Poster-1-13

Studies of the artificial flux pinning in ternary Nb_3Sn multifilamentary wires with internally oxidized nanoparticles

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Nb_3Sn is still defending its place against high temperature superconductors in high-field applications, like high-resolution NMR spectrometers, fusion magnets and laboratory magnets, and has even regained interest pulled by the projected Future Circular Collider of CERN. To meet the expectations of applications requiring ever increasing performance, we are implementing the internal oxidation process to increase the defect density in Nb_3Sn (grain boundaries and nanoprecipitates) and thus improve pinning force and consequently critical current density. Internal oxidation involves Nb-alloys containing high oxygen-affinity elements like Zr or Hf and an oxygen source (SnO_2). Using the X-ray Absorbing Near-Edge Structure (XANES), we demonstrated that the oxide nanoparticles (HfO_2 or ZrO_2) are formed during the synthesis of Nb_3Sn[1], which limits the growth of Nb_3Sn grains and increases the grain boundary density[2]. Based on Transmission Electron Microscopy images we determined the precipitate size to be in the 4-10 nm range, approximately twice the coherence length of Nb_3Sn (3nm), which makes them effective pinning centers. The pinning enhancement is set by size and number concentration of nanoparticles, which are strongly influenced by Nb_3Sn formation temperature[3]. A deep understanding of the nanoparticle growth mechanism is required to bring the internal oxidation process to industrial, kilometer-long wires.

[1] G. Bovone et al., "X-Ray Absorption Spectroscopy to Investigate Precipitated Oxides in Nb_3Sn Wires with an Internal Oxygen Source," in IEEE Transactions on Applied Superconductivity, vol. 34, no. 3, pp. 1-5, May 2024, Art no. 6000205, doi: 10.1109/TASC.2024.3354232.

[2] Bovone, G., et al. "Effects of the oxygen source configuration on the superconducting properties of internally-oxidized internal-Sn Nb_3Sn wires." Superconductor Science and Technology 36.9 (2023): 095018.

[3] F. Lonardo et al., "Influence of the Heat Treatment on the Layer J_c of Internal-Sn Nb_3Sn Wires with Internally Oxidized Nanoparticles," in IEEE Transactions on Applied Superconductivity, vol. 34, no. 5, pp. 1-5, Aug. 2024, Art no. 6000305, doi: 10.1109/TASC.2024.3355353.