Development of High-strength and High Strain Tolerant CORC® Conductors for High-Field Magnets

Danko van der Laan[1,2], Jeremy Weiss[1,2], Kyle Radcliff[2], Shreyas Balachandran[3], U.P. Trociewitz[3], D. Abraimov[3], A. Francis[3], J. Gillman[3], D.S. Davis[3], Y. Kim[3], V. Griffin[3], G. Miller3, L.D. Cooley[3], D.C. Larbalestier[3], H.W. Weijers[4], Keyang Wang[5], V.A. Anvar[5] and Arend Nijhuis[5]

[1]Department of Physics, University of Colorado, Boulder, Colorado, U.S.A.
[2]Advanced Conductor Technologies LLC, Boulder, Colorado, U.S.A.
[3]Applied Superconductivity Center, National High Magnetic Field Laboratory, Florida State University, Tallahassee, Florida, U.S.A.
[4]Robinson Research Institute of Wellington, New Zealand
[5]University of Twente, Enschede, the Netherlands

Email: danko@advancedconductor.com

***Abstract* — The brittle nature of high-temperature superconductors requires elaborate means to protect them against the high stresses associated with high-field magnet operation. A small, fully impregnated CORC® cable insert solenoid magnet was successfully tested in a 14 T background field, where it operated at over 4 kA and experiencing a peak field of 16.77 T and a JBr source stress of 275 MPa. CORC® cables in larger magnets will experience higher stress, and likely higher axial strains, requiring an optimization of the CORC® conductor with respect to axial tensile critical stress and irreversible strain limit. Such optimization has been performed by minimizing the tape winding pitch of the helical wind of the REBCO tapes, allowing us to mechanically decouple the brittle REBCO film from the overall CORC® conductor. As a results, we were able to reach a tenfold increase in the irreversible strain limit under axial tension to over 7% in optimized CORC® wires, compared to only 0.6 % in single REBCO tapes. In addition, high-strength alloy and composite cores allowed the critical tensile stress of CORC® conductors to exceed 600 MPa, making them some of the strongest superconductors available. We will show how the effect of axial tensile stress and strain on the critical current of short CORC® wires measured in liquid nitrogen is supported by analytical and finite element modeling. The breakthrough in which the irreversible strain limit of high-strength CORC® conductors exceeds that of all other HTS and most low- temperature superconductors by a factor of 10 to 20 presents a monumental shift for HTS magnet technology. It allows a significant simplification of the magnet design and construction, while bringing reliable high-field superconducting magnets for compact fusion machines, the next generation of particle accelerators, and 40 – 60 T research solenoids within reach.**

***Keywords (Index Terms)* —CORC® conductors, insert magnet, irreversible strain.**

IEEE CSC & ESAS SUPERCONDUCTIVITY NEWS FORUM (global edition), December 2021.
Submitted October 27, 2021; Selected November 20, 2021. Invited presentation HF-5 given at CCA 2021, October 11 – 15, 2021, Virtual.