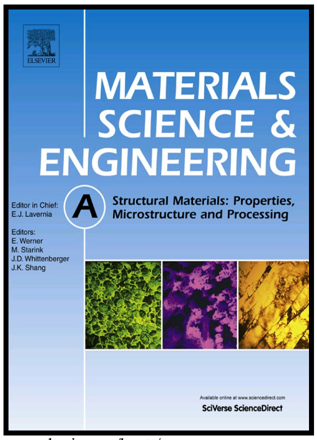
Author's Accepted Manuscript



www.elsevier.com/locate/msea

Mechanical Properties and Uniformity of Fe-MgB_2 Wires upon Various Wire Drawing Steps

Fırat Karaboğa, Asaf Tolga Ulgen, Hakan Yetiş, Mustafa Akdoğan, Murat Pakdil, Ibrahim Belenli

PII: S0921-5093(18)30283-1
DOI: https://doi.org/10.1016/j.msea.2018.02.073
Reference: MSA36160

To appear in: *Materials Science & Engineering A*

Received date: 4 December 2017
Revised date: 19 February 2018
Accepted date: 20 February 2018

Cite this article as: Fırat Karaboğa, Asaf Tolga Ulgen, Hakan Yetiş, Mustafa Akdoğan, Murat Pakdil and Ibrahim Belenli, Mechanical Properties and Uniformity of Fe-MgB_2 Wires upon Various Wire Drawing Steps, *Materials Science & Engineering A,* https://doi.org/10.1016/j.msea.2018.02.073

Mechanical Properties and Uniformity of Fe-MgB_2 Wires upon Various Wire Drawing Steps

Fırat Karaboğa[a,*], Asaf Tolga Ulgen[b], Hakan Yetiş[c], Mustafa Akdoğan[c], Murat Pakdil[d] and Ibrahim Belenli[c]

[a]*Department of Medical Imaging Techniques, Vocational School of Health Services, Abant Izzet Baysal University, 14030 Bolu, Turkey.*
[b]*Department of Electric and Electronic Engineering, Faculty of Engineering, Sirnak University, 73000 Sirnak, Turkey.*
[c]*Department of Physics, Faculty of Arts and Science, Abant Izzet Baysal University, 14030 Bolu, Turkey.*
[d]*Department of Mechanical Engineering, Faculty of Engineering, Abant Izzet Baysal University, 14030 Bolu, Turkey.*

Abstract

Effect of drawing process on the mechanical properties and cross-sectional uniformity of Fe/MgB_2 mono-filamentary wires were investigated in this study. Successive cold drawing steps were applied with and without intermediate strain relief annealing steps. Micro-hardness measurements of the drawn wires were taken from the polished cross-sections. Tensile tests were performed on the 120 *mm* long wires samples. Microstructural properties of the sheathing material and that of the superconducting core were studied using SEM. Uniformity of the cross-sectional area in final mono filamentary wires was studied on SEM images of the polished cross-sections. Excessive mechanical deformation of the soft iron sheathing metal via drawing was assessed and discussed.

Keywords: Superconducting Wires, Magnesium Diboride, Micro-hardness and Mechanical Properties.

1. Introduction

It is well known that plastic deformation induced by conventional forming methods such as rolling, drawing or extrusion can significantly increase the strength of metals. However, this increase in strength is usually accompanied by loss of ductility. MgB_2 wires have potential for future applications provided that production of wires with sufficiently high current carrying capacity reliable along long lengths is made possible using low cost production methods. Powder-in-tube (in-situ/ex-situ) is one of the cheapest/simplest methods for producing MgB_2 wires [1]. Also, there is a wide range of industrial application experience with well-developed fabrication processes in wire drawing. A ductile metal sheath which is chemically compatible with MgB_2 core is necessary for making long superconducting wires. Producing long length conductors requires extensive elongation of the sheathing metals. Any material defect either present in the sheathing from the beginning or occurred at initial stages of fabrication will be magnified greatly during wire elongation stages.

In-situ process is more flexible with respect to chemical doping and hence leads to MgB_2 with improved performance in higher magnetic fields [2]. The ratio of superconducting cross-sectional area to cross-sectional area of the metal sheath is one of the important fabrication parameters for current carrying capacity and densification of the core. Superconducting fraction of a composite wire is important to achieve high critical current densities and it is better to be kept as high as possible. Achieving this aim requires the use of metal tubing with larger core volume ratio which is only possible with large diameter tubes or thin walled tubes.

On the other hand, very thin metal sheathing will not survive against drawing force and break immaturely. So, optimization of volume ratio of metal sheathing to superconducting material is essential. Another requirement is that the final diameter of the superconducting wire should be small enough for elasticity which is required for winding into coil form either for storage or magnet winding. As a result, extensive elongation is unavoidable in superconducting MgB_2 wire fabrication through powder-in-tube (PIT) method. This extensive elongation of the sheathing metals in wire making can cause very divergent microstructures which result in heavily changed mechanical properties.

Micro-hardness testing is often used to examine the mechanical properties and strongly related to the composition and structure of the samples [3] thus can be used to analyses the materials for industrial applications