§12. Superconducting Properties of MgB_2 Wires Synthesized with External Mg Diffusion Process

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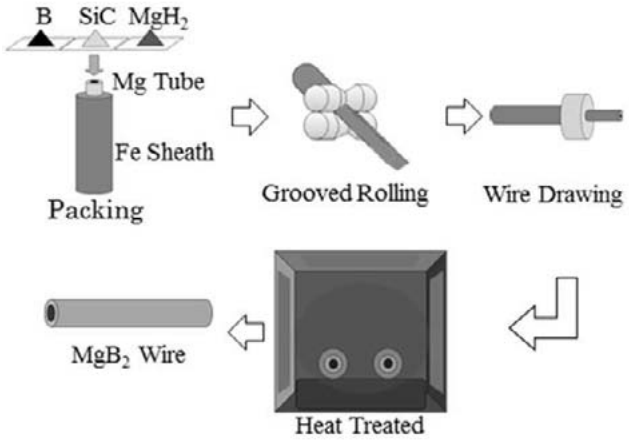
MgB_2 superconductor with highest critical temperature Tc of 39 K in metallic superconductors is expected to be useful for superconducting magnet and power applications. The powder-in-tube PIT process is currently used for fabricating MgB_2 wires and tapes. However, the PIT process leads to voids in MgB_2 superconductor due to the reaction between Mg and B powder, resulting in low critical current density Jc. In previous study[1)-2)], external Mg diffusion process successfully leaded to MgB_2 structure without voids, however, chemical composition of MgB_2 core considerably deviate from stoichiometric composition of Mg:B=1:2 and to be B rich (Mg poor) of 1:3.9. In present work[3)], effects of MgH_2 addition into B powder on superconducting properties and structure of MgB_2 core synthesized with external Mg diffusion process have been reported.

Fig. 1 shows preparation procedure of MgB_2 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% Mg_2 powder addition was encased in the Mg tube to form Fe/Mg/B(SiC+MgH_2) 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℃ for 5 h in Ar gas atmosphere. The critical current Ic at 4.2 K of specimens was measured by a four-probe resistive method, the criterion of the Ic measurement being 1 μV/cm. The core Jc was calculated by dividing Ic by the cross-sectional area of the MgB_2 core.

According to SEM images taken on the fractured cross-section of MgB_2 wire, the MgB_2 superconducting core was synthesized through diffusion reaction between Mg metal and B powder with MgH_2 addition. The MgB_2 core forms dense structure with a few voids due to thermal decomposition of MgH_2. The residual Mg which has not reacted with B powder remains around iron sheath. The Mg/B ratio of MgB_2 core is evaluated to be 1:2.4 by EPMA analysis, being slightly B rich in comparison with that of no MgH_2 addition.

Magnetic field dependence of core Jc at 4.2 K for the MgB_2 wires is shown in Fig. 2. The Ic at 4.2 K and 10 T for the MgB_2 wire with/without MgH_2 addition are 9.3 A and 15 A, which Ic values correspond to core Jc of 110 A/mm^2 and 205 A/mm^2, respectively. The low Ic and Jc of MgB_2 wire with MgH_2 addition may result from a voids in MgB_2 core. The Jc values of diffusion processed MgB_2 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 MgB_2 wires are promising candidate for superconducting applications in Liquefied hydrogen of 20 K or higher field than 10 T.



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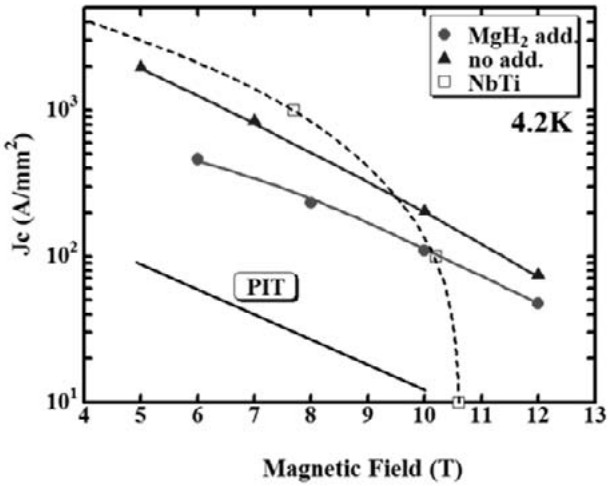

Fig. 2. Magnetic field dependence of Jc at 4.2 K for the MgB_2 wires.

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. Sympo., (2013) C-6, 21.