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Physica C 408–410 (2004) 655–656
PHYSICA C
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Properties of $YBa_2Cu_3O_y$-textured superconductor foams

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Abstract

Using the combination of standard ceramic processing and an infiltration technique, single domain superconductor foam of Y123 has been prepared. In this report we present magneto-transport measurements of these foams. The investigations reveal superconducting properties being similar to those of bulk melt processed materials. The magnetic hysteresis vs field measurements show a high anisotropy of the critical current density up to $J_c^{ab}/J_c^c \sim 7$, in good agreement with the observation of a strong texture as determined from neutron diffraction measurements.

Keywords: YBaCuO foam; Magneto-transport properties; Neutron diffraction; Texture

Recently, a superconducting material being processed as a foam structure has been reported [1]. This new morphology seems to be an alternative 3D structure to solve the mechanical handling for the 2D fabric materials [2] and may be a good candidate for increasing interfacial flux pinning if the pores can be made sufficiently small. Many other prospects are related to the foam structure like e.g. more efficient heat transfer, faster oxygenation and less related microcracking, possibility of reinforcement and of interlocking connections etc. One of the central questions is whether this novel superconductor structure is similar to YBCO bulk material in terms of microstructure, superconducting properties and performances.

The details of the preparation process of Y211 foam as a starting precursor are reported elsewhere [1]. The resulting Y123 have the nature of a foam while demonstrating microstructural features of a single domain bulk sample (inset Fig. 2). The final Y123 foam structure is favorable to coolant connectivity (liquid nitrogen bath) during quenching process due to its large surface area. Magnetization, resistivity and texture (D1B-ILL) measurements have been performed. Fig. 1 (inset) shows the resistive transition of a typical Y123 foam sample. The $\rho(T)$ curves for the *ab*-planes and *c*-axis orientations exhibit a narrow superconducting transition ($\Delta T \approx 1.5$ K) with T_c (onset) ≈91.5 K and $T_c(\rho = 0)$ 90 K. At 300 K, we can deduce an anisotropy ratio $\rho_c^c/\rho_c^{ab} \sim 8$. The zero field cooled magnetization curve (Fig. 1) shows a narrow transition, with an onset at 92 K, comparable to the $\rho(T)$ curves. But one can observe a saturation of magnetization at 70 K showing a narrow jump probably due to the degradation of thin 123 struts with time during exposure to atmosphere usually observed on thin or thick films.

The magnetic J_c values are estimated for both directions. A critical current density of $J_c^{ab} \approx 40$ kA/cm^2 at 0 T can be deduced for current parallel to the *ab*-planes. A $J_c^c \approx 15$ kA/cm^2 is obtained for currents parallel to the *c*-axis, leading to an anisotropy factor J_c^{ab}/J_c^c of about 7 at 2 T.

Texture data (Fig. 2) show very strong intensity variations when the sample is rotated relative to the

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doi:10.1016/j.physc.2004.03.098

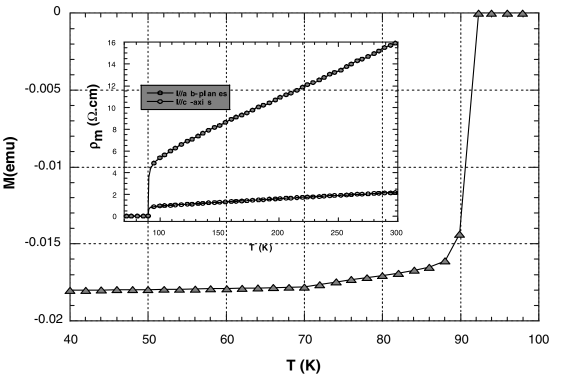

Fig. 1. $M(T)$ curve showing the narrow superconducting transition. Inset: $\rho(T)$ curves for currents injected through *ab*-planes and *c*-axis bar samples.

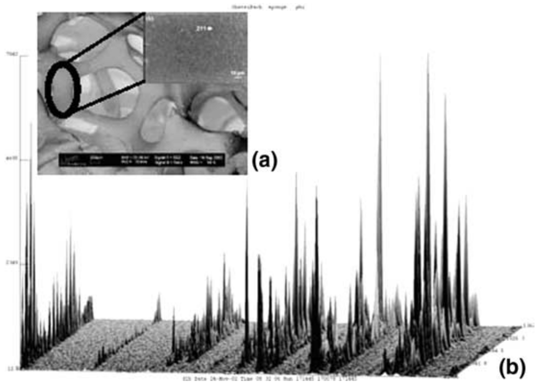

Fig. 2. Neutron diffraction measurements showing the textured foam structure. Inset: SEM picture (a) of the fractured Y123 foam. Optical microscopy (b) of the polished surface of the struts with residual Y211 in the Y123 matrix.

neutron beam. These data are treated using the combined approach [3], which allows simultaneous determinations of phase ratio, texture, structure, cell parameters, and crystallite sizes of both phases. We obtained 46(1)% of Y123 and 54(2)% of Y211 in this sample, with respective cell parameters of ($a = 3.8128(6)$ Å, $b = 3.8803(9)$ Å, $c = 11.662(4)$ Å) and ($a = 12.158(4)$ Å, $b = 5.645(2)$ Å, $c = 7.117(3)$ Å), in good agreement with literature. The isotropic crystallite sizes are estimated to 136(32) and 139(43) nm, respectively, for the two phases. The orientation distribution function was refined [4,5], then used to recalculate the $\{0\,0\,\ell\}$ pole figure of Y123 (deduced from Fig. 2). While no texture was observed for the Y211 phase, the Y123 phase shows very high level of orientations, with a maximum as high as around 100 times the random powder. The sample ($1 \times 1 \times 1$ cm^3) exhibits only two main orientation components with widths at half-maxima of 10° approximately, and orientations close to the main axes of the sample.

The texture development in this sample is very similar to the MTG-samples of such phases. It is interesting to note a similar high degree of texture in spite of the extremely complex shapes of the alveoli of the foam, explaining the anisotropy and the relatively good superconducting properties of the sample.

In conclusion, the properties of superconducting foam have been investigated. The measurements of magnetic hysteresis versus field reveal a high anisotropy of critical current density of 7, in good agreement with the observation of a strong texture.

Acknowledgements

This work was supported by the German Ministry for Education and Research (BMBF) under grant N 7571. EG thanks the "French Ministère de la Recherche et de la Technologie" for his Ph.D. fellowship.

References

[1] E.S. Reddy et al., American Ceramic Society Bulletin 81 (12) (2002) 35.
[2] E. Sudhakar Reddy et al., Journal of Materials Research 16 (2001) 955.
[3] D. Chateigner et al., ILL Highlights 1997 (1998) 28.
[4] S. Matthies, G.W. Vinel, Physica Status Solidi B 112 (1982) 111.
[5] L. Lutterotti, S. Matthies, H.-R. Wenk, in: J.A. Szpunar (Ed.), Textures of Materials, vol. 2, NRC Research Press, Ottawa, 1999, p. 1599.