§8. Influence of Boron Particle Size on Nanostructure of Low Activation MgB_2 Wire

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MgB_2 is expected superconducting material for using in nuclear fusion reactors because its radioactivity property is lower than Nb-based superconductors. Then, it is effective for fabrication homogenous structure to heat treat at low temperature for a long period. Hishinuma *et al.* reported a new synthesized process using an Mg_2Cu compound instead of pure metal Mg [1]. At the process, high T_c (37-39 K) MgB_2 wire can be fabricated at 150℃ lower temperature than Mg melting point. From our previous study, the critical current properties of Mg_2Cu doped MgB_2 are strongly affected by morphology of initial B powders. In this study, we try to estimate influence on microstructure and critical current of morphology of initial B powders.

The precursor powders are mixed Mg, Mg_2Cu and B powders the ratio of 0.94 : 0.03 : 1.97. The powders filled in Ta sheath and heat-treated for fabricating MgB_2 phase. The prepared wires were heat-treated at several temperature from 450 to 550 °C for 200 h in an Ar atmosphere. The initial B powders were used 2 kinds powders, natural B and B-11 powders. The each average B grain sizes were about 0.88 μm. The ratio of B-10 to B-11 of natural B powder is 2 : 8 as the same as that of natural isotope. The critical current properties were measured by four-terminal method. The microstructural observation were carried out by using scanning electron microscopy (SEM), transmission electron microscopy (TEM) and scanning-TEM (STEM).

The J_c shows the highest value, 1800 A･mm^{-2}, at the wire using natural B powder heat-treated at 500 °C. In contrast, the J_c of the wire using B-11 powder heat-treated at 550 °C has 2100 A･mm^{-2}, which is the highest value among the all wires fabricated in this study.

Figure 1 show STEM-BF images and electron diffraction patterns of non-reacted B in MgB_2 wires fabricated at 500 °C for 200 hour using Natural B (a) or B-11 (b) powders. The non-reacted B grains in the wire using natural B are amorphous phase. In contrast, those of the wire using B-11 are crystalline phase having the size of more than 1 μm. The permeation distance into B of Mg atoms is estimated less than 500 nm at lower temperature than melting point of Mg (650 °C) [2]. In addition, the required temperature to react with Mg of crystalline B is higher than these of amorphous B. Therefore, the residual B of large size is formed by remaining the crystalline B grain as non-reacted B after heat treatment. It indicates the crystalline B grains of the large size react at 550 °C and the J_c of the wire using B-11 powders heat-treated at 550 °C is higher than these of the wire heat-treated at 500 °C. Furthermore, the large size B grains may reduce mobility of powders under wire drawing and fabricate inhomogeneous structure.

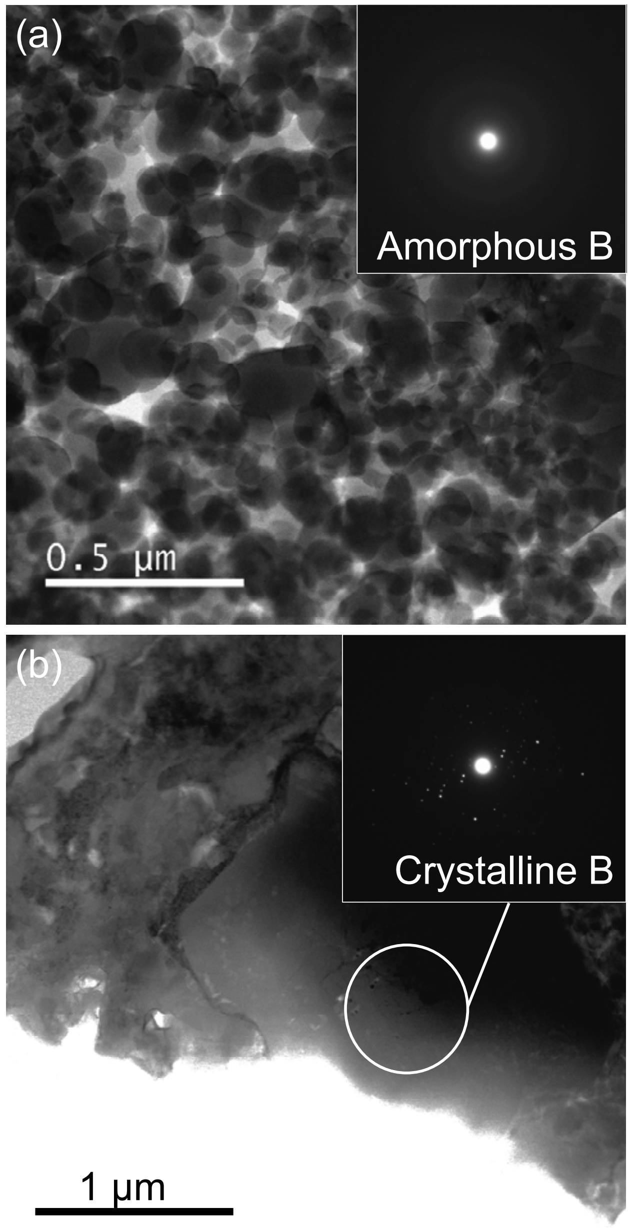

Fig. 1. STEM-BF images of non-reacted B in MgB_2 wires using Natural B (a) or B-11 (b) powders.

1) Y. Hishinuma et al.: Supercond. Sci. Technol. **20** (2007), 1178-1183.
2) J. D. DeFouw, D. C. Dunand: Physica C **470** (2010), 648–653.