Nb_3Sn COATING OF HALF-WAVE COAXIAL RESONATOR*

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ABSTRACT

Superconducting thin films have the potential of reducing the cost of particle accelerators. Among the potential materials, Nb_3Sn has a higher critical temperature and higher critical field compared to niobium. Sn vapor diffusion method is the preferred technique to coat niobium cavities. Although there are several thin-film-coated basic cavity models that are tested at their specific frequencies, the Half-wave resonator could provide us data across frequencies of interest for particle accelerators. With its advanced geometry, increased area, increased number of ports and hard to reach areas, the half-wave resonator needs a different coating approach, in particular, a development of a secondary Sn source. We are commissioning a secondary Sn source in the coating system and expand the current coating system at JLab to coat complex cavity models.

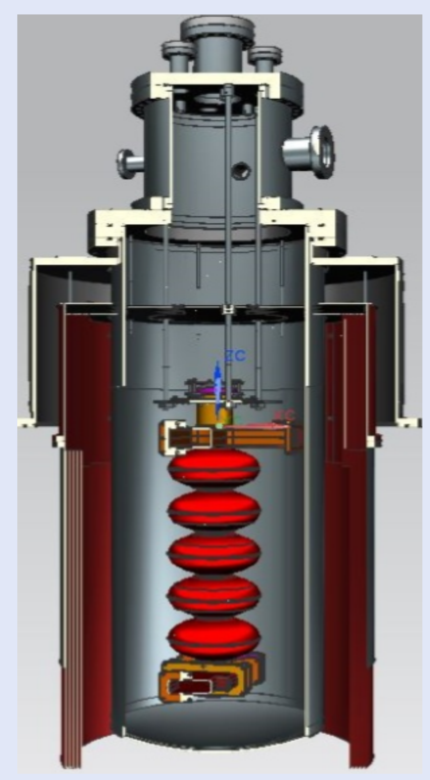
CAVITY DEPOSITION SYSTEM AT JLAB

Nb_3Sn deposition system at Jlab contains two main parts:

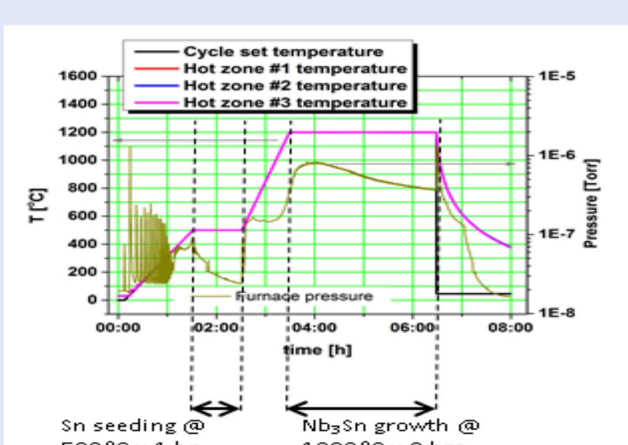
- coating chamber that hosts the cavity to be coated - built out of niobium as a 40" long x 16" diameter cylinder.
- furnace that provides the desired heating to the coating chamber [1] - commissioned to reach 1250 ^{0}C with the furnace vacuum in 10^{-7} Torr range.

The typical coating process at JLab consists of,

- a nucleation step which involves the tin chloride evaporation at 500 ^{0}C for 1-hour.
- a deposition step which involves the evaporation of tin for 3-hours at 1200 ^{0}C, which is favorable to form Nb_3Sn phase on substrate niobium [2].



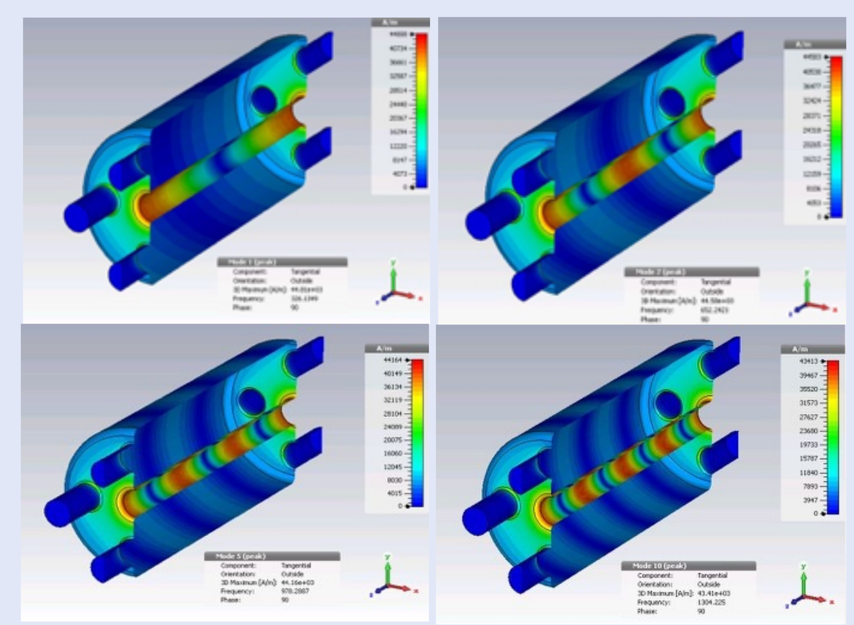
Nb_3Sn coating system.



