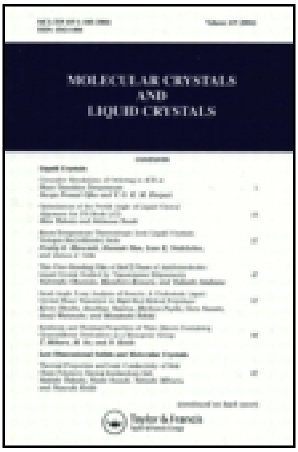

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Superconducting Characteristics of Metal Mixed Bi-Pb-Sr-Ca-Cu-O Composites

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Abstract Gold powder was mixed with a Bi-Pb-Sr-Ca-Cu-O superconductor for the purpose of improving its superconducting characteristics, especially, the critical current density, Jc. The Gold powder was uniformly dispersed into the superconductor as a metal. The critical transition temperature at zero resistance(Tc^{zero}) increased by the Au addition into the Bi-Pb-Sr-Ca-Cu-O superconductor up to 30 wt%. The Jc value was enhanced by the Au mixing and a maximum Jc of 1082 A/cm^2 was obtained for the composite with the Au 30 wt% addition. The value was approximately twice as high as that for the Bi superconductor without gold.

INTRODUCTION

Oxide superconductors have a merit in their high critical transition temperature(Tc). Particularly, the critical transition temperature at the zero resistance(Tc^{zero}) for the Bi-Sr-Ca-Cu-O superconductor with lead addition[1] exceeded 100 K. However, the critical current density, Jc, for the Pb added Bi-Sr-Ca-Cu-O superconductor, is considerably low compared with that for the practical superconductors. Furthermore, the Jc value decreased greatly by the magnetic flux application.[2] This may be mainly resulted from the existence of the non-superconductive secondary phase formed at grain boundaries and of pores between grains.[3]

In this investigation, gold powder was mixed with the Bi-Pb-Sr-Ca-Cu-O superconductor so as to prevent the non-superconducting phase from forming and to fill the pores in sintered pellets.

EXPERIMENT

Bi_2O_3(purity : 99.9 %), PbO(purity : 99 %), $SrCO_3$(purity : 99.5 %), $CaCO_3$(purity : 99 %), and CuO(purity : 99.9 %) were weighted in an atomic ratio of 1.85 : 0.35 : 1.9 : 2.0 : 3.1[4] and then mixed. The mixed starting material was thoroughly pulverized by a Planetary Micro Mill(Pulverisette 7) from Fritsch Co. The mixture was calcined at 1071 K for 12 h in a dry air flowing atmosphere and then pulverized again by the same mill. An appropriate amount of gold powder(purity : 99.9 %, grain size : < 150 μm) was mixed with the Bi-Pb-Sr-Ca-Cu-O powder. The Bi-Pb-Sr-Ca-Cu-O and Au mixed powder was pressed into pellets at a pressure of 2.65 x 10^8 Pa. These pellets were sintered at 1118 K for 30 h in a dry air flowing atmosphere. The sintered pellets were hydrostatically pressed at the same pressure and then sintered again at 1118 K for 70 h in the same atmosphere.

The phases of the sintered samples were determined by an X-ray powder diffraction analysis. The electrical resistivity and the critical current density(Jc) were measured by the standard four probe method. The resistivity measurement was carried out at the current density of 10 mA/cm^2. Jc was determined by a 1 μV/cm criterion. The microstructure of the composites was investigated with a scanning electron microscope(SEM)(S-800) from Hitachi Co. Ltd. The magnetic susceptibility was measured by a rf-SQUID meter(HSSM-1000) from Hoxan Co.

RESULTS AND DISCUSSION

Figure 1 shows the resistivity vs. temperature curves for a Bi-Pb-Sr-Ca-Cu-O superconductor without Au mixing, which is denoted as a standard, and an Au

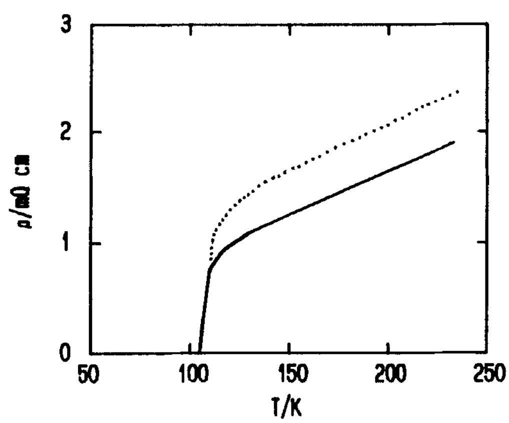

FIGURE 1 Resistivity vs. temperature curves for Bi standard(··········) and Au 30 wt% mixed Bi composite(———).

30 wt% mixed composite. By the gold addition, the resistivity decreased in comparison with that for the Bi standard in the normal conducting region. The transition from a normal state to a superconducting one was steep in both samples. The temperature width for the superconducting transition was approximately 6 K and Tc^{zero} was around 107 K for both the standard and the Au mixed composite.

