§28. Fabrication and Superconductivity of Low Activation MgB_2 Wire Using Small Particle Sized Boron-11 Isotope Powder

Hishinuma, Y., Yamada, S.,
Kikuchi, A. (NIMS),
Shimada, Y., Hata, S. (Kyushu Univ.),
Matsuda, K. (Univ. Toyama)

The future Deuterium (D) –Tritium (T) self-burning fusion reactor is sure to form 14 MeV neutron and alpha particle. The superconducting magnet to confine D-T plasma will be irradiate high energy neutron, and it was activated significantly. For example, the decay time of the Nb-based superconductors such as Nb-Ti, Nb_3Sn and Nb_3Al was estimated to be above 20,000 years. On the other hands, the decay time of V_3Ga and MgB_2 are within 1 year. We thought that MgB_2 and V_3Ga will be promising candidate and alternative materials of the "Low activation superconducting magnet system", and then MgB_2 is alternative material of commercial Nb-Ti. We reconsidered the raw materials in order to improve the superconductivity and activation property. The commercial natural Boron powder consists of two kinds of isotopes powder, which are boron-10 (^{10}B; 19.78%) and boron-11 (^{11}B; 80.22%). The nuclear reaction cross-section of the ^{11}B isotope is shown in fig. 1 The ^{11}B isotope is stable for the neutron irradiation without (n,α) reaction and it can reduce nuclear heating from 2.58 to 0.13 W/cm^3. The both larger temperature margin (Tc-liquid helium) and the reduced nuclear heating will be contributed to the cooling system simplification.

In this study, we approached to the critical current density enhancement by the small particle size of the ^{10}B isotope powder. We prepared the two kinds of average particle sized ^{11}B isotope powders, which were obtained to 5.70 and 1.44 μm. These ^{11}B isotope powders were used as the boron source material to make 19-core MgB_2 wire via PIT process, and then they are so-called "Coarse B sample" and "Fine B sample", respectively. Fig.2 shows that the magnetization loops of the 19-core MgB_2 wires using different particle sized ^{11}B isotope powders. The magnetization width of the fine B sample was increased compared with the coarse B sample, it mentioned that the MgB_2 volume fraction was increased by the fine particle sized ^{11}B isotope powder. Generally, it is well known that MgB_2 phase was formed by the Mg-B diffusion reaction, and the diffusion distance of Mg to B was estimated to 300 ~ 500 nm from the kinetic reaction rate constant[1]. They suggested that the fine particle sized ^{11}B isotope powder was effective to increase of MgB_2 volume fraction. Fig. 3 shows that comparison between J_c-B performances of the 19-core MgB_2 wires using different particle sized ^{11}B isotope powders. J_c-B performance of the fine B sample was improved compared with that of coarse B sample. This is caused by the increase of MgB_2 volume fraction. Furthermore, J_c-B performance of fine B sample was comparable to the crystalized natural B sample. We thought that finer particle sized ^{11}B isotope powder required to the further J_c-B improvement.

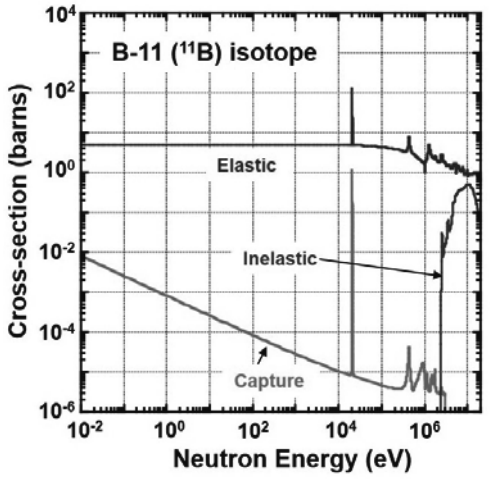

Fig. 1 The nuclear reaction cross-section of the ^{11}B isotope

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

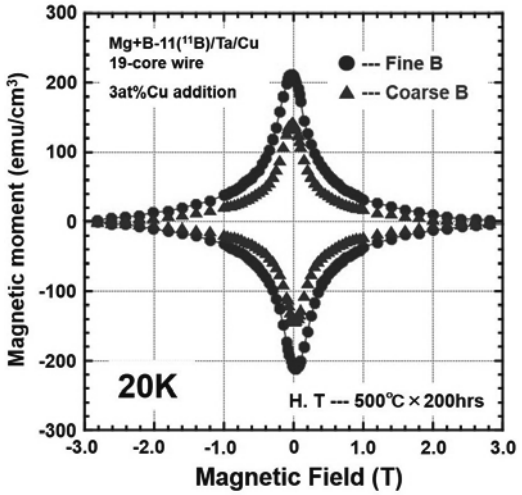

Fig. 2 The magnetization loops of the 19-core MgB_2 wires using different particle sized ^{11}B isotope powders

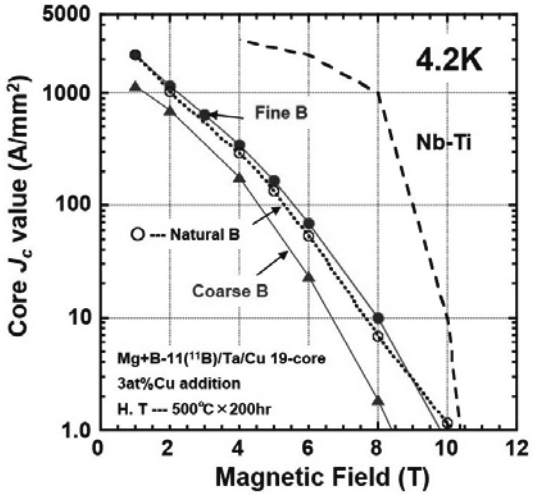

Fig.3 Comparison between J_c-B performances of the 19-core MgB_2 wires using different particle sized ^{11}B isotope powders