High Field Magnets with $Bi_2Sr_2CaCu_2O_{8+x}$ /Ag alloy Round Wire

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Introduction

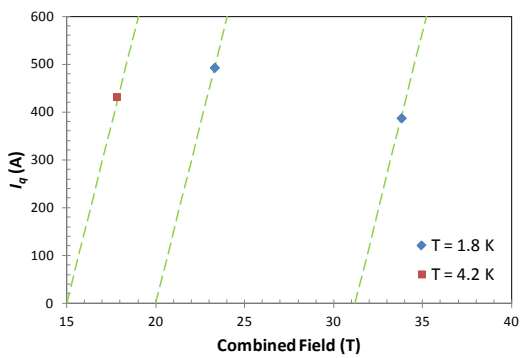
$Bi_2Sr_2CaCu_2O_{8+x}$ (Bi-2212) is the only High Temperature Superconductor (HTS) available in round wire form. However, relatively low critical current densities and thick and chemically incompatible insulations [1] have long been the limiting factors for high field magnet applications. Recent progresses in the understanding of Bi-2212 wire processing have led to more than double their critical current density [2] (more than 600 A/mm^2 at 20 T), by using an overpressure heat treatment that densifies the wire during the heat treatment processing. In addition, a newly developed commercial temperature tolerant 15 μm thick TiO_2 based insulation has become available that is 10 times thinner than the current alumino-silicate or silica braided insulations provided by the conductor manufacturers, which significantly enhances the winding current density in coils.

Experimental

A small test coil was wound using Bi-2212 round wire insulated with the TiO_2 based insulation. The coil was heat treated in synthetic air at a total pressure of 10 atm. After the heat treatment the coil was epoxy impregnated and instrumented for low temperature in-field measurements. The coil was tested in-house in the 31.2 T resistive magnet.

Figure 1 (left): Bi-2212 layer wound coil mounted on the probe. The coil specifications are: 71.2 mm long, 14.3 mm ID, 36 mm OD, ~30 m total conductor length.

Figure 2 (right): Quench current *vs.* field relationship of coil for different bath temperatures.



Results and Discussion

The coil generated an additional magnetic field of 2.6 T for a total of 33.8 T at a helium bath temperature of 1.8 K, corresponding to a winding current density of 187 A/mm^2 at quench *i.e.* a conductor engineering current density of about 225 A/mm^2. Though the coil was safely quenched multiple times for different ramp rates, the coil was limited by the performance of the terminals. Due to space restrictions of the currently solely available over pressure furnace, the coil was heat treated with the terminals reaching into the non-homogeneous zone of the furnace. The terminal sections were thus heat treated at lower temperatures than the coil, yielding their lower transport performance. This was corroborated by the finding that short samples cut as witness samples from the ends of the coil, *i.e.* in the terminal region, performed significantly below expectations. Nevertheless, the transport properties of the coil showed a more than two-fold increase of the winding current density over previous coils.

Conclusions

The performance of this coil clearly demonstrates that Bi-2212 round wire is becoming a viable conductor for high magnetic field applications whose limits have yet to be explored in coils. These results open up a whole area of potential applications ranging from NMR to High Energy Physics, where a round electromagnetically isotropic wire that can be easily cabled is highly preferable over the highly aspected tape conductors.

Acknowledgements

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References

[1] M. Dalban-Canassy, *et al.,* Supercond. Sci. and Technol., **25**, no. 11, p. 115015, Nov. 2012.
[2] J. Jiang, *et al.*, Supercond. Sci. Technol., **24**, no. 8, p. 082001, Aug. 2011.