AS GROWN $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_y$ FILMS BY AN OFF AXIS RF MAGNETRON SPUTTERING

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$\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_y$ (BSCCO) films were in situ grown by an off axis rf magnetron sputtering. The sputtering targets were stoichiometric $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_y$ compounds. The sputtering gas was a mixture of O_2 and Ar and the sputtering pressure varied from 50 - 100 mTorr. The films were grown at 570 - 600 °C. After growth the films were quickly cooled down to 300 K in 30 minutes. One found that the distance from the substrate to the target d is an important factor in affecting the deposition rate of the as grown BSCCO films. By reducing the distance d to 3 cm, we have achieved a deposition rate of about 1500 Å per hour in a sputtering power of 60 watts and sputtering pressure of 70 mtorr. With optimum growth conditions where the substrate temperature was kept at 580 - 600 °C and the pressure was kept at 70 - 80 mTorr, superconducting BSCCO films with zero resistance at 75 - 85 K can be reproduced.

Since the discovery of the high- T_c oxide compounds [1], a great deal of efforts worldwide has been put into the development of thin film technologies. The most widely studied was Y-Ba-Cu-O films, which has now successively been fabricated by in-situ method [2]. But, the oxide compounds of the Bi-Sr-Ca-Cu-O have so far been proved difficult to make by in-situ techniques. In this paper we report the in-situ growth of Bi-Sr-Ca-Cu-O films by means of an off-axis rf magnetron sputtering technique.

The as-grown $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_y$ (BSCCO) thin films were prepared on MgO (100) with a single $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_y$ composites target. The diameter of the target was 5.1 cm and the distance from the target to the substrates was around 3 cm. The sputtering gas was a mixture of Ar and O_2 with a total sputtering pressure of about 50 - 100 mTorr. The films were grown at 550 - 600 °C; the sputtering power was 60 watts; and the deposition rate was 1500 Å/hr. After the growth of the films, the heater was turned off and the pressure of the chamber was maintained at the same value as that of the sputtering condition, and the samples were cooled down rapidly below 100°C in about 20 - 30

minutes.

The resistance of the films was measured by a conventional four-probe method. Four electrical leads were connected to the samples by silver paints. The current to the sample in the electrical measurements was 3 mA. The structural analysis was carried out by an x-ray diffractometer (Siemens model D500).

Various sputtering methods have been employed in preparing the as-grown BSCCO thin films, e.g. the ac-sputtering [3], the dc-sputtering [4], and the rf-sputtering [5]. The qualities of the films and the composition of the films are influenced by the temperature of the substrate, the distance from the target to the substrate and the sputtering pressure in those studies [3-5]. In this work, the composition of the target and the distance from the target to the substrates were kept fixed and the substrate temperature and the oxygen partial pressure were varied to study the effects of these parameters on the superconductivity of the as-grown BSCCO films.

The temperature dependence of $R(T)/R(280\text{K})$ for films prepared at four different temperatures 560°C (B-1), 570°C (B-2), 580°C (B-3), 590°C (B

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-4) is shown in figure 1. The best film (B-3) shows T_c (zero resistance) at about 85K. The superconducting properties of the as-grown films as indicated by the results are rather sensitive to the sputtering temperature.

Figure 2 shows the effects of the growth pressure on the resistive transition for samples

Figure. 1. The temperature dependence of $R(T)/R(280K)$ for films prepared at four different temperatures 560°C (B-1), 570°C (B-2), 580°C (B-3), 590°C (B-4).

Figure. 2. The effects of the growth pressure on the resistive transition in a mixture gas ratio 7:3 of Ar and O_2 at 100, 90 and 80 mTorr respectively.

Figure. 3. The influence of the pressure for BSCCO films prepared in a mixture ratio of Ar/ O_2 5:5, 7:3, and 100% O_2 .

Figure. 4. The typical x-ray diffraction pattern for most samples.

prepared at 570°C in a mixture gas of Ar and O_2 (7:3) at 100, 90 and 80 mTorr respectively. The sputtering pressure clearly affects the superconductivity of the as-grown BSCCO films.

Figure 3 shows the influence of the pressure for BSCCO films prepared in a mixture gas of Ar and O_2 (5:5, 7:3, and 100% O_2). Each curve in Figure 3 represents the best result within its own sputtering mixture gas. In Figure 4, a prominent 2212-phase with a preferred orientation with the crystal c-axis perpendicular to the substrate surface is shown by the x-ray diffraction measurements for most samples.

In conclusion, superconducting BSCCO-2212 phase films were in-situ grown in this present work by an off-axis rf magnetron sputtering method with a single target of $Bi_2Sr_2CaCu_2O_y$ composites. Under optimum sputtering conditions, the as-grown superconducting BSCCO films with zero resistance at 75 - 85 K could be reproduced.

References

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