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Formation and Superconducting Properties Of As Grown Bi-Ca-Sr-Cu-O Films By AC Sputtering

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Abstract. We have in situ grown Bi-Ca-Sr-Cu-O films by ac sputtering. The substrates were heated to 630 - 670°C during ac sputtering. The sputtering was first carried out in a mixture of Ar(70%) and O₂(30%) at a pressure of 0.2 mbar. Then the mixture of Ar(70%) and O₂(30%) was replaced by pure O₂ and the sputtering was kept for another one hour. Superconducting Bi₂CaSr₂Cu₂O_y(2122) films with zero resistance at 70-75 K can be reproduced. The critical fields of the as grown films parallel to c-axis and ab-plane has been measured. The estimated zero temperature coherence lengths are $\xi_c = 3.3$ Å and $\xi_{ab} = 36.1$ Å respectively for the (2122) phase.

Thin films of high-T_c superconductors in the system Bi-Ca-Sr-Cu-O have been prepared by different methods, for example, magnetron sputtering (Fu et al 1989), laser ablation (Fork et al 1988), and electron beam evaporation (Kuroda et al 1988) In this work we reports the in situ growth and superconducting properties of Bi-Ca-Sr-Cu-O films by ac sputtering.

Bi-Ca-Sr-Cu-O films were prepared by ac sputtering. Two targets with the same composition of Bi_{1.5}Pb_{0.5}Ca_{1.5}Sr_{1.75}Cu₂O_y were mounted in the ac sputtering system face to face with a distance of about 1.5 cm. The substrate was MgO(100) which was heated to about 650° during sputtering. The sputtering was first carried out in a mixture of Ar(70%) and O₂(30%) at a pressure of 0.2 mbar for about 8 hours. After that process the sputtering gas was replaced by pure O₂ and the sputtering was kept for another one hour. Finally the sample was cooled down to room temperature in about

Figure 1. Temperature dependence of resistance of the as grown film.

one hour. The extra sputtering process in pure O_2 was found to be successful in preparing Bi-Ca-Sr-Cu-O films. Films grown this way are shiny and smooth. Films with zero resistance at 70 - 78 K can be reproduced. Typical thickness of the films was about 0.5-1.5 μm .

Figure 1 shows typically the temperature dependence of resistance of the as grown film. The film was in situ grown at 655 $^{\circ}C$. The film shows an onset at 110 K and zero resistance at 78 K. The X-ray diffraction shown in Figure 2 indicates that the film is highly oriented with c-axis normal to (100) plane of the MgO substrate. The diffraction peaks can be identified with low T_C $Bi_2CaSr_2Cu_2O_y(2122)$ phase with $c = 3.05$ nm indicating that the film is mainly the (2-1-2-2) phase.

In preparing high T_C Bi-Ca-Sr-Cu-O films we have employed an extra pure O_2 sputtering process and found that this extra process is very useful in preparing the superconducting film. This has been demonstrated in Figure 3 for samples b and c. Samples b and c were in situ grown at 630 $^{\circ}C$. However, sample b was not subjected to an extra sputtering process in pure O_2 whereas sample c did. One can see that sample c shows a better superconducting property compared with that of sample b. The data indicate that this extra sputtering process in pure O_2 plasma does help the incorporation of O_2 into the sample, therefore it results in improving the superconductivity of sample c.

We have measured the resistance as a function of temperature in magnetic fields parallel to c-axis and ab-plane respectively. The current to the sample was 1 mA. The resistance was measured by a four probe method. The critical fields estimated from 50% resistive transition show a linear temperature de-

Figure 2. Powder X-ray diffraction pattern of the as grown film.

Figure 3. Temperature dependence of resistance for samples b and c. Sample c was subjected to an extra sputtering process in pure O_2 while sample b did not.

pendence as shown in Figure 4. From the linear temperature dependence of the critical fields we obtain $dH_{C2,ab}/dT = -6.7$ T/K and $dH_{C2,c}/dT = -0.61$ T/K in fields parallel to ab-plane and c-axis respectively. The anisotropic factor,

$(dH_{C2,ab}/dT)/(dH_{C2,c}/dT)$, is 10.9 for the (2122) phase. We note that $dH_{C2,c}/dT$ is close to single crystal data (Iye Y et al 1988) of $YBa_2Cu_3O_{7-y}$. However, the value of $dH_{C2,ab}/dT$ obtained in this work is 1.5 - 2.0 times larger than that of $YBa_2Cu_3O_{7-y}$ single crystal data which are in the range of -3.0 T/K to -4.0 T/K. The zero temperature coherence lengths are $\xi_{ab} = 36.0$ Å and $\xi_c = 3.3$ Å. In calculating zero temperature coherence lengths, we have used the relations $\xi_c(0)/\xi_{ab}(0) = H_{C2,c}/H_{C2,ab}$ and $\xi_{ab}^2 = \phi_0/2\pi H_{C2,c}$, where ϕ_0 is the flux quantum. The zero temperature critical fields were obtained from (Werthamer et al 1966) $H_{C2}(0) = 0.69T_C(dH_{C2}/dT)T_C$.

Figure 4. Critical fields as a function of temperature obtained from 50% resistive transition for fields parallel to ab-plane and c-axis respectively.

In conclusion we have in-situ grown Bi-Ca-Sr-Cu-O films by ac sputtering with an extra sputtering process in pure O_2 . This extra sputtering process in O_2 helps the corporation of oxygen into the film. Superconducting films with zero resistance at 70-78 K can be reproduced for the (2122) phase. The estimated zero temperature coherence lengths are $\xi_c = 3.3$ Å and $\xi_{ab} = 36.0$ Å for the (2122) phase.

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References

- Fu S.M. et al. 1989 Physica **C162-164**, 619
- Fork D K, Boyce J B, Ponce F A, Johnson R I, Anderson G B, Connell G A N, Eom B and Geballe T H 1988 Appl. Phys. Lett. **53** 337
- Kuroda K, Mukaida M, Yamamoto M and Miyazawa S 1988 Jpn. J. Appl. Phys. **27** L625
- Iye Y et al. 1988 In superconducting materials ed Nakajima S and Fukujama H (JJAP Series 1) PP46-8
- Werthamer N. R. et al. 1966 Phys. Rev. **147** 295