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Ultra-Low Cost Approach to Superconducting Nb3Sn RF Cavities Using Melt Casted Bronze Structures

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Energy to Power Solutions (e2P) in collaboration with the Thomas Jefferson National Accelerator Facility (JLAB) have investigated a novel approach to fabricating Nb3Sn SRF cavities using an ultra-low cost melt casting fabrication process. e2P's simple melt casting techniques can be used to fabricate nearly any superconducting Nb3Sn structure using either the Bronze Route (BR) or Internal-Tin (IT) processes. Due to the ease of the BR melt casted approach, initial efforts were geared primarily towards this process; however, our patent pending process can be used for a wide variety of RF structures, including the IT Nb3Sn fabrication technique as well as normal conducting copper conducting cavities.

Multiple 10 mm x 10 mm coupons of varying tin (Sn) content ranging from 11% to 19 % (Sn atomic weight) were reaction heat treated using a modified BR processing technique. All of the coupons were mechanically polished and cleaned prior to Nb film deposition but were not chemically etched. The mechanically polished bronze coupons of varying Sn content were initially coated with a 0.5-1 um thick Nb film at JLAB using an Electron Cyclotron Resonance (ECR) RF sputtering technique under varying processing conditions of substrate temperature and incident ion energies. After Nb film deposition in JLAB's ECR chamber, samples were then heat treated in a separate furnace in an attempt to form the superconducting Nb3Sn phase. Samples were heat treated in both a vacuum furnace at JLAB and inert Ar atmosphere at e2P. Samples heat treated in the vacuum furnace at JLAB showed superior surface smoothness. Post heat treated samples were then tested for its superconducting transition temperature (Tc) using AC susceptibility measurements.

Most of the heat treated samples that were examined using SEM/EDX seemed to show a reasonable correlation of Tc onset and transition width (delta T) of the initial/starting Sn content to the desired stoichiometric Nb3Sn phase, where the lower starting Sn content coupons resulted in lower Tc's with broader transition widths and the higher starting Sn coupons resulted in higher Tc's with narrower transition widths. The best samples had Tc's ~18 K and delta T's ~ 1 K.

Two samples were further tested for RF surface resistance (Rs) and Quality Factor (Q) at JLAB. These RF measurements were performed at 7.5 GHz using a calorimetric technique and showed a Tc onset ~ 16 K; however, values of Rs were quite disappointing with corresponding Q values ~ 1065 nearly 4 orders of magnitude lower than similar high quality Nb3Sn films directly deposited substrates by JLAB.

Substantial improvements in the processing variables ranging from higher quality of the initial melt casted structures with higher Sn content, to better polishing and chemical surface treatments will be necessary to realize improved RF performance metrics.

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