Preparation and Its Properties of YBCO Superconductor Induced by Seeds

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Abstract

The $SmBa_2Cu_3O_x$ single crystals were used as seeds to induced YBCO growth in MTG process. As the result, the large bulk oriented YBCO superconductors were prepared with dimension of plane 21mm and 32mm in diameter and 10mm in height. The typical J_c value of the sample is $6.5\times 10^4 A/cm^2$ and its flux float force is $4.6N/cm^2$. The oxygen absorption in large bulk textured YBCO samples in pure oxygen was studied at several constant temperatures. It can be divided into two steps: a chemical reaction step and a diffusion step.

1. Introduction

In order to improve the critical current density of YBCO superconductor, it is necessary to produce highly textured micro structures. Various processes such as melt textured growth(MTG)[1], quench melt growth(QMT)[2], powder melt process (PMP)[3] and zone melting[4] have been proposed. Using above processes, the critical current density of small YBCO sample has achieved request of practical application. For the application of YBCO material on superconductive axle and magnetic floating system, it is necessary to prepare the large bulk YBCO sample with high critical current density.

2. Experimental

The sample of $YBa_2Cu_3O_x$ matrix for MTG process mixed with 15wt% Y_2BaCuO_5(211) phase. After MTG process, The Textured YBCO samplecontained about 20wt% 211 phase which the optimal value as the flux pinning center. Under 30~40MPa pressure, the precursor sample with dimension of plane 25mm and 38mm in diameter and 12mm in height were made for MTG process. The MTG process was as following: heated the sample from room temperature to 1100℃ in 90 minutes, stabilized temperature at 1100℃ for 1 hour ; reduced the temperature to 1040℃, placed $SmBa_2Cu_3O_x$ single crystal on the surface of YBCO sample and reduced the temperature to 1020℃ in 30 minutes; reduced the temperature to 990℃ at the rate of 1~2℃ per hour; reduced the temperature to room temperature in 3~5 hours. In order to study the oxygen absorption process in large bulk textured YBCO, the sample in pure oxygen was heated at several constant temperatures. The structure and the superconductivity were studied.

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3. Result and Discussion

In the MTG process, $SmBa_2Cu_3O_x$ seeds were used to induce the growth of YBCO crystal. The large bulk oriented YBCO samples were prepared with dimension of plane 21mm and 32mm in diameter and 10mm in height. They are highly textured which was proved by X-ray

diffraction(see figure 1).

They grew in accord with the orientation

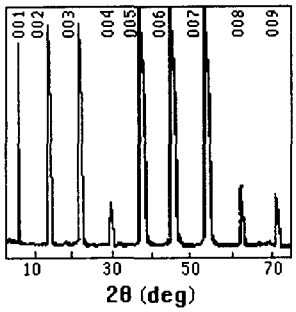

Figure 1. X-ray diffraction pattern of large bulk YBCO sample.

of $SmBa_2Cu_3O_x$ seed. The growth plane was ab plane that was in accord with horizontal plane. The about $10\times5\times2mm^3$ sample cut from large bulk YBCO were annealed under 1atm oxygen flow at 400℃ for 24 hours. The magnetic hysteresis loops of the samples were measured by a vibrating sample magnetometer. From measurements of the magnetization Vs applied field and using Bean critical state model, critical current density was determined. The results are shown in fig. 2.

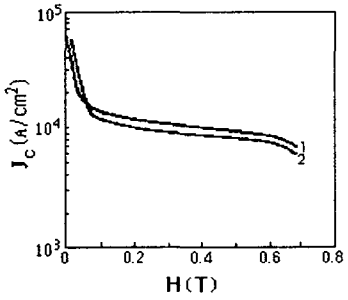

Figure 2. The relation of critical current density of oriented YBCO and magnetic field.

The typical J_c value is $6.5\times10^4A/cm^2$ (0.01T, 77K). The flux float force of the large bulk YBCO sample also was measured and its value is $4.6N/cm^2$.

It is well known that oxygen plays an important role in the superconductivity of YBCO. The oxygen absorption process in same large bulk YBCO sample was studied by thermogravimetry method at several constant temperatures. The one in textured YBCO samples with different volume also were studied. The experimental results are shown in figure 3 and figure 4. From the figures, it can be seen that the best temperature.

