Tr. J. of Physics
22 (1998) , 65 – 68.

Characterization of *Sb* Doped *YBaCuO* Superconducting Ceramics

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Received 13.09.1996

Abstract

In this study the structural characteristics of Sb_2O_3 doped $YBa_2Cu_3O_{7-x}$ superconductive ceramics are investigated by electrical and XRD analyses. It is determined that, while in undoped specimens the value of T_c is equal to 92 K, this value is negatively influenced by the addition of Sb. Structural phase results obtained from XRD analysis confirm the result obtained from the electrical measurements.

Introduction

Since the discovery of high T_c superconductors, many experimental and theoretical studies have been carried out in order to find out the mechanism of superconductivity for these new ceramic superconductors. Many efforts have been made to solve the weak-link problem which arises in $YBa_2Cu_3O_{7-x}$ type ceramics. Ag and Ag_2O doping in YBCO ceramics has provided positive results in increasing the J_c current density and thus improving the mechanical properties of the structure [1-2]. In YBCO ceramics the weak-link nature of the grains is known as a specific property of these structures. During the doping procedure many undesired metals and oxides get into chemical reactions with YBCO and thus negatively influence the superconductive transition temperature. For this reason element selection for doping is very limited and, furthermore, the degree of doping must be strictly controlled. C. Nquyen et al. have obtained with Au doped YBCO ceramics results similar to Ag doped specimens [3]. The superconductivity characteristics of YBCO ceramics are closely related with the tetragonal-orthorhombic phase transition developed with respect to oxygen stoichiometry. The important parameters affecting this phase transition are heating temperature and atmospheric conditions. Paulose et al. have indicated that the doping of Sb_2O_3 with $YBa_2Cu_3O_{7-x}$ has considerably improved the amount of oxygen absorption [4]. S. Jin et al. have reported that by 5 % Sb_2O_3 doping, despite the decrease in the value of T_c, reduction in grain size and the increase in the porous structure, an improvement is obtained in the value of J_c current density [5]. In the same study, another positive result has been reported with the acceleration of oxygen kinetics at the tetragonal-orthorhombic phase transition of Sb_2O_3 doping.

In this study, our aim is to explain the effect of 3-5 % (wt) Sb_2O_3 doping on the structural characterization in YBCO ceramics.

Experimental Procedure

In this study, at first $Y_2O_3, BaCO_3$ and CuO powder having 99.99 % purity are weighted in desired molar amounts and it is provided that they are throughly mixed by grinding. This mixture is initially heated for 20 hours at $900°C$. The obtained material is ground again and shaped into pellets with a thickness of 1.2 mm and a diameter of 13 mm under 500 MPa pressure. The pellets then are applied to a second heating treatment for 20 hours at $930°C$. Following this procedure, the air-cooled pellets are again throughly ground into powder form. To these powder specimens Sb_2O_3 are doped by 3 % and 5 % formula weight of the superconductive $YBa_2Cu_3O_{7-x}$ ceramics.

They are once more formed into pellets and are applied to a final heating treatment for 20 hours at $930°C$. Resistance-temperature data have been obtained by using the DC four point probe method and XRD patterns have been obtained by Rigaku D. Max.3C.XRD in the $2\theta = 0 - 50°$ range.

Results and Discussion

The resistance-temperature variations of the samples are shown in Figure 1. While the value of T_c in Sb_2O_3 undoped sample is limited to 92 K, in 3 % doped samples $T_c = 87K$ and the $5\%Sb_2O_3$ doped sample behaved as a semiconductor loosing its superconducting characteristic. The results obtained from resistance-temperature measurements show that Sb_2O_3 doping, a specific increase in resistances of samples has also been observed. The X-ray diffraction patterns of samples are given in Figure 2. While in undoped and 3 % doped sample peaks belonging to the $T_c = 92K$ superconductive phase are obtained, no peak belonging to superconductive phase is observed in 5 % doped samples. M. Munugesan et al. have indicated that in 0.5 % wt Sb_2O_3 doping the non-superconductive phase will form at $2\theta = 43.8°, 30.3°, 42.9°$ and $53.2°$ and that these samples will loose their superconductive characteristics [6]. These nonsuperconductive phases, named as YBa_2SbO_6 has specifically appeared in our 5 % doped samples and are indicated by (x) in Fig. 2b and 2c. The resistance-temperature variations and X-ray diffraction patterns of the samples complete each other. When the X-ray diffraction results for the undoped and $3\% Sb_2O_3$ doped structures are compared, a specific reduction in the magnitude of the superconductive peaks are seen in 3 % doped samples. As the percentage of Sb_2O_3 doping increases, the resistances also systematically increase in the samples.

This study is carried out on bulk form samples in the atmospheric conditions. In yttrium group superconductors, oxygen stoichiometry and heating atmospheric conditions are important parameters. In this study, one could conclude that Sb_2O_3 doping influences the oxygen stochiometery negatively and carrying out the final sintering process in an environment containing no oxygen is an important factor in obtaining this result.

