Fig. 1: Temperature dependence of electrical resistivity of 10% Pr-doped $YBa_2Cu_3O_{7-X}$ in air.

Figure 2 shows the temperature variation of dc magnetic susceptibility (χ) of Pr-doped $YBa_2Cu_3O_{7-X}$ has tendency to decrease slightly with increasing the temperature in the range from room temperature to about 660°C, but does not obey the Curie-Weiss Law. Above 660°C χ begins to decrease at a more rapid rate with an increasing temperature upto 990°C, suggesting the presence of a phase change at around 660°C. The transition temperature observed in the χ-T curve is in agreement with that in ρ measurements at around 650°C. The present results, therefore, confirm that the phase exists at around 650°C. This transition seems to correspond to that observed in earlier X-ray and neutron diffraction measurements, which implies that the transition is probably of the orthorhombic-to-tetragonal type. The transition is considered to be a kind of order-disorder transition associated with the change occupancy factors of oxygen sites in the oxygen-deficient CuO_{1-x} plane between BaO layers.

Thus, a transition was observed at around 650°C in both ρ and χ measurements. This transition temperature seems to correspond to that observed in the earlier in situ

measurements of x-ray and neutron diffraction, thereby confirming that the transition is of the orthorhombic-to-tetragonal type.

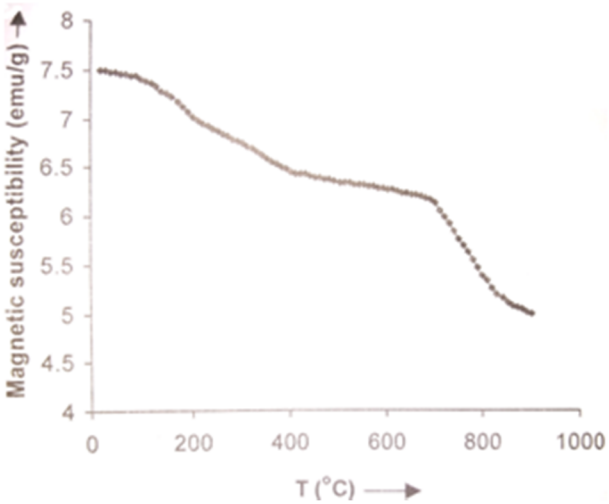

Fig. 2: Temperature dependence of de magnetic susceptibility of 10% Pr-doped $YBa_2Cu_3O_{7-X}$ in air.

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