Operation of High Temperature Superconducting Bi-2212 Test Coils up to 34T

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Funding Grants: D.C. Larbalestier (US DOE-OHEP DE-SC0010421); G.S. Boebinger (NSF DMR-2128556);
Florida State University Office of the Vice President for Research special allocation for Bi-2212 commercialization

The high-temperature superconductor (HTS) called Bi-2212 (after its chemical formula, $Bi_2Sr_2Ca_1Cu_2O_{8+x}$) is unique among commercial HTS materials because the conductor is formed, not as a tape, but as a round wire that contains many superconducting filaments. This macroscopically isotropic wire can then be twisted for low AC-losses and can furthermore be easily formed into cables. Bi-2212 wire is reliably produced in long lengths that exceed one kilometer and that are now featuring the ability to carry superconducting current densities, J_E (4K, 5T), as high as 1200 to 1400A/mm^2.

The small "Teo" test coils use less than 50m of Bi-2212 wire, thus providing an efficient way to test Bi-2212 conductor and magnet technologies that include reinforcement, insulation, and epoxy materials. Teo test coils are typically 80mm tall and < 38mm diameter in order to fit into the MagLab's 31T resistive magnet. *A recent set of Teo test coils produced a peak field of 34T when energized inside the 31T resistive magnet. The Bi-2212 wire current density (J_E) of 464A/mm^2 that was achieved in the Teo test coils would be sufficient to produce larger HTS research magnets in the commercially-attractive 25T range*. Furthermore, the Teo test coils supported a peak hoop stress between 237MPa and 273MPa, well over the breaking stress of the bare Bi-2212 wire, which demonstrates a capability to reliably reinforce Bi-2212 wires when wound into coils. The coils were ramped at rates of up to 3200A/s with no degradation to the quench current after high ramp rates.

This robust operation of multiple Teo test coils in fields exceeding 30T is an important demonstration to MagLab collaborators, including the US-DOE Magnet Development Program developing 16T dipole magnets using HTS, Princeton Plasma Physics Laboratory pursuing fusion ohmic heating solenoids, as well as MagLab commercial partners Cryomagnetics and Oxford Instruments developing compact 25T HTS magnets.

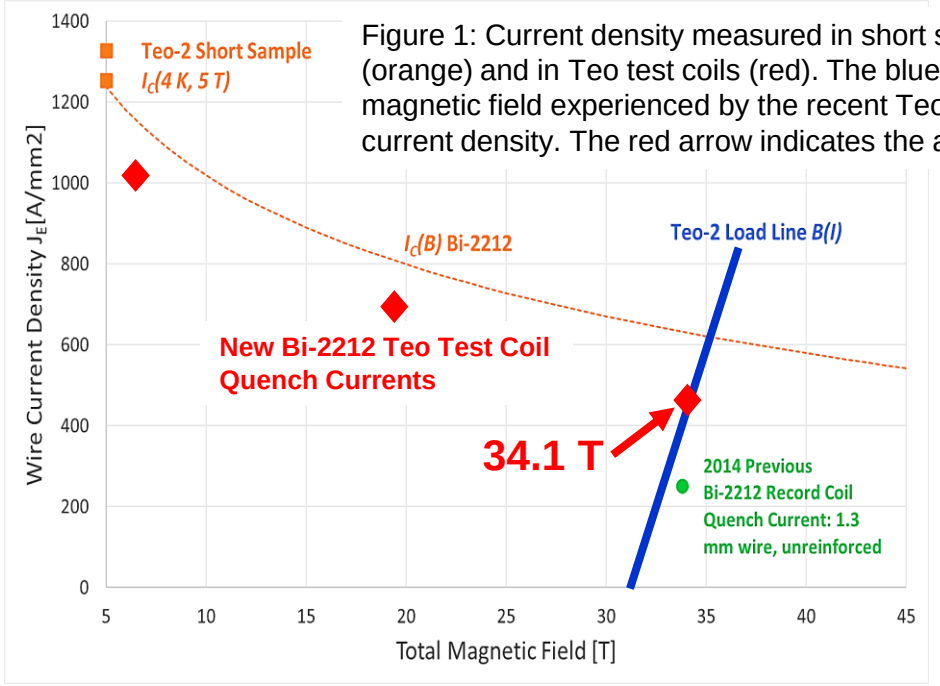

Figure 1: Current density measured in short samples of Bi-2212 wire (orange) and in Teo test coils (red). The blue line indicates the total magnetic field experienced by the recent Teo test coil for a given current density. The red arrow indicates the achievement of 34.1T.

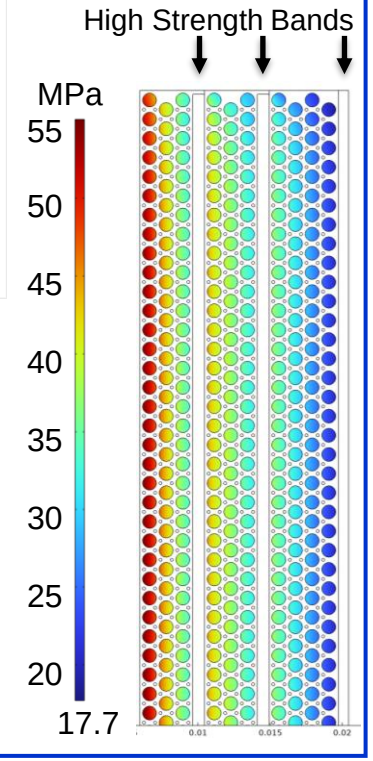

Figure 2: A cross-section of the Teo test coil made from Bi-2212 round wire, depicted as circles in the figure. The stresses in the Bi-2122 wire, indicated by the color coding, are reduced by the reinforcing presence of high-strength overbanding material.

Facilities and instrumentation used: Coil testing performed in the Applied Superconductivity Center (ASC) OX-3 15T LTS magnet and the DC Field Facility's 31T, 50mm bore resistive magnet. Over-pressure heat treatment performed in the ASC 50-bar "Deltech" furnace. Modelling using the ASC COMSOL multi-physics and high-performance work-station at ASC.

Citation: [1] E. S. Bosque, Y. Kim, U. P. Trociewitz, C. L. English, and D. C. Larbalestier, *"System and Method to Manage High Stresses in Bi-2212 Wire Wound Compact Superconducting Magnets,"* Appl.No. 16390512, Dec. 26, 2019 **https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2019245646**