An R&D Milestone for Bi-2212 High Temperature Superconducting Magnets

D.S. Davis[1,2], Y. Kim[1,2], U.P. Trociewitz[1,2], L.D. Cooley[1,2], D.C. Larbalestier[1,2], S. Minter[3]

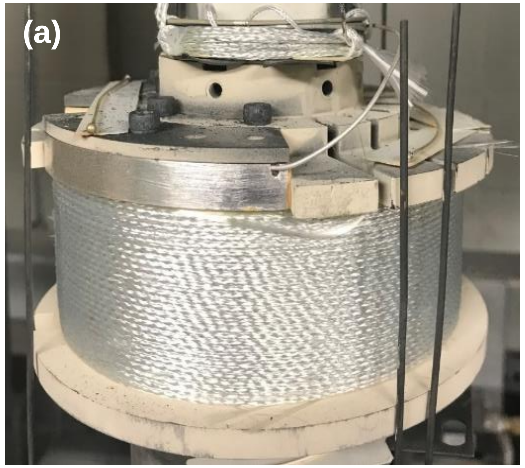
1. Florida State University; 2. Applied Superconductivity Center - MagLab; 3. Cryomagnetics LLC.

Funding Grants: S. Minter, US DOE flow through (PO#35917), D.C. Larbalestier (DE-SC0010421), G.S. Boebinger (NSF DMR-2128556)

There is growing interest in Bi-2212 ($Bi_2Sr_2Ca_1Cu_2O_{8+x}$) conductor in the R&D community as well as in industry and recently an additional manufacturer has joined the scene making Bi-2212 wire. Bi-2212 is unique among commercial high temperature superconductors (HTS) as it is the only one available in multifilament, round wire, architecture and thus does not suffer from screening current effects. Macroscopically it performs isotropically, i.e. no difference in properties upon changing the orientation of an applied magnetic field. Bi-2212 can be internally twisted to reduce charging losses, just like Nb-Ti and Nb_3Sn. Also, Bi-2212 can be cabled easily and it is regularly produced on length scales exceeding a kilometer with reproducible performance over long lengths.

High field HTS magnets require reinforcement to operate reliably under high loads. To evaluate a specific reinforcement scheme laid out by numerical modeling, a thick 26 layer, 30 turn coil was made with 200m of 1mm diameter Bi-2212 wire (coil ID = 44.6mm, OD = 115, h = 40.3mm). The coil was tested in a background of 12T from a 160mm large bore superconducting magnet.

At a quench current density J_e of **573A/mm²**, a combined peak field of **17.9T** was reached, and the coil withstood a source stress of **386MPa**, which is about twice the breaking stress of unreinforced Bi-2212 wire. This performance is a significant improvement over coils made previously. The coil operated stably at 70% of short sample transport and in low cycle fatigue testing (25 cycles). During quenching, a matrix current density in the Ag sheath of the conductor of **726A/mm²** was maintained without coil degradation. With this performance, the coil reaches a milestone for the MagLab's collaboration with Cryomagnetics LLC. It also represents significant progress toward the design requirements of a planned 28T NMR magnet as it approaches the expected stress level of ~400MPa in that magnet.



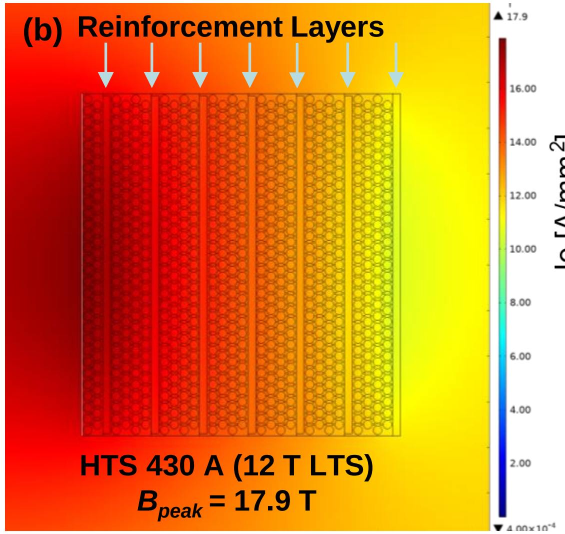
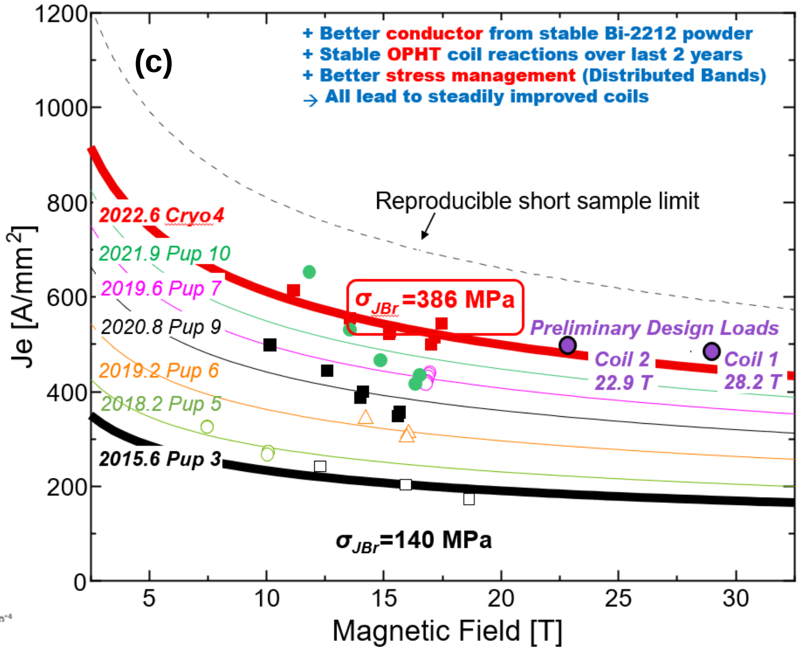


Figure: (a) A coil made with Bi-2212 strand after heat-treatment. **(b)** Schematic cross section and field map of the Bi-2212 coil. The arrows point to the locations of the reinforcement layers embedded in the coil. **(c)** The improvement of Bi-2212 current density, *Je*(*B*), over time. Almost three times the source stress could be mitigated in the most recent coil "Cryo-4" (red line) compared with the initial "Pup-3" test coil (black line at bottom). The preliminary design loads for a planned 28T NMR magnet system (purple) are close to the present-day Cryo-4 performance.



Facilities and instrumentation used: Applied Superconductivity Center's 14T, 160mm large bore superconducting magnet, ASC high-speed data acquisition system.

Citation: E. Bosque, Y. Kim, U.P. Trociewitz, C.L. English, D.C. Larbalestier, System and Method to Manage High Stresses in Bi-2212 Wire Wound Compact Superconducting Magnets, U.S. non-provisional patent application, FSU Ref. no. 18-063, 2019.