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

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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. T. Noda et al. was reported that the half-life of the $MgB_2$ superconductors until handling level showed within 1 year [1]. However, $J_c$ value of $MgB_2$ wire is lower, and its property need to have competitive for the Nb-Ti alloy superconducting wire in order to realize practical applications. We tried to fabricate the Cu addition using $Mg_2Cu$ compound into $MgB_2$ wires having metal Ta sheath and reported that $J_c$ properties were improved by the small amount of $Mg_2Cu$ addition. In this study, we tried to fabricate 100 m scaled long wire in order to investigate the possibility of commercial wire deformation for practical applications. Furthermore, we also made the small solenoid coil using long $MgB_2$ wire and excitation test of the small coil was carried out.

The precursor mixture powder was made by metal Mg powder (99.9%, -200 mesh), $Mg_2Cu$ compound and amorphous B powder (99.9%,-submicron). The mixture 1at%Cu addition powder was tightly packed into the inner area of Ta /Cu tubes. Ta sheath is barrier material between Mg and Cu diffusion. Wire drawing was carried out at SWCC Co. Ltd based on the research collaboration, and we confirmed that the long wire which had about 1.30 mm of diameter without the breaking. We reconsidered heat treatment condition in order to make $MgB_2$ coil and the low temperature diffusion was approached. This process was lower temperature and long time sintering and its pattern was suitable to apply the solenoid coil. A part of the long wire was heat treated at 450℃ for several hours above 100 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 1at%Cu addition samples by the low temperature diffusion at 450℃ is shown in Fig. 1. $J_c$ property in the low temperature diffusion was improved by the extending of heating time. In the case of 450℃, The optimum time was 200 hours and the maximum $J_c$ value was obtained to be 500 A/mm$^2$ over at 4.2 K under 6 T. Furthermore, $J_c$ property of $MgB_2$ wire via low temperature diffusion was higher than that of commercial Nb-Ti wire under the low magnetic field below 3 T. This suggested that $MgB_2$ wire via low temperature diffusion process was one of the alternative materials of the Nb-Ti wire at 4.2 K application. In order to investigate workability of $MgB_2$/Ta wire via low temperature diffusion, we tried to fabricate small solenoid coil using 100 m scaled long wire and excitation test was carried out. The typical excitation test result is shown in Fig. 2. The five excitation test was carried out with changing sweep rate. The coil $I_c$ was obtained to be 230 A and no $I_c$ degradation and sweep rate dependence of the coil were observed during excitation test. The center magnetic field of the coil was obtained to be 2.62 T, and the load factor of the coil was comparable to 88 % from the coil $I_c$ value and generated magnetic field. We confirmed good workability of Cu addition $MgB_2$/Ta/Cu mono-cored wire for long direction.

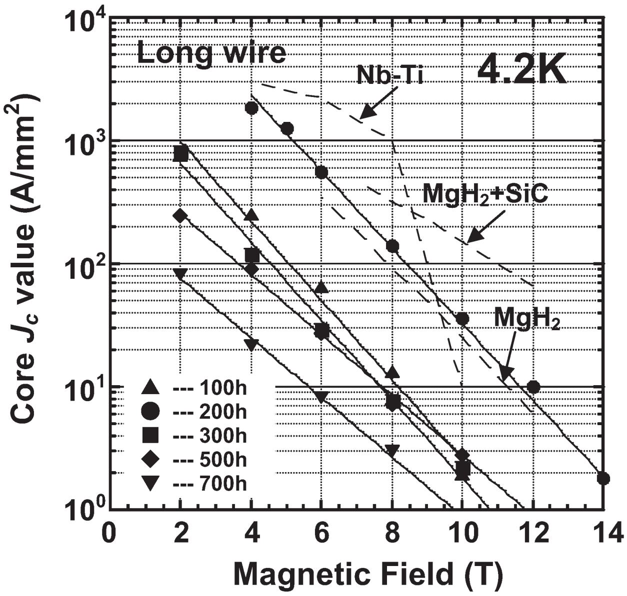


Fig. 1 Typical Core $J_c$-B performances of the 1at%Cu addition $MgB_2$ wire by the low temperature diffusion at 450℃.

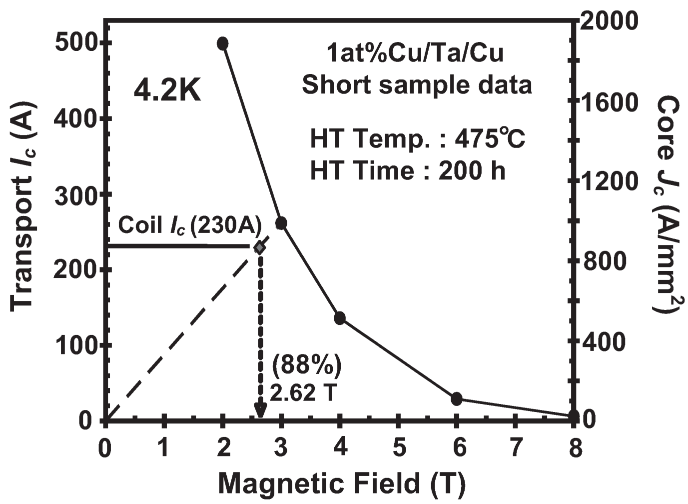


Fig.2 The excitation test result of the small solenoid coil made by 100 m scaled long $MgB_2$ /Ta/Cu mono-cored wire.

[1] T. Noda et al., J. Nucl. Materi. 329-333 Part.2 (2004) 1590-1593.