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PREPARATION OF Y-Ba-Cu-O SUPERCONDUCTING FILMS ON $SrTiO_3$ AND MgO SUBSTRATES BY CHEMICAL VAPOR DEPOSITION

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Abstract YBaCuO superconducting films were prepared at 850°C on $SrTiO_3$(100) and MgO(100) by chemical vapor deposition using β-diketone metal chelates. The films deposited on $SrTiO_3$(100) showed Tc of 87-92 K and Jc above 10^5 A/cm^2 at 77.3 K and 0 T. Tc and Jc of the films on MgO(100) were 80-89 K and below 10^4 A/cm^2 at 77.3 K and 0 T, respectively.

INTRODUCTION

Y-Ba-Cu-O(YBaCuO) superconducting films have already been prepared using various techniques in order to investigate their physical properties and their usability for applications[1-3]. $SrTiO_3$ and MgO single crystals are widely used as substrate materials for YBaCuO films. Critical current densities(Jc) higher than 10^5 A/cm^2 at 77.3 K and 0 T have already been reported for films prepared by chemical vapor deposition(CVD) on $SrTiO_3$(100) substrates. Critical current densities in the range of 10^4 A/cm^2 at 77.3 K and magnetic fields up to 27 T were also measured for CVD-YBaCuO films[4,5]. However, the Jc of the CVD-YBaCuO films on MgO has not yet been reported. This paper is concerned with the structure and superconducting properties of CVD-YBaCuO films prepared on $SrTiO_3$(100) and MgO(100).

EXPERIMENTAL

The β-diketonates used as source materials were $Y(thd)_3$, $Ba(thd)_2$ and $Cu(thd)_2$ (where (thd) represents 2,2,6,6-tetramethyl-3,5-

heptanedionato). The evaporation temperatures of the source materials were in the range of 115-255°C. Each evaporated source was introduced with Ar gas (total 450 ml/min) into a hot-wall CVD reactor. Oxygen gas(250 ml/min) was separately introduced into the reactor. Total gas pressure was maintained at 10 Torr during the deposition. Deposition temperature and time were 850°C and 1 h, respectively.

After deposition, the films were cooled down from 850°C to room temperature at a rate of 15°C/min under 1 atm of oxygen(in-situ oxygen treatment). Substrates used were $SrTiO_3$(100) and MgO(100) single crystals(5x10x1 mm^3).

X-ray diffraction (XRD) patterns of the deposited films were obtained by the standard 2θ-θ method. The resistivity and the critical current of the films were measured by a DC four-probe method with Au electrodes sputtered on the film. Analysis of the film composition was carried out by Auger electron spectroscopy(AES).

RESULTS AND DISCUSSION

The XRD patterns of CVD-YBaCuO films on $SrTiO_3$(100) and MgO(100) are shown in Figure 1(a) and (b). Observed high relative intensities of (00l) peaks indicate that the c-axis is oriented perpendicular to the substrate.

Table I summarizes the c-axis lengths calculated from the (007) peak position, integral widths (PIW) of the (007) peak, and integral widths of the rocking curve (RIW) for the (007) peak. The c-axis length of the film on $SrTiO_3$(100) was smaller than that of the film on MgO(100). However, the integral widths of the films on $SrTiO_3$(100) and MgO(100) were almost the same. The crystallite size evaluated from the integral width was above 2000 Å. The film on MgO(100) has a larger integral width of the rocking curve compared to the film on $SrTiO_3$(100). This indicates that the degree of the c-axis orientation of the film on MgO(100) is lower than that for the film on $SrTiO_3$(100). The reason for this behavior may be ascribed to the large lattice mismatch

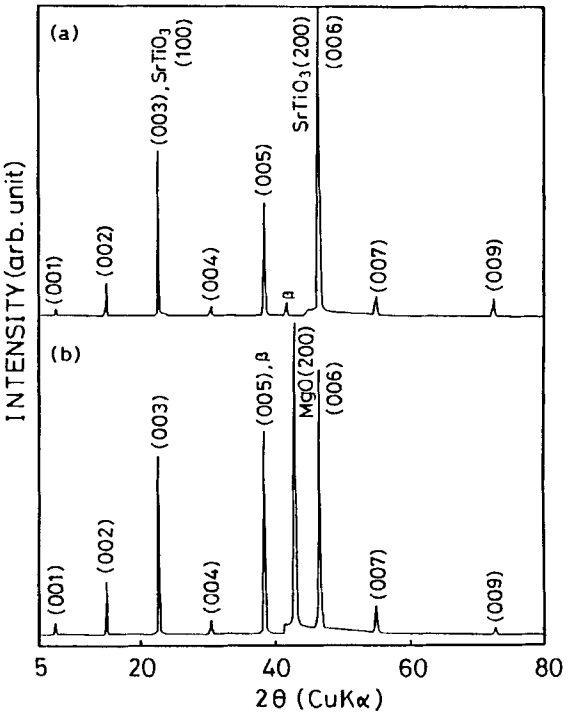

FIGURE 1 X-ray diffraction patterns of CVD-YBaCuO films on $SrTiO_3$(100) and MgO(100).

