§8. Superconducting Properties of Cu Addition MgB_2 Superconducting Wires under Liquid Hydrogen Temperature

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The construction of the lower carbon society has been closed up largely as part of the restraining the warming of earth's atmosphere. The nuclear-fusion power generation is one of the clean energy sources for the lower carbon society. We have proposed that the simultaneous transport both superconducting power transmission and liquid hydrogen as the new energy sources, which is so-called "Hybrid Energy Transfer Line (HETL)" [1]. In the view points of the social restore of the fusion technology, we have developed Cu addition MgB_2 superconducting cable made in NIFS under liquid hydrogen temperature (20 K). In previous study, I_c-B performances of Cu addition MgB_2 wire under various temperatures from 4.2 K to 30 K were measured to investigate J_c property around high temperature region. We found that Cu addition MgB_2 wire via low-temperature diffusion process was the influential candidate material for the HETL [2]. The feature of the Cu addition MgB_2 wire via low-temperature diffusion process is higher J_c property below magnetic field of 4 T compared with Nb-Ti alloy wire [2]. In the large current superconducting cable such as HETL, the transport I_c performance is important factor compared with magnetic field property. However, many non-reactive boron particles were observed into MgB_2 core matrix by SEM observation. These non-reactive boron particles were act as the barrier of current path. Consequently, microstructure control was one of the most effective to enhance superconducting properties.

In order to improve the superconducting properties of Cu addition MgB_2 wire, the optimum nominal boron composition to of Cu addition MgB_2 wire was reconsidered. In our case (Cu addition using Mg_2Cu compound), MgB_2 formed by the low-temperature diffusion process, and this reaction route is following as;

$$(0.94\ Mg + 0.03\ Mg_2Cu) + 1.97\ B = 0.985\ MgB_2 + 0.015\ MgCu_2 \quad \text{---- (1)}$$

The stoichiometric boron composition in our case was obtained to be 1.97 mol. In order to investigate optimum nominal boron composition on the superconducting properties, the various mono-cored precursor wires which had nominal boron composition from 1.57 mol to 2.17 mol were prepared. The nominal boron composition of Cu addition MgB_2 precursor wires via low temperature diffusion process summarized to the Table.1. The precursor powders adjusted nominal boron composition from 1.57 mol to 2.17 mol were packed into metal Ta tube. MgB_2/Ta composite tubes were carried out wire deformation using drawing dies to 1.04 mm diameter. These prepared mono-cored wires were heat-treated at 500℃ for 200 hours in Ar atmosphere.

Table.1 The nominal composition of Cu addition MgB_2 precursor wires via low temperature diffusion process

	Nominal B composition	Variation
Sample A	1.57	-20%
Sample B	1.67	-15%
Sample C	1.77	-10%
Sample D	1.88	-5%
Sample E	1.98	0%
Sample F	2.07	+5%
Sample G	2.17	+10%

The Magnetization (M)-Temperature (T) curves of Cu addition MgB_2 wires having various nominal boron compositions are shown in Fig.1. These M-T curves were measured by SQUID magnetometer. No change of the critical transition temperature (T_c) values in the MgB_2 wire having various nominal boron compositions was observed. It suggested that the difference of nominal boron composition was not effective factor in T_c property. However, T_c value of the sample having excess nominal boron composition (B=2.17) was remarkably smaller than those of other nominal boron composition. The magnetic moment shown in Fig.1 was normalized using MgB_2 core volume. This normalized magnetization is obtained the MgB_2 volume fraction in the core. On the samples having much smaller nominal boron composition (1.57~1.87 mol), large magnetization width showed clearly compared with stoichiometric nominal boron composition (B=1.97) samples, and it suggested that MgB_2 volume fraction was able to be increased by the poor nominal boron composition. In the future, nominal boron composition effect for the transport J_c property will be investigated.

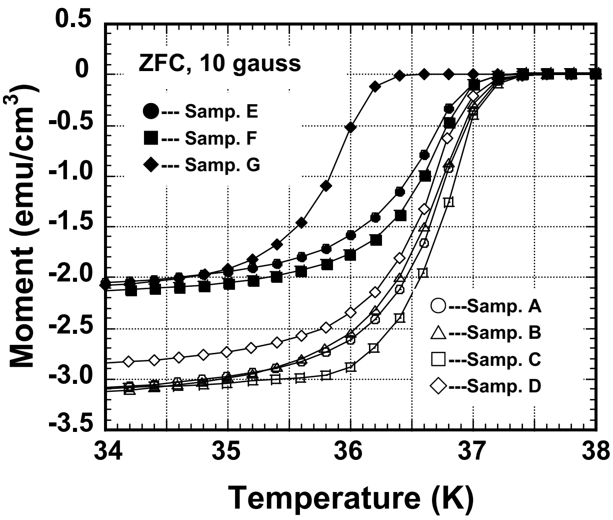

Fig.1 The nominal boron composition dependence of T_c and magnetization widths in Cu addition MgB_2 precursor wires via low temperature diffusion process (500℃×200h)

[1] S. Yamada et. al, 2008 *J. Phys.: Conf. Ser.* **97** 012167.
[2] Y. Hishinuma et.al, SUST, **20** (2007), p.1178-1183