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Nb_3Sn Films Depositions from Targets Synthesized via Liquid Tin Diffusion

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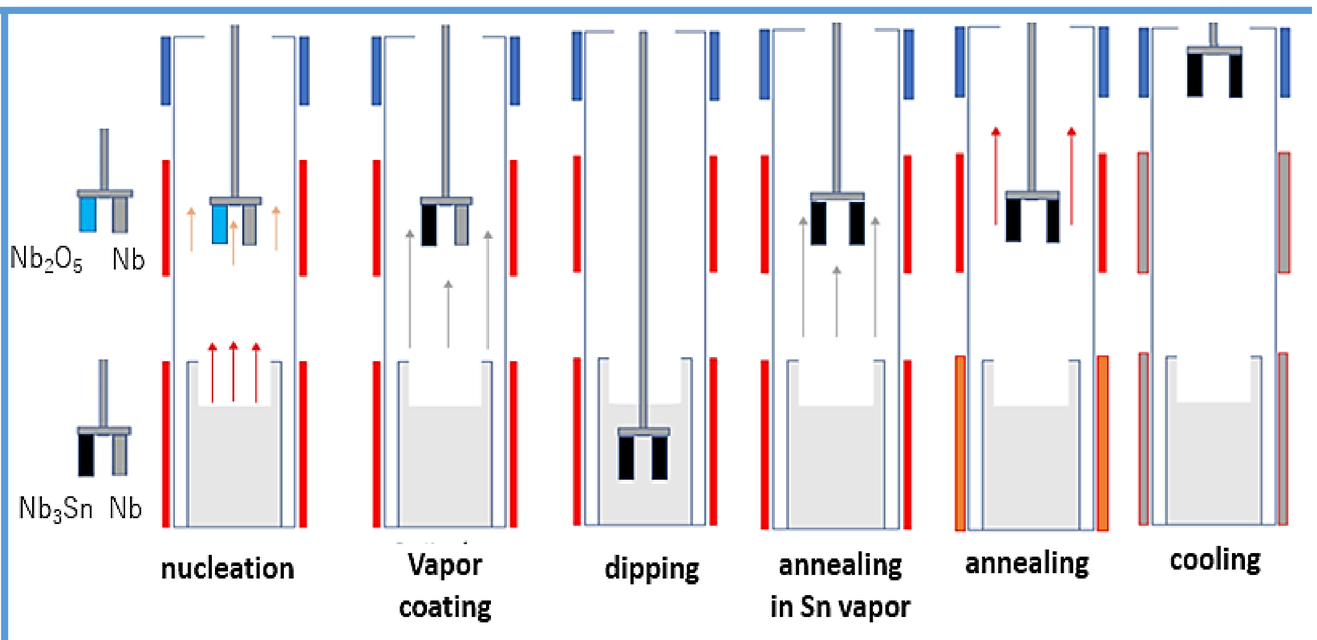
Abstract

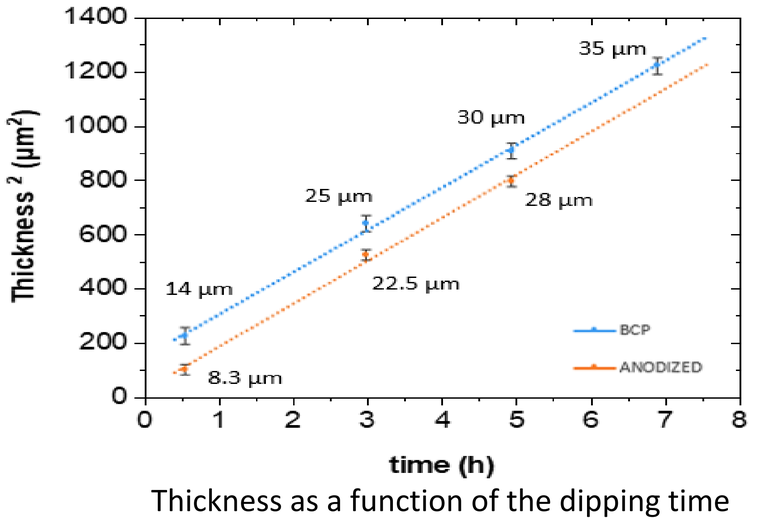
The deposition of Nb_3Sn on copper cavities is interesting for the higher thermal conductivity of copper compared to common Nb substrates. The better heat exchange would allow the use of cryocoolers reducing cryogenic costs and the risk of thermal quench. Magnetron sputtering technology allows the deposition of Nb_3Sn on substrates different than Nb, however the coating of substrates with complex geometry (such as elliptical cavities) may require targets with non-planar shape, difficult to realize with classic powder sintering techniques. In this work, the possibility of using the Liquid Tin Diffusion (LTD) technique to produce sputtering targets is explored. The LTD technique is a wire fabrication technology, already developed in the past at LNL for SRF applications, that allows the deposition of very thick and uniform coating on Nb substrates even with complex geometry. Improvements in LTD process, proof of concept of a single use LTD target production, and characterization of the Nb_3Sn film coated by DC magnetron sputtering with these innovative targets are reported in this work.



