§2. Effect of Grain Refinement of ^{11}B Powders in an *In-situ* Fabrication Process of MgB_2 Superconducting Wires

Shimada, Y., Kashiwai, T., Hata, S., Nakashima, H. (Kyushu Univ.),
Hishinuma, Y.

MgB_2 superconducting wire is considered to be promising for using in a nuclear fusion reactor [1]. For practical use of MgB_2 wires under neutron irradiation, there are several fundamental issues. The first issue is about nuclear characteristics of boron. There are mainly two types of boron isotopes: B-10 and B-11. Because B-11 has neutron irradiation resistance, an MgB_2 superconductor being stable against neutron irradiation ($Mg^{11}B_2$) can be fabricated using B-11 as a starting material. The second issue is about non-reactive B grains in fabricated MgB_2 wires. The remaining non-reactive B grains degrade superconducting properties of MgB_2 fabricated by an *in-situ* process [2]. The size of non-reactive B grains may depend on the size of initial B powders before heat treatment to form MgB_2. Because a typical grain size of commercial B-11 powders is large (>5 μm), grain refinement of commercial B-11 powders may be effective for reducing the amount of non-reactive B-11 grains in MgB_2 wires. We investigated the grain refinement of B-11 powders on magnetic susceptibility and microstructure in MgB_2 wires.

We carried our grain refinement of a commercial B-11 powder using a ball-milling process. The average B-11 grain size was refined from 5 μm to 1.44 μm by the ball milling. MgB_2 wires were fabricated by an *in-situ* process using a mixed powder of Mg powder and the coarse (commercial) or refined B-11 powder. The magnetic susceptibility was measured at 10 K using an MPMS-7 superconducting quantum interference device (SQUID). Scanning transmission electron microscopy (STEM) observation was carried out for microstructural characterization. Samples for the STEM observation were prepared by a focused ion beam (FIB) milling process.

Figure 1 demonstrates the effectiveness of the B-11 grain refinement on the magnetization of MgB_2 wires at 10 K. The magnitude of magnetization is larger for the fine powder (Fine B-11) than the coarse powder (B-11).

STEM microstructural observation revealed that use of the finer B-11 powder increases a volume fraction of the superconducting MgB_2 phase in the MgB_2 wires. This microstructural observation result is consistent with the magnetic susceptibility result in Figure 1. However, as shown in Figure 2, non-reactive B areas still remain even in the MgB_2 wire fabricated using the finer B-11 powder. Therefore, the further refinement of B-11 powder and/or the further optimization of the *in-situ* fabrication process are necessary to improve superconducting properties of $Mg^{11}B_2$ wires.

1) Hishinuma, Y. *et al.*: *IEEE Trans. Appl. Supercond.* **17** (2007) 2798-2801.
2) Shimada, Y. *et al.*: *IEEE Trans. Appl. Supercond.* **21** (2011) 2668-2671.

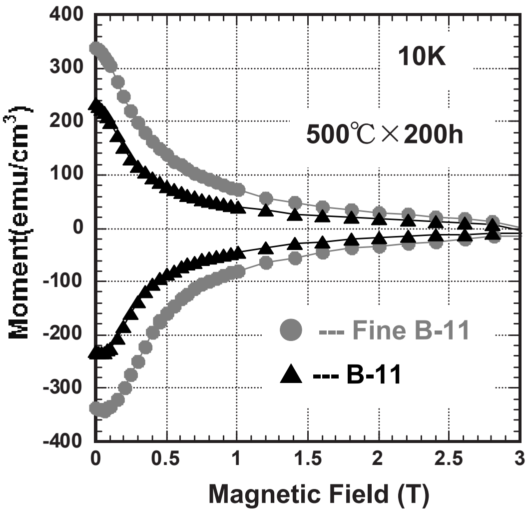

Fig. 1. Magnetization curves at 10 K for MgB_2 wires fabricated using a coarse (commercial) B-11 powder (B-11) or a fine (ball-milled) B-11 powder (Fine B-11).

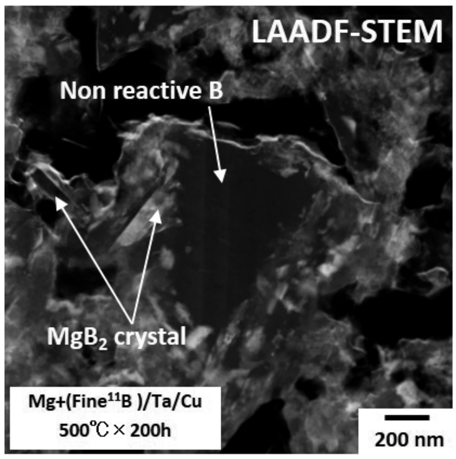

Fig. 2. STEM annular-dark field image of MgB_2 wire fabricated using the fine B-11 powder.