Sn content and alloying effects in ITER Nb_3Sn strand

M. C. Jewell[1], A. Godeke[2], P. J. Lee[1], and D.C. Larbalestier[1]

[1]*Applied Superconductivity Center, University of Wisconsin – Madison, Madison, WI*
mcjewell@wisc.edu
[2]*Faculty of Science and Technology, University of Twente, Enschede, The Netherlands*
a.godeke@tnw.utwente.nl

The optimization of ITER Nb_3Sn bronze-processed composite strand has been accomplished through both advancements in mechanical drawing of the strand to fine filament sizes and progress in optimizing the quality of the Nb_3Sn superconducting layer. Despite the advancements, further improvement of the Nb_3Sn layer would be desirable in terms of increasing the performance envelope (and thereby the operating margin) of the magnets in both field and temperature. This can be done by (1) increasing the H(T) superconducting envelope, and/or (2) reducing the H(T) superconducting transition breadth, which is inherently large due to the presence of Sn gradients imposed by the diffusional nature of the heat treatment reaction. In recent DC high-field measurements of the resistive superconducting transition down to 1.4 Kelvin (K), a Ta-doped and a Ti-doped ITER Nb_3Sn conductor are shown to have almost identical “best bit” upper critical field (H_{c2}) values at 0 K, but significantly different transition widths. Both conductors have a maximum $\mu_0 H_{c2}(0) = 29.5\pm0.1$ Tesla (T), but the Ta-doped wire has a 0 K H_{c2} distribution of 2.8 T, while the Ti-doped wire has a 0 K H_{c2} distribution of 2.0 T. We explain this result in terms of the Sn supply and Sn distribution in the bronze-route geometry. In the same set of measurements, a bulk, binary Nb_3Sn needle with a wide range of chemical homogeneity is shown to have almost identical H(T) properties to the commercial ITER wires. This result is surprising since the ternary additions (Ti or Ta) in the commercial wires are expected to enhance Hc2 by at least one Tesla. We compare the performance of this inhomogeneous bulk needle to chemically homogeneous binary and ternary bulk samples.

This work was supported by the US Dept. of Energy, Division of High Energy Physics (DE-FG02-91ER40643), and also benefited from NSF-MRSEC (DMR-9632427) supported facilities. The authors thank R. Lund and R. Sakidja for sample fabrication assistance.