Fabrication of High Tc Superconducting Films by CVD Process

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YBaCuO thick films were fabricated by plasma enhanced chemical vapor deposition, and the crystallinity and the superconducting properties were investigated. The growth temperature to obtain the thick films was decreased by around 150 °C due to plasma enhancement. The zero resistivity temperatures for films grown at 590 °C and 620 °C were 55 and 80 K, respectively.

Keywords : YBaCuO, Chemical vapor deposition, Thick films, $SrTiO_3$

1. INTRODUCTION

Chemical vapor deposition (CVD) is thought to be one of the most desirable methods for preparing superconducting thick films. However, high growth temperatures of over 750 °C[1] have been required to grow superconducting YBaCuO thick films. Thus, a concerted effort has been made to decrease the growth temperature to enable CVD to be applied to electronic processes, because a reaction between the superconductor and the substrate proceeds at such a high temperature[2]. In this paper, we discuss the fabrication of YBaCuO thick films by using CVD, their crystallinity, and their superconducting properties.

2. EXPERIMENTAL PROCEDURE

A magneto microwave plasma type apparatus was used for growing the superconducting thick films. The frequency of the microwave, which was generated by a magnetron, was 2.45 GHz. The tetramethylheptadione complexes of Y, Ba and Cu were employed as metal sources. They were sublimated and transferred to the growth chamber with Ar carrier gas. Oxygen gas was an oxidant. $SrTiO_3$ (100) single crystals polished with phosphonic acid at 90 °C were used as substrates. The substrate size was 10 mm × 5 mm. The typical growth conditions were as follows: the sublimation temperatures and the Ar flow rates for the Y, Ba, and Cu complexes were 100 °C and 25 cm^3/min, 250 °C and 25cm^3/min, and 120 °C and 25 cm^3/min, respectively. The O_2 flow rate was 10~50 cm^3/min and the deposition pressure was 0.4 Torr. The crystallinity was investigated by X-ray diffraction (XRD). The chemical composition of the films was determined by inductively coupled plasma (ICP) spectroscopy. The electrical properties were determined by the conventional four probe method.

3. RESULTS AND DISCUSSION

The effect of the plasma enhancement on the composition of the prepared thick films is shown in Fig. 1. The preparation temperature was 550 °C. The (Y+Ba)/Cu ratio decreased with increasing microwave power. These composition changes reflect a difference in the stability of organometalic compounds against plasmas.

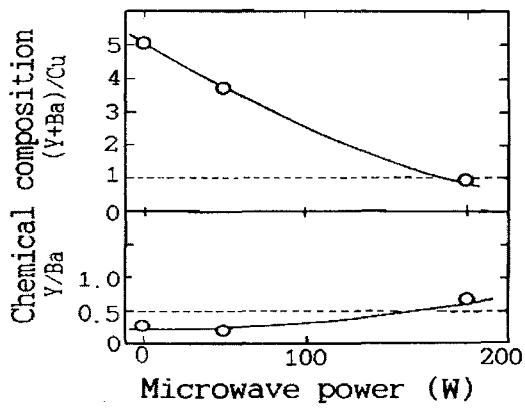

Fig. 1. The composition ratios plasma enhanced superconducting thick films, as measured by ICP spectroscopy.

The X-ray diffraction patterns of films grown under different plasma conditions are shown in Fig. 2. Not all the diffraction peaks detected for the film grown without plasma enhancement could be assigned to $Y_1Ba_2Cu_3O_{7-X}$

The film grown at a microwave power of 100 W indicated weak $Y_1Ba_2Cu_3O_{7-X}$ peaks in addition to the peaks detected for the film grown without plasma enhancement. All the diffraction peaks detected for the film grown at 200 W could be assigned to $Y_1Ba_2Cu_3O_{7-X}$. These results indicate that plasma enhancement promotes the formation of the $Y_1Ba_2Cu_3O_{7-X}$ structure.

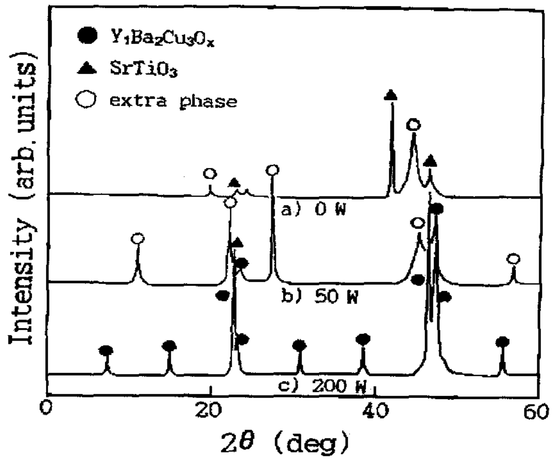

Fig. 2. The X-ray diffraction patterns for thick films grown by plasma enhanced CVD.

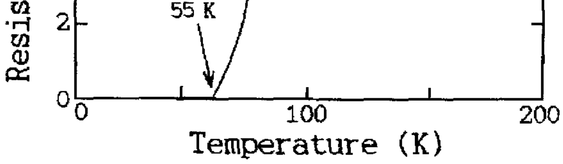

Fig. 3. The temperature dependence of the electrical resistivity for the film grown by plasma enhanced CVD at 550 °C and a microwave power of 200 W.

The electrical resistance of the films grown at room temperature with microwave powers of 0W, 50 W, and 200 W were 10^6 Ω , 4×10^3 Ω and 2.5×10^3 Ω , respectively. The temperature dependence of the resistivity for the film grown at a microwave power of 200 W is shown Fig. 3. This thick film showed a super conducting transition in which the Tc onset and the Tc offset were 80 K and 50 K, respectively. These results indicate that the plasma enabled the superconducting oxide film to grow at a low temperature. The temperature dependence of the resistivities for the films grown at 620 °C and under microwave powers of 100W showed zero resistivity at 30 and 80K, respectively. The critical current density at 77 K was found to be 10^5 A/cm^2.

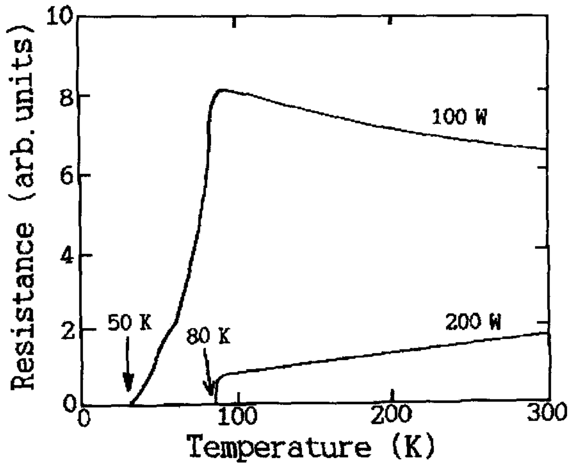

Fig. 4. The temperature dependences of the electrical resistivities for the films grown by plasma enhanced CVD at 620 °C and microwave powers of 100 W and 200 W.

4. CONCLUSION

The effects of plasma enhancement on $Y_1Ba_2Cu_3O_{7-X}$ thick films grown by CVD were investigated. It was revealed that plasma enhancement could decrease the growth temperature for obtaining superconducting oxide films. By plasma enhancement, superconducting films could be grown above 590 °C. A film grown by plasma enhancement at 620 °C had a zero resistivity temperature of 80 K and a critical current density of 10^5 A/cm^2 at 77 K.

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