Optimized LTD process scheme

Methods and Characterizations (LTD)

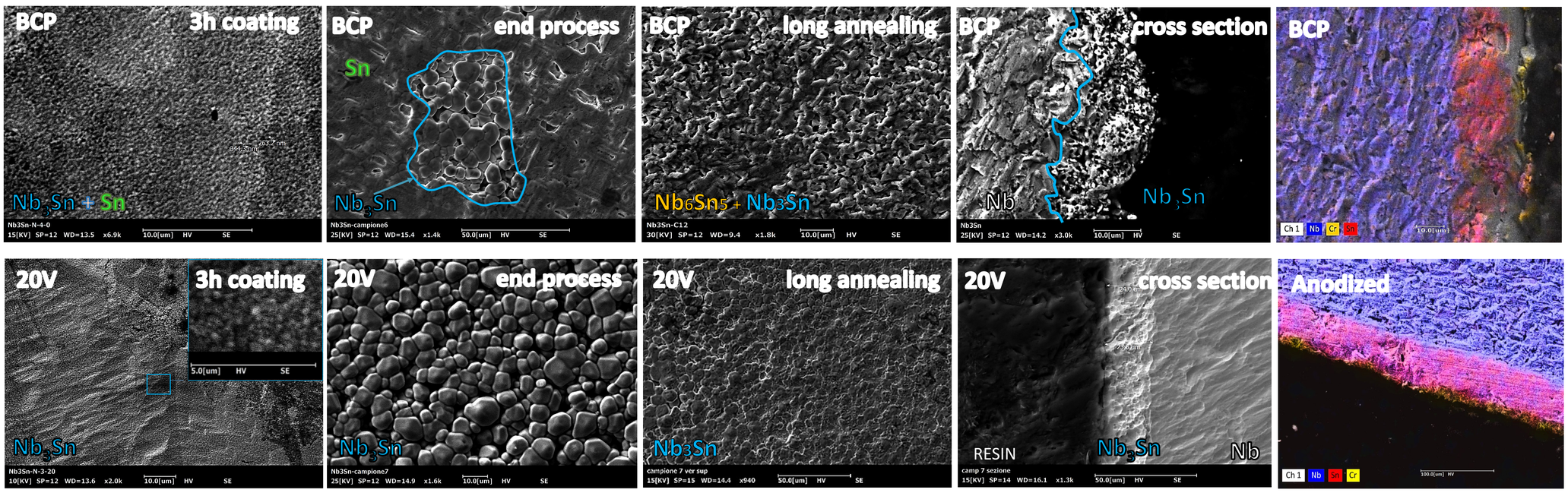
The samples are fixed to the manipulator by niobium wires and the system is heated and evacuated to a base pressure of 10^{-8} mbar. During the optimization process of the LTD technique, the following parameters were investigated: the influence of Nb anodization, the dipping time and the annealing time in the presence and absence of tin vapor. The great constraints found in old processes without Nb anodization are the formation of percolating paths inside the material with consequent incorporation of tin on the surface and small sintering of the grains. The anodization of the substrate has a beneficial effect on the whole process, in fact it is observe Nb_3Sn crystallites with correct stoichiometric composition and larger than 8 microns. The morphological and structural characterization (SEM, EDS and XRD) are used to understand the quality of the film obtained.



