Nb_3Sn Coating of a 2.6 GHz SRF Cavity by Sputter Deposition Technique

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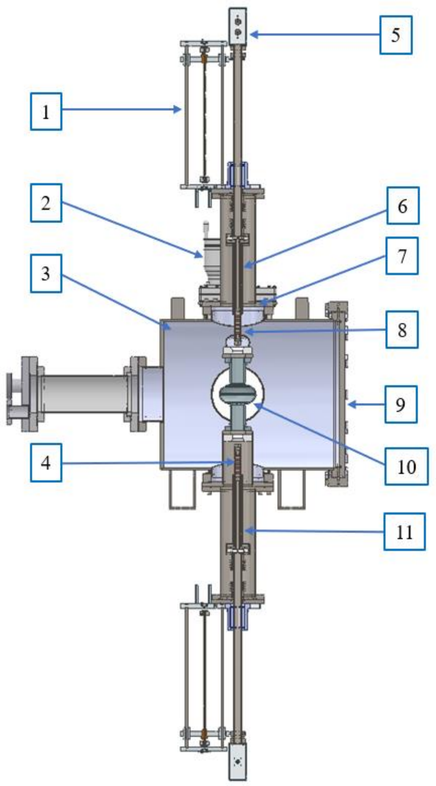
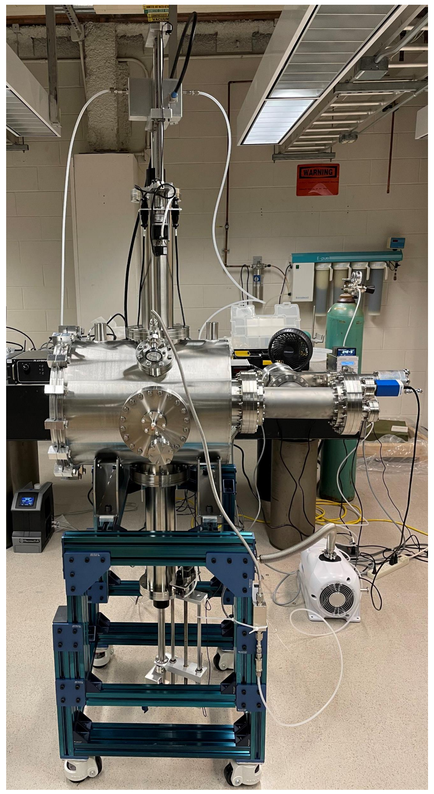
Abstract

A cylindrical magnetron sputtering system is commissioned at Old Dominion University and operated to deposit Nb_3Sn on the inner surface of a 2.6 GHz single-cell Nb SRF cavity. Using two identical cylindrical magnetrons for Nb-Sn multilayer sequential sputtering followed by annealing, Nb_3Sn films are deposited on Nb substrates at the equivalent positions of the cavity's beam tubes and the equator. The T_c of the films are 17.61 to 17.76 K. Also, ~1.2 μm thick Nb_3Sn is deposited onto the cavity surface. The first results from samples and cavity coatings and the operation of the cylindrical sputtering system are discussed.

Design of cylindrical sputter coater



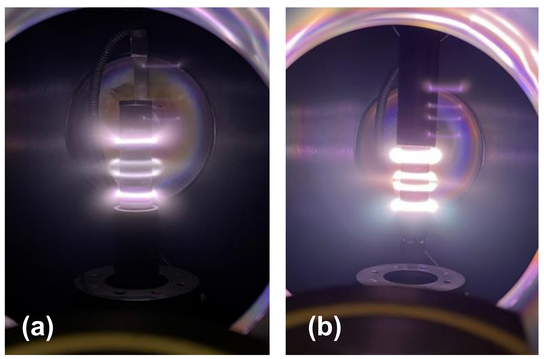


Left: A sketch of the cylindrical magnetron sputtering system (1) Magnetron movement controller shaft, (2) Gate valve, (3) Vacuum chamber, (4) Magnets, (5) Water flow controller, (6) Top magnetron, (7) 8'' ConFlat (CF) port of top magnetron, (8) Tube target, (9) Chamber door, (10) 2.6 GHz Nb SRF cavity, (11) Bottom magnetron. The magnetrons were made by Plasmionique to fit an ODU custom chamber. Right: Image of commissioned cylindrical magnetron sputtering system.

Operation

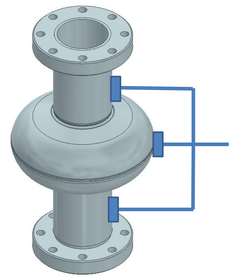
Nb and Sn tube target of dimension 0.9'' OD x 0.8'' ID x 4.5'' (99.99% purity) are installed on Top and Bottom magnetron, respectively.

10 mTorr deposition pressure with 50 SCCM Ar gas flow are used.