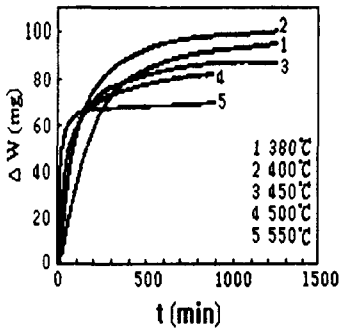

Figure 3. Weight change Vs heating time of textured YBCO sample at different temperature under pure oxygen, W_0=9.7603g.

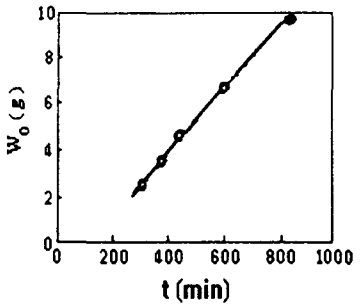

Figure 4. The relation of the time for oxygen absorbed to saturation and the primitive weight of textured YBCO samples at 400℃.

is 400℃ for oxygen absorption and the time needed for the absorbed to saturation is direct proportional to the volume of sample. The reaction fraction α_t of oxygen absorption at

constant temperature can be expressed by $\alpha_t = \Delta W_t / \Delta W_\infty$, where ΔW_t is the weight change of sample at time t, ΔW_∞ is the weight change of sample when it is saturated with oxygen. The whole oxygen absorption process at constant temperature can be divided into two steps : a chemical reaction controlled step which fits the formulation of the nucleus shrinkage model with cylindrical symmetry

$$F_C(\alpha_t) = 1 - (1 - \alpha_t)^{1/2} = k_C t \qquad (1)$$

and a diffusion controlled step which fits the formulation

$$F_D(\alpha_t) = (1 - \alpha_t)\ln(1 - \alpha_t) + \alpha_t = k_D t \qquad (2)$$

where k_C is the rate constant of the chemical reaction step, k_D is the rate constant of the diffusion step and t is the reaction time. When the oxygen absorption in textured YBCO sample occurred in pure oxygen, the relation of α_t and t for the chemical reaction step fitted model(1), as shown in figure 5 and for the diffusion controlled step fitted model(2) as shown in figure 6.

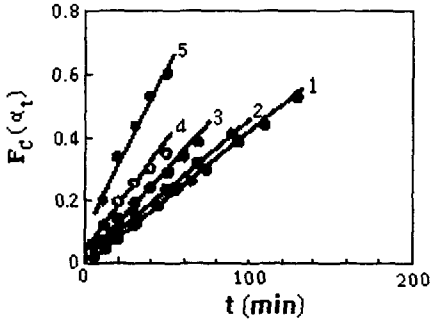

Figure 5. Kinetic function $F_C(\alpha_t)$ Vs time in the chemical reaction controlled step.

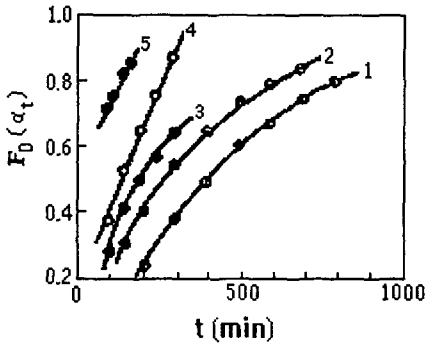

Figure 6. Kinetic function $F_D(\alpha_t)$ Vs reaction time in the diffusion controlled step.

4 Conclusions

Using the $SmBa_2Cu_3O_x$ seed to induce the growth of YBCO crystal, the large bulk oriented YBCO superconductor were prepared by MTG process which grew in accord with orientation of the seed. The growth plane was ab plane and in accord with horizontal plane. The typical J_c value is $6.5\times10^4 A/cm^2$ and the flux float force is $4.6N/cm^2$. The best temperature is 400℃ for oxygen absorption and the time needed for the absorbed to saturation is direct proportional to the volume of YBCO sample.

References

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