The temperature profile used for coating Nb cavities. The temperature profile demonstrates the temperature from the three thermocouples located inside the furnace, but outside the coating chamber.
The vacuum curve shows the pressure in the furnace, again outside the coating chamber. The pressure inside the coating chamber is typically about 10^{-5} Torr and increases during the coating run up to about 10 mTorr [3].

HALF-WAVE CAVITY

- Cylindrical-coaxial resonator which has TEM modes other than TE and TM modes , allowing data across wide range of frequency.
- The high surface magnetic field is concentrated on the inner cylinder.
- Center for Accelerator Science (CAS) at ODU recently developed another half-wave cavity (frequency range of 325MHz to 1.3GHz).

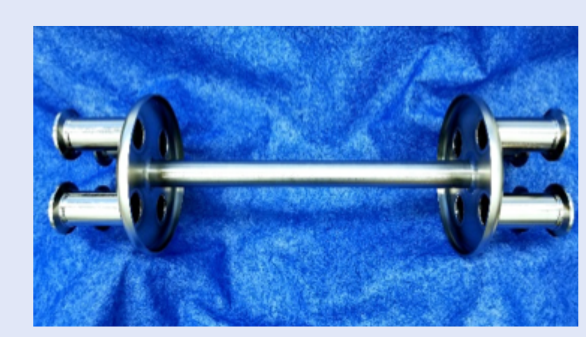


Surface magnetic field distribution of the TEM1, TEM2, TEM3, and TEM4 modes (CST Studio).

Cavity Parameters

Parameter	Unit	Value
Cavity length	mm	459
Outer conductor radius	mm	111
Inner conductor radius	mm	20
Peak electric field, E_p	MV/m	15.6
Peak magnetic field, B_p	mT	56
TEM1, TEM2, TEM3, TEM4 frequencies	MHz	327.7,655.3, 982.9,1310.5
Geometric factor, G	Ohm	61,123,185,247

Complete half-wave coaxial resonator.



Inner conductor sub assembly.

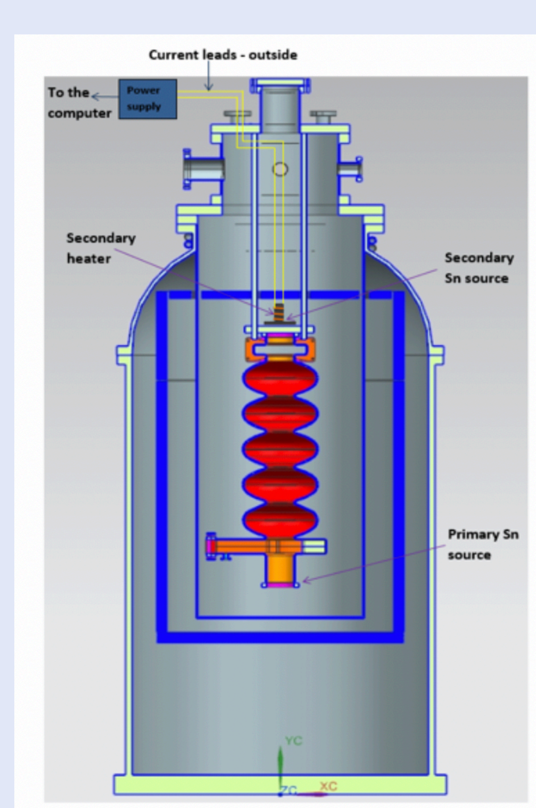
SECONDARY TIN SOURCE – DESIGN AND FABRICATION

- Low tin flux from a single tin source.
- Increased area of the new cavities.
- increased number of ports with hard to reach areas
- Temperature gradient through the cavity .

→ New crucible to host a secondary tin source and a heater from top.

