Contribution ID: **93** Type: **not specified**

Exploring the high field potential of Nb3Sn Strand

Tuesday 10 April 2018 08:30 (20 minutes)

Significant progress has been made in the last year in advancing the critical current density of RRP® and PIT Nb3Sn strand by more efficient use of the non-Cu volume used to make the Nb3Sn. For RRP® we show how changing the intermediate heat treatment step to better mix the Cu and Sn and avoid unnecessary Nb dissolution can enable critical current density values above 2900 A/mm2 (12 T, 4.2 K) for sub elements as small as 35 µm in diameter. We also show how design changes for PIT conductors have significantly increased the volume fraction of Nb3Sn, driving Jc up to nearly 2700 A/mm2 (12 T,4.2 K). However, the performance of both types of strands is still well below the FCC goals, and strand for FCC will need to be targeted for 16-18 T performance, not 12-15 T. For high field performance, it becomes more important to optimize the irreversibility field of the conductor. In particular, doping is crucial to increasing the upper critical field of Nb3Sn and we show how EXAFS can be used to identify the lattice locations of the dopant atoms in high performance Nb3Sn strand. For the first time we show that Ta atoms can occupy either the Nb or Sn sites and thus that the Ta atoms compete with the diffusing Sn for the Sn sites during reaction. By contrast, Ti always sits on Nb sites, perhaps explaining the faster and more homogeneous reaction we find for Ti doping. It does seem that the disorder potential of double-doped (Ta+Ti) with higher Kramer field (Hk) and upper critical field (Hc2) extrapolations deserves further examination for FCC use. We also include our first characterizations of ZrO2 containing strands where we find, for now significantly depressed Hc2 values, in spite of their enhanced pinning site density.

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Session Classification: Magnets

Track Classification: EASItrain