



Contribution ID: 291

Type: Talk

## **【183】 Influence of Oxygen Source on the High Magnetic Field Behavior of Nb<sub>3</sub>Sn Wires Manufactured via Internal Oxidation**

*Thursday 12 September 2024 18:00 (30 minutes)*

Enhancing  $J_c$  and  $B_{c2}$  in Nb<sub>3</sub>Sn wires is crucial for developing the 16 T dipole magnets needed for the Future Circular Collider (FCC-hh). A refinement of the Nb<sub>3</sub>Sn grain size is the most straightforward strategy to obtain an improved  $J_c$  performance. To this end we implemented an internal oxidation process that controls the Nb<sub>3</sub>Sn grain growth via oxides nanoparticles formed during the synthesis. The process consists in adding an oxygen source (OS, typically SnO<sub>2</sub>) into the wire layout, which decomposes during heat treatment. The oxygen reacts with electropositive atoms in the Nb alloy (Hf or Zr) to form oxide nanoparticles that impede Nb<sub>3</sub>Sn grain growth. We manufactured simplified multifilamentary wires containing an OS that showed Nb<sub>3</sub>Sn grain size down to 50 nm (compared to 110 nm without OS) and enhanced  $J_c$  exceeding the FCC-hh specifications (non-Cu  $J_c$  of 1500 A/mm<sup>2</sup> at 16 T, 4.2 K). Through resistive measurements performed at the Laboratoire National des Champs Magnétiques Intenses (LNCMI) in Grenoble, we measured at 4.2 K record-high  $B_{c2}$  values of 29.2 T and 29.3 T for Zr and Hf additions, respectively (99 % criterion of the superconducting transition). Magnetic measured in a VSM-SQUID showed that oxide precipitates also contribute to the vortex pinning as point defects. As a complement to the test of the superconducting properties we performed advanced structural characterization to investigate formation and role of the oxide precipitates. X-ray Absorption Near Edge Structure (XANES), performed at the Phoenix beamline in PSI, showed that oxide precipitation occurs at the reaction front, while no oxides were found in the alloy after the heat treatment. Using transmission electron microscopy (TEM) we studied the dimensions of the oxide precipitates, on average in the 4–8 nm range after synthesis at 650 °C. Enhancing synthesis temperature from 650 to 700 °C coarsens the precipitates, that become less effective pinning centers at 4.2 K. This study highlights the crucial role of incorporating OS to enhance  $J_c$  through the combined effect of grain refinement and a modified pinning mechanism. Our final goal is to achieve full control of the internal oxidation process in order to transfer the results obtained so far to application-ready wires scalable for industrial production.

**Author:** BOVONE, Gianmarco

**Co-authors:** Dr BUTA, Florin; LONARDO, Francesco; BONURA, Marco; LE BOEUF, D.; BORCA, Cecilia (Universita e INFN Torino (IT)); HUTHWELKER, T.; HOPKINS, S. C.; BOUTBOUL, Thierry (CERN); SENATORE, Carmine

**Presenter:** BOVONE, Gianmarco

**Session Classification:** Magnetic fields for materials research

**Track Classification:** Magnetic fields for materials research