Contribution ID: **76** Type: **Oral**

Increasing the High-Field Performance of Nb3Sn Wires by Pinning Landscape Modification

Tuesday, 12 April 2016 11:30 (30 minutes)

While Nb_3Sn is certainly a very promising candidate for the superconductor to be used in the FCC's magnet system, the highly demanding performance requirements of the project call for significant advances in the fabrication of this material. In particular, relative to currently available Nb_3Sn wires an increase of the critical current density J_c by roughly 50% in a background field of 16 T will be required.

We present data obtained from the hitherto most extensive neutron irradiation study on Nb_3Sn wires. Samples of five state-of-the-art industrial wires were subjected to sequential irradiation up to a fast neutron fluence of more than $3 \cdot 10^{22}$ m^{-2}. Changes in the superconducting parameters caused by the irradiation were assessed by means of SQUID magnetometry in a wide temperature range after each irradiation step. By means of pinning force analyses we were able to show that fast neutron irradiation leads to the introduction of material defects which act as point-like pinning centers. This pinning landscape modification significantly changes both the magnitude and the functional dependence of the volume pinning force, leading to a large J_c enhancement at high magnetic fields.

These results fuel our hopes that the ambitious J_c requirements for the FCC magnets can be met by designing a new generation of Nb_3Sn wires with an improved pinning landscape. This may be accomplished for instance by introducing normal-conducting nano-particles whose size should be approximately equal to that of the irradiation induced defects.

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Session Classification: Conductor Development II

Track Classification: Superconducting Magnets