**Bi-2212 Round Wire for High Field, High Homogeneity Magnets**

Trociewitz, U.P.; Hilton, D.K.; Kim, Y.; Bosque, E.; Chen, P.; Davis, D.; Jiang, J.; Hellstrom, E.E.; Lu, J.; McGuire, D.; English, L.; Miller, G.E.; Miller, S.; Mauch, W.; Kametani, F.; Matras, M.; Noyes, P.; Litvak, I.; Brey, W.; Larbalestier, D.C. (NHMFL) and van der Laan, D. (ACT)

**Introduction**

The NHMFL is committed to the development of high field quality magnets beyond 30 T (1 GHz) for high-resolution NMR spectroscopy using high temperature superconductors (HTS) [1]. During the past year we designed, built, and characterized several test coils and one large insert magnet using Bi2Sr2CaCu2O8-x (Bi-2212) round wire (dubbed “Platypus”) that was operated inside our 16.5 T, 110 mm bore low temperature superconducting (LTS) Oxford magnet.

**Experimental**

Several analytical and FEA models were developed and results were implemented into the coil designs to understand and control the mechanical and electro-magnetic properties of these complex, multi-component coil assemblies. These models covered all scenarios that the coils are exposed to, starting from high temperatures during heat treatment to cool down to 4.2 K and their operation under large electro-mechanical stresses. Round wire-wound coils require an ortho-cyclic winding approach that can introduce asymmetries in the coil geometry and consequent field inhomogeneities. A procedure of clocking the wire crossovers was developed to address this issue and verified on a full size copper wire model coil. A total of three layer-wound short (2 cm high) and thick (18 layers) test coils, one long (24 cm, 179 turns) and thin (4 layers) solenoid and a full size solenoid of 24 cm length (18 layers, 179 turns) plus a compensation coil pair to correct for the Z2 field component were built using 1.3 mm diameter twisted Bi-2212 wire made by Oxford Superconducting Technology (OST). The first three coils were processed in the new Deltech high pressure furnace at 50 bar total pressure (1 bar O2) and tested in the cell-4, 20 cm large bore resistive magnet (LBRM), while the latter one was nested inside our Oxford Instruments 16.5 T low temperature superconducting (LTS) outsert magnet. For this coil an electrical bus system was developed in collaboration with Advanced Conductor Technologies (ACT) using REBCO CORCTM cable to provide power to both the solenoid and compensation coil pair.

**Results and Discussion**

 The four test coils did not show any conductor leakage after the overpressure heat treatment, however a small electrical short was observed within the winding pack of the third short test coil . All three short coils generated field inside the LBRM close to specification. The third coil was deliberately quenched and its short disappeared. The fourth long test coil was only tested with respect to its resistance due to time restrictions. In contrast to the test coils, and for reasons that are still under investigation, the full size solenoid and compensation coil pair developed a substantial 2212 leakage and severe electrical shorts throughout the winding pack after the high pressure heat treatment. The electrical shorts prevented the coil from performing to full specification, as only large field screening could be measured during the testing in the LTS outsert magnet.

**Fig.1** (top): The Platypus solenoid revealed the presence of several leaks after the heat treatment.

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**Fig. 2** (right): The fully assembled Platypus magnet (solenoid and compensation coil pair) with CORC buses and instrumentation wiring attached

[1] D. Larbalestier et al., Nature Materials 13, 375-381 (2014).