§1. Superconducting Properties and Workability of MgB_2 Thin Wires

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Since discovery of superconductivity with critical temperature T_c of 39 K in MgB_2, many efforts on the superconductors have been made in development of conductors as well as fundamental researches. In particular, improvement of critical current density J_c in MgB_2 superconducting wires and tapes has gained world-wide interest for practical applications. The high T_c suitable for cooling by cryocoolers, the light weight, low material cost and the possibility to produce long lengths of conductors are useful for applications.

There are two different methods for fabricating MgB_2 wires and tapes by the powder in tube (PIT) process. One is the ex-situ process, in which a commercially available MgB_2 powder is utilized as raw material. Another is the in-situ process, in which a mixed powder of Mg and B is used. The former process is simpler since no heat treatment is necessary to synthesize MgB_2, while the superconducting properties depend sensitively on the qualities of the starting MgB_2 raw powder. The latter process is more attractive due to higher transport current performance. In present work, superconducting properties and workability of the in-situ PIT processed MgB_2 thin wires sheathed with stainless steel have been studied relating with the microstructures [1)-3)]. The MgB_2 thin wires are attractive to level sensor for liquid hydrogen as well as current lead with small heat load. The MgB_2 level sensor is particularly promising for hydrogen society in near future.

Fig. 1 shows the preparation procedure of in-situ PIT processed MgB_2 thin wires. Magnesium hydride MgH_2 and amorphous B powders were packed into an austenitic (18Cr-8Ni) stainless steel (SUS304) tube outside diameter of 1 mm and inside diameter of 0.6 mm. The tube was drawn into monocore round wires of 0.2 mm - 0.1 mm in diameter through dies with no crack without intermediate annealing. Diamond dies are used for wires thinner than 0.2 mm in diameter The heat treatment was performed to synthesize MgB_2 superconductor at 630 ℃ for 5 h in Ar gas atmosphere. The microstructures of the MgB_2 core were observed using an optical microscope and scanning electron microscope (SEM), respectively. Sheath/core ratio of cross-section of the wire is 4.6 as shown in Fig. 1. The critical current I_c at 4.2 K of the specimens was measured by a four-probe resistive method, the criterion of the I_c measurement being 1 μV/cm.

Vickers hardness HV of the SUS304 sheath versus reduction rate of the MgB_2 wire is shown in Fig. 2. Reduction rate is defined as the difference between initial and final cross section divided by initial cross section. HV hardness increases sharply with increasing the reduction rate due to work hardening. The HV exceeds HV500 in reduction rate of 96% (0.2 mm in diameter) and reaches HV541 in 98% (0.14 mm) and HV599 in 99% (0.1 mm), although the HV hardness decreases down to HV348 by around HV250 through heat treatment of 630℃ for 5 h.

The I_c of the MgB_2 wire at 4.2 K and self-field is 4.4 A, which I_c corresponds to J_c of 3,140 A/mm^2. In future work, Chemical doping with carbon additives such as SiC, nano C and carbon hydrates will be conducted for improvement of I_c in magnetic field.

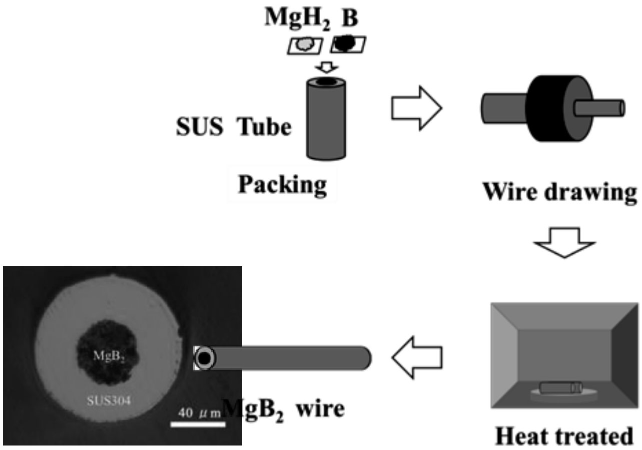

Fig. 1. Preparation procedure of in-situ PIT processed MgB_2 thin wires sheathed with stainless steel.

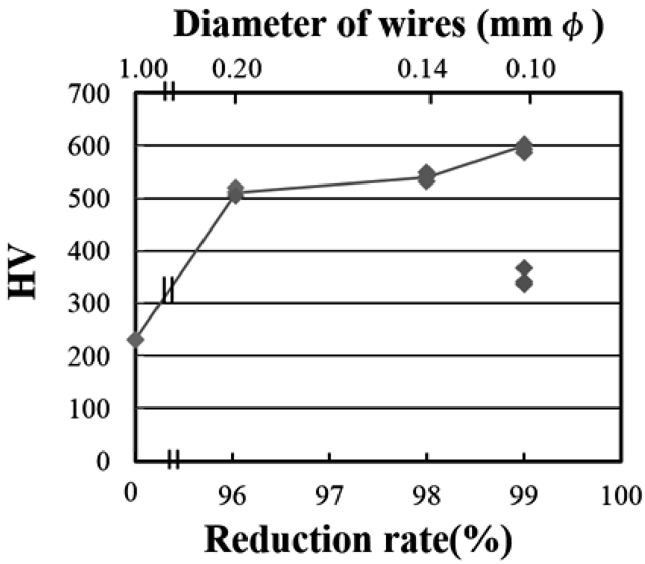

Fig. 2. Vickers hardness of stainless steel sheath versus reduction rate (diameter) of MgB_2 thin wires.

1) Yamada, Y. et al. :IEEE Trans. Appl. Supercond., **22** (2012) 6200304.

2) Kajikawa, K. et al. :AIP Conf. Proc. 1573 (2014) 905.

3) Miyashita, T. et al. :26th SAS Intell. Sympo., (2014) C-8, 27.