Co-sputtering of Nb_3Sn into SRF cavity using composite target and optimizing surface homogeneity

M. S. Shakel, H. E. Elsayed-Ali, Old Dominion University, Norfolk, VA
G. Eremeev, Fermi National Accelerator Laboratory, Batavia, IL
U. Pudasaini, A. M. Valente-Feliciano, Thomas Jefferson National Accelerator Facility, Newport News, VA

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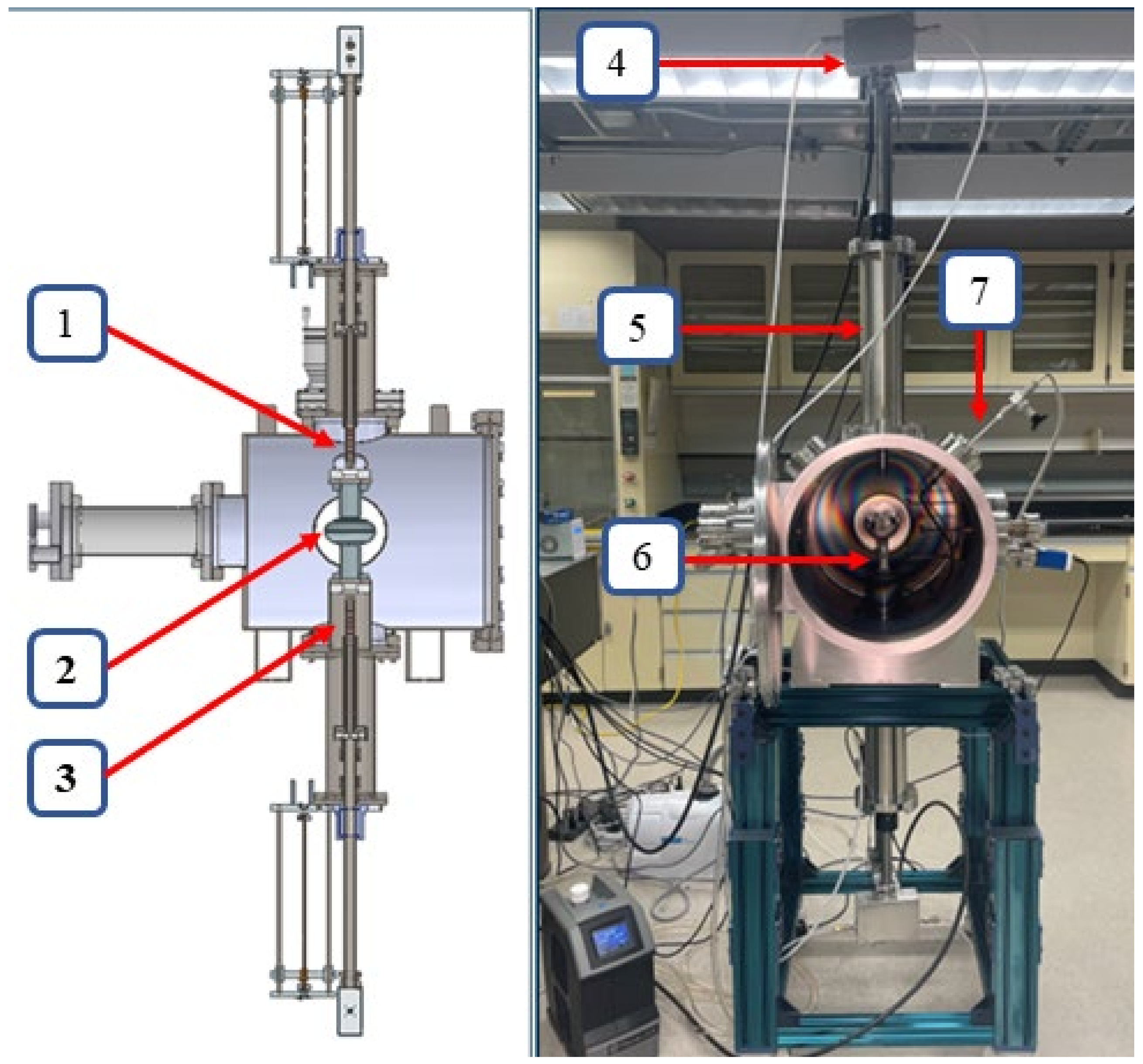
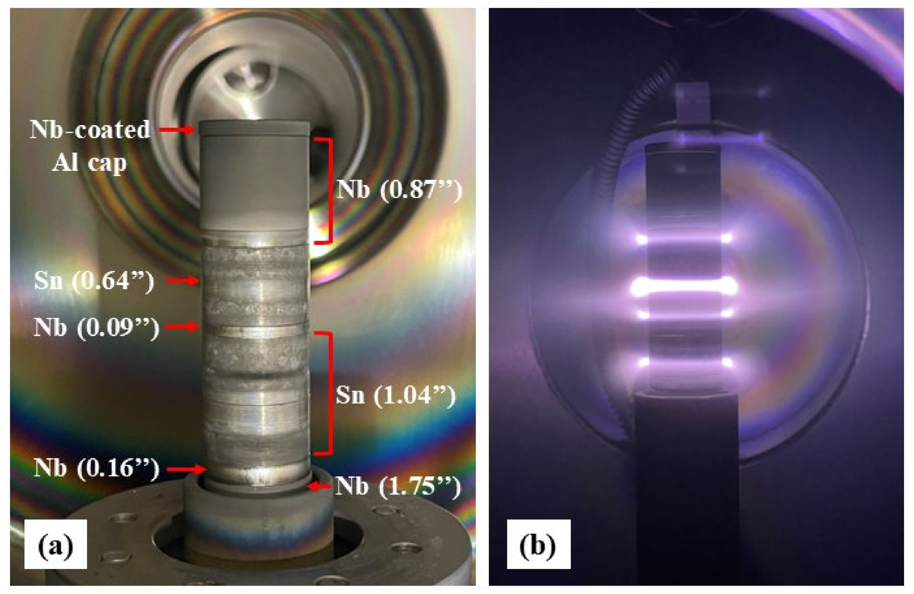
Abstract

