ANOMALOUS HIGH TEMPERATURE ELECTRICAL BEHAVIORS IN $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_y$ OXIDES

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The high temperature resistivity (27 - 900 °C) and the x-ray diffraction (27 - 500 °C) have been measured to investigate the anomalous transport behaviors in 90 K $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_y$ (BSCCO) oxides. A very sharp peak in the high temperature resistivity measurement was observed to occur at a specific temperature T_p as the BSCCO samples were exposed to various gas environments. These specific temperatures are at 275 °C, 389 °C and 450 °C respectively for BSCCO samples in the oxygen (1 atm), vacuum (1 mtorr) and the flowing helium (1 atm) environments. No significant decomposition was detected by the powder x-ray diffraction at temperatures near $T_p \pm 100$ °C. The x-ray diffraction data suggest that the change in the lattice parameters possibly causes the sharp peak of the high temperature resistivity data; which therefore affects the superconducting transition temperature of BSCCO samples.

Among $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_y$ (BSCCO) compounds, the oxygen content affects the superconductivity and is strongly dependent on the growth condition [1]. A sharp peak have been observed in the resistivity and the differential thermal analysis in BSCCO thin films [2] and bulk materials under the oxygen atmosphere [3]. In this work, we performed the measurements of the high temperature resistivity and the x-ray diffraction to investigate the transport behaviors in BSCCO compounds.

BSCCO samples with a normal composition were prepared by mixing an appropriate amount of Bi_2O_3 , CaCO_3 , SrCO_3 and CuO . The well mixed powder was preheated in air at 880 °C for 40 minutes. The preheated powder was thoroughly ground, pressed into pellets and annealed in air at 860 °C for 20 hours. Samples with different oxygen contents were obtained by a slow cooling process in furnace, a quick cooling in air or in liquid nitrogen. The magnetic data taken with a SQUID magnetometer for these samples are shown in figure 1. The sample quenched in the liquid nitrogen shows the highest $T_c = 88$ K and have the largest drop in the magnetic susceptibility.

The high temperature resistivity data performed

Figure 1. Temperature dependence of the magnetization data for samples A, B and C. Sample A was quenched in the liquid nitrogen, sample B was cooled in air and sample C was cooled in furnace.

under different gas environments for BSCCO samples with T_c at 88 K are shown in figure 2. A sharp increase in the resistivity was observed with a peak temperature, T_p , at 275 °C, 387 °C and 450 °C respectively for samples measured in the flowing oxygen (1 atm), vacuum (1 mtorr), and the

*Supported by National Science Council of R.O.C. under grant No. NSC81-0208-M003-019.

Figure 2. High temperature resistivity for three different gas environments a, b, and c; a was under 1 atm of helium flow, b was under the O_2 flow, while c was under vacuum.

flowing helium (1 atm). We note that there is a small shoulder in the resistivity data near 275 °C for the sample measured in vacuum. Since T_p for the sample measured in oxygen is at 275 °C, so the shoulder is caused by the residual oxygen in the vacuum chamber. The resistivity drops drastically as the temperature of the sample is heated above T_p and becomes very stable as the sample was cooled down to room temperature from 800 °C. A structural phase transition was suggested to interpret the resistivity anomaly which is quite different from that of the $YBa_2Cu_3O_y$ system [4]. Therefore the x-ray diffraction pattern from 27 to 800 °C were carried out for BSCCO samples with T_c at 88 K under the previously mentioned environments. Unfortunately, no significant structural phase transformation or the decomposition was observed. Besides, we also did not see any change in the high temperature magnetization data near T_p using a vibrating sample magnetometer.

Finally, we tried to stabilize the high temperature phase for BSCCO samples to investigate correlation between the lattice parameters and the anomaly in the resistivity. Samples with a post annealing in the previously mentioned gas environments to T_m for 5 hours followed by a rapid quenching in the liquid nitrogen was considered to be the stabilized phase. The a/c values of the lattice constant as a function

Figure 3. a/c ratio as a function of the post annealing temperature under different gas environments a, b and c.

of T_m for the stabilized samples calculated from the room temperature x-ray data is shown in figure 3. A minimum was found in the a/c ratio which is close to T_p . From the crystal structural point of view, the data suggest that the anomaly in the high temperature resistivity is probably due to the change of the a/c value. We noted that T_c is closely correlated to the lattice parameter a for samples in the flowing oxygen, to the lattice parameter c for samples in the flowing helium, and to the lattice parameters a and c for samples in vacuum. We observed that the longer the a value is for samples in the flowing oxygen, the higher T_c is; while the longer the c value is for samples in the flowing helium, the higher the T_c value is.

In summary, we observed the resistivity anomaly in BSCCO compounds and related the anomaly to the variations of the lattice parameters as indicated by the data from the x-ray diffraction pattern.

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