SRF 2021

28 June 2021 – 02 July 2021

CYLINDRICAL MAGNETRON DEVELOPMENT FOR Nb_3Sn DEPOSITION VIA MAGNETRON SPUTTERING

Poster # THPTEV015

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Abstract

Due to its better superconducting properties (critical temperature T_c~ 18.3 K, superheating field H_{sh}~ 400 mT), Nb_3Sn is considered as a potential alternative to niobium (T_c~ 9.25 K, H_{sh}~ 200 mT) for superconducting radiofrequency (SRF) cavities for particle acceleration. Magnetron sputtering is an effective method to produce superconducting Nb_3Sn films. We deposited superconducting Nb_3Sn films on samples with magnetron sputtering using co-sputtering, sequential sputtering, and sputtering from a stoichiometric target. Nb_3Sn films produced by magnetron sputtering in our previous experiments achieved DC superconducting critical temperature up to 17.93 K and RF superconducting transition at 17.2 K. A magnetron sputtering system with two identical cylindrical cathodes that can be used to sputter Nb_3Sn films on cavities has been designed and is under development now. We report on the design and the current progress on the development of the system.

Nb_3Sn fabrication processes and results

Process 1

Sputtering was performed at a 3 mTorr Ar pressure with a constant DC current of 150 mA on a substrate heated up to 800 °C.

Parameters optimized
- Deposition pressure
- Substrate temperature
- Annealing temperature
- Annealing time

Film properties:
- Good T_c ~17.83 K
- Nb_3Sn phase only
- Sn rich clusters
- Sn deficiency on surface

Process 2

Multiple layers of Nb and Sn films with a thickness of 20 and 10 nm respectively. The multilayers were annealed at 950 °C for 3 h.

Parameters optimized
- Thickness of multilayers
- Substrate temperature
- Annealing temperature
- Annealing time

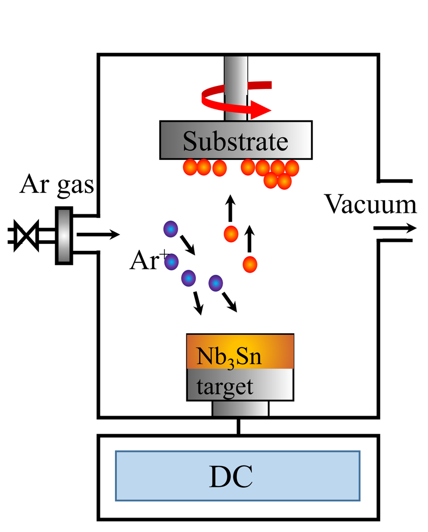
Film properties:
- Good T_c~17.93 K
- Nb_3Sn phase only
- Voids are observed
- Sn deficiency were found after annealing

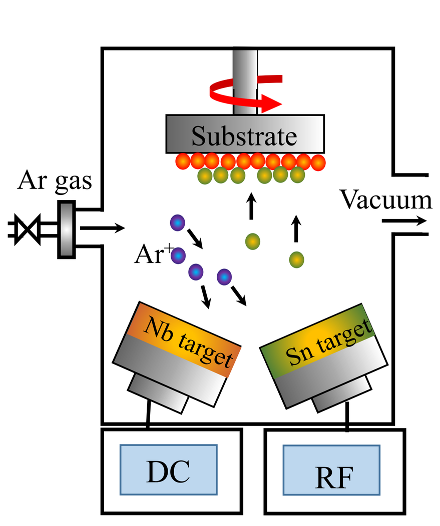
Process 3

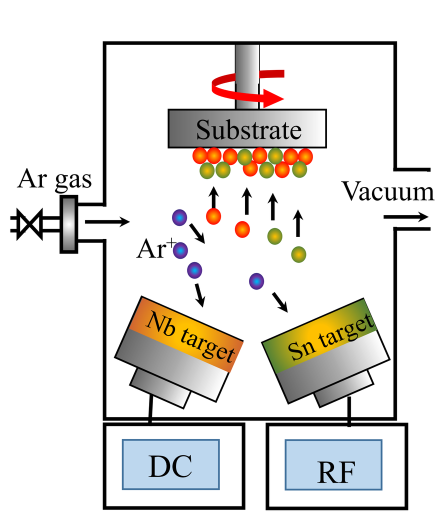
The powers of both targets were optimized to maintain the film stoichiometry and the cosputtered samples were further annealed.