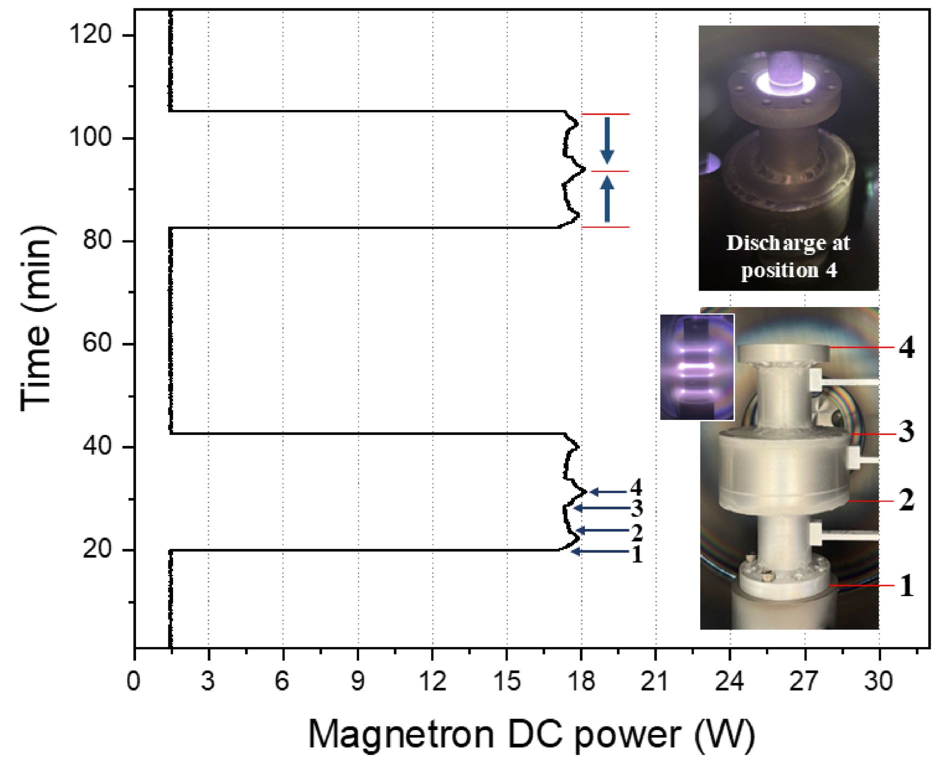
Nb_3Sn coating method for superconducting radiofrequency (SRF) cavity has been developed following co-sputtering of Nb-Sn composite target using a DC cylindrical sputter coater. Deposition parameters and annealing strategies were optimized for uniform Nb_3Sn coating. 1.5 µm Nb-Sn film was deposited onto 2.6 GHz Nb SRF cavity and annealed at 600°C for 6 h, followed by 950°C for 1 h. Cryogenic RF testing confirmed Nb_3Sn formation with T_c = 17.8 K. A post-annealing light Sn recoating process improved the cavity's performance, achieving $Q_0 = 8.5 \times 10^8$ at 2.0 K.

