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Physical Vapor Deposition of Bronze-Route Nb3Sn for SRF Cavities

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We have investigated Nb3Sn film growth via bronze route by magnetron sputtering of Nb films on to bronze substrates for potential application in SRF cavities. Two main routes were followed: 1) deposition of 500 nm equivalent Nb onto hot (650 ℃ to 775 ℃) bronze substrates, where Nb3Sn formed during the Nb deposition; 2) deposition of Nb onto bronze substrates at lower temperature (200 ℃) with a follow up reaction heat treatment (650 ℃ – 775 ℃). Control of oxidation is paramount, since oxidation at the Nb-bronze interface blocks the Nb-Sn diffusion reaction, in addition to consumption of the intended coating by niobium oxides. Residual impurities P and S have deleterious effects similar to oxidation. Cu-15%wt Sn and Cu-15%wt Sn – 0.3%wt Ti bronzes with zero P were used as the substrates. Nb3Sn coatings obtained by both routes show surface roughness < 15 nm within regions defined by the bronze grain structure. Critical temperature of 14–16.5 K is obtained for films with 22 - 26% Sn, indicating a loss of ~2 K due to elastic compression of the Nb3Sn since thermal contraction is dominated by the bronze. Samples made via route 1 showed relatively large columnar grains with the length of the film thickness while samples made using the route 2 showed smaller grains. Both samples did not show any cracks in the Nb3Sn film even after a thermal cycle from room temperature to 4.2 K. Management of thermal expansion mismatches is a key challenge going forward, and adaptations using more complicated methods are ongoing.
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