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

Matsuda, K., Nishimura, K., Ikeno, S. (Univ. Toyama), Hishinuma, Y.

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 have been succeeded, and their onset Tc have been confirmed about 39 K [1]. In this research project, we have investigated to obtain a billet of MgB_2/Al composite materials which has better formability to wires and superconductivity for superconducting coils in nuclear fusion reactors.

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. The procedure for forming a composite material billet by 3DPC method was described in our recent report in detail [1]. The volume fraction (V_f) can be controlled within 10 – 50%. In billets used in this study, V_f of MgB_2 powders was about 40 % - such billet will be referred to as a high V_f sample. Also this billet was extruded by a hot-extruding machine of 50 t or 400 t to a rod 10 mm in diameter, and to 3 and 1 mm wires. Superconducting, thermal properties and electrical resistivity were measured by means of the Physical Property Measurement system and SQUID (Quantum Design, Co., Ltd.). Samples for these measurements were cut from the composite material billets in the form of 1 mm cubes. The microstructures of composite materials were observed by a scanning electron microscope (SEM) and transmission electron microscope (TEM) in order to establish arrangement and size of particles, chemical composition and crystallography.

Fig. 1 shows appearance and microstructure of the extruded 3 mm dia. wire from the high V_f MgB_2/Al composite material and there were no remarkable defects on cross sections cut parallel to the extruded direction. SEM-EDS analysis and XRD measurement were also applied to the billet, rod and wire in order to reveal impurities or reaction products like Mg-Al or Mg oxides but no defects have been detected. Fig. 2 shows the extruded 1 mm in diameter, high-V_f MgB_2/Al composite material wire. Its surface was smooth without any cracks, however, behavior of the electric resistivity and existence of *Tc* was not so clear now because of inhomogeneous distribution of powders in this thin wire. The temperature dependence of electrical resistivity for 1 and 3 mm wires of the high-V_f MgB_2/Al composite materials are shown in Fig. 3. Behavior of decreasing resistivity is similar to results obtained for the billet and 10 mm rod [1]. Namely the resistivity of these wires dropped down at 39 -37 K (onset *Tc*) to 0 Ωm. For thin wires further technology improvements are obviously needed.

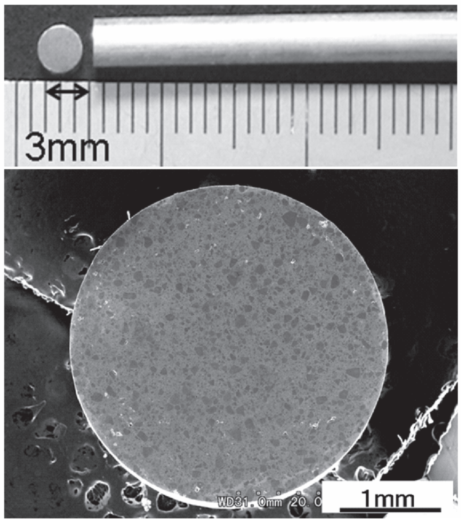

Fig.1 Macrostructure of the extruded wire 3 mm in diameter from the high-V_f MgB_2/Al composite material: (a) appearance of the extruded sample, and (b) SEM image of its cross section

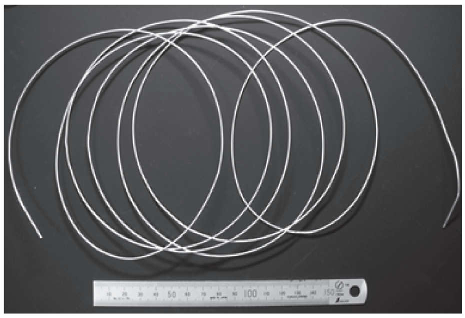

Fig. 2 Appearance of the extruded wire 1 mm in diameter from the high-V_f MgB_2/Al composite material.

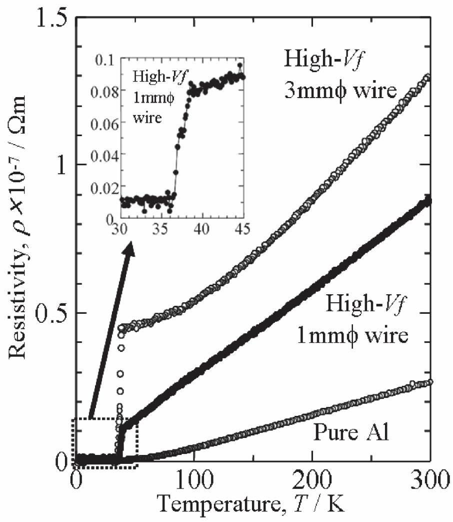

Fig.3 Temperature dependence of electrical resistivity of the extruded 3 and 1 mm high-V_f MgB_2/Al composite material wires and of the pure aluminium.

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