Cylindrical sputter coater



Co-sputtering of Nb and Sn





- Co-sputtering discharge at 11 mTorr
- Nb-Sn film on flat Nb sample on the beam tubes and equator location

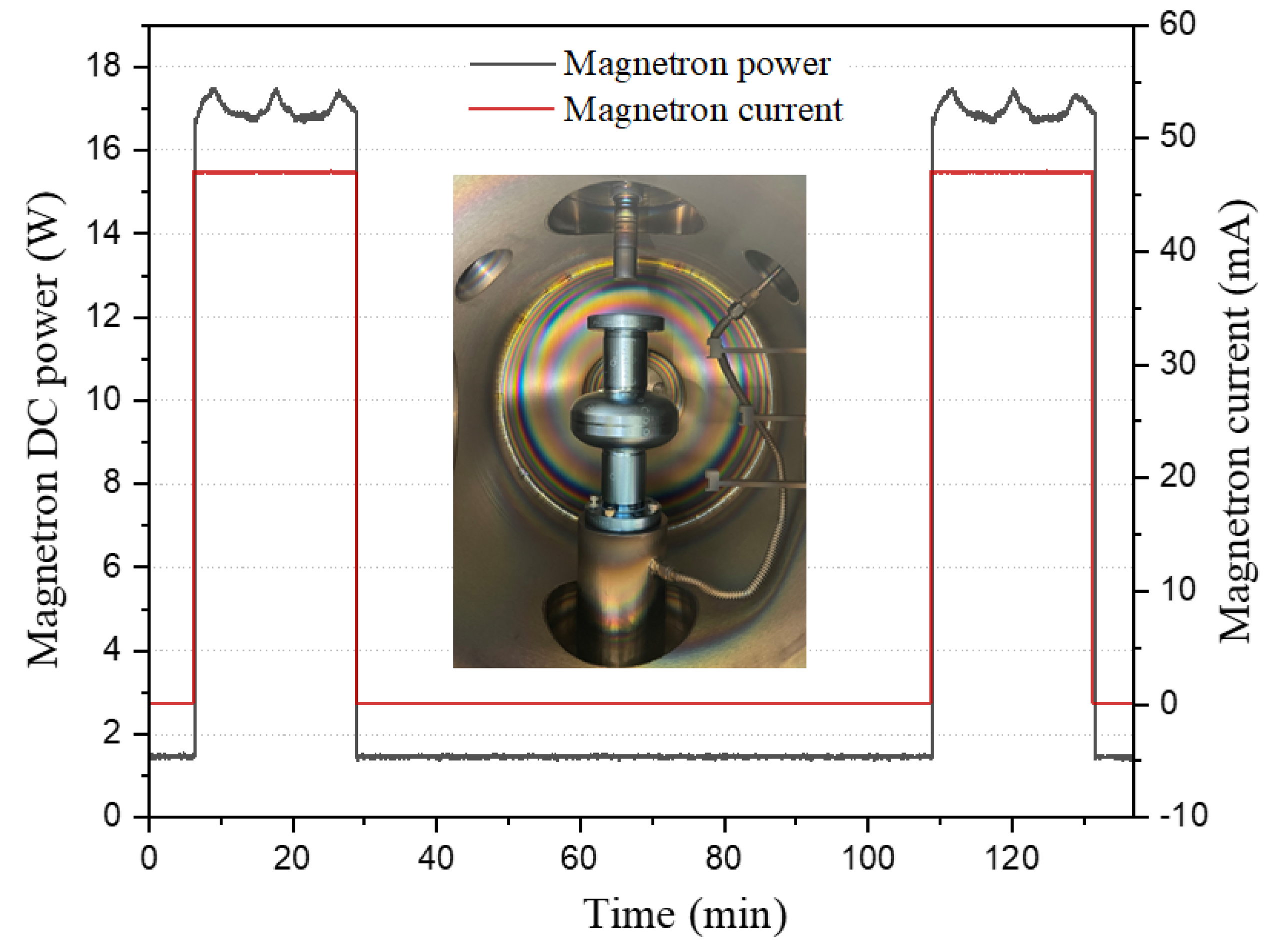
Discharge power profile during co-sputtering inside mock cavity

