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THE HIE-ISOLDE SUPERCONDUCTING CAVITIES: SURFACE TREATMENT AND NIOBIUM THIN FILM COATING

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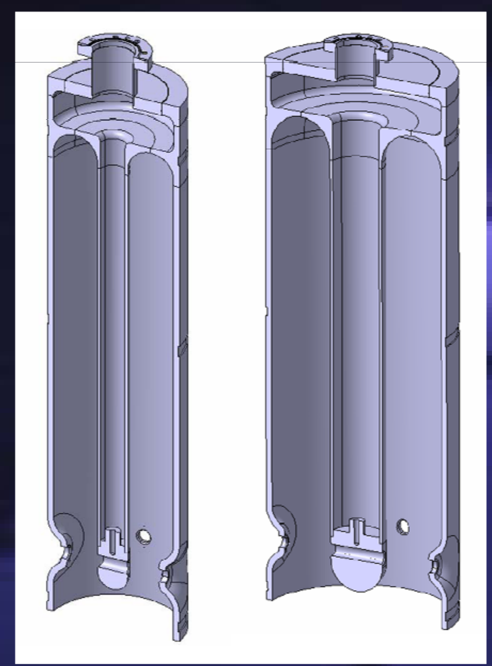
BACKGROUND

HIE ISOLDE LINAC

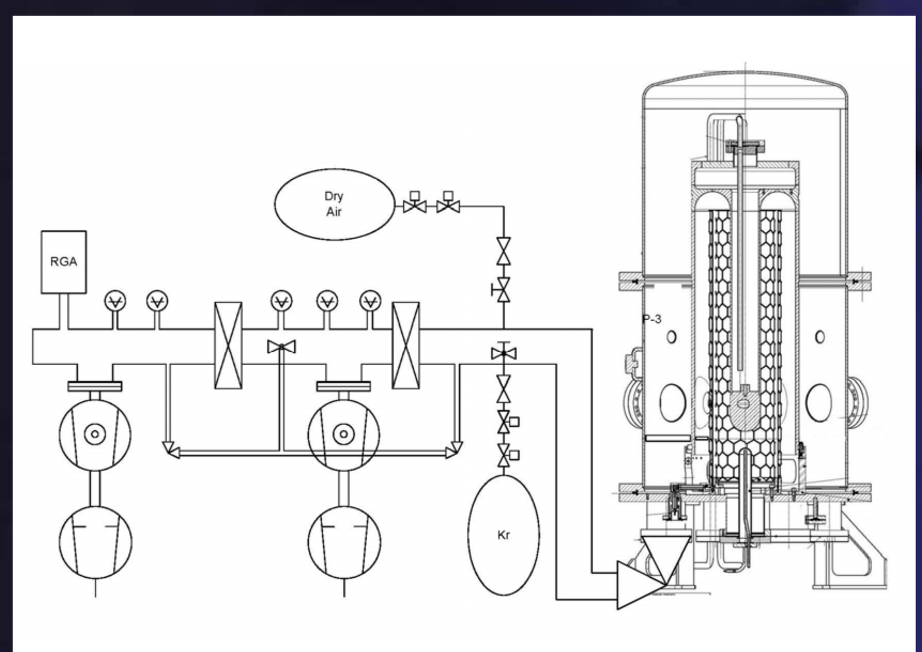
An energy upgrade of the HIE ISOLDE Radioactive Ion Beams facility is planned at CERN for the next 3-5 years. The upgrade consists of boosting the energy of the machine from 3MeV/u up to 10MeV/u with beams of a mass-to charge ratio of 2.5<A/q<4.5 and it is based on superconducting quarter wave resonators (QWRs).

QWR R&D ACTIVITY PROGRAM

For the foreseen upgrade of the ISOLDE complex a new superconducting LINAC based on sputtered Nb/Cu Quarter Wave Resonators (QWRs) of two different beta families is planned to be installed in the next three to five years. A prototype cavity of the higher beta family is currently being developed. In this poster the latest developments on the sputtering technique for this kind of cavity geometry and the first cold RF measurements are shown.



BIASED DIODE SPUTTERING



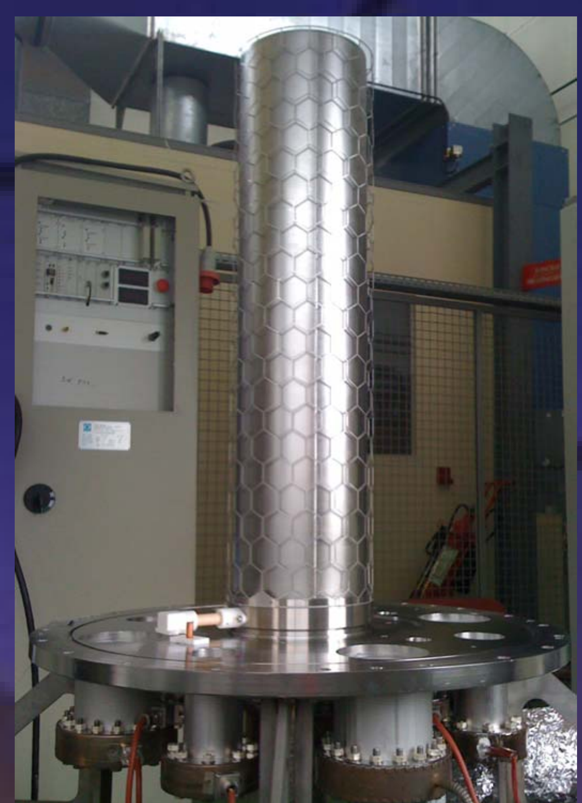
The coating system is designed for Bias Diode Sputtering. Inside a class 10 clean room the cathode-grids structure and the cavity and the vacuum chamber are assembled. The closed chamber is then connected to the pumping system outside the clean room.

