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Effects of deposition parameters on superconducting NbTiN thin films for use in SRF multilayer structures

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"For the last few decades, the material of choice for SRF cavities has been bulk niobium. RF performance of bulk Nb cavity has already approached its theoretical limit. To enhance RF cavity performance and cost-efficiency, research has shifted towards the use of other alternative higher T_c materials, such as NbN, $NbTiN$, MgB_2, etc. However, the use of alternative superconducting materials, despite their higher T_c, may not allow high accelerating gradients and quality factors greater than Nb due to their smaller H_{c1}. Addressing this problem, Alex Gurevich in 2006 proposed a theory involving superconductor-insulator-superconductor (SIS) structures to shield an underlying superconductor from the applied magnetic fields, thus increasing the maximum accelerating gradient beyond the bulk Nb limits.

$NbTiN$ is one of the most promising alternative materials to Nb, which already displayed high-quality factors in coated cavities for research. The present work focuses on the deposition of high T_c (17.3 K) $NbTiN$ thin films, primarily due to their high T_c and they also encompass all the benefits of NbN while displaying superior metallic conduction characteristics with higher titanium content. We used the industrial coating machine, CC800, to deposit single layers of $NbTiN$ thin films onto silicon (Si), a thick film of Nb, and aluminium nitride (AlN) substrates using DCMS and HiPIMS techniques. The primary focus here is solely on optimizing $NbTiN$ thin films for potential future use in SIS structures. The impact of various deposition parameters on the microstructure, phase formation, and subsequent superconducting properties of $NbTiN$ films deposited on various substrates are presented. The results indicate that HiPIMS yields films characterized by higher density and fewer voids in comparison to DCMS. Following the successful optimization of $NbTiN$ thin films, they will be utilized for the development of SIS structures."

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