Bi2212 Conductor and Coil Technology for High Field Magnets

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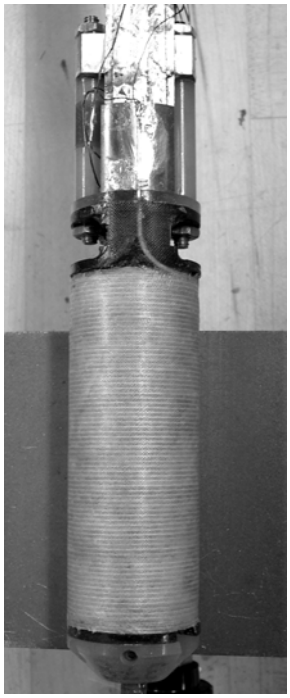
With the need for ever higher magnetic fields and rising costs of energy, conventional magnet technologies, resistive as well as superconducting, are reaching their limits. Right now there are only three superconducting materials in technically applicable form available, whose transport properties show weak field dependence at high fields and reach far beyond 25 T, the physical limit of Nb_3Sn conductors: the tape conductors $YBa_2Cu_3O_{7-\delta}$ (YBCO) and $Bi_2Sr_2Ca_2Cu_3O_{10}$ (Bi2223), and round wire $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi2212). Though transport properties of Bi2212 do not currently match YBCO, Bi2212 has particular technological relevance as it is available in round wire geometry and its full technological potential is not fully explored and is yet to be reached. As a driver for research and development of high field magnet technology using Bi2212 conductor, the concept of a 7 T insert magnet generating 25 T in 18 T background field has been developed, which builds on the experience gained during the previous 5 T insert coil program. The preliminary magnet design calls for a four-section layer-wound coil, each section having 10 layers, using round AgMg-alloy sheathed, braid-insulated Bi2212 conductor (1.3 mm OD) employing a wind and react approach. After manufacturing, thermo-processing, and characterizing a series of small (10 layers, 12 turns) coils it became clear that before committing large amounts of conductor to a specific magnet design various questions need to be answered:

- Why are transport properties of coils consistently lower than transport properties of short samples?
- Does thermo-processing of solenoids with larger thermal mass affect transport properties?
- What is the in-field performance of wind-and-react layer wound coils?
- What is the practical stress limit of layer wound and epoxy impregnated coils?

In an effort to address these questions, several fully processed coils have been dissected and superconducting and microstructural properties of extracted short samples have been studied. It could be shown that coils up to a layer count of 15 can be processed yielding homogeneous properties throughout the layers. Recently a medium size coil has been manufactured and was tested in magnetic background fields up to 31 T using one of the resistive magnets at the NHMFL. The coil dimensions were ID = 15 mm, OD = 38 mm, h = 100 mm, with 10 layers, 75 turns, and a total conductor length of 66 m, figure 1. At 31 T this coil repeatedly generated an additional field of about 1 T without degradation making it the first HTS wire-wound coil to reach beyond 30 T, figure 2. Though the coil did not perform at its expected level it still reached a winding current density J_w of about 100 A/mm^2 surpassing J_w of the previous 5 T insert by more than 10%. It is suspected that one reason of the coils reduced performance was related to the small winding ID needed to operate the coil inside the small bore of the resistive outsert. Further experiments are on the way to understand and develop magnet technology based on Bi2212 round wire.



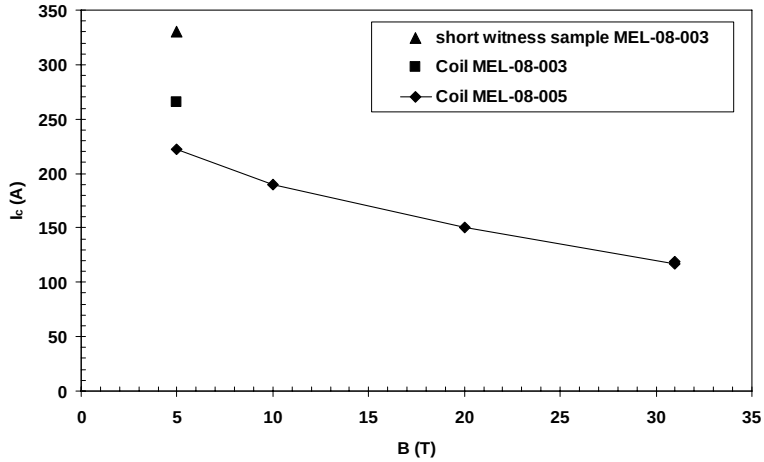


Figure 1. (left) View of the coil tested in 31 T background field.

Figure 2. (top) $I_c(B)$ data of the coil tested in 31 T background field (MEL-08-005), a coil previously tested at 5 T (MEL-08-003 with 32 mm ID, 56 mm OD, 10 layers, 90 mm high, 670 turns), and short 5 cm long witness sample.