Highly efficient twisted multifilament Bi-2212 round wires

Y. Oz[1], D. Davis[1], J. Jiang[1], E. E. Hellstrom[1,2], D. C. Larbalestier[1,2],

1. Applied Superconductivity Center, National High Magnetic Field Laboratory, Florida State University, Florida, 32310, USA;
2. 2. FAMU-FSU College of Engineering, Tallahassee, Florida, 32310, USA;

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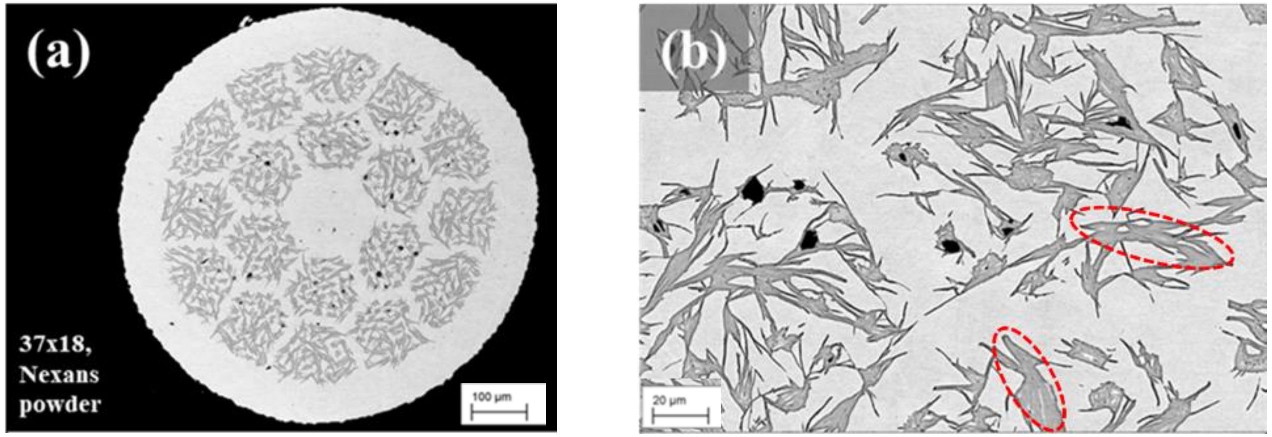
$Bi_2Sr_2Ca_1Cu_2O_x$ (Bi-2212) is one of only two superconducting materials that can be used to build electromagnets capable of generating magnetic fields that exceed 25T, the long-standing practical limit of superconducting magnets based on Nb_3Sn. However, the same manufacturing process that promotes the high-current-carrying capacity necessary for generating high magnetic fields also forms unwanted interconnections between separate superconducting filaments in Bi-2212 round wires. These intermittent interconnections couple the ideally discrete filaments, which increases unwanted magnetization and heat generation when the superconducting magnet is charged or discharged.

Researchers accessed the diverse array of electromagnetic characterization techniques at the MagLab's Applied Superconductivity Center to characterize the electrical performance and magnetic loss properties of state-of-the-art, high-performance Bi-2212 round wires. The wires were twisted to minimize magnetization losses. It was found that all wires had losses (normalized to wire volume) that are near to - or even below - the maximum loss limit specified by the ITER project, the biggest nuclear energy project in the world. Certain configurations of Bi-2212 round wires with widely separated filaments had even lower losses, so low as to approach specifications required for motors, generators, and other electrical infrastructure applications.

The results highlight the versatility of round wire Bi-2212 for high-field, low-loss applications. The publication of this work in the journal *Superconductor Science and Technology* claimed the 2022 Jan Evetts Award sponsored by the Institute of Physics.



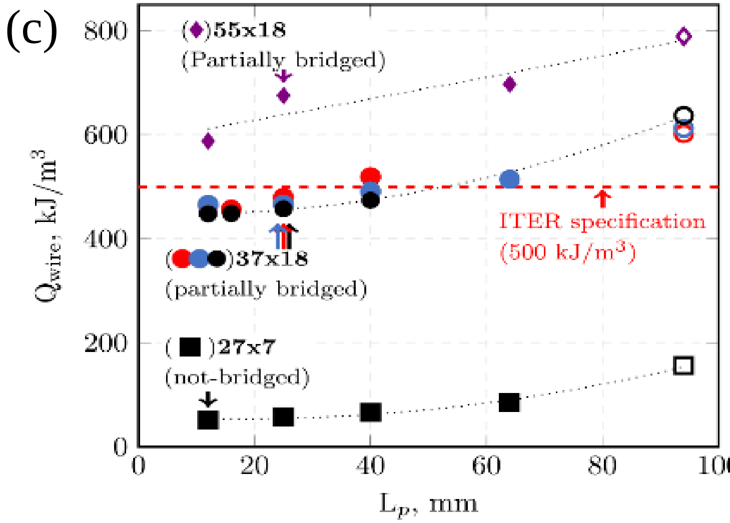


Fig: (a) A cross section view of a Bi-2212 superconducting round wire used in the study, showing 18 bundles, each of which contains 37 superconducting filaments, and (b) a closeup of some of the bundles from the same cross section. The red ovals highlight unwanted filament inter-connections that increase magnetization losses. (c) Magnetization loss per cycle as a function of twist length (L_p) normalized to wire volume. Losses are very close to - and even below - the ITER specification (red dashed line) for maximum magnetization losses.

Facilities and instrumentation used: Applied Superconductivity Center. Instrumentation included Thermo Fisher Scientific Helios G4 high resolution Scanning Electron Microscope, Oxford Instruments 14T Vibrating Sample Magnetometer, Oxford Instruments 15T Superconducting Magnet

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