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

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High Tc superconductors (HTS) can be synthesized by the two components diffusion process in shorter reaction time than that of the HTS prepared by the conventional sintering process. In the Bi-Sr-Ca-Cu-O system, a homogeneous HTS layer of $Bi_2Sr_2CaCu_2O_8$ (Bi2212) is easily synthesized through the diffusion reaction between Bi-free Sr-Ca-Cu oxide substrate and Bi-Cu oxide coating. In the present study, the transport current performance and the structure of Bi2212 HTS conical tubular bulk will be reported. The conical shaped tube may be expected to yield larger transport current due to the larger cross-sectional area at warm joint and smaller heat leakage due to the smaller cross-sectional area at cold joint in comparison with the cylindrical bars or tubes. The Bi2212 HTS conical tubes by the diffusion process are attractive for current leads in conventional superconducting magnets as well as cryogen-free superconducting magnets[1) - 4)].

Fig. 1 demonstrates the HTS conical tube specimen 34/29 mm in outside/inside diameter at the larger end, 24/19 mm in outside/inside diameter at the smaller end and 100 mm in length. (a) is as diffused specimen with Ag contacts of 20 mm in length on both ends. The specimen shown in (b) is soldered to both Cu end caps using commercial Sn-Pb solder. Four voltage taps were attached on the both Cu end caps (V1 and V4) and to the HTS (40 mm between V2 and V3). Five cernox resistance thermo sensors were attached on the both Cu end caps (T1 and T5) and to the HTS (distance of every 20 mm between T2, T3 and T4). The larger end (warm joint) for the specimen and Cu current leads were cooled by a 1-Stage Gifford-McMahon (GM) cryocooler. The smaller end (cold joint) for the specimen was cooled by a 2-Stage GM cryocooler. Resistive heaters were installed on the Cu leads and the cooling stage of the cryocooler to adjust the temperature of the conical specimen. The capacity of transport current is 1,000 A for the power source. Magnetic field of 0.5 T is always applied perpendicular to the specimen current using a pair of Nd-B-Fe permanent magnets. Then, the specimen was installed into a cryostat, and cooled in a vacuum to be 10 K at cold joint and 40K at warm joint for 20 h.

Transport current and current density versus temperatures at warm joint under 0.5 T for the Bi2212 conical specimen is shown in Fig. 2. The transport current was supplied at a ramp rate of 20 A/s. Arrows in the figure indicate that the transport current exceeds the capacity limit of 1,000 A. The critical temperature of transport current of 1000 A at 0.5 T for the specimen is 57.4 K, which corresponds to the current density of 33 $A/mm^2$ for the Bi2212 layers at warm end. The transport current decreases with increasing temperature at the warm joint of the conical specimen, and is about 800 A at 60.2 K, 600 A at 62.5 K and 200 A at 70 K, respectively. Present Bi2212 conical tubes seem to be promising as current leads for superconducting magnets.

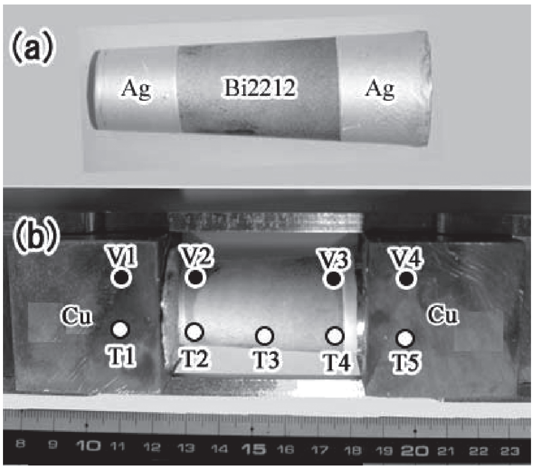


Fig. 1. Bi2212 conical tubular specimen with Ag contacts at both ends. (a)as diffused, (b)connected to Cu end caps. Totally 4 voltage taps and 5 cernox resistance thermo sensors were attached on the surface of HTS and Cu caps.

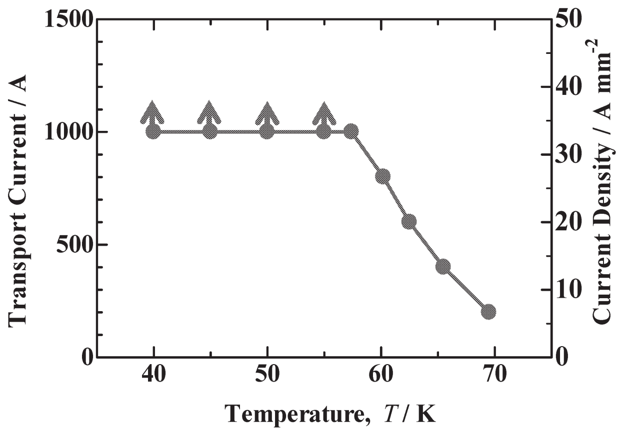


Fig. 2. Transport current and current density versus temperatures at warm joint under 0.5 T for the Bi2212 conical specimen.

References
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