§1. Increase of MgB_2 Phase Volume Fraction by the Reduce Particle Sized Boron Powder

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1. Introduction and Motivation

MgB_2 has higher critical transition temperature (T_c) of 39 K compared with the other metallic superconducting compounds. Furthermore, the features of MgB_2 compound are not only higher T_c but also binary chemical composition, lower specific gravity and lower cost. In addition, it is well known that MgB_2 compound is one of the low activation superconducting materials. The induced radio-activity of MgB_2 compound remarkably lower than that of Nb-based superconducting materials, and the half-life period of MgB_2 compound was estimated within 1 year. MgB_2 will be one of the attractive superconducting materials to use under the higher neutron irradiation and flux environment applications such as future fusion reactor, and then it will be alternative material of Nb-Ti wire in these field applications. However, critical current density (J_c) of MgB_2 wire was remarkably lower than Nb-Ti wire, and J_c enhancement is required to apply for the fusion application. In previous studies, the secondary (impurity and non-reactive) phase and voids were observed in MgB_2 matrix after the heat treatment, and then these are the lowering factors of J_c property. In order to improve J_c property by microstructure control of MgB_2 matrix, the reduce particle sized metal boron powder was prepared as the raw boron material on the in-situ MgB_2 wire.

2. Sample and reduce particle sized boron powder preparations

Precursor mixture powders were made by metal Mg powder (99.9%), Mg_2Cu compound and conventional natural boron powder. The Cu additional composition of precursor powder was fixed to the optimum 3 at%Cu. The reduce particle sized boron powder was made using the high-speed vibrated milling. Boron powder and tungsten carbide (WC) ball were set into the WC pot. When boron powder was set into the WC pot, liquid nitrogen was also used in order to drive off the air gas. The milling time was 1, 3 and 5 minutes. The particle size distributions of some reduce particle sized boron powder are shown in fig.1. The particle size distributions of the boron powder after various vibrated milling time are shown in Fig. 1. The particle size distribution of conventional boron powder had two main peaks around 1.5 and 0.5 μm, and then average particle size was obtained to 1.07 μm. In the case of the atomized boron powder using high-speed vibrated milling during 1 minute, the particle size distribution was also shown two main peaks around 0.5 and 0.2 μm, and then average particle size was obtained to 0.22 μm, which value was corresponded to about 1/5 compared with conventional boron powder. These mentioned that the particle size of boron powder could be reduced by the high-speed vibrated milling. According to the XRD analysis of all atomized boron powders, the diffraction peaks of B_2O_3 phase were not observed at all. The liquid N_2 into WC pot was effective to restrain the boron oxidation.

3. Increase of MgB_2 phase volume fraction by reduce particle sized boron powder

Typical magnetization curves of MgB_2 wires using reduce particle sized boron powder as a function of the vibrated milling time is shown in Fig. 2. The magnetic moment was normalized by the total volume of wire filaments. T_c values of MgB_2 wire using reduce particle sized boron powder were almost obtained to 36.5 K and they were same to the MgB_2 wire using conventional boron powder. On the other hands, magnetization moment which was normalized by the total core volume was increased by the reduce particle sized boron powder. This suggested that the volume fraction of MgB_2 phase was increased and reduce particle sized boron promoted to form MgB_2 phase.

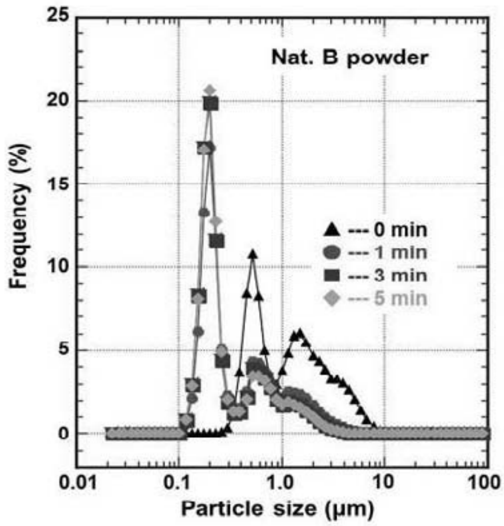

Fig.1 Typical particle size distributions of the boron powder after various vibrated milling time

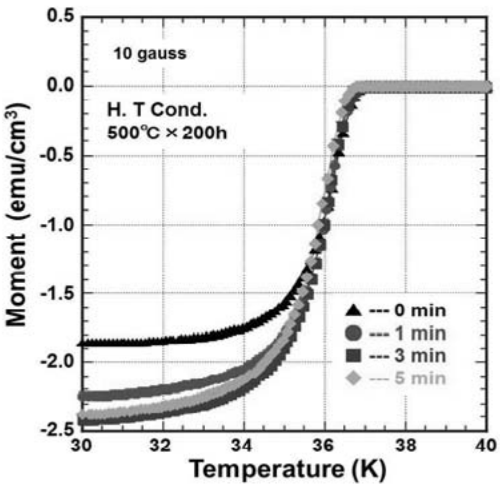

Fig.2 Typical magnetization curves of MgB_2 wires using reduce particle sized boron powder as a function of the vibrated milling time