

Bulk $\text{GdBa}_2\text{Cu}_3\text{O}_7$ Superconductors Prepared by Single Direction Melt Growth (SDMG) : Key Points to Understand their Behaviour Under a Time-Dependent Magnetic Field

N. Rotheudt¹, D. Szewczyk², P. Stachowiak², J. F. Fagnard¹, T. Hlasek^{3,4}, J. Plechacek³, and P. Vanderbemden¹

¹ Montefiore Research Unit B28, University of Liège, Liège B-4000, Belgium

² Institute for Low Temperature and Structure Research, 50-422 Wrocław, Poland

³ CAN SUPERCONDUCTORS, s.r.o., Ringhofferova 66, 251 68 Kamenice, Czech Republic

⁴ Department of Inorganic Chemistry, University of Chemistry and Technology Prague, Technická 5, Prague 6 166 28, Czech Republic

Bulk, large grain $\text{GdBa}_2\text{Cu}_3\text{O}_7$ superconductors prepared by the ‘Single-Direction Melt Growth’ (SDMG) process [1,2] are known to exhibit an unprecedented homogeneity of their superconducting properties [3]. Hence, they offer great ability as trapped field superconducting magnets or magnetic shields and screens [4]. In most engineering applications, however, the superconductor is subjected to several cycles of the applied field. Examples include a bulk magnet in a rotating machine or a superconducting magnetic screen subjected to a changing stray field. The goal of this communication, therefore, is to highlight key parameters required to predict and study the change of properties of an SDMG bulk superconductor when it is subjected to repeated cycles of applied field. For low-frequency magnetic fields, we study the magnetic screening properties of a disk-shaped superconducting bulk. Experimentally, the screening factor SF that we obtain after up to 30 cycles of low-frequency applied field is the same (at the maximum field) as the SF after the first ramp from zero field to its maximum. Numerically, we show that the relative decay of SF between successive occurrences of the maximum field is smaller than the decay that would be obtained if the maximal field was maintained. Hence, the key parameters are the magnetic relaxation and the penetration depth in the bulk, since a higher penetration depth leads to a smaller SF and a faster magnetic relaxation. At higher frequencies of applied field, the hysteresis losses may yield a temperature increase which, in turn, affects the magnetic properties. To predict this self-heating, we provide experimental data on the thermal properties of SDMG bulk samples ($\text{GdBa}_2\text{Cu}_3\text{O}_7 + 0.4 \text{ mol Gd}_2\text{BaCuO}_5 + 10\% \text{ Ag}_2\text{O}$) and compare them to those of other bulk samples ($\text{YBa}_2\text{Cu}_3\text{O}_7$ and $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_8$). Among others, we investigate the anisotropy of both the thermal conductivity and the electrical resistivity, the peaks appearing in the temperature-dependent specific heat and the temperature dependence of the irreversibility line ($H||ab$ and $H||c$). Practical implications for engineering applications are discussed.

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