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High magnetic shielding properties of an MgB_2 cup obtained by machining a spark-plasma-sintered bulk cylinder

Laura Gozzelino[1,2], Roberto Gerbaldo[1,2], Gianluca Ghigo[1,2], Daniele Torsello[1,2], Valentina Bonino[2,3], Marco Truccato[2,3], Mihai A Grigoroscuta[4,5], Mihail Burdusel[4], Gheorghe V Aldica[4], Viorel Sandu[4], Iuliana Pasuk[4] and Petre Badica[4]

[1] Department of Applied Science and Technology, Politecnico di Torino, I-10129 Torino, Italy
[2] Istituto Nazionale di Fisica Nucleare, Sezione di Torino, I-10125 Torino, Italy
[3] Department of Physics, Interdepartmental Centre NIS, University of Torino, I-10125 Torino, Italy
[4] National Institute of Materials Physics, 077125 Magurele, Ilfov, Romania
[5] University Politehnica of Bucharest, 060042 Bucharest, Romania

E-mail: laura.gozzelino@polito.it and badica2003@yahoo.com

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Abstract

Superconductors are key materials for shielding quasi-static magnetic fields. In this work, we investigated the shielding properties of an MgB_2 cup-shaped shield with small aspect-ratio of height/outer radius. Shape and aspect-ratio were chosen in order to address practical requirements of both high shielding factors (SFs) and space-saving solutions. To obtain large critical current densities (J_c), which are crucial for achieving high magnetic-mitigation performance, a high-purity starting MgB_2 powder was selected. Then, processing of the starting MgB_2 powder into high density bulks was performed by spark plasma sintering. The as-obtained material is fully machinable and was shaped into a cup-shield. Assessment of the material by scaling of the pinning force showed a non-trivial pinning behaviour. The MgB_2 powder selection was decisive in enlarging the range of external fields where efficient shielding occurs. The shield's properties were measured in both axial- and transverse-field configurations using Hall probes. Despite a height/outer radius aspect ratio of 2.2, shielding factors higher than 10^4 at $T = 20$ K up to a threshold field of 1.8 T were measured in axial-field geometry at a distance of 1 mm from the closed extremity of the cup, while SFs $> 10^2$ occurred in the inner half of the cup. As expected, this threshold field decreased with increased temperature, but SFs still exceeding the above mentioned values were found up to 0.35 T at 35 K. The shield's shape limits the SF values achievable in transverse-field configuration. Nevertheless, the in-field J_c of the sample supported SFs over 40 at $T = 20$ K up to a field of 0.8 T, 1 mm away from the cup closure.

Keywords: magnetic shielding, MgB_2 bulk superconductors, machinable bulks

(Some figures may appear in colour only in the online journal)

1. Introduction

Owing to their ability to expel magnetic flux, superconducting materials have been demonstrated to be promising candidates for the fabrication of efficient low-frequency passive magnetic shields. In particular, their use is crucial in several kinds of applications, for instance when shielding magnetic flux density over 1 T [1–3] or very low magnetic field background [4–6] is required.

Shielding properties of superconducting bulks with cylindrical and planar geometries and made from different materials have successfully been investigated [7–11]. Moreover,