TABLE I XRD data of YBaCuO films

	$SrTiO_3$(100)	MgO(100)
c_o (Å)	11.683	11.693
PIW(007) (2θ)	0.23°	0.24°
RIW(007) (θ)	0.46°	0.66°

PIW: integral width of a peak

RIW: integral width of a rocking curve

between $YBa_2Cu_3O_y$ and MgO(8-10%) compared to the mismatch between $YBa_2Cu_3O_y$ and $SrTiO_3$(2%). Another reason may be due to differences in the single crystal perfection of the substrates.

The temperature dependence of the resistivity of the films on

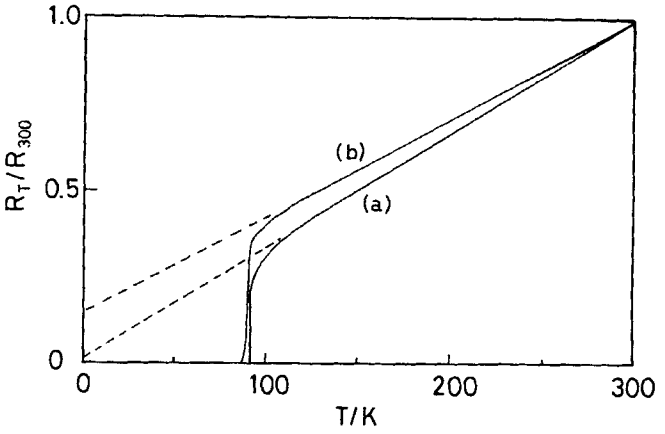

FIGURE 2 Normalized resistivity versus temperature of CVD-YBaCuO films on $SrTiO_3$(100)(a) and MgO(100)(b).

$SrTiO_3$(100) and MgO(100) is shown in Figure 2. The resistivity of both samples decreases linearly with decreasing temperature, but the transition width of the film on $SrTiO_3$ was smaller compared to the YBaCuO film on MgO. Superconducting transition temperature Tc (resistivity zero: R=0) of the films on $SrTiO_3$(100) and MgO (100) are at 92 K and 86 K, respectively.

Tc(R=0) of the films prepared on MgO(100) was lower than that of the films on $SrTiO_3$(100) and did not exceed 90 K. Komatsu et al.[6] and Yan et al.[7] reported that impurities of Sr, Ti and Mg had decreased the Tc of $YBa_2Cu_3O_{7-x}$ and shortened the c-axis length. However, we could not detect these impurities in the films by AES analysis. Moreover, the CVD-YBaCuO film on MgO(100) with lower Tc(R=0) had a larger c-axis length than the films on $SrTiO_3$(100).

It is well-known that the oxygen deficiency of $YBa_2Cu_3O_y$ reduces Tc and expands c-axis length[8]. The Tc and c-axis length in the present study agree with the reported values. The oxygen content in the films on MgO(100) might be lower than that in the films on $SrTiO_3$(100), although the films on both substrates received the same in-situ oxygen treatment after deposition. We suppose that this might be caused by the difference in the degree of c-axis orientation or in the discrepancies of the thermal expansion coefficient between the film and substrate.

The highest Jc value measured at 77 K and 0 T among the films on $SrTiO_3(100)$ and MgO(100) were $2.0x10^6$ and $8.0x10^3$ A/cm^2, respectively. It was reported that the misorientation of the $YBa_2Cu_3O_y$ grains depressed the values of Jc[9]. The low Jc of the films on MgO(100) may be related to the deviation of c-axis orientation.

To summarize, YBaCuO superconducting films were prepared by CVD. Tc and Jc of the films on $SrTiO_3(100)$ were superior to those on MgO(100). The films on $SrTiO_3(100)$ had Tc(R=0) of 87-92 K and Jc of 10^{5-6} A/cm^2 at 77.3 K and 0 T.

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