

§12. Superconducting Properties of MgB₂ Wires Synthesized with External Mg Diffusion Process

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MgB₂ superconductor with highest critical temperature T_c of 39 K in metallic superconductors is expected to be useful for superconducting magnet and power applications. The powder-in-tube PIT process is currently used for fabricating MgB₂ wires and tapes. However, the PIT process leads to voids in MgB₂ superconductor due to the reaction between Mg and B powder, resulting in low critical current density J_c. In previous study¹⁾⁻²⁾, external Mg diffusion process successfully led to MgB₂ structure without voids, however, chemical composition of MgB₂ core considerably deviate from stoichiometric composition of Mg:B=1:2 and to be B rich (Mg poor) of 1:3.9. In present work³⁾, effects of MgH₂ addition into B powder on superconducting properties and structure of MgB₂ core synthesized with external Mg diffusion process have been reported.

Fig. 1 shows preparation procedure of MgB₂ wires by external Mg diffusion process. A pure Mg tube of 4/2.5 mm in outside/inside diameter was inserted into a pure iron tube of 8/4 mm, and then amorphous B powder mixed with 5 mol% SiC nano-sized powder and 10 mol% Mg₂ powder addition was encased in the Mg tube to form Fe/Mg/B(SiC+MgH₂) composite. The composite was fabricated into 1.8 mm square wire through grooved-rolling and then drawn into round wire of 1.0 mm in diameter without intermediate annealing. The heat-treatment was performed at 630°C for 5 h in Ar gas atmosphere. The critical current I_c at 4.2 K of specimens was measured by a four-probe resistive method, the criterion of the I_c measurement being 1 μV/cm. The core J_c was calculated by dividing I_c by the cross-sectional area of the MgB₂ core.

According to SEM images taken on the fractured cross-section of MgB₂ wire, the MgB₂ superconducting core was synthesized through diffusion reaction between Mg metal and B powder with MgH₂ addition. The MgB₂ core forms dense structure with a few voids due to thermal decomposition of MgH₂. The residual Mg which has not reacted with B powder remains around iron sheath. The Mg/B ratio of MgB₂ core is evaluated to be 1:2.4 by EPMA analysis, being slightly B rich in comparison with that of no MgH₂ addition.

Magnetic field dependence of core J_c at 4.2 K for the MgB₂ wires is shown in Fig. 2. The I_c at 4.2 K and 10 T for the MgB₂ wire with/without MgH₂ addition are 9.3 A and 15 A, which I_c values correspond to core J_c of 110 A/mm² and 205 A/mm², respectively. The low I_c and J_c of MgB₂ wire with MgH₂ addition may result from a voids in MgB₂ core. The J_c values of diffusion processed MgB₂ wires are one order of magnitude higher than that of PIT processed wires, and higher than that of NbTi at higher field than 10 T.

The external Mg diffusion processed MgB₂ wires are promising candidate for superconducting applications in Liquefied hydrogen of 20 K or higher field than 10 T.

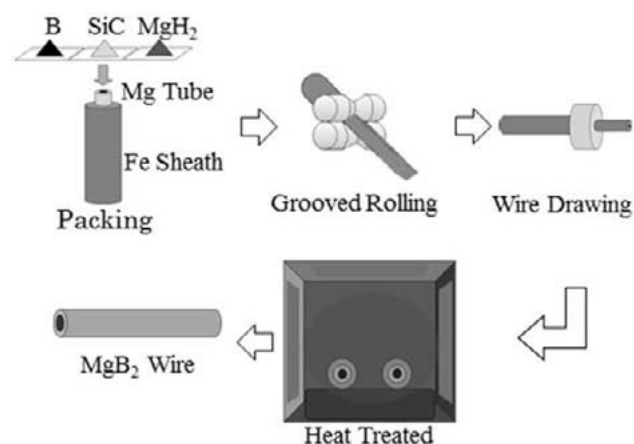


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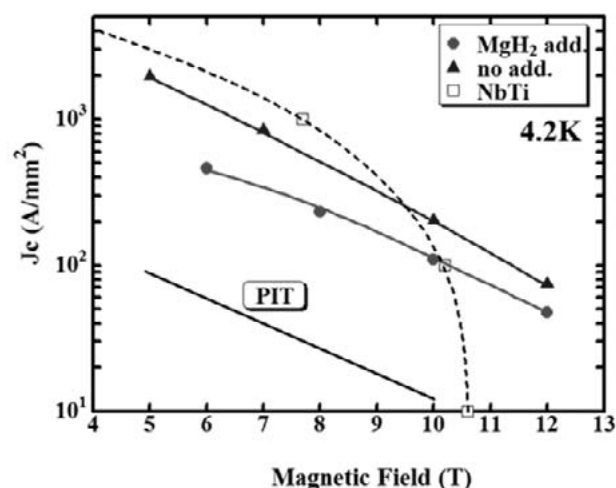


Fig. 2. Magnetic field dependence of J_c at 4.2 K for the MgB₂ wires.

- 1) Yamada, Y. et al. :IEEE Trans. Appl. Supercond., **22** (2012) 6200304.
- 2) Yamada, Y. et al. :ICEC24-ICMC2012, 15P-P09-09, 80.
- 3) Ouchi, H. et al. :25th SAS Intell. Sympto., (2013) C-6, 21.