The results for the magnetic susceptibility measurements for the standard and the Au 30 wt% mixed composite are presented in Figure 2. Tc^{on} was about 115 K and a diamagnetic signal sharply increased at the temperatures below 107 K. Therefore, a considerable part of the pellets for both the Bi standard and the Bi-Au composite was found to consist of a high Tc phase of the 2223 phase. The observed mass susceptibility for the Bi-Au composite(Figure 2 (b)) is smaller than that for the Bi standard(Figure 2 (a)) in the superconducting region. In this case, the mass of the Au powder was included in the total mass of the composite. By subtracting the Au mass from the total one, the real volume susceptibility(χ_v) for the Bi-Au composite was obtained. The χ_v value for the composite was almost equal to that for the standard as shown in Figure 2 (c). Therefore, the volume fraction of the superconductor in the composite is almost equivalent to that in the standard.

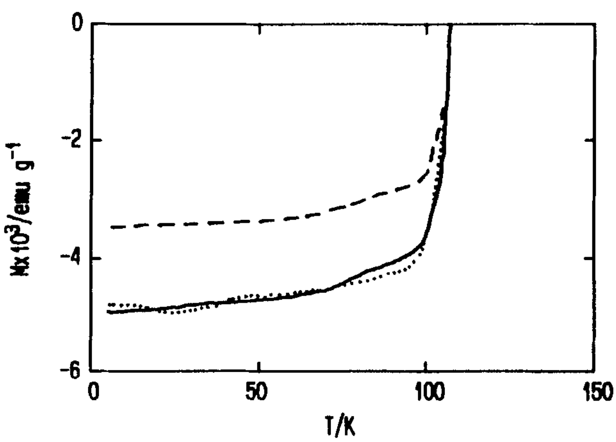

FIGURE 2 Temperature dependences of magnetic susceptibilities.
(a) : Bi standard(··········)
(b) : Au 30 wt% mixed Bi composite(- - - -)
(c) : Au 30 wt% mixed Bi composite after calibration(———)

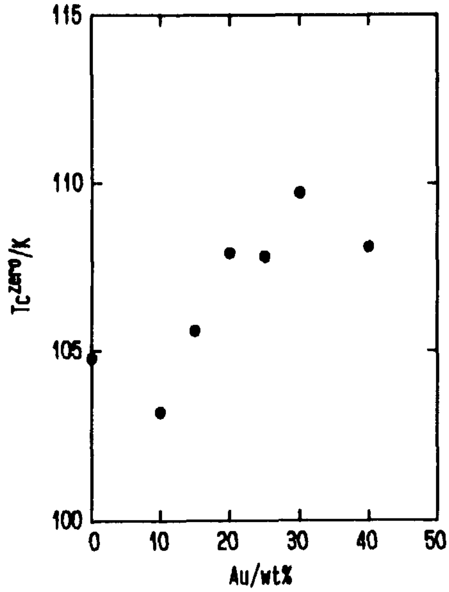

FIGURE 3 Tc^{zero} deviation with added Au wt%.

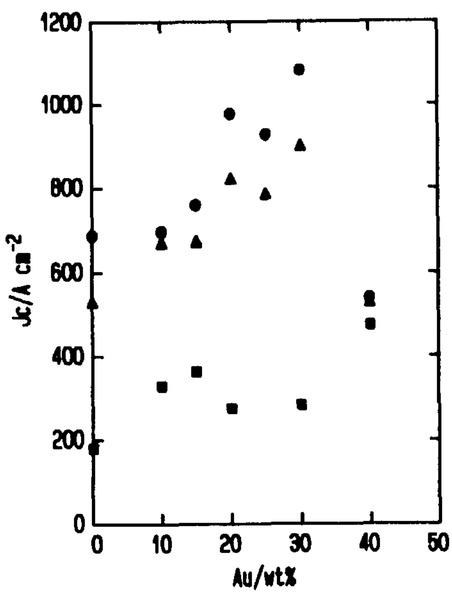

FIGURE 4 Relationship between Jc at 77 K and mixed Au wt%.
● : thickness(0.030 ~ 0.047 cm)
▲ : thickness(0.035 ~ 0.051 cm)
■ : thickness(0.085 ~ 0.095 cm)

Figure 3 shows the relationship between Tc^{zero} and the Au wt% for the Bi-Au composites. Tc^{zero} for the standard was 104.8 K. By the gold(10 wt%) addition into the Bi standard, Tc^{zero} decreased. In the case of the Au mixing more than 20 wt%, however, Tc^{zero} became higher than that for the standard. When the powder was added up to 30 wt%, a maximum Tc^{zero} of 109.8 K was obtained. Tc^{zero} considerably decreased by the 40 wt% gold mixing.

The results for the Jc measurements at 77 K for the Au mixed composites are presented in Figure 4. The Jc values monotonously increased with the Au addition up to 30 wt%. However, Jc decreased by the Au mixing more than 30 wt%. In addition, the Jc value was enhanced by the decrease of the composite thickness even for the same Bi-Au composites. Although the Jc value is normalized in itself, it varies according to the sample size. Therefore, the Jc value obtained must be described with the sample size. In this Jc measurement, the size for the composite(Au 30 wt%) which showed a maximum Jc of 1082 A/cm^2, was 0.9188 x 0.1605 x 0.0298 cm^3.

CONCLUSION

Gold powder was equally dispersed in the Au mixed Bi-Pb-Sr-Ca-Cu-O composites as a metal. Tc^{zero} for the Bi-Au(30 wt%) composite became 5 K higher than that for the standard. The Jc value for the Bi-Au(30 wt%) composite was 1082 A/cm^2 and was twice as high as that for the Bi standard. However, the Jc value varied according to the sample size. Therefore, the sample size should be clearly described with the Jc value.

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