Top beam tube	Equator	Bottom beam tube
1.7 µm	1.5 µm	1.8 µm

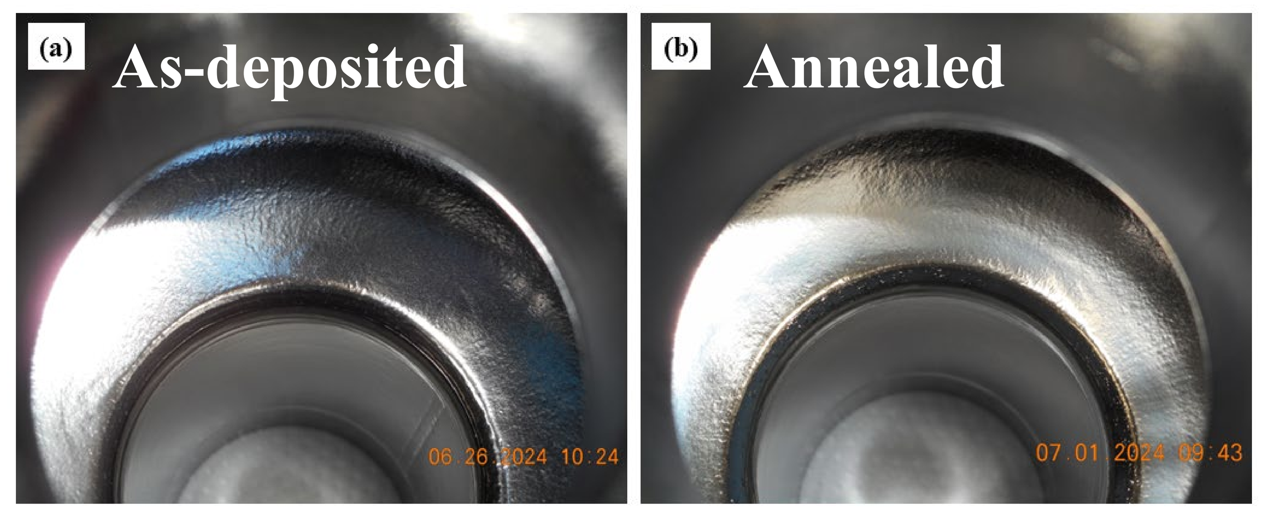
- **Post-deposition annealing at 950 °C for 3 h**

Left: sketch of the cylindrical magnetron sputtering system (1) Top magnetron (2) SRF cavity, (3) Bottom magnetron, (4) Water flow controller, (5) Magnetron shield, (6) Bottom magnetron, (7) Ar gas feedthrough. Right: Image of cylindrical magnetron sputtering system.