DC Plasma discharge. (a) Nb at 30 W, (b) Sn at 8 W.

Multilayer Sequential Sputtering

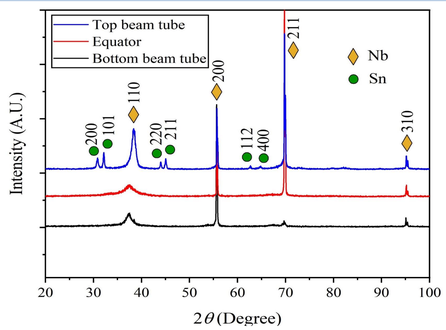


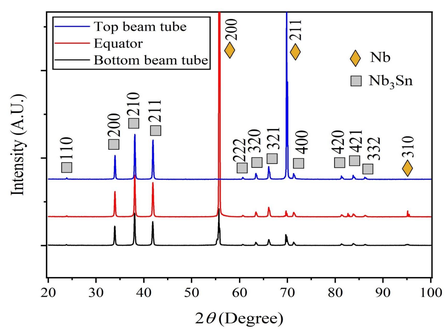
Sketch of a 2.6 GHz Nb SRF cavity and mount replicating three positions the cavity

Mulitlayers of Nb (layer thickness ~50 nm) and Sn (layer thickness ~25 nm) are deposited on Nb substrates, mounted at three equivalent positions of the cavity.

Position	Total thickness of film (nm)
Top beam tube	840
Equator	1200
Bottom beam tube	824

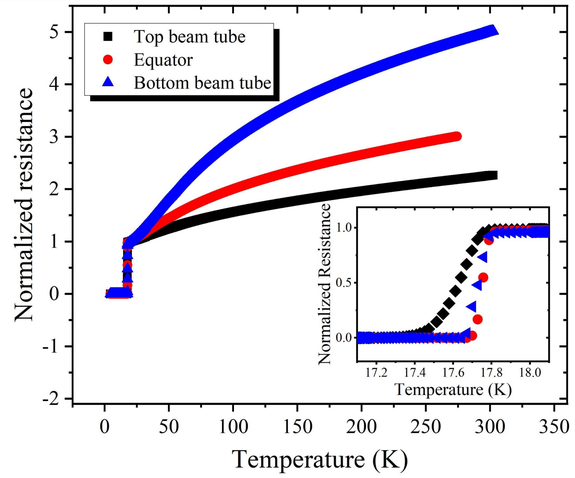
Characterizations





Top figure: XRD pattern of as-deposited films shows Nb and Sn diffraction peaks. Bottom figure: XRD pattern of annealed samples at 950 °C for 3 h; No diffraction peaks from any compound other Nb_3Sn are observed. Nb peaks are coming from substrate.

Positions	Sn (at.%) of As-deposited films	Sn (at.%) of Annealed films
Top beam tube	33	22
Equator	32	19
Bottom beam tube	25	19



Sample resistance with temperature down to 4 K using four-point probe method. Inset shows the superconducting transition region of the films.

Position	T_c (K)	ΔT_c (K)	RRR
Top beam tube	17.61	0.24	2.26
Equator	17.76	0.06	3.00*
Bottom beam tube	17.73	0.1	5.01

Superconducting properties of the Nb_3Sn film. The highest T_c of 17.76 K and lowest ΔT_c of 0.06 K are observed for the film at the equator location.

*Equator sample's RRR values is calculated from the ratio of the resistance at 275 K to that at 20 K. Other RRR values are measured from the ratio of resistance at 300 K to that at 20 K.

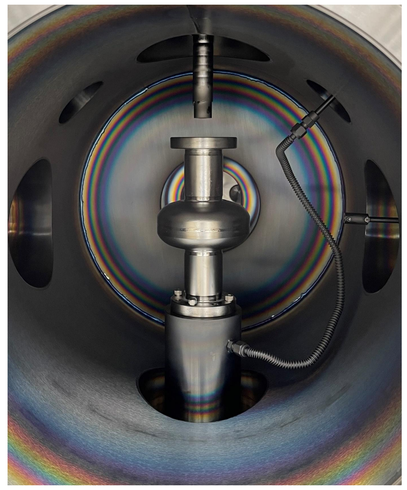


Image of 2.6 GHz Nb cavity installed in the system. Coated cavity with ~1.2 μm thick Nb_3Sn will be tested soon.

Conclusion

We have commissioned a cylindrical magnetron sputtering system and used it to deposit Nb_3Sn films on flat samples at equivalent positions of equator and beam tubes of a 2.6 GHz Nb SRF cavity. The samples have T_c of 17.61–17.76 K and ΔT_c of 0.06–0.24 K. We have also coated an SRF cavity using the same conditions as used to coat the flat test samples. The cavity testing is in progress.

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