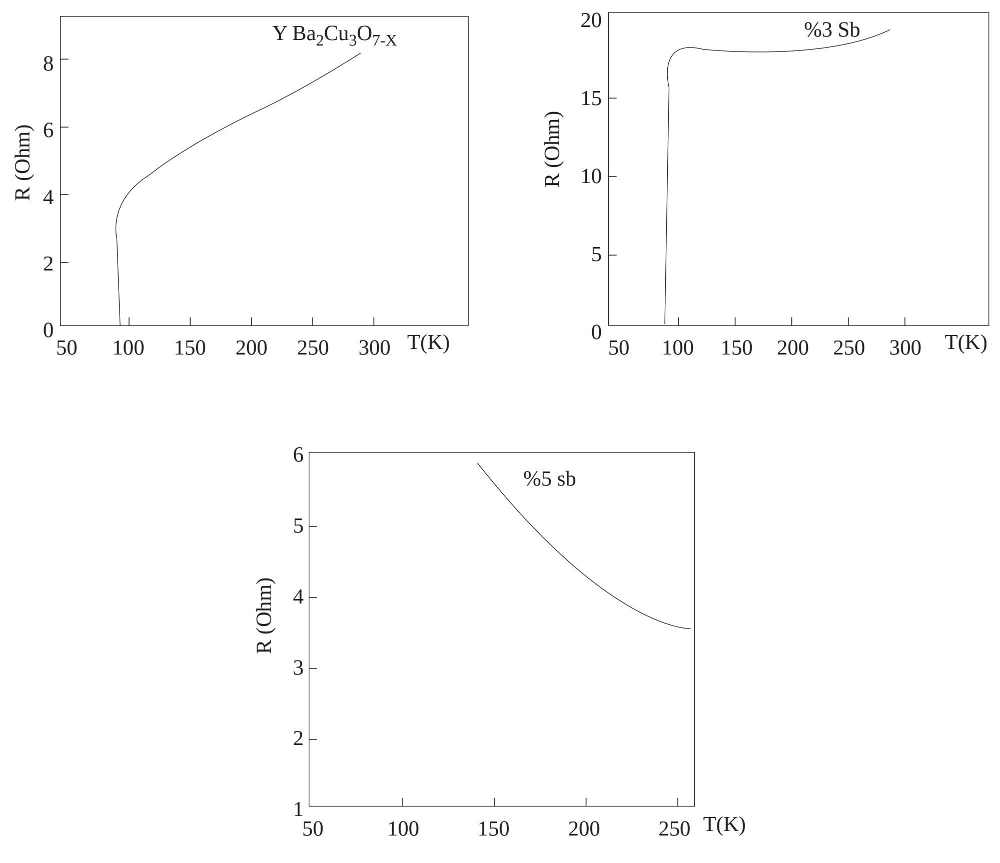

Figure 1. Temperature dependence of electrical resistance for samples.

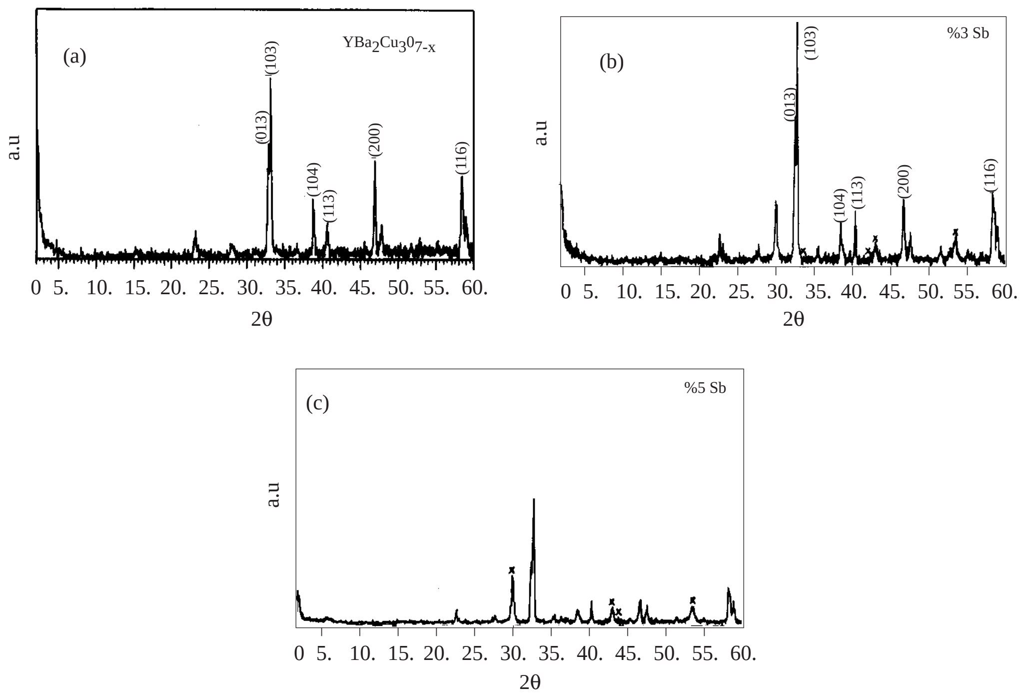

Figure 2. X-ray diffraction patterns of samples.

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