Thickness as a function of the dipping time

BCP treatment

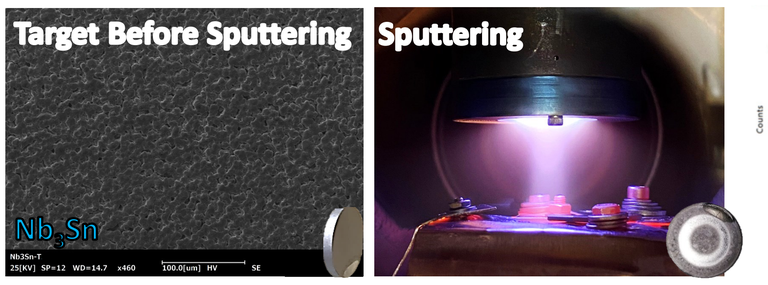
BCP + Anodization treatment

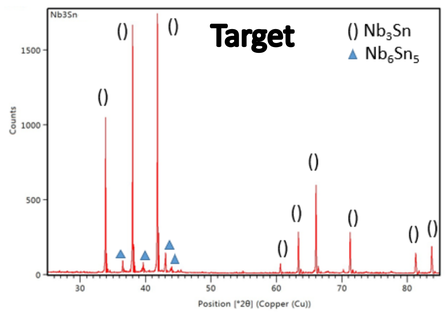


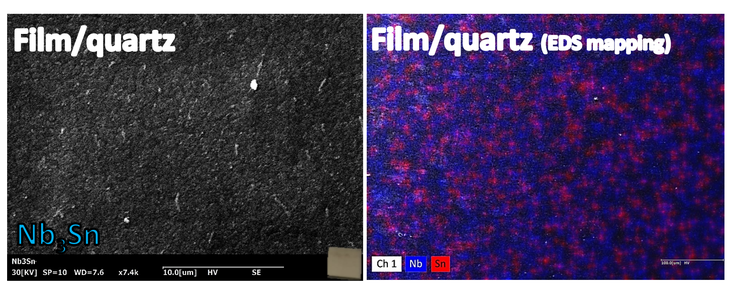
SEM micrographs of the LTD process steps for both sample types

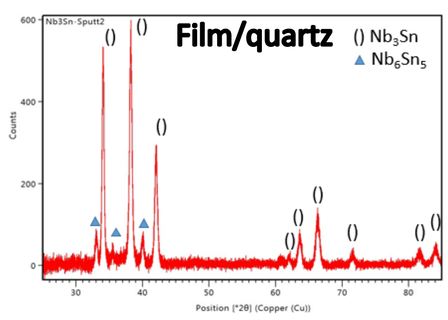
DC Magnetron Sputtering

The DC Magnetron Sputtering system consists of an ultra-high vacuum pumping system, a 1-inch magnetron for housing the target obtained via LTD and a heatable sample holder. The system is heated to 750°C and evacuated to a base pressure of 10^{-6} mbar. The post process annealing can be performed to increase A15 phase of the deposited film. Only Nb_3Sn targets with anodization treatment are used to deposit Nb_3Sn on quartz.









SEM micrographs and XRD pattern of the LTD target and the deposit film on quartz.

Results and conclusions

It has been demonstrated that the controlled nucleation process is fundamental for an efficient success of the process in terms of film quality. The dipping time is the predominant factor in increasing the film thickness. The 5-hours processes allow to obtain 28 µm sufficient for the deposition of 1 µm of Nb_3Sn via DCMS sputtering. The "hybrid" heat treatment is essential to obtain a correct stoichiometry and minimization of the spurious phases.

The single-use thick film planar targets of Nb_3Sn via LTD technique for DC magnetron sputtering depositions were obtained and successfully used. The coating has characteristics and stoichiometry comparable to the starting target thick film of Sn 24-25%.To eliminate chromium contamination in the LTD process, a niobium screen will be inserted inside the chamber In the near future the LTD optimized process will be implemented on cylindrical geometry cathodes and a systematic study on sputtering deposition parameters will be performed.

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