§27. Evaluation for Superconducting Property of Extruded MgB_2/Al Composite Material Wires Fabricated via 3 Dimensional Penetration Casting Method

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B, Mg and Al are low activation elements and these are possible to apply for a low activation superconducting magnet in the new advanced fusion reactor. MgB_2 superconductor is also one of those materials and its wires have been fabricated by the PIT method. Our research group is developing hybrid aluminum based composite materials reinforced by functional ceramic powders using by our special technique so-called 3 dimensional penetration casting (3DPC) method. Fabrication of a billet of MgB_2/Al composite materials by 3DPC method, extrusion of its billet to 10mmϕ rods, 3mmϕ and 1 mmϕ wires have been succeeded. Their onset Tc have been confirmed about 39 K [1]. Our subject in this research is as follows:

1. Refinement of MgB_2 particles to improve extrudability of MgB_2/Al composite material.
2. Indium (In) addition to aluminum matrix to improve Jc.
3. Application of Mg for the matrix of the composite.

MgB_2 powders were provided by Kojundo Chemical Laboratory Co., Ltd., at purity higher than 99% and with size smaller than 40 μm. Received powders were gently ground in an agate mortar to break any aggregation, refined and filtered smaller than 25μm. The procedure for forming a composite material billet by 3DPC method was described in our recent report in detail [1]. 99.9% In-ribbon was added in to the molten Al matrix before 3DPC method. The volume fraction of MgB_2 powders was about 40 - 60 %. Also this billet was extruded by a hot-extruding machine of 50 t or 400 t to a rod 10 mmϕ in diameter, and to 3mmϕ and 1 mmϕ wires. Superconducting, thermal properties and electrical resistivity were measured by means of the Physical Property Measurement system (PPMS) and SQUID (Quantum Design, Co., Ltd.).

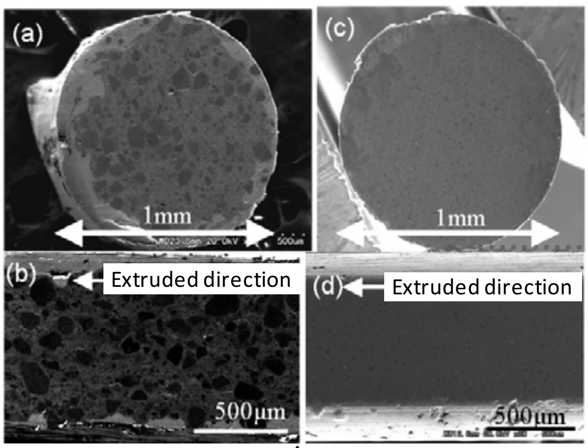

Fig. 1 SEM images of extruded 1mm↕ MgB2/Al wires. (a) cross section and (b) longitudinal section obtained for normal particles. (c) cross section and (d) longitudinal section obtained for refined particles.

Fig. 1 shows SEM images of extruded 1mmϕ MgB_2/Al wires. Comparing to normal particles of MgB_2 ((a), (b)) and refined MgB_2 ((c), (d)), no aggregation and cracks have been observed. Fig. 2 shows relation between *Jc* and applied magnetic field for In-free MgB_2/Al and In added MgB_2/Al composite materials. *Jc* was calculated using Bean's equation. *Jc* of In-added MgB_2/Al composite materials showed higher *Jc* at higher magnetic field than that of In-free MgB_2/Al composite material. This is suggested that In-addition to Al-matrix is effective for higher *Jc* of MgB_2/Al composite material. Fig. 3 shows the relation between temperature and for Mg-based MgB_2 composite materials. Mg- or Mg alloy-based MgB_2 composite materials fabricated our 3DPC method have been also showed drastic decreasing of *Tc* around 37-39K as well as MgB_2/Al composite materials, successfully.

[1] Matsuda K., et al., Mater.Trans. **47, (2006)** 1214.

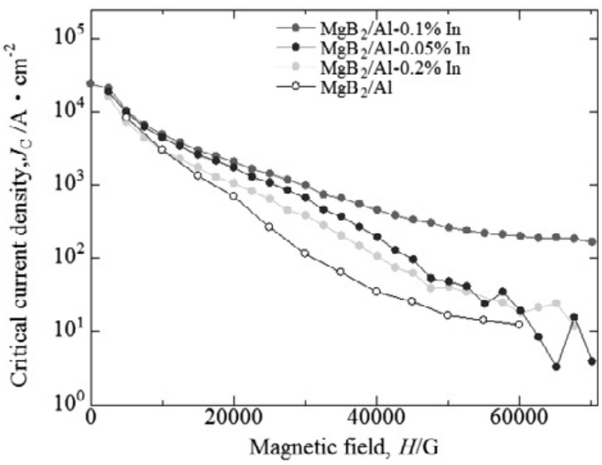

Fig. 2 Relation between Jc and applied magnetic field for In-free MgB2/Al and In added MgB2/Al composite materials.

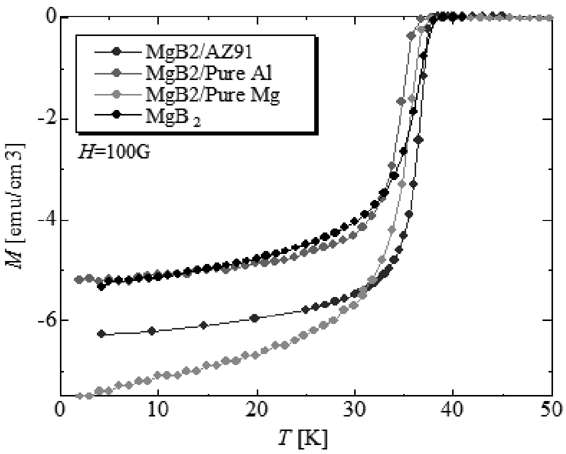

Fig. 3 Relation between temperature and for Mg-based MgB2 composite materials.