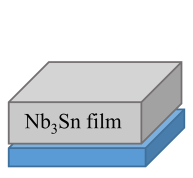
Parameters optimized
- Nb:Sn power ratio
- Substrate temperature
- Annealing temperature

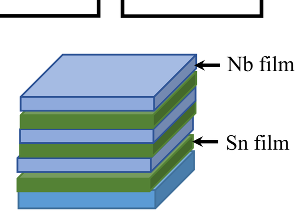
Film properties:
- Good T_c ~17.60 K
- Nb_3Sn phase only
- No voids
- Sn deficiency observed after annealing

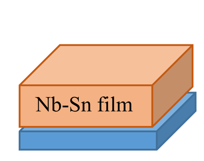


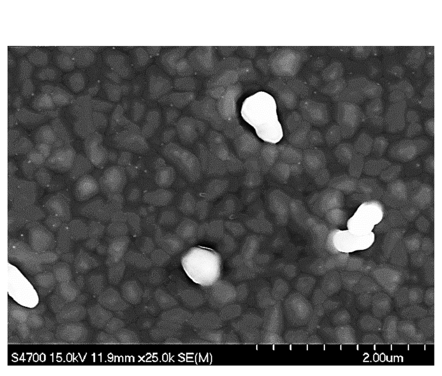


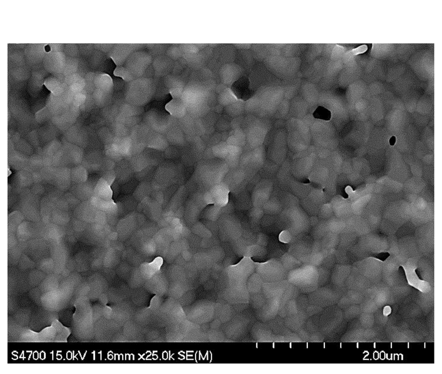


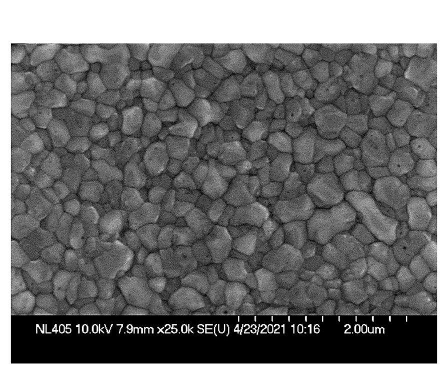








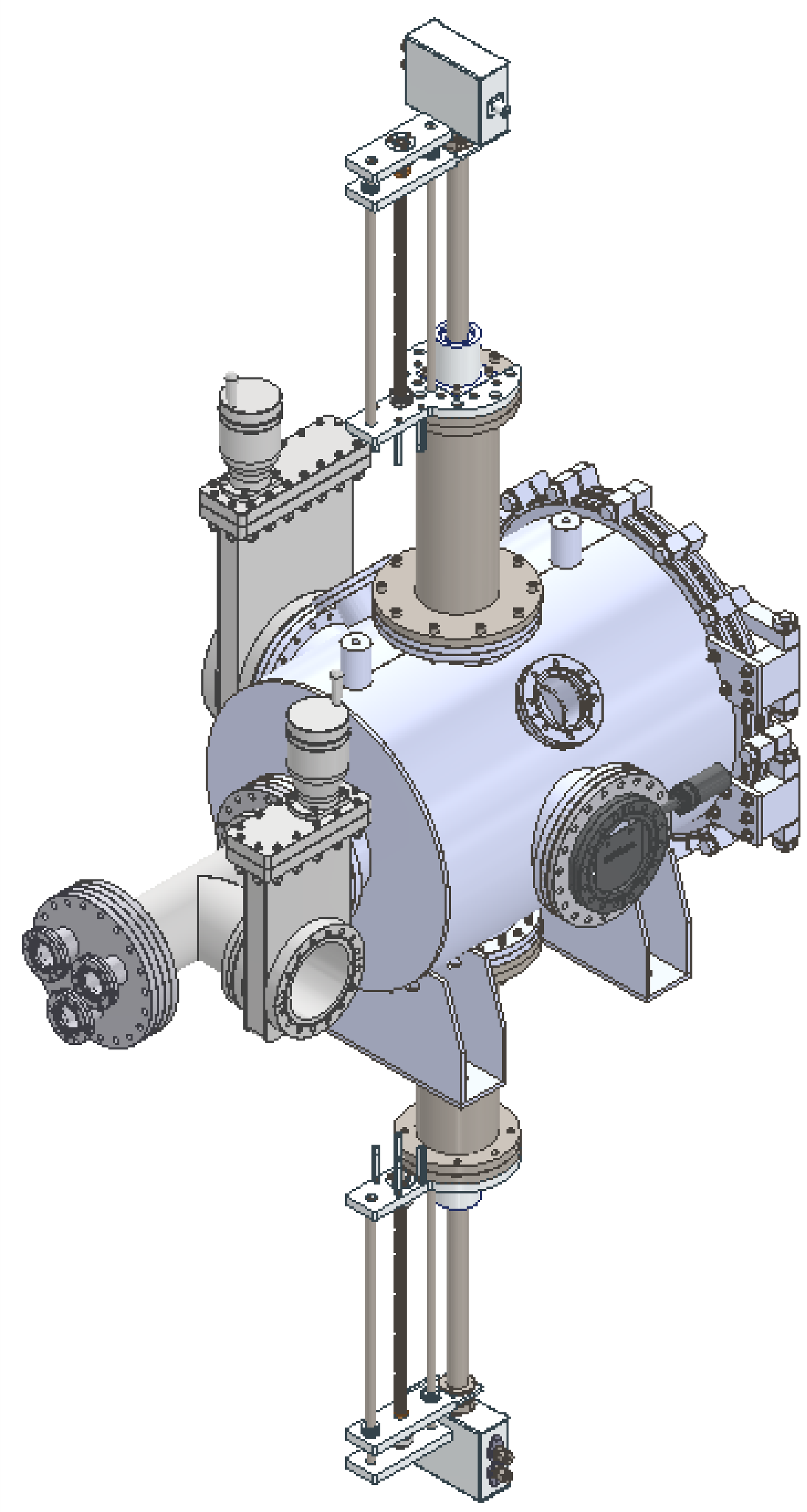




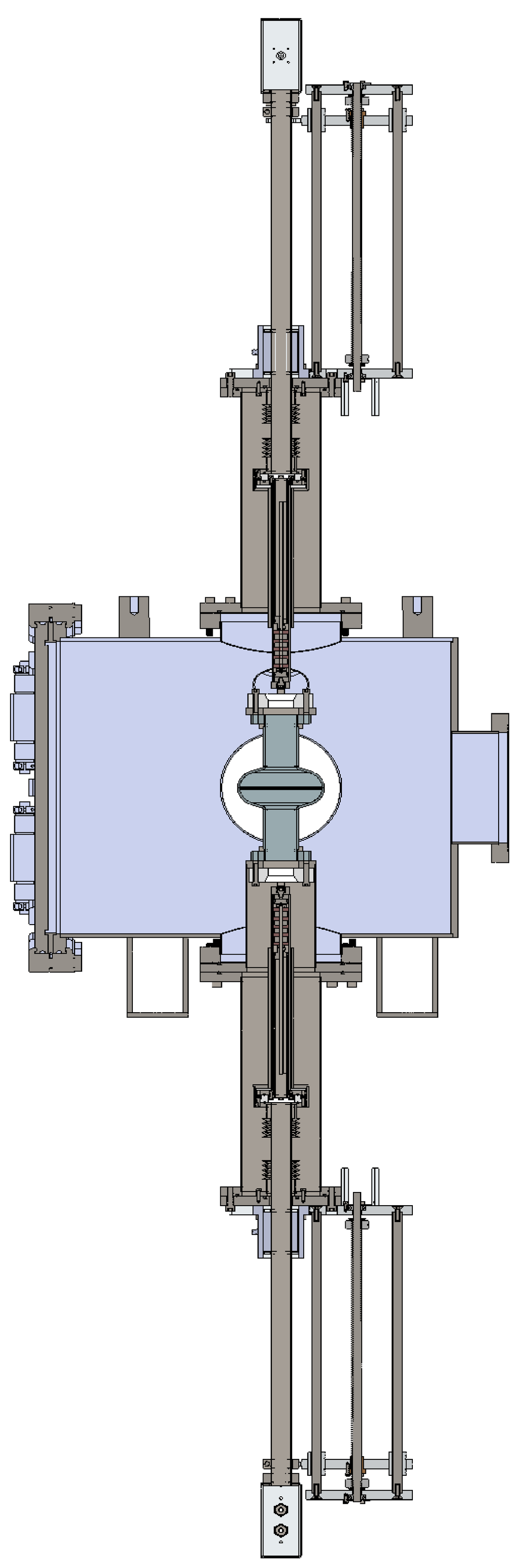
Cylindrical magnetron sputtering system

A cylindrical magnetron sputtering system for deposition of a multilayer Nb and Sn layers, with its associated computer control unit has been