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[Invited] Development of high-strength CORC® conductors with record-breaking irreversible axial tensile strain limit exceeding 7 %

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Cuprate high-temperature superconductors (HTS), such as RE-Ba2Cu3O7-d (REBCO, RE=rare earth) coated conductors, (Bi,Pb)2Sr2Ca2Cu3O10-x tapes and Bi2Sr2CaCu2O8-x wires, have enabled the development of high-field superconducting magnets. The brittle nature of HTS requires elaborate means to protect them against the high stresses associated with high-field magnet operation, which so far have prevented reliable high-field HTS magnets to becoming a reality. Here we report the results of an extensive optimization campaign to increase the mechanical strength and resilience to axial strain of CORC® conductors. Minimizing the tape winding pitch of the helical wind of the REBCO tapes allowed 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.

Primary authors: VAN DER LAAN, Danko (Advanced Conductor Technologies); WEISS, Jeremy (Advanced Conductor Technologies and University of Colorado, Boulder); Mr RADCLIFF, Kyle (Advanced Conductor Technologies); BALACHANDRAN, Shreyas (NATIONAL HIGH MAGNETIC FIELD LAB); WANG, keyang (University of Twente); V A, Anvar (University Of Twente); Dr NIJHUIS, Arend (University of Twente)

Presenter: VAN DER LAAN, Danko (Advanced Conductor Technologies)

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