Contribution ID: **30** Type: **Oral presentation**

Electrochemical Bronze-Route Nb3Sn for SRF Cavities

Thursday, 12 November 2020 09:00 (20 minutes)

Electrochemical methods are presented to prepare substrates, deposit Nb and bronze coatings, and set up reactions for Nb3Sn for a potential application in SRF cavities. Specifically, this paper presents firstly our understanding on the electrochemical mechanisms that hinder the proper preparation of substrate and coating layers and secondly methods of overcoming such limitations developed in our research. While the bronze route demands the surface preparation of Cu-Sn alloy, preferably using electropolishing, it is found to be impossible because electrochemical properties of Cu-Sn alloy, which are significantly different from those of pure copper by the presence of Sn, leads to the formation of a surface layer consisting of tin oxides and tin salts, notable tin phosphate, tin sulfate, tin chlorate, and tin chromate. These compounds have a formation energy lower in the electrochemical sequence compared to copper and copper salts, making it impractical to avoid the spontaneous formation of these surface contaminants during electropolishing. On the other hand, electroplating of a bronze thin film on niobium substrate as well as other metallic substrates, an alternate possibility of Nb3Sn cavity structure, is found to be possible by the use of either sequential deposition Cu/Sn layers or co-deposition of Cu-Sn alloy on Nb. Finally, successful plating of Nb on bronze was achieved through understanding of disproportionation reactions related to niobium ions, implementation of non-aqueous solution methods, and prevention of the chemical mechanism contaminating the Nb electrodeposits. For the first time in history, we were able to produce metallic Nb coating with quality sufficient to be considered for SRF applications. A model structure mimicking the Nb3Sn SRF cavity has been under construction by using all electrochemical processes, highlighting results of which will be presented.
This work is supported by the U.S. Department of Energy, Office of Science, Office of High Energy Physics under Award No. DE-SC 0018379. A portion of this work was performed at the National High Magnetic Field Laboratory, which is supported by National Science Foundation Cooperative Agreement No. DMR-1644779 and the State of Florida.

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Session Classification: Growth Studies

Track Classification: Growth studies