Nb_3Sn coting into SRF cavity and RF results

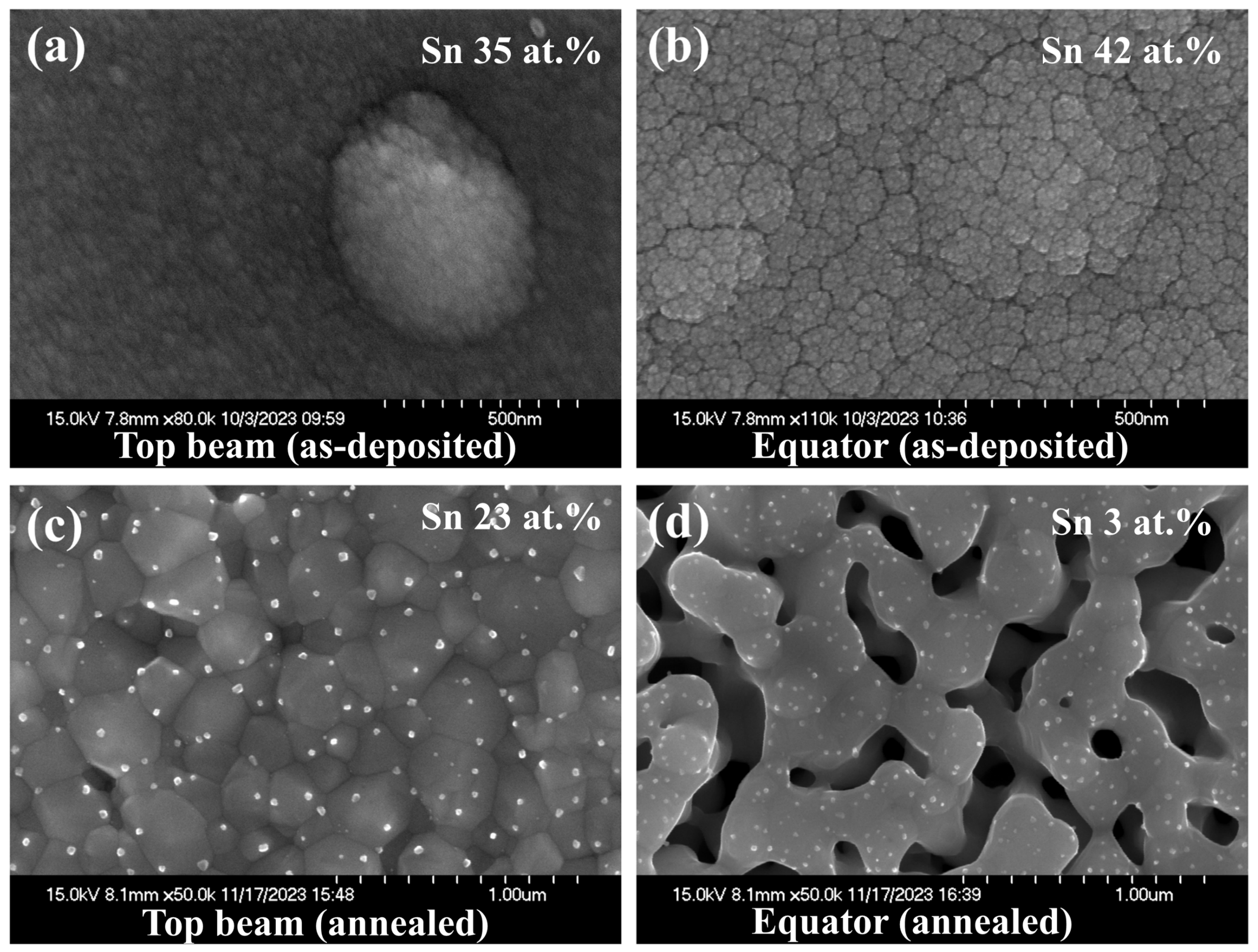


- ✓ SRF cavity coating
