Contribution ID: **507** Type: **Contributed Oral Presentation**

Innovative thin film technologies for nano-engineering and optimizing Nb3Sn superconductor beyond state-of-the-art

Monday 10 July 2017 12:15 (15 minutes)

A novel patented electro-chemical technique to produce Nb3Sn thin films was reproduced in US labs. The Nb3Sn phase is obtained in a two-electrode cell, by electrodeposition from aqueous solutions of Sn layers and Cu intermediate layers onto Nb substrates. Current densities are between 20 mA/cm2 and 50 mA/cm2, and bath temperature is between 40C⊠ and 50⊠C. Subsequent thermal treatments in inert atmosphere are realized at 700⊠C to obtain the Nb3Sn superconducting phase, which is typically between 5 and 10 ⊠m in thickness. Nb3Sn benchmark samples were first produced at ANL. Then the technique was further optimized, and samples were characterized for superconducting properties, including Tc0 by transport and inductive measurements, using the existing FNAL infrastructure. The samples critical temperature Tc0 ranged from 17.0 K and 17.7 K, and the samples upper critical field Bc20 ranged between 22 T and 24 T. Flux pinning models in granular A-15 based on Josephson-coupled arrays and anisotropic flux pinning by grain boundaries predict that the Jc of A-15 superconductors could be largely improved by elongating their grain structure and/or nano-engineering the materials. In a next phase of this work, these thin films will be used to test theoretical predictions, as well as flux pinning properties of additional elements inexpensively and with fast turnaround. Since the electrochemical deposition method is scalable in size and controllable on curved surfaces, applications to superconducting magnetic shields and SRF are in principle possible. In parallel to sample development and fabrication, some R&D effort was put in the electro-polishing of the samples'outer surface at JLab for future surface resistance measurements, to test adequacy to SRF applications.

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Session Classification: M1OrD - Focused Session: Superconducting Thin Films for SRF and Magnets Applications