§4. MgB_2 Superconducting Thin Wires for Current Lead Application

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1. Introduction

Since the discovery of superconductivity in MgB_2 having critical temperature Tc of 39 K, many researches and developments on critical current Ic in MgB_2 wires and tapes have been performed for practical applications. In this report, superconducting properties and workability of in-situ powder-in-tube PIT processed MgB_2 thin wires sheathed with iron and stainless steel have been studied.

2. Experimental

Magnesium hydride MgH_2 and amorphous B powders mixed with 5 mass% SiC nano-sized powder were encased into pure iron tube. The tube was fabricated into square rod by a grooved-rolling and then into a wire by cold drawing. The wire was inserted into an austenitic stainless steel s.s. (SUS304) tube to form s.s./Fe sheathed MgB_2 composite wires by cold drawing. The heat treatment was performed at 630℃ for 10 h in Ar gas atmosphere. The Ic at 4.2 K was measured by a four-prove resistive method and magnetic field was applied perpendicular to the specimen current.

3. Results and Discussion

Fig. 1 shows optical micrographs taken on the cross-sections of s.s./Fe-sheathed MgB_2 composite wires of 0.53 ~ 0.19 mm in diameter. The MgB_2 core was still square shaped by grooved rolling. Cross-sectional area and sheath/core ratio of MgB_2 composite wires are listed in Table I. The cross-sectional area of MgB_2 core, Fe and s.s. sheath decreases by aroud a half in each drawing of wires.

Magnetic field dependence of the Ic at 4.2 K for MgB_2 wires of 0.53 and 0.27 mm in diameter with 0 ~ 5% SiC is shown in Fig. 2. The addition of nano-sized SiC powder apparently enhances the transport Ic at 4.2 K in higher magnetic field than 2-3 T. However, the Ic increased with decreasing the amount of SiC addition in lower magnetic field than 2 T. The Ic for the MgB_2 wire of 0.53 mm in diameter without SiC addition reaches to 200 A, which corresponds to the Jc of 4,300 A/mm^2.

Fig. 3 shows heat leakage between 20 K and 4.2 K versus length of MgB_2 composite wires of 0.53 ~ 0.19 mm in diameter. The heat leakages are inversely proportional to the length of MgB_2 wires, and are calculated to be 0.65 mW for the MgB_2 wire of 0.53 mm in diameter and 200 mm in length. The heat leakage of MgB_2 composite wire depends mainly on the pure iron sheath with higher thermal conductivity in comparison with that of stainless steel sheath. The sub-mW class heat leakage of the MgB_2 wires enables to apply to the various sensors in liquid hydrogen such as level sensor and to the current lead in carrying current with no power consumption at low temperature.

1) Yamada, Y. et al.: IEEE Trans. Appl. Supercon. 17(2007)2911.
2) Ohki, S et al.: Trans. MRS-Japan 35(2009) to be published.

Table 1. Cross-sectional area and sheath/core ratio of MgB_2 thin wires.

diameter (mmφ)	(a) 0.53	(b) 0.38	(c) 0.27	(d) 0.19
S.S. (mm^2)	0.099	0.052	0.027	0.013
Fe (mm^2)	0.064	0.036	0.019	0.0092
MgB_2 (mm^2)	0.047	0.024	0.012	0.0061
sheath/core ratio	3.48	3.60	3.67	3.72

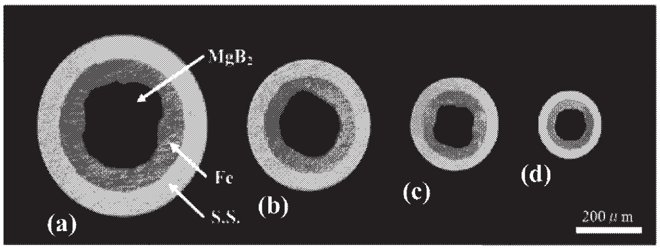

Fig. 1. Cross-section of in-situ PIT processed MgB_2 thin wires of 0.53 – 0.19 mm in diameter.

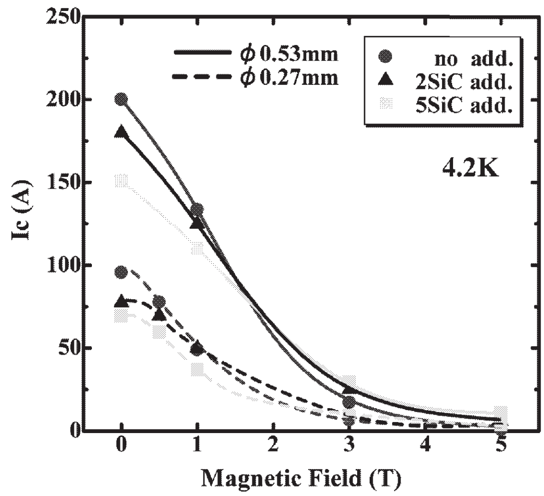

Fig. 2. Magnetic field dependence of core Ic at 4.2 K for the MgB_2 wires of 0.53 and 0.27 mm in diameter.

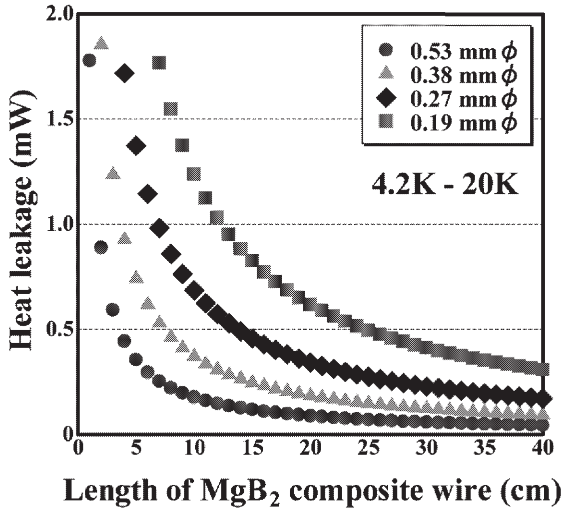

Fig. 3. Heat leakage between 20 K and 4.2 K versus length of MgB_2 thin wires of 0.53 – 0.19 mm in diameter.