- ✓ Using fixed magnetron current



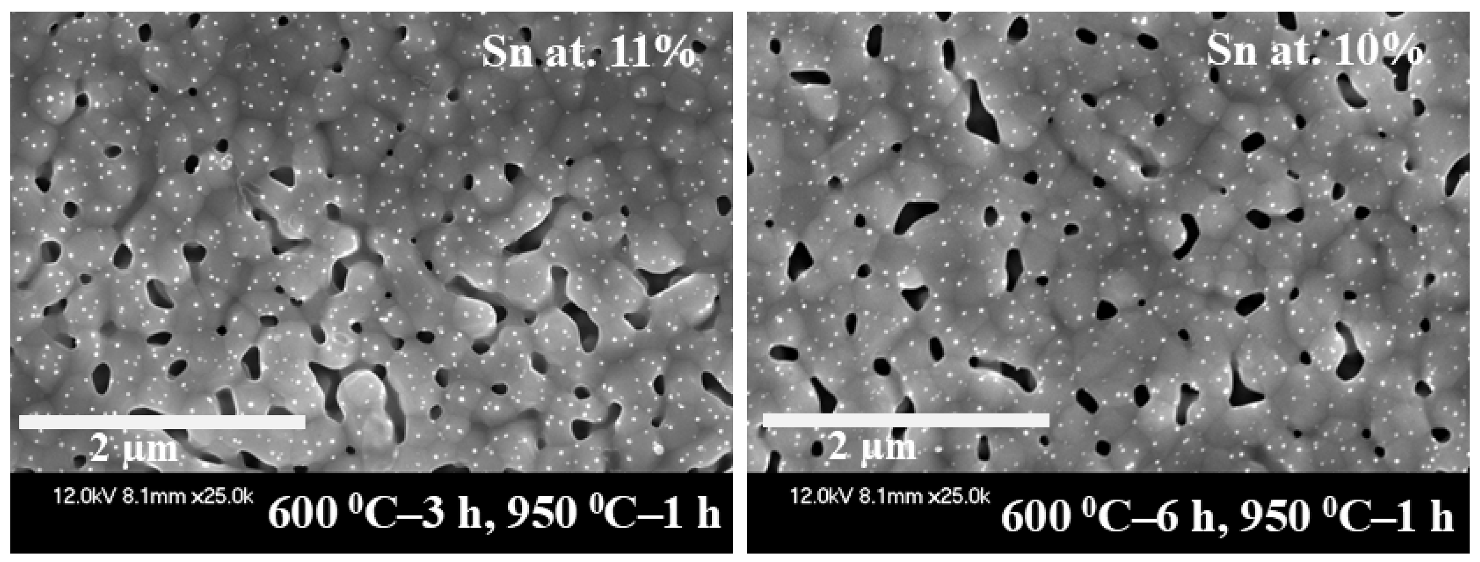
- ✓ Uniform coating
- ✓ No peeling or particles