Secondary Sn Source

- 2.5" outer diameter and 1" inner diameter Niobium tubes.
- Sn and $SnCl_2$ are placed in between the tubes.
- heated by the secondary heater – made of Molybdenum coil leads insulated with fish spine beads.



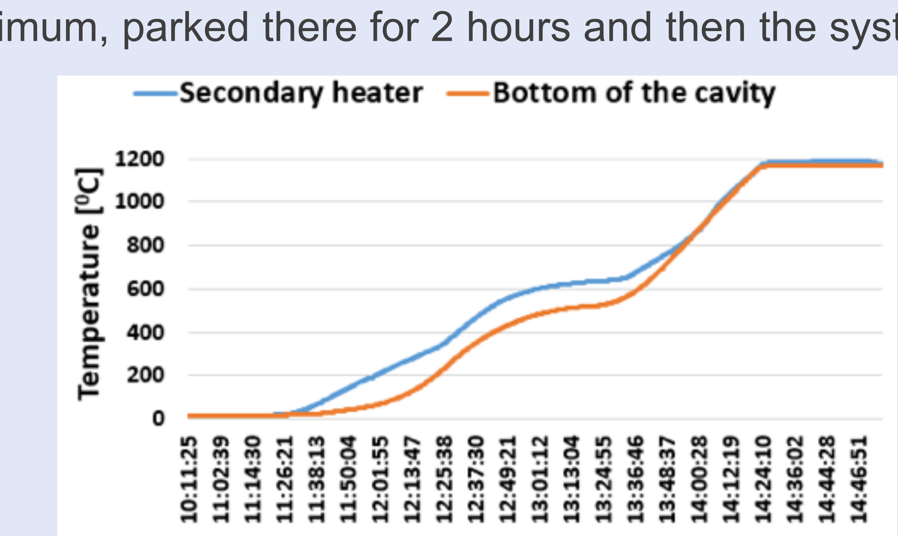
Cavity coating system model with the secondary Sn source and the heater with a 5-cell cavity.

Secondary Sn source (Left) and the heater (Right).

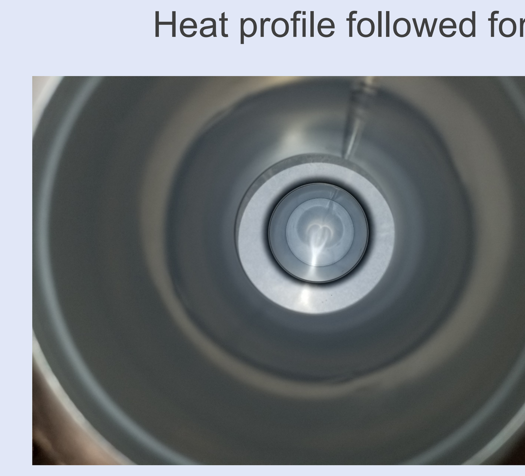
SECONDARY TIN SOURCE – COMMISSIONING

- Secondary Sn source and the heater was tested with TE1NS001 single cell cavity.
- heater was powered manually with a power supply increasing the voltage in steps of 5V up to 25V.
- Same heating profile used for the furnace is followed in the secondary heater - when the temperature is at the maximum, parked there for 2 hours and then the system was allowed to cool down gradually.

TE1NS001 single cell assembly with the secondary Sn source and the heater.



Heat profile followed for both heaters.



Inside the coated cavity.

SUMMARY AND FUTURE PLANS

We have designed and fabricated a new crucible to host the secondary tin source, which we believe will help to produce a uniform Nb_3Sn coating inside a cavity with complicated geometry The secondary Sn source and the heater have been commissioned with the TE1NS001 single-cell cavity. The half-wave cavity is at the finishing stage prior to the base line test. We plan to coat a half-wave cavity within the next few months and then move into the other complex cavities.

ACKNOWLEDGEMENT

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REFERENCES

[1] G. Eremeev, W. Clemens, K. Macha, H. Park and R. Williams, "Commissioning of Nb_3Sn cavity vapor diffusion deposition system at JLAB", in *Proc. IPAC'15*, USA, pp. 3512-3514.
[2] U. Pudasaini, G. Eremeev, Charles E. Reece, J. Tuggle and M. J. Kelley, "Insights into formation of Nb_3Sn film during the vapor diffusion process", in *Proc. SRF'17*,China, pp. 539-542
[3] G. Eremeev, Charles E. Reece, M. J. Kelley, U. Pudasaini and J. Tuggle, "Progress with multi-cell Nb_3Sn cavity development linked with sample materials characterization", in *Proc. SRF'15*,Canada, pp. 505-511