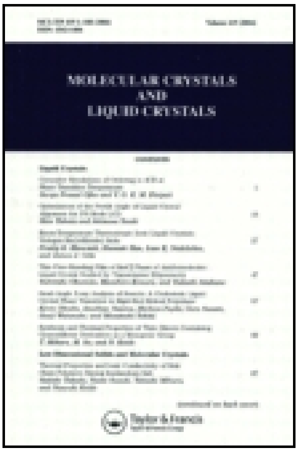

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Effects of Grain Size Distribution on Critical Transport Current Density in $HoBa_2Cu_3O_7$

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EFFECTS OF GRAIN SIZE DISTRIBUTION ON CRITICAL TRANSPORT CURRENT DENSITY IN $HoBa_2Cu_3O_7$

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Abstract The measurements of the critical transport current density of the ceramics $HoBa_2Cu_3O_7$ were made by the resistivity method. The relation between the critical transport current densities and the distribution of the grain size has been studied over the verious samples of $HoBa_2Cu_3O_7$ which prepared under the different sintering time at 1230K. Similar temperature dependences of the critical transport current densities were obversed for all the samples near T_c, and thus a similar Josephson junction was suggested to be in the bulk caused by their grain boundaries. It is believed that the distribution of the grain size is an important parameter for transportation in this case. Thus, the sintering time at 1230K for preparation of $HoBa_2Cu_3O_7$ affects the grain growth rather than the state of the grain boundaries.

INTRODUCTION

Enhancement of the critical current density attracts much interest from the viewpoint not only of practical application but also of the investigation of the oxide superconducting mechanism. Many efforts have been made for the preparation of high-J_c YBCO materials, for example, for the thin film, tape, fiber, sintered ceramic material and so on. In this study, the conventionally sintered ceramic samples will be discussed. It is generally acceptable that the different sintering processes produce the ceramics of the different particle size distribution, different densities and different grain boundaries which influence the critical transport current densities. From the results of the temperature dependences of the critical transport current densities and of the distribution of the grain size for a series of the ceramic samples of $HoBa_2Cu_3O_7$, we can furtherly discuss the relation between grain boundaries, grain size and sintering condition.

EXPERIMENTAL

To study the effect of the grain size distribution on the critical transport current densities, various samples of $HoBa_2Cu_3O_{7-y}$ compound were made by solid state reaction. High purity reactants, $BaCO_3$, Ho_2O_3 and CuO (99.99, 99.9 and 99.99% purity, respectively, from Rare Metallic Co.,Ltd. Japan) were mixed in stoichiometric proportions and ground with an agate mortar and a pestle. The mixture was heated at 1170K for 12h, the grinding and the heating steps were performed twice. These materials were pressed into pellets, three of them were sintered in flowing oxygen at a temperature of 1230K for 12, 24 and 50 hours, and namely sample A, B and C, respectively, and then cooled slowly to room temperature. The samples were identified by powder X-ray diffraction with Cu $K\alpha$ radiation. The oxygen contents of the samples were determined by iodometric titration as $HoBa_2Cu_3O_{6.96}$, $HoBa_2Cu_3O_{6.97}$, and $HoBa_2Cu_3O_{6.96}$, respectively. Therefore, the oxygen contents of them can be considered to be no difference in this paper. The critical transport current densities, the electrical resistivities and the AC magnetic susceptibilities which respectively employed resistivity method, dc four-probe method and the Hartshorn bridge method, were measured over the range 20~300K by using the apparatus manufactured by Chino Co.,Ltd., Japan. For the critical transport current density measurements as well as the electrical resistivity measurements, the samples were cut and shaped into $0.05\times 0.35\times 1.20cm^3$ tetragonal prisms. Gold (Au) was evaporated onto the regions where the probes touched. To form a good contact with the thick copper lead wires, a kind of solder, SERASOUZA 123 (prepared by ASAHI GLASS Co.,Ltd., Japan) was used and soldered between the samples and the copper lead wires by Ultrasonic Soldering Mate (made by ASAHI GLASS Co.,Ltd., Japan). The contact resistance was estimated to be less than 10mΩ. The microstructures were observed by using JSM-T300 SCANNING MICROSCOPE (manufactured by JEOL Co.,Ltd., Japan).

