

§5. Development of High Temperature Superconducting Current Feeders in NIFS (2) Application of Bi-2212 Bulk Fabricated by Diffusion Process to the HTS Current Lead

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1. Introduction

The National Institute for Fusion Science (NIFS) is planning to develop High Temperature Superconducting (HTS) current feeders for large-scale superconducting coils. The development is progressed in the frame of the LHD International Mutual Experiment (LIME) with the Forschungszentrum Karlsruhe (FZK) and the Max-Planck Institut für Plasma Physik (IPP) in Germany, and universities and laboratories in Japan centering on Tokai University. The test results of Bi-2212 bulk fabricated by diffusion process, applicable to HTS current leads, are described.

2. Bi-2212 Bulk Fabricated by Diffusion Process

Bi-2212 ($\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+x}$) bulk fabricated by the diffusion process is expected as an alternative material for HTS current leads. Bi-2212 oxide layer has been synthesized by diffusion process between Bi-free 0212 substrate and Bi-Cu 2001 coating layer. A uniform Bi-2212 diffusion layer about 150 μm in thickness is synthesized around both outside and inside of the cylindrical tube. High current transport tests of a Bi-2212 tube fabricated by diffusion process have been conducted in NIFS with Tokai University.

Fig. 1 shows a photograph of a Bi-2212 tube 20/16 mm in outer/inner diameter and 55 mm in length. The surface of the tube with 30 wt% Ag addition to the coating layer was covered with the precipitated Ag after diffusion reaction. The Ag precipitated on the surface about 50 μm thick was removed using etching reagent except for both ends which enable low resistive contact to the copper electrodes. Fig. 2 shows a schematic drawing of the sample holder for the high current transport test. The tube specimen was soldered to the copper electrodes at both ends. One electrode was attached line with NbTi/Cu compacted strand cables to avoid mechanical damage caused by thermal contraction.

The high current transport tests have been conducted in liquid helium. The Bi-2212 tube was successfully excited up to 6.25 kA and was broken at 6.38 kA. No voltage was observed at the HTS part just before the mechanical break. However, both joint voltages were about 1 mV at 6 kA, which means high contact resistance of 0.17 $\mu\Omega$ due to insufficient soldering between Bi-2212 tube and copper electrodes. The quench was initiated at the joint. Therefore, the critical current density of the Bi-2212 diffusion layer can be estimated to be more than 380 A/mm^2 at 4.2 K.

We are progressing to the next stage based on the success of the preliminary tests. Development and high current transport tests are planned using a larger size bulk

tube with an outer/inner diameter of 28/20 mm and a length of 200 mm as shown in Fig. 3. Mechanical reinforcement of a bulk tube is also investigated by wrapping glass epoxy tapes on the outer side of the tube or by adding reinforcing materials to the ceramic substrate.

3. Summary

A Bi-2212 bulk fabricated by the diffusion process is expected as an alternative material for HTS current leads. A Bi-2212 tube 20/16 mm in outer/inner diameter and 55 mm in length was successfully excited up to 6.25 kA and the critical current density of the diffusion layer can be estimated more than 380 A/mm^2 at 4.2 K.

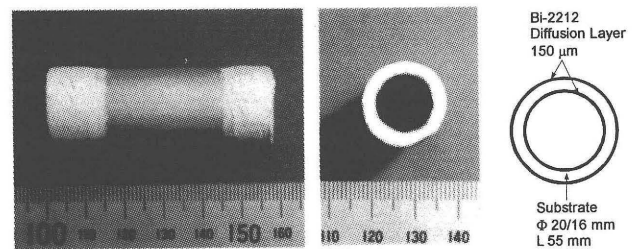


Fig. 1. A photograph of a Bi-2212 tube specimen 20/16 mm in outside/inside diameter and 55 mm in length.

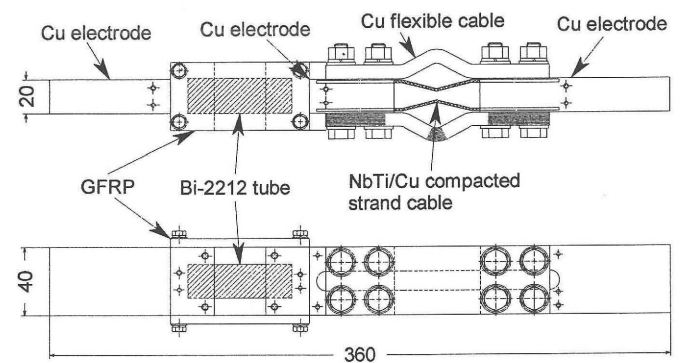


Fig. 2. A schematic drawing of the sample holder for the high current transport test.

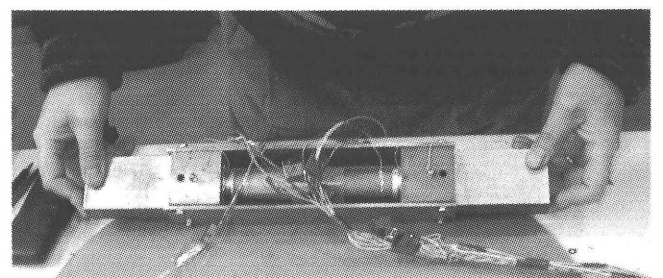


Fig. 3. A photograph of a Bi-2212 tube specimen 28/20 mm in outside/inside diameter and 200 mm in length.

Reference

- 1) Yamada, Y., Takiguchi, M., Suzuki, O., Tachikawa, K., Iwamoto, A., Tamura, H., and Mito, T. "Transport performance of Bi-2212 current leads prepared by a diffusion process", IEEE Trans. Applied Superconductivity, Vol.11, No.1 (2001) pp.2555-2558.