§22. The Comparisons of Superconductivity between Low Activation MgB_2 Wires using Various Kinds of the Boron-11 Isotope Powders

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MgB_2 compound has higher critical temperature (T_c) value, which value was obtained to 39 K, and is also composed by the simply chemical composition and the relatively lower cost materials such as magnesium (Mg) and boron (B). In addition, it is well known that MgB_2 compound is one of the low activation superconducting materials alike various V-based superconductors (V_3Ga and $V_2(Hf,Zr)$ Laves phase), because half-life time of the MgB_2 is estimated to be about 1 month and it is much shorter than that of Nb-based superconductors such as Nb-Ti and Nb_3Sn.

On the other hand, the natural boron material consists of two kinds of isotopes such as the ^{10}B and ^{11}B. The natural abundance of these isotope is known as the 19.78 % of ^{10}B and the 80.22 % of ^{11}B, respectively. The ^{10}B isotope has larger neutron absorption reactive cross section compared with the ^{11}B isotope, and it is unstable against the neutron irradiation. Finally, the ^{10}B isotope and is easy to transform to helium gas by the (n, α) nuclear reaction. We thought that the ^{10}B isotope was unacceptable as the boron source material to make the low activation MgB_2. The ^{11}B isotope is more stable against the neutron irradiation without (n, α) nuclear reaction. So, the ^{11}B isotope promoted the low activation property and was the most preferable boron source material of the MgB_2 wire under the neutron irradiation environment application.

In this study, we fabricated various Powder in-tube (PIT) processed MgB_2 wires using crystallized and amorphous ^{11}B isotope powder as the boron source. And, the comparisons of critical current density (J_c) between different kinds of ^{11}B isotope powders as the boron source material was investigated.

The particle size distributions of various ^{11}B isotope powder as the boron source in this study is shown in Fig. 1. In the case of the crystallized ^{11}B isotope powder (Sample A and B), the particle size was distributed in the wide range between 20 μm and 0.2 μm. The average particle size of these powders were obtained to be 5.70 and 1.443 μm, respectively. On the other hand, in the case of the amorphous ^{11}B isotope powder (Sample C), the particle size was distributed in the narrow range between 2.0 μm and 0.2 μm. The average particle size was obtained to be 0.863 μm.

Comparisons of core J_c-B properties in Cu addition MgB_2/Ta/Cu multifilamentary wires using various ^{11}B isotope powder is shown in Fig. 2. J_c property was improved with smaller average particle size of the ^{11}B isotope powder. J_c improvement was caused by the increase of the MgB_2 volume fraction due to the smaller particle size of the ^{11}B isotope powder. MgB_2 phase was formed by the Mg-B solid diffusion reaction, and the diffusion distance of Mg to B was estimated to about 500 nm from the kinetic reaction rate constant[1)]. Therefore, the fine particle size was one of the effective to increase of MgB_2 volume fraction.

Furthermore, J_c value of the amorphous ^{11}B isotope powder sample was obtained to above 1,000A/mm^2 at 4.2 K under 3 T, and J_c-B performance was higher than that of the crystallized ^{11}B isotope powder. These suggested that the finer particle amorphous isotope powder was preferable ^{11}B source material to improve J_c property.

1) J. D. DeFouw et al., Acta Mater., **56**, (2008), 5751.

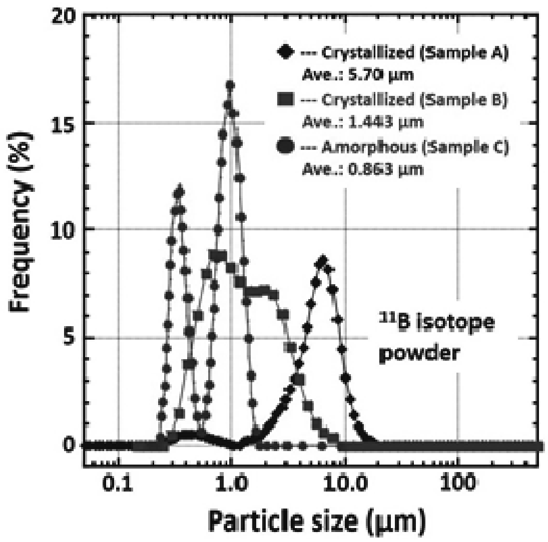

Fig.1 The particle size distributions of various ^{11}B isotope powder as the boron source in this study

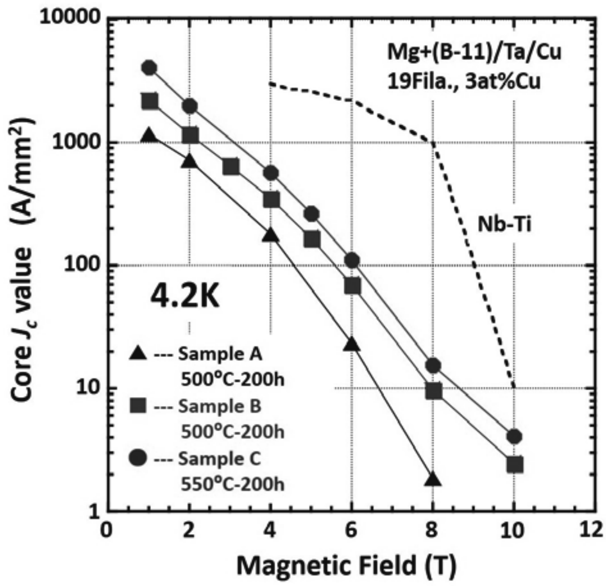

Fig.2 The Comparisons of core J_c-B property in the MgB_2/Ta/Cu multifilamentary wires using various ^{11}B isotope powder