§22. Study on Mechanical Properties of Large Single-grain Superconducting Bulks Fabricated by RE Compositional Gradient Technique

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Increase of the size of RE-Ba-Cu-O (RE: Y or rare-earth elements) superconducting bulk materials is required for the development of high performance devices equipped with the superconducting bulk. Since a RE-Ba-Cu-O bulk is single-grain fabricated by melt-processing using a seed crystal, it is difficult to obtain large bulk pieces due to the undesirable nucleation at the position away from the seed crystal. Recently, a RE-Ba-Cu-O super-large single-grain bulk of 150 mm in diameter has been successfully produced. In order to overcome the problem about the undesirable nucleation, a new process based on the difference in the peritectic decomposition temperature of RE-Ba-Cu-O was employed in the basic melt-growth processing. Since superconducting bulk materials are subjected to electro-magnetic force and thermal stress in the superconducting devices, understanding of the mechanical properties of the superconducting bulks is important. In this study, we evaluated the fracture strength and fracture toughness of the RE-Ba-Cu-O super-large single-grain superconducting bulk at 77 K.

The (Gd,Dy)-Ba-Cu-O super-large single-grain bulk of 150 mm in diameter was used for the sample. Dy content in the bulk sample increases with increase of the distance from the seed crystal. Decrease of the peritectic decomposition temperature with increase of the Dy content suppresses the undesirable nucleation during the melt-processing. Specimens were cut from the bulk sample. Evaluations of the fracture strength and the fracture toughness were carried out through 4-point bending tests of plain specimens and V-notched specimens, respectively. The specimen was immersed into the liquid nitrogen bath, together with the bending test jig.

Fig. 1 shows the fracture strength at 77 K and room temperature of the plain specimens cut from the super-large bulk sample. Specimens A were cut from the bulk sample such that they did not contain the RE compositional boundaries between two regions with different Dy content. Specimens B contained the boundaries. Data points with asterisk were obtained from the specimens cut from the region near the top surface of the bulk sample. Since the porosity near the surface is extraordinarily low, the fracture strength of that region is high. The average values shown in Fig. 1 are obtained excluding the data points with asterisk. There is no significant difference in the average fracture strength value between Specimens A and B. The fracture strength at 77 K is higher than that at room temperature due to the reduction of inter-atomic distance by cooling.

Fig. 2 shows the fracture toughness at 77 K evaluated through the bending tests of the V-notched specimens. The average values of the fracture toughness of Specimens A and Specimens B are also similar to each other. Both the fracture strength and the fracture toughness of the super-large single-grain bulk sample are comparable to those of smaller Gd-Ba-Cu-O and Dy-Ba-Cu-O bulks with 30-46 mm in diameter reported elsewhere.

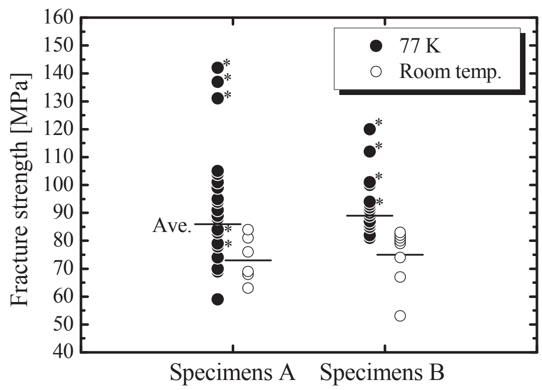

Fig. 1. Fracture strength at 77 K and room temperature evaluated through bending tests of plain specimens cut from (Gd,Dy)-Ba-Cu-O super-large single-grain bulk 150 mm in diameter. Specimens A were cut from the bulk sample such that they did not contain the RE compositional boundaries between two regions with different Dy content. Specimens B contained the boundaries.

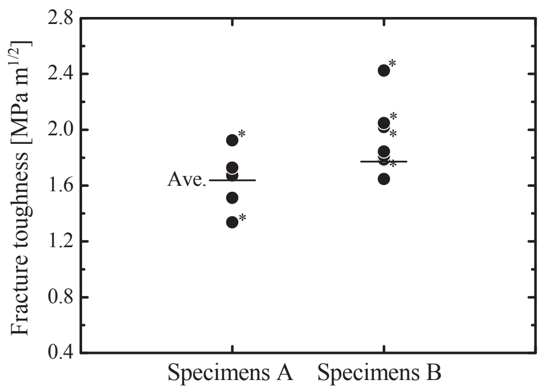

Fig. 2. Fracture toughness at 77 K evaluated through bending tests of V-notched specimens.