§14. Design and Optimization of High Tc Superconductors for Current Lead Application

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High temperature superconductors HTS can be synthesized through the two components diffusion process in an appreciably shorter reaction time than that of the HTS prepared by the conventional sintering process. In the Bi-Sr-Ca-Cu-O system, a thick and homogeneous HTS layer of $Bi_2Sr_2CaCu_2O_{8+X}$ (Bi2212) is easily synthesized by the diffusion reaction between Bi-free Sr-Ca-Cu oxide substrate and Bi-Cu oxide coating [1)]. In the present study, scaling-up of the specimen dimension and the transport current performance of Bi2212 HTS conical tubular bulk specimen will be reported. Referring to the transport performance and heat load due to the Joule heating at the joint and heat leakage through the bulk specimen, the Bi2212 HTS cylinders synthesized by the diffusion process seem to be promising for a current lead in both cryocooler-cooled superconducting magnets [2)] with small allowable heat load and conventional superconducting magnets with large transport current [3) 4)].

Fig. 1 schematically shows the preparation procedure of Bi2212 HTS conical tubular specimen through the diffusion process . The substrate is composed of Bi-free Sr-Ca-Cu oxide with the composition ratio of Sr:Ca:Cu =2:1:2. The calcined Sr-Ca-Cu oxide powder was formed into conical tubes 37/29 mm in outside/inside diameter at the larger end, 27/19 mm in outside/inside diameter at the smaller end, and 200 mm in length by cold isostatic pressing. It was then sintered at 1020°C in open air. The coating is composed of Bi-Cu oxide with the composition ratio of Bi:Cu=2:1. The calcined Bi-Cu oxide powder with 30wt%Ag_2O addition was mixed with wax to form slurry, and was coated around the conical substrate. The diffusion reaction was performed at 850°C for 20h in open air to produce the Bi2212 HTS layer about 150 μm in thickness around both outside and inside of the conical tubes. Ag added to the coating accumulates on the surface of the specimen after the reaction. Then, the Ag paste was coated around both ends of the diffusion specimen, and was heat-treated at 800°C in air to form the Ag contacts.

The transport performance for the Bi2212 HTS specimen at 4.2K and self-field is shown in Fig. 2. No voltage on the HTS part(between V2 and V4) was generated at a transport current of 6,500A. The HTS voltage appeared at near 6,800A, and a voltage of 40μV on HTS part was generated at 7,000A which corresponds to the current density of 32,000A/cm^2. The voltages of both joints increased with increasing transport current, and were 450μV at lower joint(V4-5) and 90μV at upper joint(V1-2) after reaching 7,000A.

The temperature dependence of transport current of the conical specimen at upper end warmed up by the attached resistive heaters was measured. The transport current decreases with increasing temperature, and is about 6,300A at 20K or 3,200A at 40K.

The total heat loads composed of heat leakage conducted through the tube and joule heating at the joint are estimated to be about 320 mW at 3,000 A between the warm end of 42 K and the cold end of 4.2 K, and is 400 mW at 2,000 A between 50 K and 4.2 K, respectively. Present Pb-free Bi2212 conical tubes seem to be promising as large transport current leads with small heat loads for superconducting magnets.

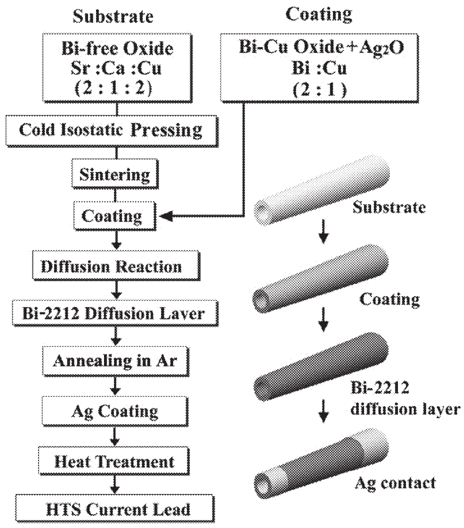

Fig. 1. Preparation procedure of the Bi2212 HTS conical specimen by the diffusion process.

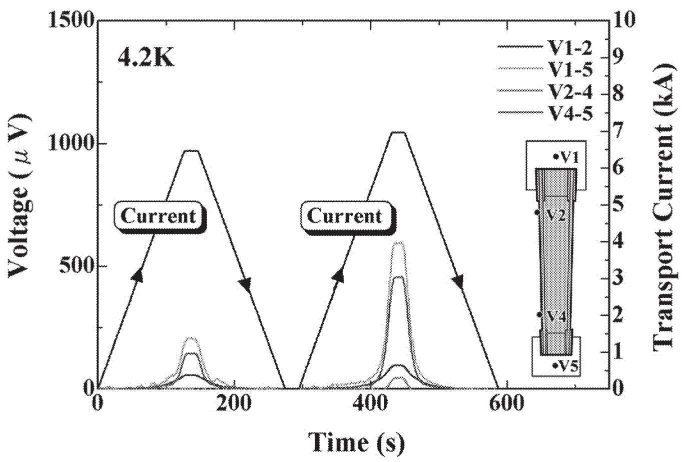

Fig. 2. Transport current performance of the Bi2212 HTS conical conductor at 4.2 K.

References

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