§8. Fabrication of HTS Low Porosity Bulks in Air and Evaluations of the Fracture Strength Properties

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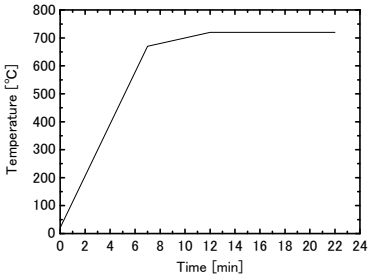
Improvements of fracture strength of melt-processed $REBa_2Cu_3O_x$ (RE123, where RE denotes rare-earth elements) single-grain bulks are crucial for the development of RE123 superconducting current leads used for magnetically confined fusion reactors. Conventional RE123 bulks have pores which cause degradation of fracture strength. Such conventional bulks are fabricated from precursors, which are prepared by cold isostatic pressing. It is deduced that pores are formed in the precursors during unloading process after the cold isostatic pressing and such pores remain in the bulks. In the present study, we try to fabricate RE123 low porosity bulks.

Our precursors were sintered with loading by using spark plasma sintering (SPS) equipment. Figs. 1 show schematic illustrations of SPS process and melt-process subsequent to it. SPS temperature and pressure were 650-750 ℃ and 50 MPa, respectively. Precursors prepared through the SPS process were heated in air up to 1150 ℃, kept at that temperature for 1 h and then cooled down to 1040℃. After that, one Nd123 seed crystal was placed on the top of them and they were gradually cooled down. Diameters of these melt-processed bulks are about 20 mm.

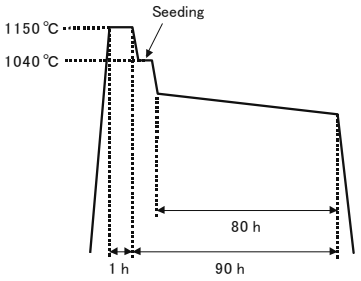
Fig. 2 shows appearances of melt-processed Dy123 bulks, which were fabricated from precursors prepared through the SPS process. SPS temperature and pressure for the left bulk were 650 ℃ and 50 MPa, respectively and those for the right bulk were 700 ℃ and 50 MPa, respectively. These bulks are denoted as Sample 650 and Sample 700, respectively. Since growth sector boundaries are observed, both bulks are regarded as single-grain bulks. One macro-crack is observed for the Sample 650 as marked by an arrow. It is deduced that SPS process for the sample 650 was not successfully completed.

Figs. 3 show trapped magnetic field profiles of both the samples. The magnetic field of the Sample 700 was similar to those of conventional bulks. Due to the macro-crack, the magnetic field of the Sample 650 has a disorder.

Polished surfaces of these bulks were observed by using an optical microscope. Although pores were observed for these bulks, porosities of these bulks were lower than those of conventional bulks. Further investigations are needed to determine optimum conditions of the SPS process for the fabrication of RE123 bulks which have few pores.



(a)



(b)

Fig. 1. Schematic illustrations of (a) SPS process and (b) melt-process.

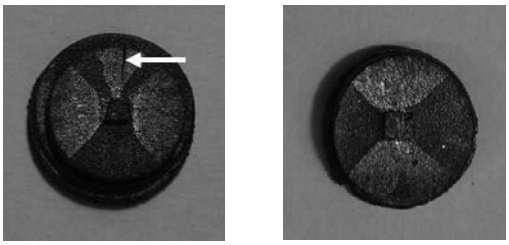
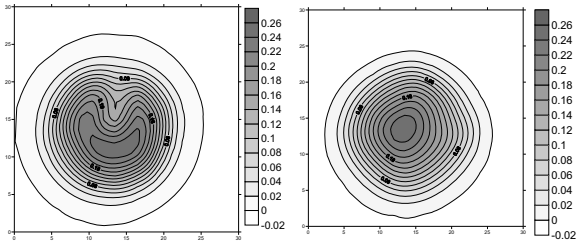


Fig. 2. Dy123 bulks fabricated from precursors prepared through SPS process. SPS temperature and pressure for the left bulk (Sample 650) were 650 ℃ and 50 MPa and those for the right bulk (Sample 700) were 700 ℃ and 50 MPa.



(a) (b)

Fig. 3. Trapped magnetic field profiles of Dy123 bulks, (a) Sample 650 and (b) Sample 700.