Alumina Fibers Mechanically Reinforce Superconducting Magnets

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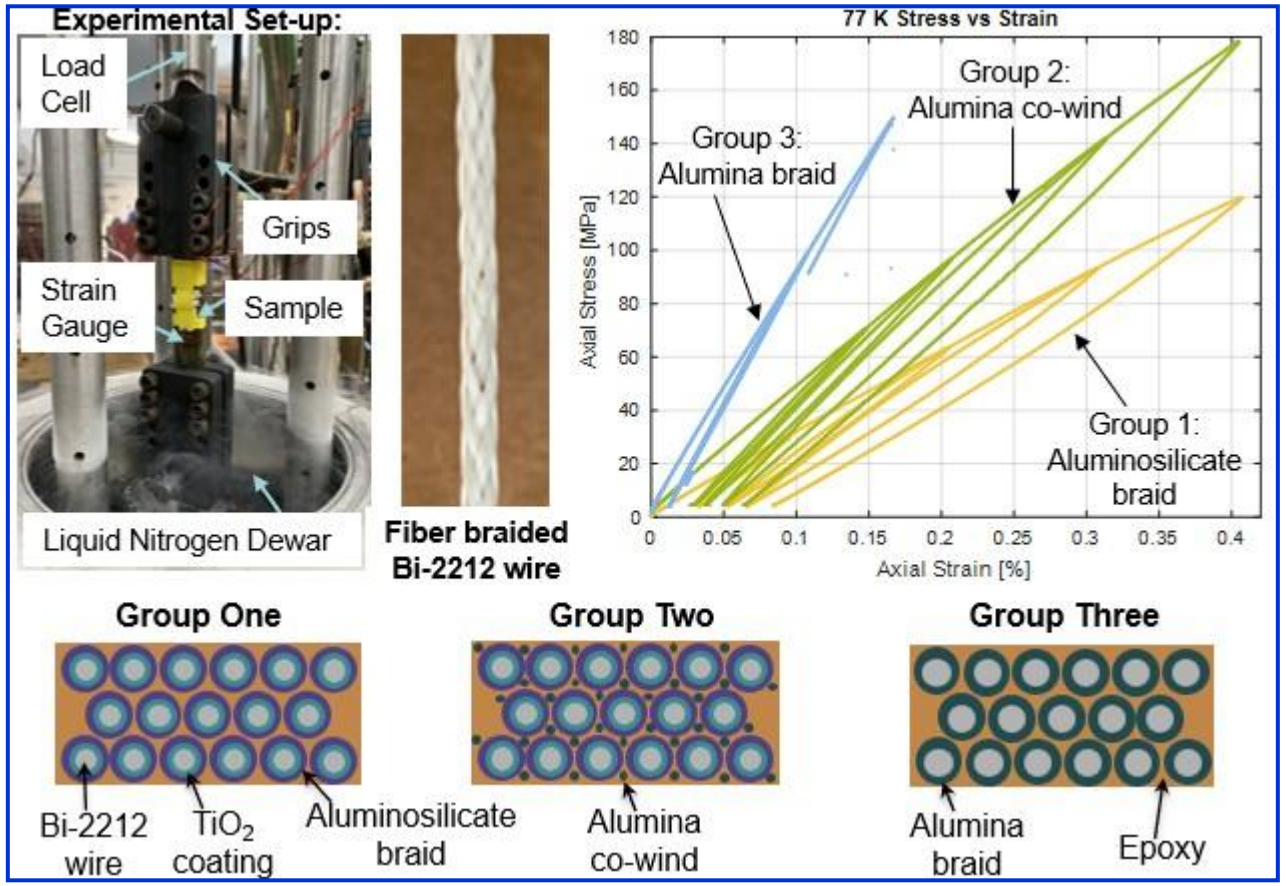
High-field magnets experience large stresses and strains under operating conditions. The higher the field, the larger the stress. The superconductor Bi-2212 is strain limited; when strain exceeds 0.4% the material can be damaged **[1]**. Therefore, Bi-2212 magnets must be mechanically reinforced to prevent damage and remain operational within high-field magnet systems **[2]**.

Here, we fabricated rectangular composite samples containing materials used in Bi-2212 magnets to test novel reinforcement techniques. Three sample groups were tested. The first group contained an aluminosilicate fiber braid around the Bi-2212 wires. The second group contained the same aluminosilicate braid with additional stronger, pure alumina co-wind fibers between the Bi-2212 wires. In the third sample group, the stronger pure alumina fibers were used to form the braid around the Bi-2212 wires. The samples underwent cryogenic tensile testing in a 250 kN load cell at 77 K. **The addition of the alumina co-wind fibers in Group Two increased the strength and stiffness of the samples by about 1.5 times** compared to the samples without the co-wind fibers in Group One. Switching the braid material to pure alumina fibers caused an even larger increase in stiffness; the **pure alumina braided samples in Group Three were 2.7 times stiffer** than the aluminosilicate braided samples in Group One.

The experiment revealed that alumina fibers both as a co-wind and a fiber braid can be used to reinforce Bi-2212 magnets. By increasing the mechanical strength and stiffness of Bi-2212 magnets, we enable them to withstand larger stresses at 0.4% strain, which in turn increases fields it is possible for the magnets to generate.



Facilities and instrumentation used: Applied Superconductivity Center, Magnet Science and Technology Materials Characterization Lab.

Citation: [1] Martin, E.C.; Kim, Y.; Trociewitz, U.P.; Davis, D.S.; Ingrole, A.; Barua, S.; Hellstrom, E.; Larbalestier, D.C.; Kametani, F., Mechanical characterization of Bi-2212 composite winding pack samples for high-field superconducting magnet design, Superconductor Science and Technology, 39 (4), 045001 (2026) doi.org/10.1088/1361-6668/ae55d9. [2] 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, Patent US 11,887,777 B2, 2024.