



Microstructure and enhanced engineering critical current density of AIMI MgB₂ strands processed with low temperature and long time



F. WanM. D. SumptionD. L. Zhangand E. W. Collings



M.A. Rindfleisch





1. Purpose

2. Experimental results

1) Monofilamentary AIMI Strand

- Microstructural analysis
- Transport Critical Current Density
- 2) Multifilamentary AIMI Strand
 - $I_{\rm C}$, $J_{\rm C}$ and Filament number
 - Microstructural analysis
 - Transport $J_{\rm C}$ and H. T. Condition
 - Transport $J_{\rm C}$ and ${\rm Dy}_2{\rm O}_3$ Doping

3. Concluding summary





Purpose

Mg-Reactive-Liquid-Infiltration (Mg-RLI)/Internal-Magnesium-Diffusion (IMD) [1] processed MgB₂ wire obtained high transport $J_{\rm C}$ s





Purpose

Our group/HTR developed Mg-RLI-processed strand by optimizing strand architecture and selecting better raw materials. Advanced-internal-magnesium-infiltration

(AIMI) strand.

H. T. Condition: 675 °C/1 ~ 4 h

Testing the transport J_C of **AIMI strands** heattreated with **625°C and 8 ~ 64 hours**





Monofilamentary Strand: Mg Infiltration



Full Infiltration

Full Infiltration



Department of Materials Science & Engineering Center for Superconducting & Magnetic Materials

Transport Layer J_c versus Heating time







Layer J_C versus Heating Temperature



Department of Materials Science & Engineering Center for Superconducting & Magnetic Materials





Multi stands have better electrical and thermal stability than mono strands OD: 0.83 ~ 1.01 mm Chemical Barrier/Outer Sheath: Nb/Monel or SS





*I*_C versus Filament Number

I_Cs of multi strands are higher than those of mono strands due to larger MgB₂ area







$$J_E = I_C / \text{Area}_{\text{whole strand}} = \text{Layer } J_C * \text{Fill Factor}$$

Fill Factor = MgB₂ Layer Area/ Whole strand Area











Layer J_C versus Filament Number







Microstructural Analysis – 18-filamentary Strand





Transport J_C versus Heating Time

18 Filaments 625 °C Heating time:8 ~ 14 hours





Department of Materials Science & Engineering Center for Superconducting & Magnetic Materials

Dy₂O₃/C Co-doping for 18-filamentary AIMI Strands





Dy₂O₃ doping level: 2wt% based on B







MgB₂ short straight wires (5 cm) Heating Temperature: 625 °C Diameter: 0.83 ~ 0.84 mm

At 4.2 K, 10 T
$$I_{\rm C} = 60 \text{ A}$$

 $J_{\rm e} = 1.06 \times 10^4 \text{ A/cm}^2$







MgB₂ Spiral (1 m) Diameter: 0.83 ~ 0.84 mm

5 T
$$I_{\rm C} = 350 \text{ A}$$

 $J_{\rm e} > 60 \text{ kA/cm}^2$



Department of Materials Science & Engineering Center for Superconducting & Magnetic Materials











675 °C/4 h



Continuous B-rich layer







Mg Infiltration into B layer





The molten Mg rod shrinked to several **liquid Mg droplets** to obtain a minimum surface area possible.



Liquid Mg droplets





Mg Infiltration into B Layer







Mg infiltration into B layer







Concluding summary

- Monofilamentary AIMI MgB₂ strands processed with low temperature and long time can obtain same transport properties as the strand processed with high temperature.
- Multifialmentary AIMI MgB₂ strands have suppressed transport J_C s due to precence of B rich phases distributed in MgB₂ matrix.
- Dy_2O_3 doping can significantly enhance the transport properties of multifilamentary MgB₂ strands.
- Low heating temperature induces the formation of relative uniform MgB₂ layer in AIMI strands.





Acknowledgements

-This work was funded by the NIH grant