RESULTS AND DISSION

The X-ray powder diffraction patterns of the three samples were analyzed. All patterns can be indexed as a single phase with orthorhombic structure. The differences of the lattice constants between the every samples are in the range of $\triangle a=\pm 0.01A$, $\triangle b=\pm 0.015A$ and $\triangle c=\pm 0.005A$ in which the differences are negligibly small. Comparing the sample A with the sample B, the latter seemed to be strongly oriented along the [0,0,n] directions. However, for the sample B and C, the degree of the orientation of the [0,0,n] directions was almost the same. The measurement of the electrical resistivity was carried out , and the results showed that the onset temperatures of the superconducting phase transition were exactly the same.

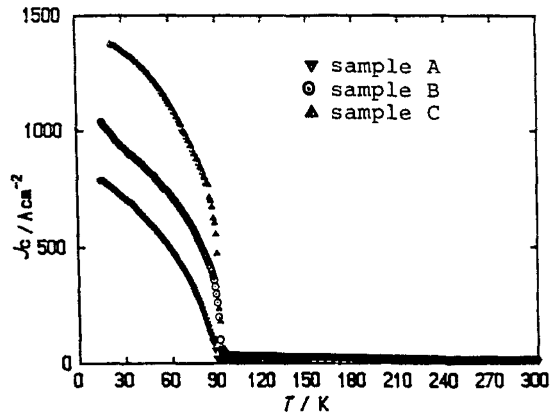

FIGURE 1 Temperature dependence of J_c

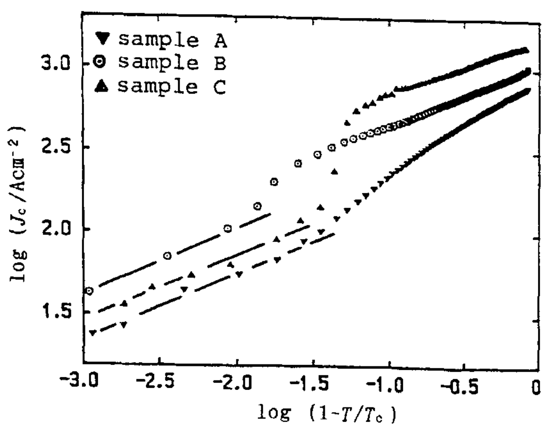

FIGURE 2 Logarithmic plots of J_c vs 1-T/T_c

Figure 1 showed the temperature dependences of the critical transport currents of the three samples A, B and C. As shown in Fig.1, it is clearly seen that the values of the critical transport current below T_c are quite different, as about 250, 550 and 900 A/cm^2, respectively, at 77K. It implies that there exist different grain boundaries, grain size distribution and/or densities and so on. In order to clarify the relation between the temperature dependences of the critical transport currents and the grain-grain boundaries, the logarithms of the critical transport current (J_c) and the conversion temperature(1-T/T_c) is taken as shown in Fig.2. The temperature dependences of the critical transport currents for the different samples indicate that, near T_c, their slope powers of log J_c against log (1-T/T_c) are estimated to be the same, about 3/2. According to some papers[1,2], it is suggested that there exist the similar Josphson junction at the grain boundaries of the bulk sample because of the similar temperature dependences of the critical transport currents. In our case , the 3/2 power slope of the log J_c against log $(1-T/T_c)$ implies that there exist superconductor-insulator-normal-superconductor (SINS) junction[3]. For temperature much lower than T_c, the abnormal change of the slope can be considered to be the delicate balance between the coupling strength of the superconducting grains and the Josphson current. It is reasonable that the values of the critical transport current for the different sintering samples mainly depend on the grain size distribution and/or on the densities of the samples rather than on the grain boundaries in the case of the similar temperature dependences of the critical currents.

