EFFECTS OF A Pb LAYER ON THE SUPERCONDUCTIVITY OF Bi-Ca-Sr-Cu-O SYSTEM

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We have studied systematically the effects of a Pb layer on the superconductivity of Bi-Ca-Sr-Cu-O films. The Bi-Ca-Sr-Cu-O films were prepared by RF magnetron sputtering from a sintered ceramic target. The sputtering was performed at room temperature. The thickness of Pb-layer varies from several hundred to several thousand angstroms. Different annealing conditions were carried out to obtain the optimum conditions for superconductivity. An improvement of T_c and an enhancement of J_c were found. The results will be reported and discussed.

Since the first report on the new high- T_c superconducting Bi-Ca-Sr-Cu-O ceramics by Maeda et al,¹ numerous studies on the Bi-Ca-Sr-Cu-O system have been done. Very recently, Takano et al.² succeeded in increasing the volume fraction of the high T_c phase by a partial substitution of Bi by Pb in the Bi-Ca-Sr-Cu-O system. In this work, we report the effects of the Pb layer on the superconducting properties of Bi-Ca-Sr-Cu-O films.

The targets were prepared by mixing $SrCO_3$, Bi_2O_3 , PbO , $CaCO_3$, and CuO powders in a proper ratio. The substrates were $MgO(100)$ single crystal. The sputtering conditions and the method to measure critical current was reported previously³. The composition of the films was analyzed by the inductively coupled plasma atomic emission spectrometry (ICP-AES). Table I shows ICP-AES data of the as-deposited films. We found that the films are deficient in Ca and Sr.

Figure 1 shows the typically the temperature dependence of resistance for samples a and b. Samples a and b have compositions of (2:0:1.6:1.3:3.1) and (2:3.2:1.4:1.7:1.5) respectively. Both samples were annealed at about 850° for 4h. The data show that the Pb-doped film has a strong metallic behavior and

TABLE I
ICP-AES data of the as-deposited films from different targets. The sputtering power is 125 watts.

Target Composition (Bi:Pb:Ca:Sr:Cu)	Film Composition (Bi:Pb:Ca:Sr:Cu)
2: 0: 1: 2: 2	2: 0: 0.4:1.2:1.6
4: 0:3.2:2.8: 5	4: 0: 1.6:2.2:3.5
1: 0: 1: 1: 2	1: 0:0.95:0.7:2.4
2:0.3:2.2: 2:3.2	2:0.27: 1.7:1.4:3.1
2: 2: 3:2.5:3.2	2: 2.5: 2.3:2.2:3.4

better superconducting properties ($T_c(R=0)=78K$) compared with that of the undoped one. The powder X-ray diffraction peaks are shown in Figure 2 for sample b.

FIGURE 1
Temperature dependence of $R(T)/R(300K)$ for samples a and b.

To study the effects of a Pb layer on the superconducting properties of Bi-Ca-Sr-Cu-O films, we have prepared two kinds of samples.

FIGURE 2
Powder X-ray diffraction peaks for sample b.

The first kind of sample has a Pb layer on the top of the as-deposited Bi-Ca-Sr-Cu-O film. The second kind of sample has the Pb layer on the MgO substrate before the deposition of the Bi-Ca-Sr-Cu-O film. Figure 3 shows the temperature dependence of resistance for samples c and d. Both samples were prepared from a (1:1:1:2) target and subjected to a 845°C annealing for 3.5h except that a 1200Å Pb layer was deposited on the surface of MgO in sample d. Bi-Ca-Sr-Cu-O film has a thickness of 1.4μm. One can see that sample c

FIGURE 3
Normalized resistance versus temperature for samples c and d.

(undoped film) shows a residual resistance while sample d has a metallic behavior and a zero resistance at 72K. An improvement of superconductivity is clearly demonstrated. The critical current density of sample d is about $5 \times 10^3 \text{ A/cm}^2$ at $0.9T_c$. This is about one order of magnitude larger than

that of the undoped film (sample r in Figure 4) at the same reduced temperature.

Figure 4 shows typically the temperature dependence of $R(T)/R(300K)$ for samples p,q,r and s. Samples p,q,r and s were prepared from a (1:1:1:2) target in a single run and have a thickness of 1.5μm. Sample r is the as-deposited film. Samples p,q and s have a Pb overlay with a thickness of 1600Å, 2400Å, and 4000Å respectively. They were annealed at 850°C for 3.5h. The data in Figure 4 tend to indicate that the Pb layer on the top of the Bi-Ca-Sr-Cu-O films is not effective in improving the superconducting properties.

FIGURE 4
 $R(T)/R(300K)$ for samples p,q,r and s.

In conclusion, we have found the Pb layer deposited on the surface of MgO is very effective in improving the superconducting properties and I_c enhancement was found. However, the Pb layer deposited on the top of the Bi-Ca-Sr-Cu-O film is not as effective as that deposited on the MgO surface in improving superconducting properties of Bi-Ca-Sr-Cu-O films.

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