Performance of Titanium-Oxide/Polymer Insulation in Bi-2212/Ag-alloy Round Wire Wound Superconducting Coils

P. Chen, U. Trociewitz, M. Dalban-Canassy, J. Jiang, E. Hellstrom, D. Larbalestier (ASC, NHMFL)

Introduction

Conductor insulation is one of the key components needed to make Bi-2212/Ag superconducting round wire successful for high field magnet applications as dielectric standoff and high winding current densities directly depend on it [1]. Besides good dielectric properties, the coating should be thin, since insulation space dilutes the overall winding current density. Since insulation has to be applied to the Bi-2212/Ag conductor before coil winding, and subsequent to winding, Bi-2212/Ag coils are heat treated in flowing pure oxygen at a maximum temperature of around 890 °C to achieve their superconducting properties. These conditions pose several challenges for an effective insulation for Bi-2212/Ag, which must be chemically compatible with Bi-2212/Ag round wires. The insulation must be permeable to oxygen, to allow both for oxygen loss during the partial melting of the Bi-2212 and subsequent oxygen uptake during solidification and full development of the overdoped state during cooling. Lastly the insulation has to be abrasion resistant to allow for handling during coil winding and thin enough to permit a high winding current density J_w without sacrificing dielectric strength.

Experimental

A TiO_2/polymer insulation coating developed by nGimat LLC was applied to test samples and a high field test coil. The insulation was investigated by differential thermal analysis (DTA), thermo-gravimetric analysis (TGA), scanning electron microscopy (SEM), dielectric properties measurement, and transport critical current (I_c) properties measurement. A coil applied with this insulation was successfully tested generating 33.8 T combined magnetic field in a 31.2 T background field at the NHMFL.

Results and Discussion

TGA results indicate that about 29% of the insulation by weight is polymer. When the Bi-2212/Ag wire is full heat treated, this decomposes with slow heating to 400°C in pure O_2. After the full reaction, we found that the TiO_2 did not degrade the critical current properties, adhered well to the conductor, and provided a breakdown voltage of >100 V, which allowed the test coil to survive quenching in 31.2 T background field, while providing a 2.6 T field increment. Fig.1 show the pictures of the insulated test coil after three subsequent processing steps.

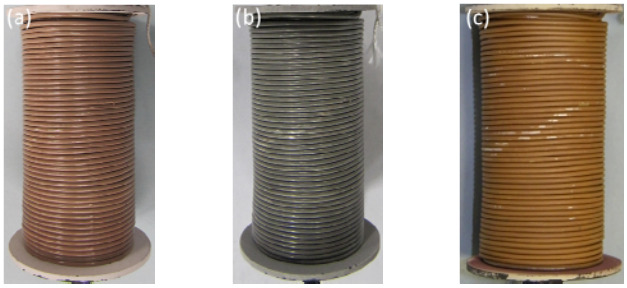

Fig.1. Insulated Bi-2212/Ag round wire wound superconducting coil, seen (a) after winding, (b) after insulation burn-off and (c) after full 10 bar OP processing.

Conclusions

In this study, a TiO_2/polymer insulation coating developed by nGimat LLC was applied to test samples and a high field test coil. A coil applied with this insulation was successfully tested generating 33.8 T combined magnetic field in a 31.2 T background field at the NHMFL. We believe that this is a valuable demonstration of the successful application of this TiO_2/polymer insulation.

Acknowledgements

This work was supported by an ARRA grant of the US Department of Energy Office of High Energy Physics and by the National High Magnetic Field Laboratory which is supported by the National Science Foundation under NSF/DMR-1157490 and by the State of Florida.

References

[1] Chen, P., *et al.*, Superconductor Science and Technology, **26 (7)**, 075009 (2013).