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Temperature-Dependent Characteristics of Sputtered Nb3Sn Thin Films (for Accelerator Applications)

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Nb3Sn thin film is the most promising candidate for the next-generation superconducting radio frequency (SRF) cavities. In this work, we successfully enabled the DC sputtering deposition of Nb3Sn films with varying thickness (100 nm - 2 μm) on either Nb or Cu substrates. More importantly, we systematically explored the effects of annealing both in situ and post-sputtering in order to achieve optimal conditions for constructing films. Preliminary results show that the sputtered films are essentially smooth, although deficiency of Sn occurred as indicated in our energy dispersive X-ray spectroscopy (EDS) analysis. After thermal anneals of increasing temperature, we observed removal of nanometer-size pinholes and a slight increase in grain size, in addition to cracking and changes in grain organization in some samples. Interestingly, triangle shaped grains were observed in one of our non-in situ-annealed samples. We can infer how the grains nucleate at the initial stage through comparison of our data from post-sputtering with recent data after high-temperature anneals. From X-ray diffraction (XRD) results, we found that our anneals can effectively crystallize film as suggested by the increased amplitude of diffraction peaks. Especially on our Cu substrate samples, we observe the appearance of Nb3Sn peaks after 600 C annealing. These initial results encourage us to refine our process to obtain high quality films for SRF use and fundamentally understand the nucleation process of sputtered Nb3Sn.

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