Pinning properties of Gd-Ba-Cu-O bulk superconductor fabricated by cold seeding method

Kazuo Inoue [a,1], Naomichi Sakai [a], Shinya Nariki [a], Masato Murakami [a]

[a] *Superconductivity Research Laboratory, ISTEC, 1-16-25 Shibaura, Minato-ku, Tokyo 105-0023, Japan*

Abstract

Gd-Ba-Cu-O bulk superconductor was fabricated with a cold seeding method. We have optimized the conditions to grow a single domain. The critical current density of the central region of the bulk was lower than the outer region in a lower magnetic field. However, the secondary peak was more remarkable. Such results are correlated with spatial fluctuation in the volume fraction of 211 phase particles.

Key words: Critical current density; Pinning; Gd123

1. Introduction

GdBa$_2$Cu$_3$O$_{7-\delta}$ (Gd123) superconductors exhibit high critical current density (J_c) and thus can trap high magnetic fields [1], which is attractive for various industrial applications.

Large grain bulk superconductors have been commonly fabricated with a hot seeding (HS) method. Although a cold seeding (CS) method is easy to apply [2], it has been difficult to grow a large bulk sample with the CS method because of a small window for a stable crystal growth.

In the present study, we have grown bulk Gd123 with the CS method with the aim of optimizing the processing conditions. We also investigated the relation between J_c and a spatial distribution of Gd$_2$BaCuO$_5$ (Gd211).

2. Experimental

Gd123 and Gd211 powders were mixed in a molar ratio of Gd123:Gd211 = 10:4 with 10 wt% Ag$_2$O and 0.5 wt% Pt. The mixtures were pressed into pellets and melt-processed in 1%O$_2$-Ar. The precursor pellet with a Nd123 seed crystal placed on top was heated to the maximum temperature ($T_{\max}$) and held for 20 h, cooled to the growth temperature (T_g) and held for 105 h. The sample was annealed at 400°C for 120 h in flowing oxygen. A spatial distribution of Gd211 was observed with a scanning electron microscope (SEM). J_c was estimated from magnetization hysteresis loops measured with a Quantum Design MPMS-XL SQUID magnetometer.

3. Results and discussion

Fig. 1 shows the top surface and cross section of the sample melted at $T_{\max}$=1000°C and grown at T_g = 970°C. A single domain has a square shape. However, the seed was melted above 1000°C and spontaneous nucleation of other grains occurred at $T_{\max}$=998°C, T_g=970°C and $T_{\max}$=1000°C, T_g=968°C, which shows that the optimum growth condition is very limited.

Fig. 2 shows SEM photographs of four locations indicated in Fig. 1. The volume fraction of 211 phase particles is lower in the central region.

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[1] Corresponding author. Fax: +81-3-3454-9287. E-mail: inouek@istec.or.jp

Fig. 3 shows the temperature dependence of dc susceptibility in 1 mT for the samples cut from four locations labeled in Fig. 1. The onset of T_c is 94 K for all the samples, but the transition width is broader in the central region.
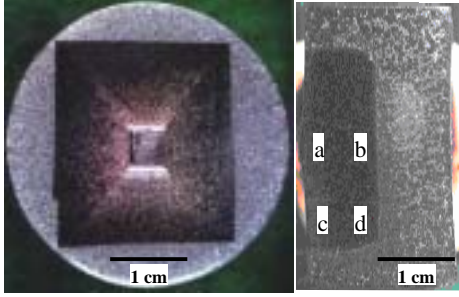

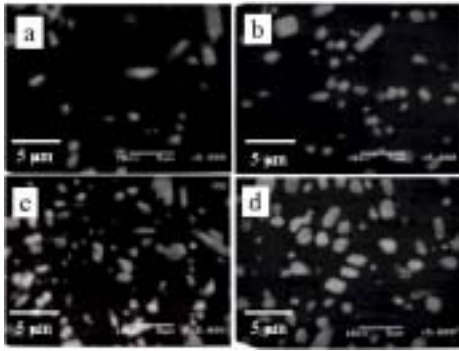Fig. 1. Top surface (left) and cross section (right) of the sample.

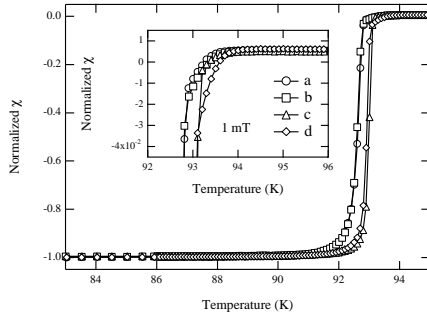Fig. 2. SEM photographs of four locations indicated in Fig. 1.

Fig. 3. Temperature dependence of dc susceptibility in 1 mT for the samples cut from four locations labeled in Fig. 1. Dc susceptibility was normalized with the value at 10 K.

Fig. 4 shows the magnetic field dependence of J_c at 77 K for the samples cut from four locations labeled in Fig. 1. J_c is lower in a low magnetic field at 77 K in the central region. However, the secondary peak is remarkable and the irreversibility field exceeds 7T in the central region. This suggests that the field-induced

pinning due to the Gd-rich cluster in Gd123 matrix is remarkable in the central region, while the interfacial pining due to 211 phase increases in the outer region. Such results are correlated with spatial distribution in 211 phase particles.
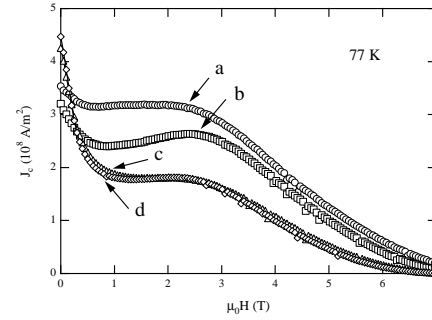

Fig. 4. Magnetic field dependence of J_c at 77 K for the samples cut from four locations labeled in Fig. 1.

Acknowledgements

References

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