

### §23. Large-Sized Cylindrical Superconductor Composed with Ni Meshes for a Current Lead

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Bi-2223 sintered bulk has a critical temperature ( $T_c$ ) over boiling point of liquid nitrogen 77 K and low thermal conductivity. It has been used as a current lead for the liquid He-free cryocooler-cooled magnet and a current limiter. However, Bi-2223 sintered bulk is fragile because a ceramic material. Ag-plated Ni wire meshes were added into Bi-2223 bulk [1]. By adding metal meshes into the sintered bulk, it can be expected that the mechanical property of the composite is strengthened for the bending stress from various directions. Small-sized cylindrical bulk of Bi-2223/Ni meshes composite, 27 mm in outer diameter, 2 mm in thickness and 50 mm in length, was experimentally prepared last year [2]. It is mentioned that, in preparing a cylindrical composite, the sample with meshes is easy to produce compared with a lot of wires.

This year we prepared large-sized cylindrical Bi-2223 sintered bulk composed with Ag-plated Ni meshes for a prototype of a current lead, 32 mm in outer diameter, 2 mm in thickness and 110 mm in length.

Cylindrical Bi-2223 bulk composed with Ni wire meshes was prepared. The mesh concentration was 18 x 18 meshes/cm<sup>2</sup> using Ni wires of 0.25 mm in diameter. The Ni meshes were plated with Ag by 0.03 mm in thickness. The Ni meshes were centered between vinyl tube and brass rod molds, and calcined powder the constant mass of 100 g was molded using an isostatic cold pressing (CIP) method with two tons. The prepared samples were sintered at 845 °C for 50 hours in air. After treatment again with CIP as an intermediate pressing, the samples were re-sintered. Fig. 1 shows prepared cylindrical sample.

$T_c$  (on-set) values of the both samples without and with the intermediate pressing and resintering process are 108 K. The  $T_c$  (off-set) value of the sample without the intermediate pressing process is at ca. 98 K. By adding the intermediate pressing and resintering process, the  $T_c$  (off-set) values shifts to ca. 101 K. It is observed that there remain two transitions in the magnetization curves. These results suggest that the sample consists of mixture of high and low temperature transition phases, which are supported with the result of XRD patterns of the surface of the sample. It was observed in both samples without and with intermediate pressing and resintering process that (00 $l$ ) peaks of Bi-2223 phase is mainly obtained indicating the  $c$ -axis oriented structure, and there are found some peaks originated from Bi-2212 phase.

$J_c$  values of the cylindrical Bi-2223/Ni meshes composite bulks were studied. The small specimens, 5 mm in width, 22 mm in length and 2 mm in thickness, were cut out from the

cylinder. The  $J_c$  values at 77 K under self-field were measured for the cylinder without and with Ni meshes and for the composite without and with intermediate pressing and resintered. The  $J_c$  values are scattered indicating the cylinder is inhomogeneous. By addition of Ni meshes to the bulk, there are two kinds of state in the samples; one is increase of  $J_c$  and another is low  $J_c$  samples. Then, with the intermediate pressing and resintering process, the tendency is emphasized. It is mentioned that the  $J_c$  values are relatively low because the superconducting phase is mixture of main phase of Bi-2223 and sub phase of Bi-2212.

Cross sectional SEM photographs in the vicinity of interface between the Bi-2223 oxide and Ag-plated Ni meshes in the cylindrical sample were taken. SEM photographs of the higher  $J_c$  samples without and with intermediate pressing and resintering process. There is found dark grey thin layer of ca. 10  $\mu$ m in thickness between Ag layer and Ni metal, which was assigned to NiO by



Fig. 1 Prepared large size Bi-2223 bulk composed with meshes

SEM-EDX. The NiO layer should be formed by oxidation of the Ni surface during the heat treatment process. The NiO layer seems not affect the superconductivity of the composite. In the high  $J_c$  samples with the intermediate pressing process, Bi-2223 plate-like grains grow and highly  $c$ -axis oriented and densely structured plate-like grains are formed around the Ag-plated Ni wires. It is mentioned that the  $J_c$  increase of the Bi-2223 bulk by composing with Ni meshes and treating with intermediate pressing process is attributed from formation of the Bi-2223 plate-like grains. In the low  $J_c$  level sample, fine crack lies across Ni wires and small voids leave around Ni wires. It is also suggested that these dislocations cause the inferior superconducting property.

#### References

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