Nb_3Sn coating on flat Nb

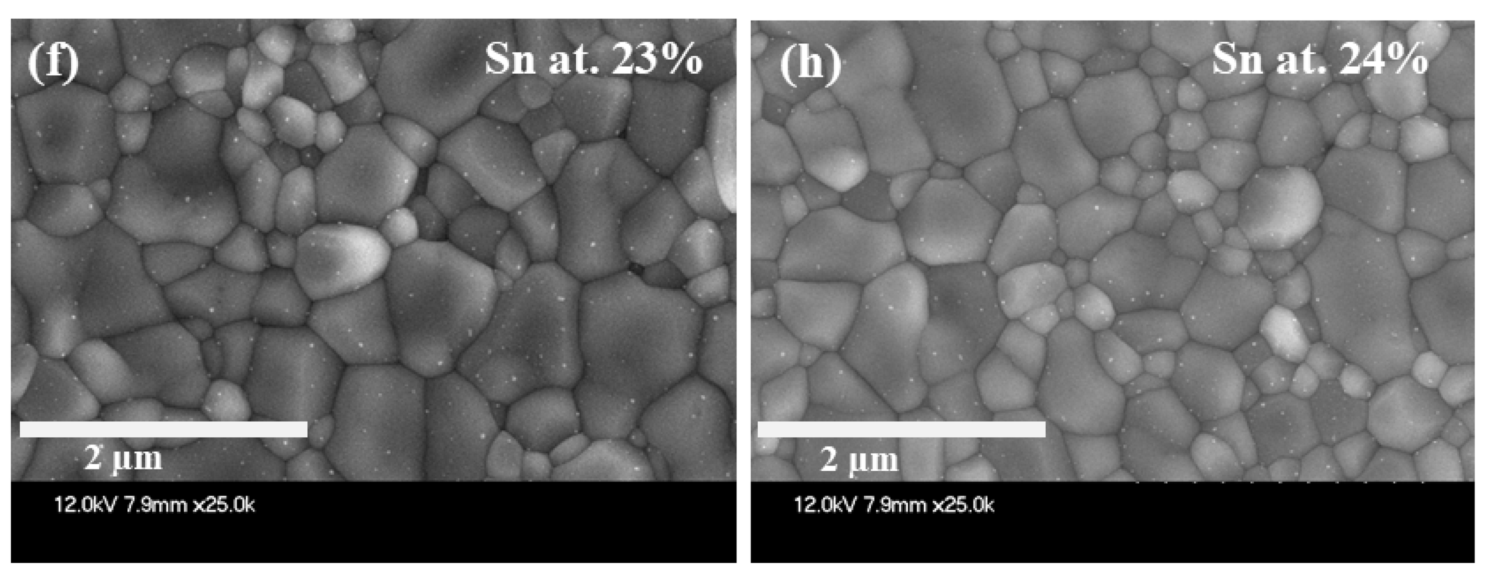


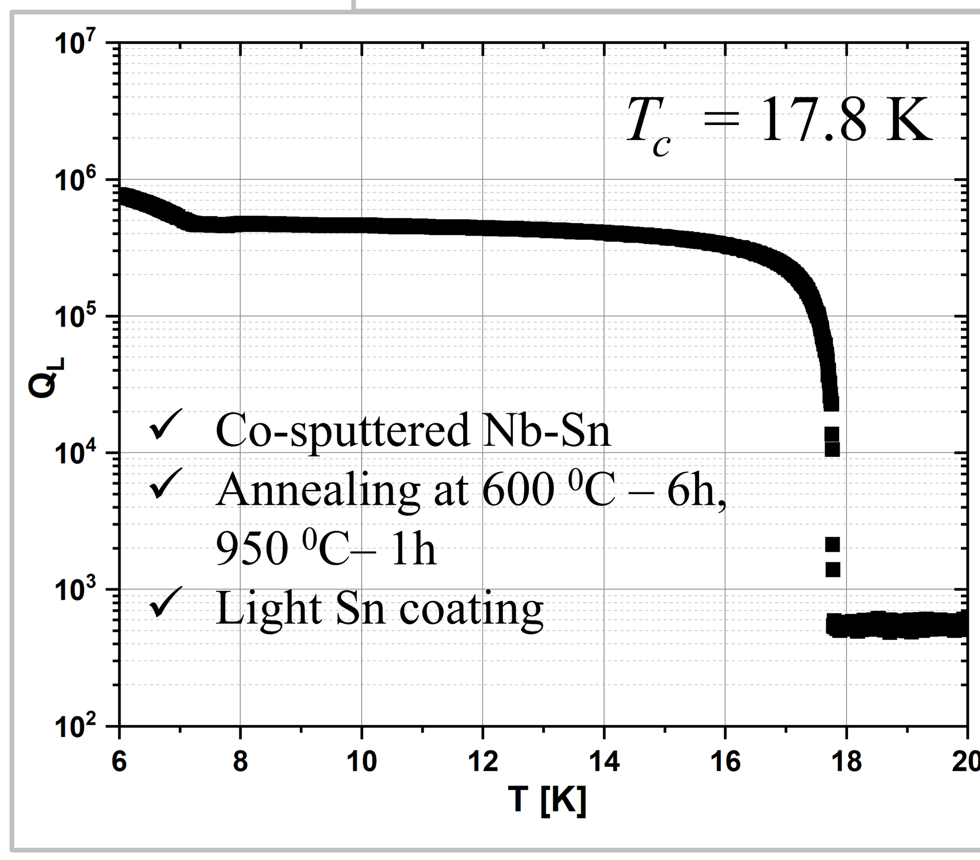
- Beam tube samples produce Nb_3Sn grains.
- Equator sample loses Sn during annealing.
- Annealing conditions are optimized to eliminated voids.

