## §5. Study on Improvement of the Mechanical Properties of HTS Bulks by Reducing Pores

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Improvements of mechanical properties of $RBa_2Cu_3O_x$ (R123, where R is rare-earth elements) bulks are indispensable for practical application of the bulks such as current lead for magnetically confined fusion reactors. Conventional R123 bulks fabricated in air or under low $O_2$ pressure have pores which cause degradation of the mechanical properties. On the other hand, R123 bulks fabricated by heating precursors in $O_2$ atmosphere have few pores. In the present study, evaluations of mechanical properties of Dy123 low porosity bulks were carried out at liquid nitrogen temperature 77 K and effects of reduction of pores on improvements of mechanical properties were investigated.

Mechanical properties of Dy123 bulks were evaluated through three-point bending tests of plain specimens and V-notched specimens cut from the bulks. Precursors for Dy123 low porosity bulks were heated in $O_2$ atmosphere up to 1423 K, kept at that temperature for 1 h and then cooled down to 1313 K. After that, one Nd123 seed crystal was placed on the top of them in air and they were gradually cooled down. The dimensions of the bending test specimens were 2.8 x 2.1 x 24 $mm^3$. Oxygen annealing was conducted for the specimens at 723 K for 100 h. Each specimen was placed on a bending test jig and immersed in the liquid nitrogen bath. Bending load was applied at 0.1 mm/min by means of INSTRON 4464 testing machine. Loading span was 21 mm.

Figs. 1 and 2 show relationship between the mechanical properties and the porosity of plain specimens cut from a conventional Dy123 bulk which has pores DyP and a Dy123 low porosity bulk DyLP[1,2]. Solid and broken lines represent approximations of the data points at 77 K[1] and room temperature[2], respectively. Owing to the increase of the net cross-sectional area and decrease of defects where the stress concentration occurs, both the Young's modulus and the bending strength of the DyLP were higher than those of the DyP. Both the Young's modulus and the bending strength at 77 K were higher than those at RT, which was compatible with the decrease of inter-atomic distance by cooling. Fracture toughness evaluated through bending tests of V-notched specimens was also improved by reducing pores as shown in Fig. 3[3].

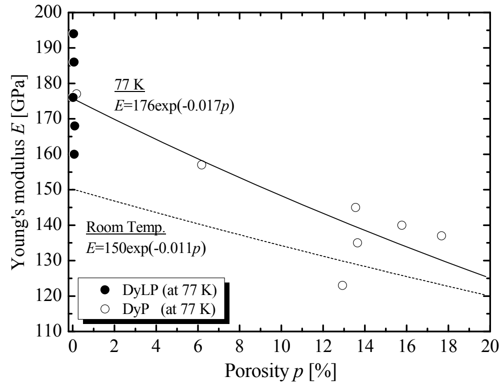


Fig. 1. Relationship between Young's modulus $E$ and porosity $p$[1,2].

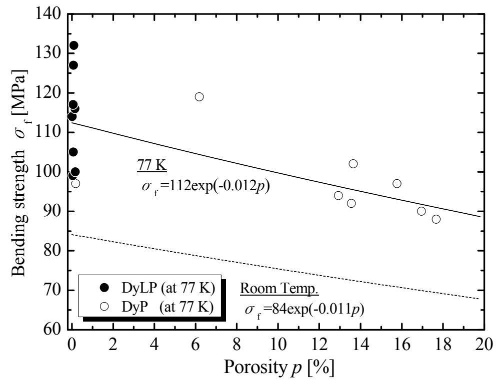


Fig. 2. Relationship between bending strength $\sigma_f$ and porosity $p$[1,2].

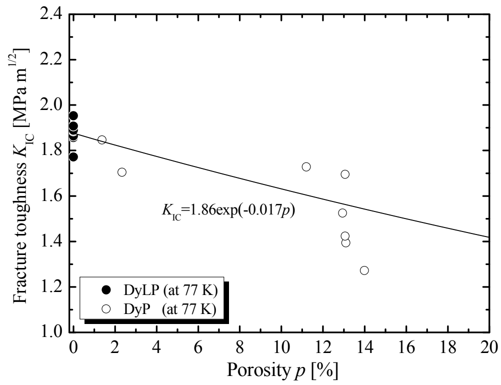


Fig. 3. Relationship between fracture toughness $K_{IC}$ and porosity $p$[3].

1) Murakami, A. et al.: IEEE Trans. Appl. Supercond. in press.
2) Murakami, A. et al.: Physica C 468 (2008) 1395.
3) Murakami, A. et al.: Physica C in press.