Tensile properties of (Gd,Y,Er)BaCuO superconducting bulk materials fabricated by infiltration growth technique

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Introduction

REBaCuO, where RE denotes rare-earth elements, superconducting bulk materials are promising for high performance magnets that can trap large magnetic field in compact space. REBaCuO bulk materials fabricated through conventional processing contain pores that cause degradation of mechanical properties. On the other hand, low porosity bulk materials can be fabricated by new processing that is called infiltration growth technique. In this study, mechanical properties of a (Gd,Y,Er)BaCuO bulk material fabricated by infiltration growth technique were investigated through tensile tests of specimens cut from the bulk material.

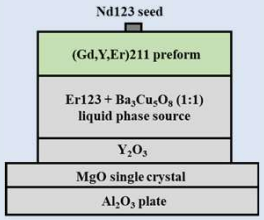
Bulk samples

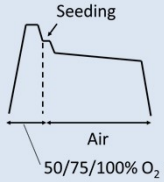
Schematic illustration of conventional processing of REBaCuO bulk materials.
$REBa_2Cu_3O_x$ (RE123) and RE_2BaCuO_5 (RE211) are mixed.

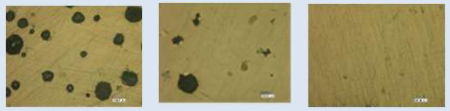
Bulk samples.

Samples	Fabrication process	Evaluation
(Gd,Y,Er)	Infiltration growth	This study
(Gd,Dy)	Infiltration growth	Ref. [1]
Dy	Melt growth in 100% O_2	Ref. [2]

[1] A. Murakami et al., Supercond. Sci. Technol., 33, 024003, (2020).
[2] A. Murakami and A. Iwamoto, IEEE Trans. Appl. Supercond., 30, 6800105, (2020).



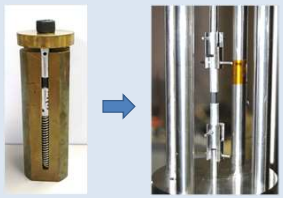




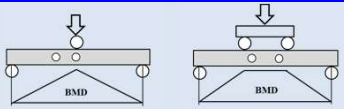
Schematic illustration of precursor used for infiltration growth of (Gd,Y,Er)BaCuO bulk material.
Stacked precursor that consists of liquid phase source and solid phase preform is used.

Melt-growth in 100% O_2 atmosphere is also effective in eliminating pores.

Tensile test procedures



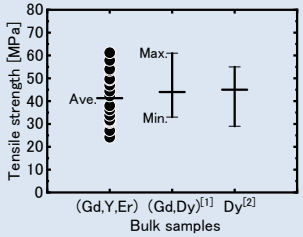
In this study, tensile tests were carried out to evaluate mechanical properties. Specimens were glued to stainless steel rods by using epoxy resin glue.



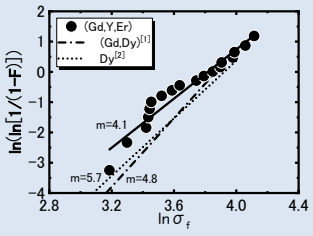
Schematic illustration of bending tests.

Bending tests are commonly carried out to evaluate mechanical properties of REBaCuO bulk materials. However, the strength data obtained through bending tests are overestimated.

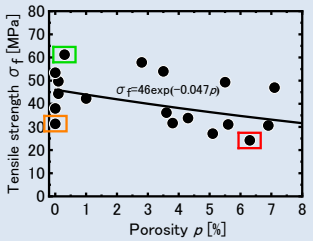
Tensile test results



Tensile strength data.



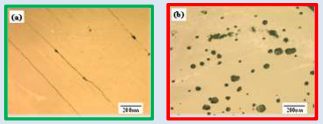
Weibull plots of tensile strength.



Relationship between tensile strength and porosity of (Gd,Y,Er).

Tensile strength data of (Gd,Y,Er) are comparable to those of (Gd,Dy) and Dy. Weibull coefficient of (Gd,Y,Er) is slightly smaller than those of (Gd,Dy) and Dy. Tensile strength increases with decrease of porosity.

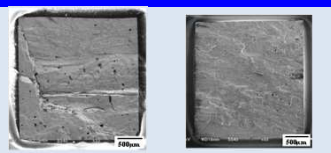
Observations on microstructures and fracture surfaces



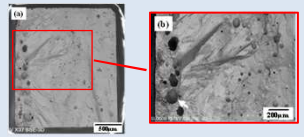
(a) Tensile strength: 61 MPa and porosity: 0.3%. (b) 24 MPa and 6.3%.

Low porosity specimen with lower tensile strength 31 MPa.

Solidified residual liquid phase is observed as marked by an arrow.

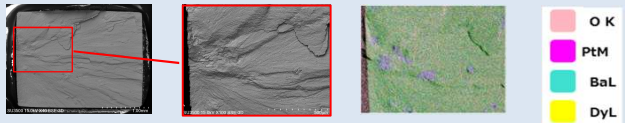


Due to the solidified residual liquid phase, fracture surface of low strength specimen (left) is relatively rough in comparison with that of high strength specimen (right).



(a) Fracture surface of low strength specimen.

Segregated RE211 particles are observed around pores as marked by an arrow.



Pt is observed around crack initiation site of a low porosity REBaCuO bulk material as reported in Ref. [2].

Conclusion

Tensile strength of specimens cut from a (Gd,Y,Er)BaCuO bulk material increases with decrease of porosity. Reductions of solidified residual liquid phase, segregated RE211 particles and Pt are effective in improving mechanical properties of low porosity REBaCuO bulk materials.

Acknowledgment

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