WBP1-3

Optimization of Sintering Conditions for Synthesizing Dense Magnesium Diboride Bulk Superconductors via Ex-Situ Spark Plasma Sintering Method

*Longji J Dadiel[1], Pavan K. N Sugali[2], Jun Sugiyama[1], Hiraku Ogino[2], Naomichi Sakai[1], Tetsuo Oka[1], Masato Murakami[1]

Shibaura Institute of Technology, Tokyo, Japan[1]
National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan[2]

Along with relatively high superconducting transition temperature (T_c), light weight, nontoxic, scalability, and simple synthesis procedures makes MgB_2 superconductors to be one of the promising candidates for accomplishing portable magnetic devices. Bulk superconductors developing for high field magnets, very high critical current density (J_c) values are required. Spark plasma sintering (SPS) is known as rapid synthesis method, suppressing the grain growth, and producing bulk products with high density into compact shapes. Therefore, the method is suitable to synthesize bulk MgB_2 [1, 2]. In this work, we have tried to synthesize bulk MgB_2 via SPS method with several synthesis conditions.
A series of samples were fabricated by varying the pulsed current intensity (350 A – 500 A). As the current intensity increased, MgB_2 decomposed mainly to MgB_4 and MgO. The impurity phase fraction was increased with raise in the pulse intensity while densification was not occurred at lower current and the 400 A was observed to be the best condition. The microstructural characterization reveals that the size of the MgB_2 grain was to be ~200 nm - 500 nm. Compared to the conventional solid-state sintering method, SPS samples own dense microstructures with remarkable grain connectivity. The obtained bulk MgB_2 materials were ~95 % dense as compared to a sintered product which possesses ~60%. The onset of T_c determined by SQUID magnetometry was ~38 K. The J_c of the sample fabricated by applying current of 400 A was exhibiting 220 kA/cm^2 at self-field and 20 K which is superior to the previous reports [1, 2]. Present results revealed that the SPS is a promising way to fabricate dense samples with improved grains connection and better densification of the bulk MgB_2 superconductors, which could be an important variant for magnetic applications. However, optimization of several parameters such as dwell time, applied pressure, doping, etc., can effectively enhance the flux pinning hence the J_c performance.

[1] J. G. Noudem et al., Journal of Applied Physics 116, 163916 (2014).
[2] C. E. J. Dancer et al., Supercond. Sci. Technol. 22, 095003 (2009).

Keywords: MgB2, Spark plasma sintering, Critical current density, Dwell time