Further information can be obtained from the temperature dependences of the AC magnetic susceptibility of the powdered samples (Fig.3). The change of the real part of the magnetic susceptibilities (χ') of the samples become sharper with increasing in the sintering time at 1230K. The differences which not caused by the grain boundaries can be judged from the measurement of the AC magnetic susceptibility of the powdered samples. Here, the distribution of the grain size for the sintering samples has been tried to be checked. The grain size was counted and measured by the observation of the scanning electron micrograph over the fracture surfaces and the polished surfaces of the bulk samples. The results are shown in Fig. 4. Only two dimensions was considered here, and a average of the length and width of the grain was taken as a averaged grain size. It is seemed that the averaged grain size increasing with sintering time agree with the result of the phenomenology for the ceramic sintering. The relation between the

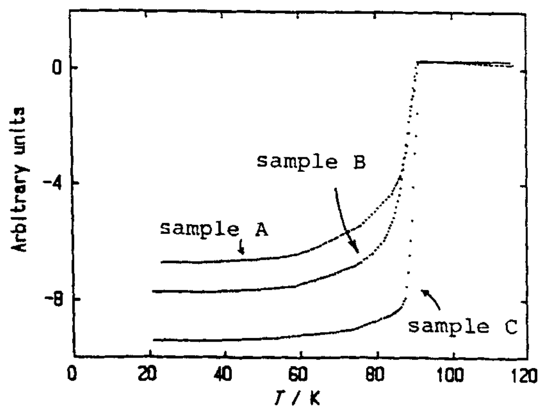

FIGURE 3 AC magnetic susceptibilities

averaged grain size distribution and the value of the critical current will be studied to be continued.

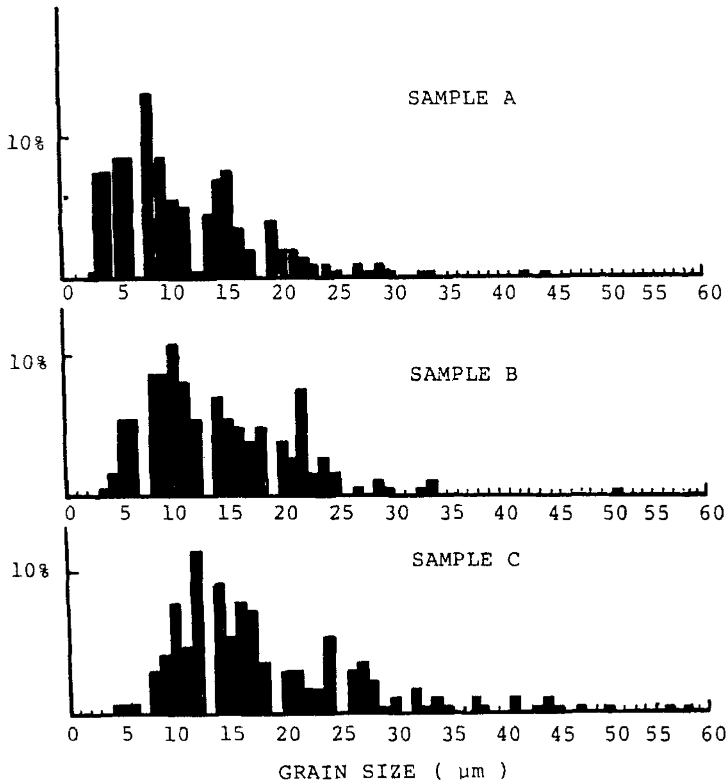

FIGURE 4 The averaged grain size ditribution of the sample A, B, C.

REFERENCES

1. P.G.De Gennes, Rev. Mod. Phys. Jan.,225 (1964).
2. S.Nagata and H.C.Yang, Physica, B 108, 997 (1981).
3. Q.Z.Zhang, Y.Takagi, T.Atake and Y.Saito,(to be published).