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Innovative Nb3Sn Thin Film Approaches and their Potential for Research and Applications

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Two different electro-chemical deposition techniques, both under US Patent Application No. 62/190, 199, to produce Nb3Sn coatings have been studied in the last few years by FNAL in collaboration with Politecnico di Milano.

In the first technique, the Nb3Sn phase is obtained by electrodeposition from aqueous solutions of Sn layers and Cu intermediate layers onto Nb substrates followed by high temperature diffusion in inert atmosphere. Subsequent thermal treatments are realized at 700□C to obtain the Nb3Sn superconducting phase. The thickness of the Nb3Sn phase was between 5.7 and 8.0 □m for the different types of samples. All samples showed superconducting transport behavior, with a maximum obtained Tc of 17.68 K and Bc20 ranging between 22.5 T and 23.8 T.

In the second technique, the synthesis of Nb-Sn coatings was carried out on Cu substrates by direct electrodeposition from 1-Butyl-3-methylimidazolium chloride (BMIC) ionic liquids at 130□C containing SnCl2 and NbCl5. No heat treatment whatsoever is necessary in this technique. The electrodeposited coatings showed a cubic Nb3Sn phase with (211) preferred orientation, a disordered orthorhombic NbSn2 phase and Sn-Cu phases. Film thickness was 200 to 750 nm in direct current mode and 500 to 1600 nm in pulsed current mode.

Both methods should be cost-effectively scalable to 3D shapes, as typical of electrochemical techniques. Whereas the second technique still requires research to optimize film homogeneity, the first can already be applied for superconducting Nb3Sn wires, i.e. use thin films to test flux pinning properties of additional elements inexpensively and with fast turnaround. Coating of SRF cavities will also be tested in the near future. The second technique, which carries great money-saving potential for future accelerators, is under active R&D.

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