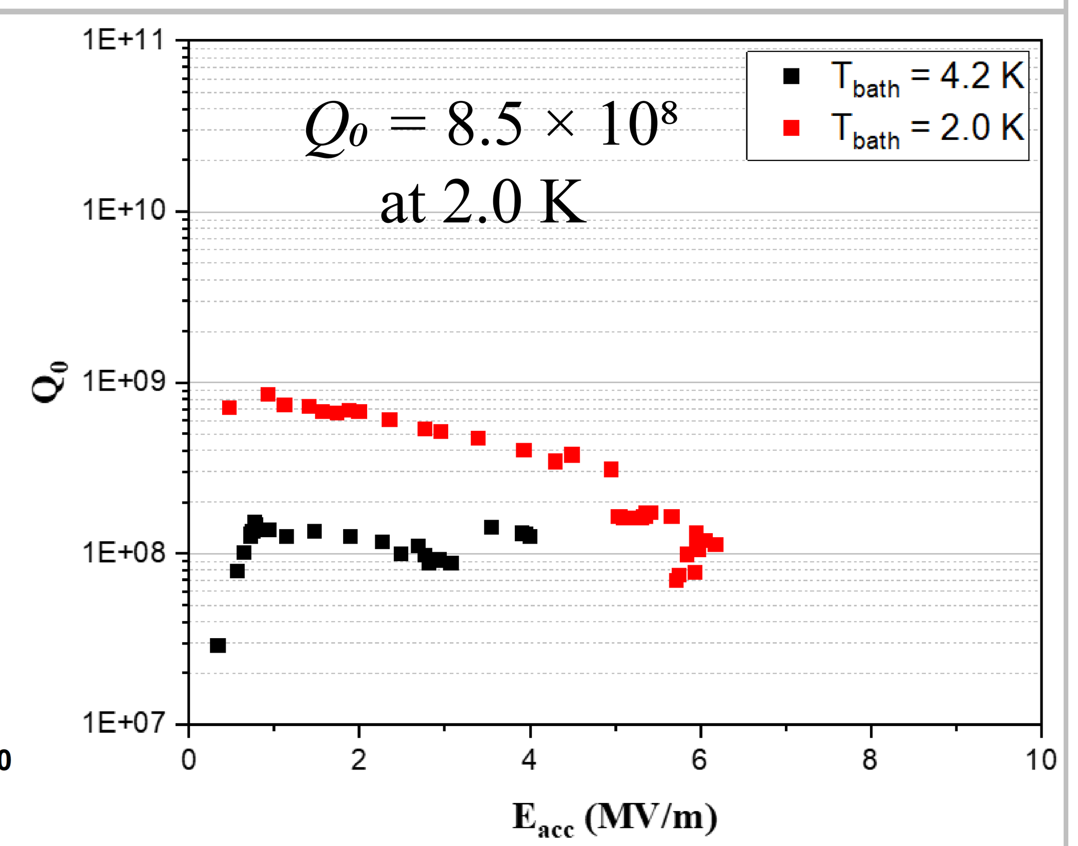
Optimizing uniformity of equator surface



Light Sn recoating treatment







Conclusion

Co-sputtering method for Nb_3Sn coating into SRF cavity has been developed, and post-deposition annealing condition is optimized. Nb_3Sn coated 2.6 GHz cavity achieved T_c of 17.8 K and $Q_0 = 8.5 \times 10^8$ at 2.0 K.

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