# §20. Fabrication of Low Activation $MgB_2$ Mono-cored Superconducting Wire for Fusion Reactor

Kikuchi, A., Iijima, Y., Takeuchi, T. (NIMS),
Hishinuma, Y.

Since the discovery of superconductivity in the Magnesium diboride ($MgB_2$) compound, the research and developments of $MgB_2$ 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 $MgB_2$ 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 $MgB_2$ superconductors until handling level showed within 1 year. We thought that $MgB_2$ 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 $Mg_2Cu$ compound into $MgB_2$ 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), $Mg_2Cu$ compound and amorphous B powder (99.9%,-submicron). $Mg_2Cu$ compound was only crushed mechanically to fine powder using ball-milling process to disperse homogenously 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℃ for 200 h was optimum temperature in the Ta sheathed wires, and then the maximum $J_c$ value was obtained to be 500 A/mm$^2$ 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 $MgB_2$ grains were formed into core. Using of Ta sheath seemed to promote diffusion reaction between Mg and B. Furthermore, the reaction of interface between $MgB_2$ core and metal Ta were not observed clearly. These suggested that metal Ta was one of the suitable sheath materials for $MgB_2$ superconducting wire. In order to investigate workability of $MgB_2$/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 $MgB_2$ wire. In the feature, we make small coil using this long wire and the excitation test of small coil will be carried out.

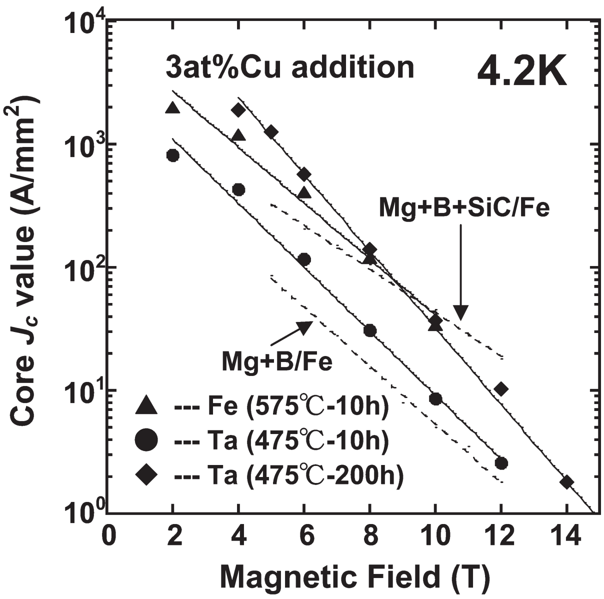


Fig. 1 Typical Core $J_c$-B performances of Cu addition $MgB_2$ wires having pure metal Fe and Ta sheath materials.

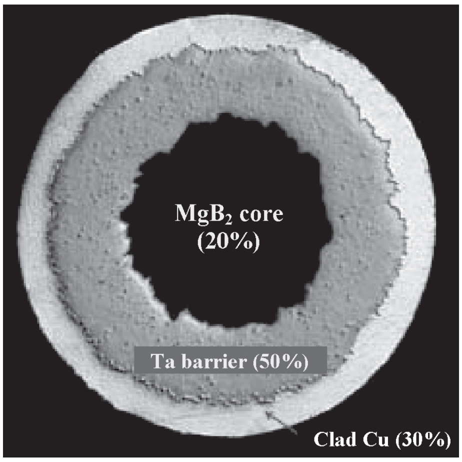


Fig. 2 Typical Optical microscopic image on the cross-section of the $MgB_2$/Ta/Cu PIT wire.