§13. Microstructural of MgB_2 Wires Fabricated by Low-temperature In-situ Processes with Mg_2Cu Addition

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An in-situ powder-in-tube (PIT) process using Mg, B and Mg_2Cu as starting powders is a promising process to fabricate MgB_2 wires at low temperatures below 773 K[1]. We investigated microstructure in the MgB_2 wires using transmission electron microscopy (TEM) and scanning transmission electron microscopy (STEM).

Foil specimens for TEM/STEM observation were prepared by focused ion beam (FIB) microsampling and milling techniques. TEM/STEM observation and energy dispersive x-ray spectroscopy (EDX) analysis were carried out at accelerating voltage of 200 kV.

MgB_2 crystals below 300 nm in sizes have plate-like shapes with (001) facets (Fig. 1), suggesting a reaction of solid B and liquid Mg-Cu. The average size of MgB_2 crystals increases with the amount of Mg_2Cu while the amount of residual B decreases. Two kinds of Mg-Cu compounds, Mg_2Cu and Cu_2Mg, are formed during the heat treatment process. Spaces between the plate-like MgB_2 crystals are filled with the Mg-Cu compounds showing orientation relationships with (001) planes of the plate-like MgB_2 crystals (Fig. 2). These Mg-Cu compounds formed between MgB_2 grain boundaries may be effective for enhancing magnetic-flux pinning but not effective for MgB_2 grain growth suppression because these compounds are formed after the crystallization of MgB_2 crystals. From critical current measurements, the optimum amount of Mg_2Cu addition is 3 mol%. This value may be determined from the microstructural advantages and disadvantages of the Mg_2Cu addition in the in-situ PIT process.

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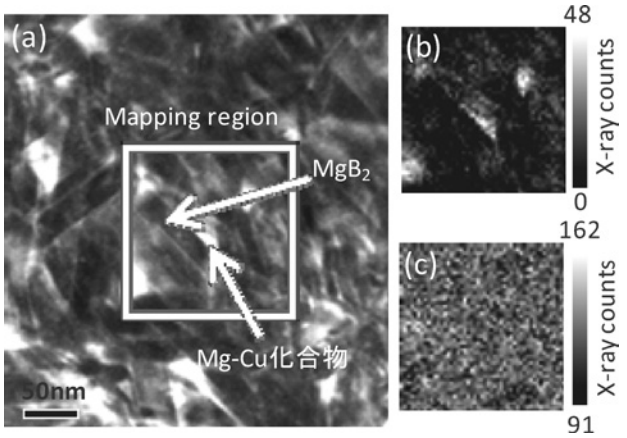

Fig. 1. STEM-EDX observation in a MgB_2 wire prepared by heat treatment at 457°C for 200 h. (a) STEM high-angle annular dark-field image, (b) Cu map and (c) Mg map.

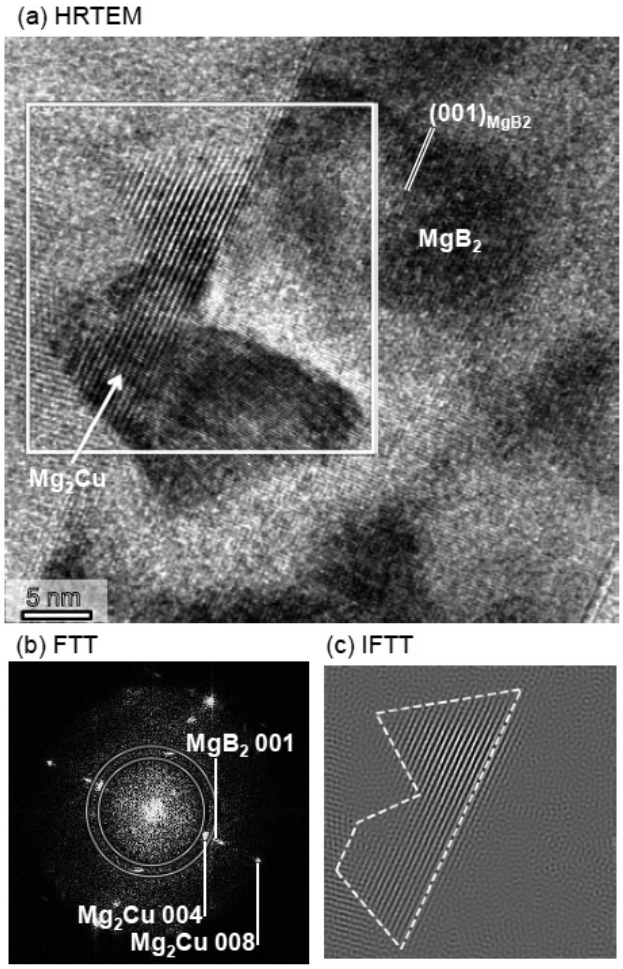

Fig. 2. Mg_2Cu phase formed on the (001) plane of MgB_2 phase. (a) HRTEM image, (b) Fourier power spectrum of the square region depicted in (a), and (c) an inverse Fourier filtering image using a doughnut-shaped aperture function depicted in (b).