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Design and development of high current density, oxide based superconductors with mechanical properties enabling their use in very high field magnets

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Superconducting oxide (HTS) –based conductors must support large stresses and strains in demanding next-generation high field applications without current density and structural degradation. This paper describes recent advances in the mechanical properties of HTS-based commercial and development stage conductors. A comprehensive design model has been established and applied to the development of very high stress and strain tolerant, reinforced HTS wires, tapes and cables with minimal added material, and consequent current density reduction. The analysis incorporates the properties of constituent materials, architecture, method of fabrication and operating conditions, to calculate axial stress, strain, bend, twist and surface indent tolerance. The method was applied to identify superior classes of reinforcement materials in comparison to the currently used stainless steels and superalloys. Conductors with mechanical properties tailored for key applications have been designed for YBCO and Bi2223 oxide based HTS tapes, as well as for Bi2212 based round wires. Based on the analysis and new reinforcement material options, prototype long lengths of reinforced Bi2223-based superconducting tapes were produced that exhibit up to 540 MPa axial stress tolerance, a 1.5 fold improvement that exceeds threshold levels required for use in a broad range of very high field magnet applications. In a second application of this approach, a scalable low cost test bed is built and applied to demonstrate the practical reinforcement of round Bi2212/silver wire, in its fully developed form allowing the much lower cost and more versatile react-and-wind fabrication of Bi2212 based coils for very high field magnets.

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