§ 9. Design Study of Current Lead made of Bi-2212 Tubular HTS

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Current leads using HTS material have been developed for large scale superconducting magnet system. NIFS and Tokai University has investigated characteristics of Bi2212 tubular bulk which was prepared by a diffusion process 1, 2). This type of HTS bulk has a potential for flexible design since Bi2212 layer can be reacted on the surface of any shapes of substrate. The maximum transport current density of 35 kA/cm^2 and the maximum transfer current of 8 kA at 4 K were achieved with the size of 38 / 30 mm in outer/inner diameters and 195 mm of length, respectively. Bi-2212 is a 0.15 mm thick layer on both outer and inner surfaces of a tube and a residual region is a bismuth-free substrate. HTS bulk has a disadvantage in a mechanical point of view. Since the bulk is a brittle material, reinforcement using fiber / epoxy would be effective since it can improve not only a mechanical strength but also a durability of the oxide without significant increase of thermal conductivity.

Requirements for a current lead are; high transport current capacity, small heat leak from warmer end to lower one, and stable under wide range of temperature. At this point of view, Bi-2212 HTS prepared by diffusion process is regarded as the most likely candidate for current lead. To get over a breakable property, reinforcement by using high strength and low thermal conductive material is proposed. Alumina fiber has a low thermal conductivity and a low thermal expansion coefficient in a wide range of temperature compare with a glass or carbon fiber. It also has a high Young's modulus and high mechanical strength. We made a prototype of reinforced Bi-2212 tubular HTS bulk using Alumina fiber and epoxy resin. The fiber was wound by using filament winding method of two layers and fixed by epoxy resin. Fig. 1 shows the original HTS tubular bulk and the reinforcement by using alumina fiber. Electrical tests for this reinforced HTS bulk were done and confirmed that the maximum current of 8 kA was achieved.

A concept design of a current lead reinforced by using a fiber with epoxy was considered. Fig. 2 shows an example of current lead design using Bi-2212 HTS with glass / epoxy reinforcement. Alumina fiber can be an alternative material for the glass fiber in the figure. The first reinforcement layer plays a role of improving overall rigidity of HTS. A spring shaped metal is a bypass current line when the HTS transfers to normal conductivity. It also acts as a deformation absorber against longitudinal tension/compression so that the material of this layer would be stainless steel. The second layer is to minimize a deformation caused by a misalignment, tensile, bend, torsion and compression. Attaching a spring shaped external support made of normal conducting material with high rigidity such as stainless steel is proposed for a current lead using this HTS bulk in points of a mechanical and an electrical stability.

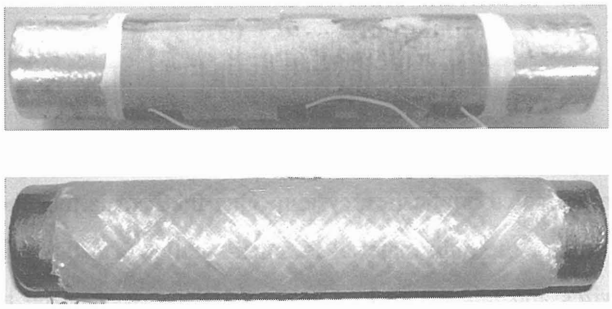

Fig. 1. Bi-2212 bulk (upper) and with alumina fiber with epoxy reinforcement (bottom).

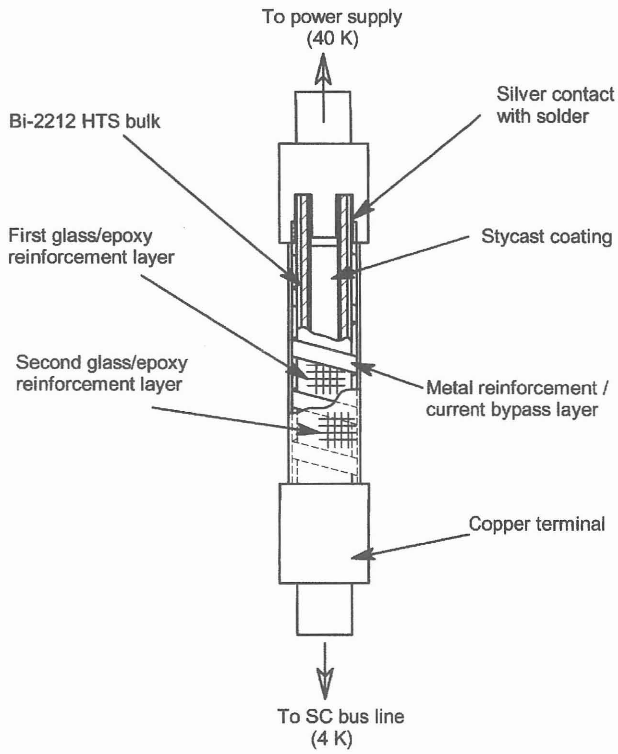

Fig. 2. Example design of current lead using Bi-2212 tubular HTS.

1) Tamura, H., et al., IEEE Transactions on Applied Superconductivity, Vol. 12, No. 1 (2002) 1319
2) Yamada, Y., et al., IEEE Transactions on Applied Superconductivity, Vol. 12, No. 1 (2002) 1332