

§20. Fabrication of Low Activation MgB₂ Mono-cored Superconducting Wire for Fusion Reactor

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Since the discovery of superconductivity in the Magnesium diboride (MgB₂) compound, the research and developments of MgB₂ wires were carried out for practical applications under the 20 K operation because of its high critical temperature (T_c) of 39 K, simple binary chemical composition and relatively low cost material. In the future applications, we think that MgB₂ wire is suitable to apply for nuclear fusion reactor because of its radioactivity property is lower than Nb based superconductors. There was report that the half-life of the MgB₂ superconductors until handling level showed within 1 year. We thought that MgB₂ compound will be desirable as candidate materials of “low activation superconducting wire” for a fusion reactor and its wire may have enough competitive for the Nb-Ti alloy superconducting wire according to the progress of critical current density (J_c) improvement. However, it was important to investigate not only J_c improvement but also selection of sheath materials in order to realize “low activation superconducting magnet”. The important factors of metal sheath materials to apply for a fusion reactor were required cold-workability, high mechanical strength, non-magnetization, non-corrosion, non-reaction and low activation. These properties of metal Ta is better than the other metal sheath. In this study, we tried to fabricate the Cu addition using Mg₂Cu compound into MgB₂ wires having metal Ta sheath, and its J_c properties were investigated.

The precursor mixture powder was made by metal Mg powder (99.9%, -200 mesh), Mg₂Cu compound and amorphous B powder (99.9%, -submicron). Mg₂Cu compound was only crushed mechanically to fine powder using ball-milling process to disperse homogeneously into precursor powder. The mixture powder was tightly packed into Fe and Ta tubes (purity of 99.99%). Wire drawing was carried out using grooved-roller and cassette-roller dies, and the precursor wires finally have about 1.04 mm of diameter without intermediate annealing. The prepared wires were heat treated at several temperatures for 10 hours in Ar atmosphere. The transport critical current (I_c) (4.2 K) were measured under magnetic fields up to 15 T by using a DC four-probe method. J_c of all samples were defined as the I_c value divided by the cross-sectional area of the powder-filled core.

The typical J_c -B performance of the 3at%Cu addition samples with Ta sheath is also shown in Fig. 1. The heat treatment condition of 475°C for 200 h was optimum temperature in the Ta sheathed wires, and then the maximum J_c value was obtained to be 500 A/mm² over

at 4.2 K under 6 T which was the highest property in the world. In the case of Ta sheathed wire, J_c property of 200 h treatment sample was remarkably higher than that of 10 h sample. Moreover, it was noteworthy that heat treatment temperature was lowered compared with Fe sheathed samples and then nano-order MgB₂ grains were formed into core. Using of Ta sheath seemed to promote diffusion reaction between Mg and B. Furthermore, the reaction of interface between MgB₂ core and metal Ta were not observed clearly. These suggested that metal Ta was one of the suitable sheath materials for MgB₂ superconducting wire. In order to investigate workability of MgB₂/Ta wire, we tried to fabricate 100 m class long wire with Cu clad. The cross-section of long wire was shown in Fig. 2. We confirmed good workability of Ta sheathed MgB₂ wire. In the future, we make small coil using this long wire and the excitation test of small coil will be carried out.

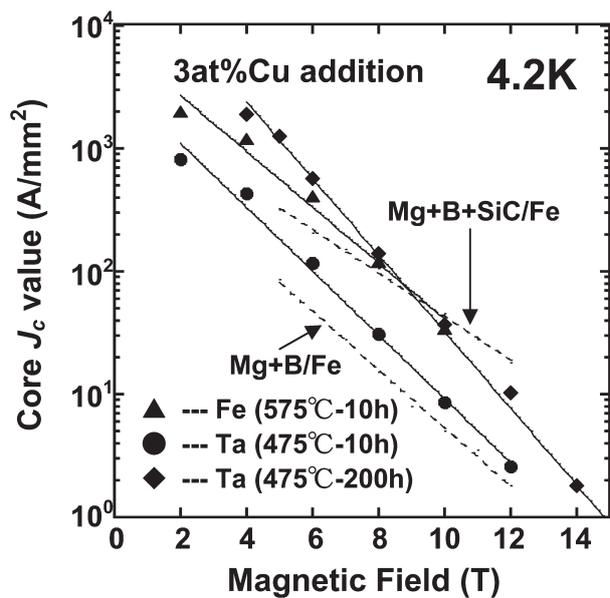


Fig. 1 Typical Core J_c -B performances of Cu addition MgB₂ wires having pure metal Fe and Ta sheath materials.

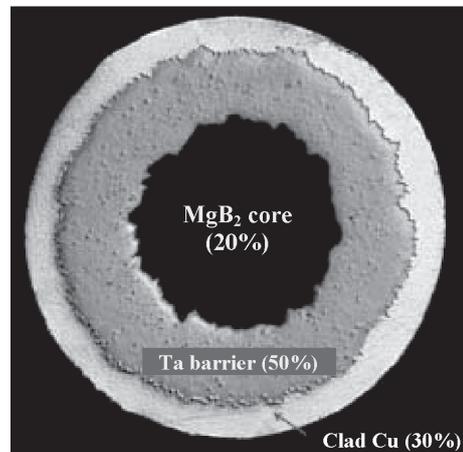


Fig. 2 Typical Optical microscopic image on the cross-section of the MgB₂/Ta/Cu PIT wire.