designed and fabricated by PLASMIONIQUE Inc. The goal of our current research is to establish a multilayer sputtering system to deposit Nb_3Sn films inside a single cell RF cavity. The system will be optimized further to apply cosputtering and sputtering from a stoichiometric target.

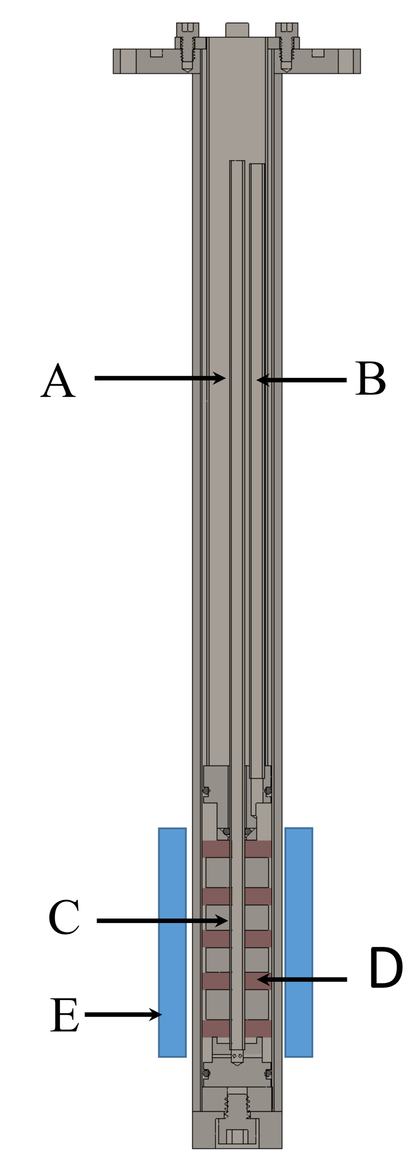
Design



3D Design of the sputter system.

