§3. Superconducting Properties and Workability of MgB_2 Thin Wires

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Since discovery of superconductivity in MgB_2 with critical temperature *Tc* of 39 K, many works on the superconductors have been made in development of conductors as well as fundamental researches. In particular, improvement of critical current density *Jc* in MgB_2 superconducting wires and tapes has gained worldwide interest for practical applications. In previous study, superconducting properties and workability of the in-situ PIT processed MgB_2 thin wires sheathed with stainless steel have been studied. However, it was difficult to draw MgB_2 thin wires of 0.1 mm in diameter due to work hardening of stainless steel[1]. In present study, superconducting properties and workability of the ex-situ PIT processed MgB_2 thin wires and tapes sheathed with cupro-nickel have been studied relating with the microstructures[2]. The MgB_2 thin wires are attractive to level sensor for liquid hydrogen 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 ex-situ PIT processed MgB_2 thin wires and tapes. Magnesium diboride MgB_2 powder with 10 vol% Indium In addition was packed into a cupro-nickel(Cu-10Ni) tube outside diameter of 6 mm and inside diameter of 3.5 mm. The tube was groove-rolled and then drawn through dies to a round wires of 1 mm in diameter with no crack. The wires were swaged to wires of 0.29 mm in diameter and flat-rolled to tapes of 0.26 in thickness. No heat treatment was performed. The cross-sectional area of the wire and tape are 0.023 mm^2 and 0.022 mm^2, respectively. Sheath/core ratio of the wire and tape is 2.3 as shown in Fig. 1.

Vickers hardness HV of the Cu-10Ni 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 increased gradually with increasing the reduction rate, and rose from 125HV to 175HV at reduction rate of 99.77%(0.29 mm ϕ) and up to 216HV at 99.97%(0.10 mm ϕ), respectively. In previous study, HV hardness of stainless steel sheath exceeded 500HV in reduction rate of 96% and reached 599HV in 99% due to work hardening. Workability of Cu-10Ni is much better than that of stainless steel.

Magnetic field dependence of *Ic* and *Jc* at 4.2 K for Cu-10Ni sheathed MgB_2 thin wires and tapes are shown in Fig. 3. The *Ic* values of the MgB_2 wires and tapes at 4.2 K and self-field are 5.3 A and 7.8 A, which *Ic* values correspond to *Jc* of 230 A/mm^2 and 312 A/mm^2, respectively. In powder addition and hard working as swaging and rolling improved the connectivity between MgB_2 grains, so that high *Ic* and *Jc* were achieved in comparison with MgB_2 wires and tapes by dies drawn and without In powder addition.

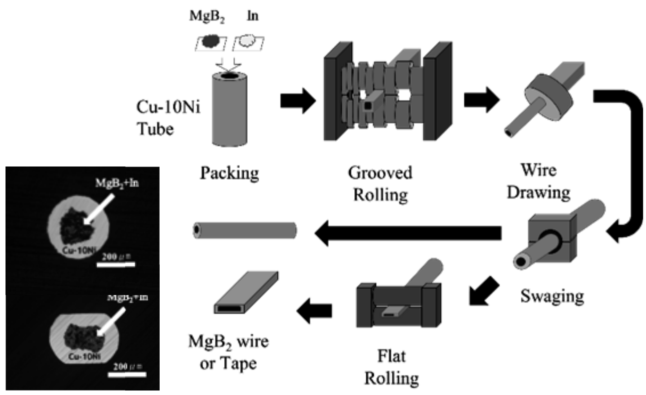

Fig. 1 Preparation procedure of ex-situ PIT processed MgB_2 thin wires and tapes sheathed with cupro-nickel (Cu-10Ni).

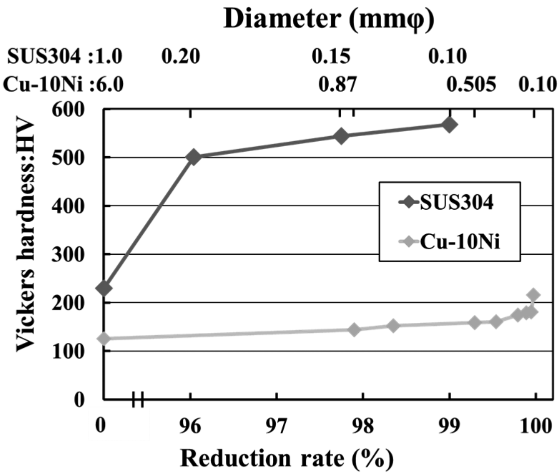

Fig. 2 Vickers hardness of cupro-nickel (Cu-10Ni) sheath versus reduction rate (diameter) of MgB_2 thin wires.

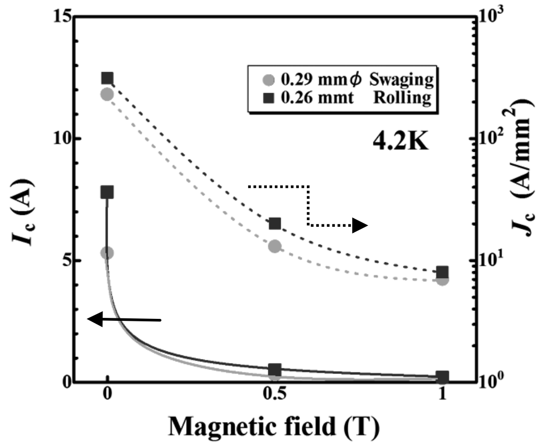

Fig. 3 Magnetic field dependence of *Ic* and *Jc* at 4.2 K for cupro-nickel (Cu-10Ni) sheathed MgB_2 thin wires and tapes.

1) Yamada, Y. et al. :IEEE Trans. Appl. Supercond., 22 (2012) 6200304.
2) Kobayashi, Y. et al. :27th SAS Intel. Sympo., (2015) C-14, 34.