# §18. Enhancement of Critical Current Density on Bi-2223 HTS Bulk for Current Lead Application

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Bi-2223 high critical temperature ($T_c$) superconductor (HTS) material is suitable to apply to the current lead for large-scaled application system such as a nuclear fusion reactor, because it has high critical current density ($J_c$) value of $10^4$ A/cm$^2$ order at 77.3 K and lower thermal conductivity compared with free oxygen copper. In fact, Bi-2223 oxide bulk material is used current lead for the liquid He-free cryocooler-cooled magnet system[1]. Bi-2223 bulk, however, has some problems to limit the application field. Typical problem is that $J_c$ value of the bulk materials is much smaller than that of the wire and tape materials.

We thought that the enhancement of the $J_c$ value is urgent for the nuclear fusion reactor application. Recently, several studies have been made on the enhancement of $J_c$ property for Bi-2223 oxide bulk. Enhancement of $J_c$ values by inserted with number of silver (Ag) sheet was reported[2),3)]. Then, we prepared the Bi-2223 sintered bulk composed with metal Ag wire, tried to improve $J_c$ property on the Bi-2223 bulk.

The Bi-2223/Ag wires composite bulk was prepared hand-made by stacking alternately the calcined powder and the Ag wires of 0.2 mm in diameter. The number of composed Ag wires of 0.2 mm in diameter was fourteen, twenty-eight and forty-two. The stacked samples were molded with metal dies, and the sample size is about 5 mm in width, 22 mm in length and 2 mm in thickness. Fig. 1 shows typical cross-sectional structure of the prepared sample composing with Ag wires of 0.2 mm diameter. The prepared samples were sintered at 840°C for 50 hours in air.

Microstructure of the interface region between the oxide and the Ag was observed using a Scanning Electron Microscope

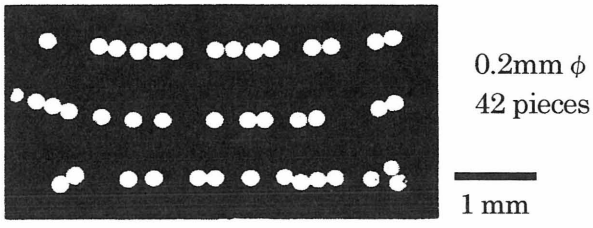


Fig. 1 Optical microscopic photograph of typical cross-sectional structure of Bi-2223/Ag wires composite bulk

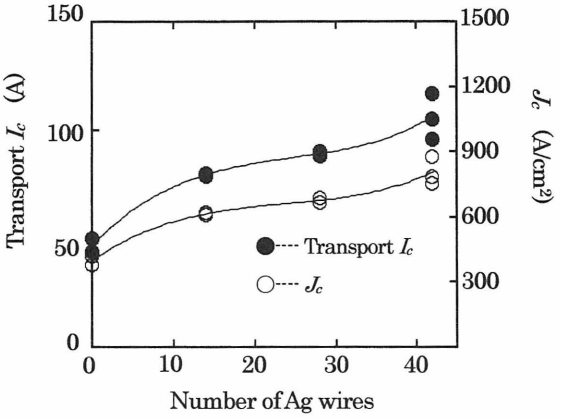


Fig. 2 The number of Ag wires vs. $I_c$ and $J_c$ values at 4.2 K and self-field.

(SEM). In evaluation of superconducting property, the transport critical current ($I_c$) was measured at several conditions as follows; at 77.3 K and self-field, and at 4.2 K and magnetic field up to 5 tesla. Transport $I_c$ was decided by using 1 $\mu$ V/cm criterion. Critical current density ($J_c$) was obtained from transport $I_c$ and cross-sectional area of Bi-2223 oxide expect for Ag wires.

From the results of SEM observation near interface between Bi-2223 oxide and Ag wire, we found that the highly c-axis oriented and densely structured Bi-2223 plate-like grains are formed along the circumferential surface of Ag wires, and the other regions in the bulk are random and porous structure in conventional Bi-2223 oxide bulk materials. The good alignment and very dense structure occurred within 20 $\mu$ m from the interface between Bi-2223 oxide and Ag wire. This suggests that highly oriented and densely structured Bi-2223 plate-like grains could be formed along surface of metal Ag wire in Bi-2223 oxide bulk.

In order to examine superconducting properties of Bi-2223 bulks when composed with Ag wire, the relationships between the number of Ag wires and transport $I_c$ and $J_c$ values at 4.2 K and self-field are shown in Fig. 2. The $J_c$ value of Bi-2223 bulk without Ag wire was obtained less than 400 A/cm$^2$ ($I_c$=50A), and the $J_c$ values of sample composed with forty-two Ag wires of 0.2 mm diameter were estimated to be about 800 A/cm$^2$ ($I_c$=100A). Both transport $I_c$ and $J_c$ values are improved with increasing number of Ag wires. In the case of measurement at 77.3K, transport $I_c$ and $J_c$ values are improved by composing with Ag wires. All $J_c$ values of the sample composed with Ag wires are higher than sample without Ag wire. The composite is the one of the effective method to improve $J_c$ property.

Reference

[1] Ohkura, K. et al. : Adv. in Superconductivity VI (1994) 735.
[2] Hishinuma, Y. et al. : Adv. in Supercond. XII (2000) 548.
[3] Hishinuma, Y. et al. : Physica C 351(2001) 409.