HIGH TEMPERATURE ELECTRICAL AND THERMAL PROPERTIES OF Bi-Ca-Sr-Cu-O SAMPLES

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The high temperature electrical and thermal properties of the multiphase Bi-Ca-Sr-Cu-O samples have been studied up to 1000K in O₂ and He atmospheres. A resistivity anomaly was found at T_c≈525K in the first heating curve, which suggests a thermodynamic reaction occurred in the samples. Upon reheating the sample the resistivity simply followed the cooling curve and never showed any features observed in the first heating curves. TGA, DTA, and TMA data measured to study the thermal properties show consistent results with electrical measurements.

Recently, Maeda et al.¹ and Tarascon et al.² have reported superconducting transition temperature greater than 100K. The superconducting Bi-Ca-Sr-Cu-O system have three superconducting phases³ with T_c's≈10K, 85K and 110K. In this work we are going to report the electrical resistivity, DTA, TGA, and TMA data, as a function of temperature up to 1000K for the multiphases Bi₂CaSr₂Cu₂O_y samples.

The samples with nominal composition were prepared from an appropriate mixture of Bi₂O₃, CaCO₃, SrCO₃ and CuO. The mixed powder was experienced 880°C preheat for 20 min., then the pressed pellet was annealing at 870°C for 10 hrs and followed by a slow cooling for sample D and air quench for sample E. The resistivity was measured by a four-probe method with Ag-paint as electrical contacts. Sample E has the smallest transition width with T_c(50%) at about 84K. Superconducting phases at about 101K and 120K were found for sample D.

Figure 1 shows the high temperature electrical resistivity for sample D in O₂ atmosphere. Four Pt-wires was connected to the sample by a mechanical pressure. Typical heating rate was about 5°C/min. For high-T_c YBa₂Cu₃O_{7-y} oxides the temperature dependence of resistivity is essentially linear for T<600K^{4,5}. Above 600K, the thermal desorption of

FIGURE 1

High temperature resistivity for sample D in oxygen atmosphere. A resistivity bump at 525K was found.

oxygen causes the electrical resistivity to deviate from the linear law. In the present work, a resistivity bump was found at T=525K. The resistivity decreases monotonously in the cooling curve. Upon reheating the sample the resistance simply followed the cooling curve and never showed any features observed in the first heating cycle. This anomaly has been rechecked and the same result was found. The resistivity anomaly was not found for 2-1-2-2 sample in helium atmosphere. The high temperature electrical resistivity of Bi₂Ca_{0.8}Sr₂Cu₂O_y single crystal has been studied systematically by Martin et al.⁶ A linear fashion in resistivity up to 650K for sample along a-b plane has been done and there is no anomaly in resistivity. Therefore the resistivity anomaly in the present work, we

FIGURE 2

DTA, TMA and TGA data for sample D in O_2 atmosphere.

believe, is probably due to a thermodynamic reaction.

To confirm the assumption, DTA, TMA and TGA measurements were performed on Du Pont 9900 system with the heating rate about $5^\circ\text{C}/\text{min}$ for samples D in O_2 atmosphere and the results were shown in Figure 2. There is an unusual structure observed at $T_g \sim 533\text{K}$ on those three measurements. This temperature T_g is about the same as that of the resistivity anomaly. These results support our assumption of a thermodynamic reaction. For DTA data, an exotherm occurs at T_g . From TMA result, the dimension change follows roughly a linear temperature dependence for $T > 650\text{K}$. However at $T < 650\text{K}$ the dimension change is irregular with a relative maximum at T_g . Our observation is similar to the TMA data in air for $\text{Bi}_{2.1}(\text{Ca}_x\text{Sr}_{1-x})_{n+1}\text{Cu}_n\text{O}_{2n+4+\delta}$ samples ($n=2$) reported by Buckley et al.⁷ They attribute their data to the oxygen loading which occurs at $\sim 600\text{K}$ and 800K . Our explanation for TMA maximum is that it is correlated to the phase transformation observed in resistivity and DTA data. The point is that if the relative maximum is related to the oxygen loading, then TGA data should show a relative maximum in weight loss. However the TGA data in Figure 2 didn't support this point. Therefore, we believe the relative

maximum in TMA is related to the thermodynamic reaction observed simultaneously in the resistivity and DTA peaks.

In order to see whether the resistivity anomaly occurs in the Bi-Ca-Sr-Cu-O samples with other compositions. Samples with a nominal composition near the vicinity of 2-1-2-2 were prepared with the same sintering conditions as that of sample D. We obtained similar resistivity anomaly and DTA peaks. The results suggest that similar thermodynamic reaction has occurred.

In conclusion, an anomaly was obtained from either electrical or thermal experiments. This suggests that a thermal decomposition has occurred in the 2122 samples. Samples with a nominal composition near the vicinity of 2-1-2-2 show resistivity anomaly and DTA features similar to that reported in 2-1-2-2 sample. The data suggest that the resistivity anomaly is a common feature in Bi-Ca-Sr-Cu-O samples with nominal composition near 2-1-2-2 and reported annealing conditions.

REFERENCES

1. H.Maeda, Y.Tanaka, M.Fukutomi and T.Asano, Jpn. J. Appl. Phys. Lett. 27 (1988) L209.
2. T.M.Tarascon, Y.Lepage, P.Barboux, B.C.Bagley, L.H.Greene, W.R.McKinnon, G.W.Hull, M.Giroud, and D.M.Hwang, Phys. Rev. B37 (1988) 9382.
3. J.M.Tarascon, W.R.McKinnon, P.Barboux, D.M.Hwang, B.G.Bagley, L.H.Greene, G.W.Hull, Y.Lepage, N.Stoffel, and M.Giroud, Phys. Rev. B 38 (1988) 8885.
4. M.Gurvitch and A.T.Fiory, Phys. Rev. Lett. 59 (1987) 1337.
5. A.T.Fiory, M.Gurvitch, R.J.Cava, and G.P.Espinosa, Phys. Rev. B36 (1987) 7262.
6. S.Martin, A.T.Fiory, R.M.Fleming, L.F.Schneemeyer, and J.V.Waszczak, Phys. Rev. Lett. 60 (1988) 2194.
7. R.G.Buckley, J.L.Tallon, I.W.M.Brown, M.R.Presland, N.E.Flower, P.W.Gilberd, M.Bowden and N.B.Milestone, Physica C 156 (1988) 629.