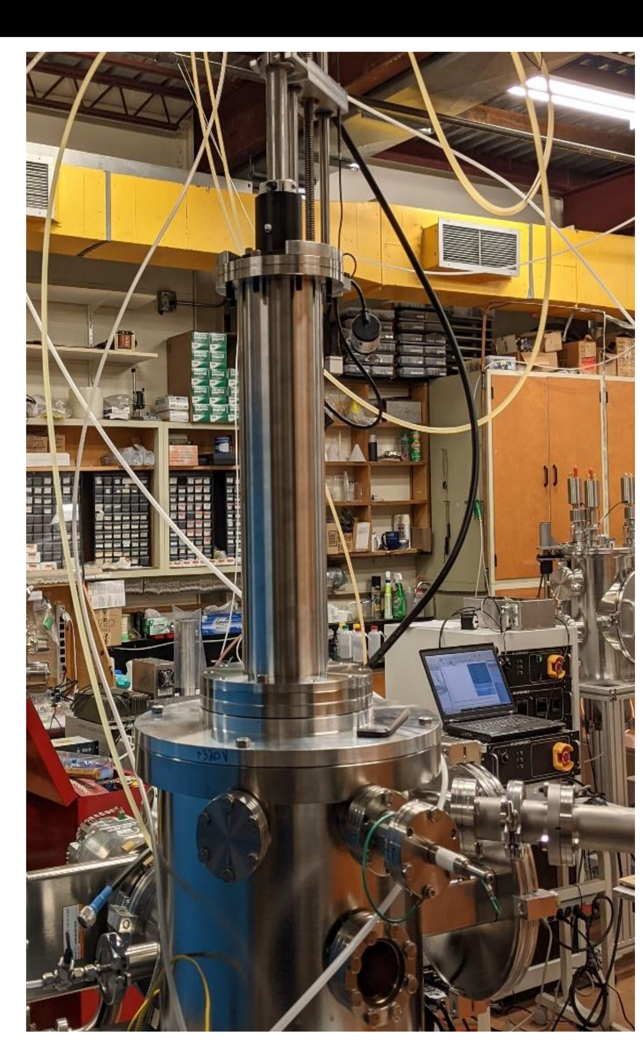


Cross-sectional view of the sputtering chamber with the 2.6 GHz RF cavity.

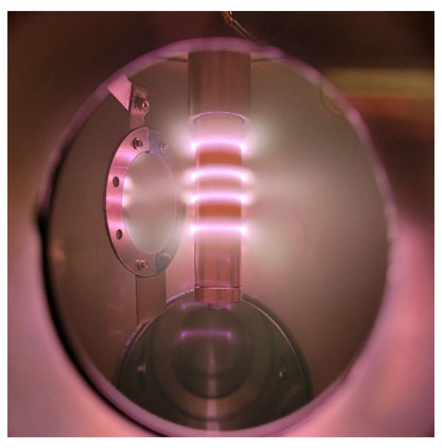


Cross-section of the individual magnetron: A. water inlet, B. water outlet, C. magnets, D. magnet spacers, E. target.

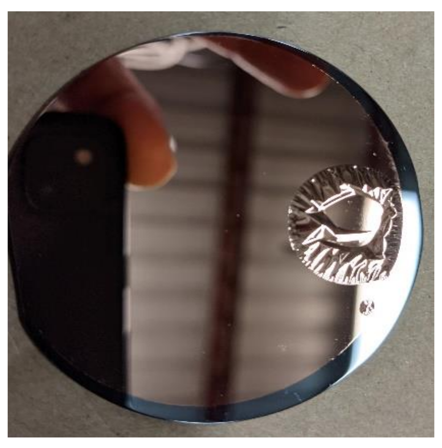
Plasma Discharge



Test station for plasma discharge.



Observation of plasma discharge with 40 W at 10 mTorr.



Picture of the coated sample placed in front of the discharge with about 100 W. A mirror coating was obtained in couple of minutes. The delaminated ring at the right side of the confirms a thick layer.

Plasma discharge obtained inside a tube identical to the beam tube of the 2.6 GHz cavity. The DC breakdown voltage at 5 and 20 mTorr was about 300 and 230 V, respectively.

Conclusion

A cylindrical magnetron sputtering system has been designed to fabricate Nb_3Sn films inside a 2.6 GHz cavity. The simulation and experimental results validated the design for SRF cavity coating. The fabrication procedure of the sputtering system has been initiated to commission the system for 2.6 GHz SRF cavity coating in 2021.

Acknowledgement

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics. The authors acknowledge Charles E. Reece and Uttar Pudasaini of Jefferson Lab for their suggestions and help with film fabrication.

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