Cathodes and grids are easily demountable as coating is foreseen for both high β and low β cavities.

Bias Diode Sputtering

At the very beginning preliminary test with biased diode configuration showed a non homogeneous distribution of the plasma so it was decided to test a cylindrical magnetron configuration

The plasma instability encountered at the beginning were completely eliminated with an upgrade of the power supplies and changing the electrical circuit connecting the cavity, the cathode and the grids.



Combined sputtering configuration

To obtain a homogeneous distribution of the film thickness along the cavity walls a combination of the bias diode coating followed by magnetron sputtering was tested. The diode to magnetron coating time ratio was selected as 5:2 and the inner grid was installed in the system in order to reduce the sputtering rate on the internal conductors.

Outcomes:

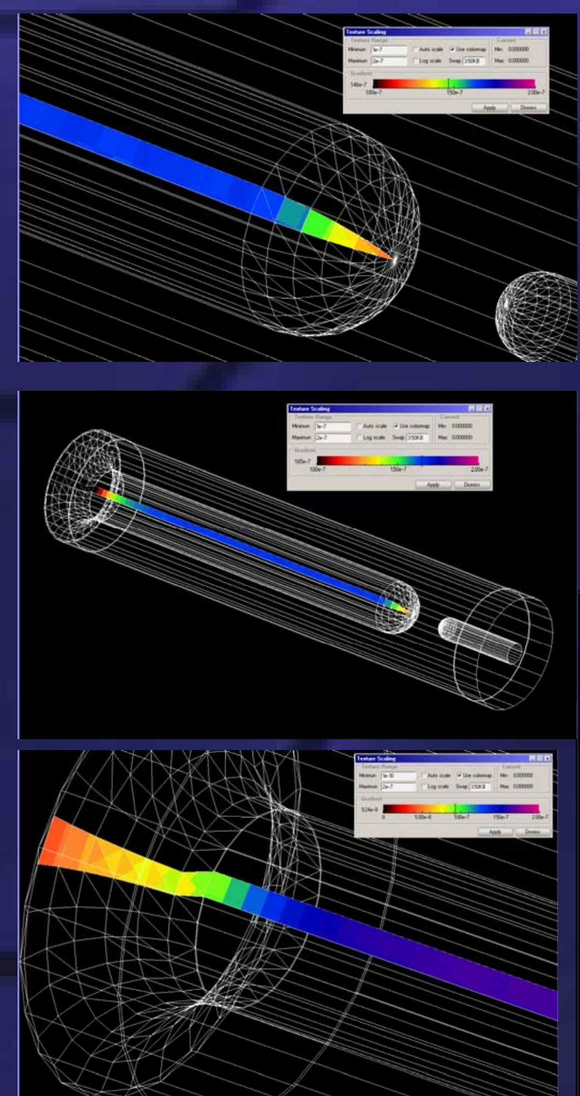
- Stable plasma
- Improvements on the thickness
- More homogeneous distribution of the plasma between outside and inside.

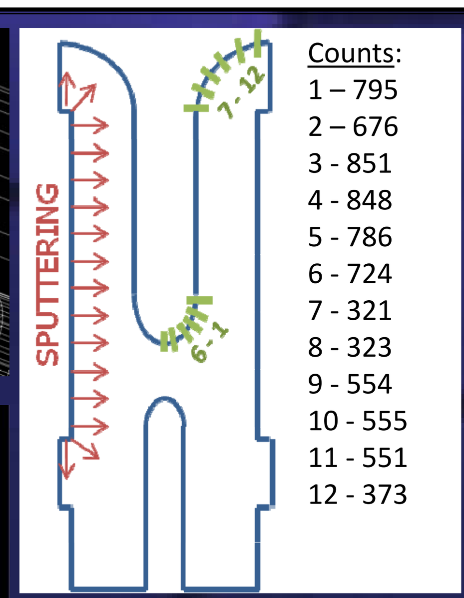
BIASED MAGNETRON SPUTTERING

Biased Magnetron Sputtering at 0.015 mbar

Calculations were run to simulate the axial magnetic field and optimize the coil heights. A multilayer coil of 1 m diameter, was built. Its dimensions and the number of layers were calculated in order to obtain a magnetic field which is homogeneous, higher than 100G and parallel to the cathode.

- the major part of the magnetron sputtering test and the first cavity coating were performed at 0.015 mbar,
- the magnetic field keeps the plasma stable on the outer side of the cathode,
- inside the cathode, the plasma is extremely enhanced giving rise to and efficient sputtering,
- the cylindrical cathode was surrounded by an external grid but no internal grid was inserted.





Biased Magnetron Sputtering at 0.003 mbar

Several simulations with Molflow+ (based on the monte carlo method and 3D raytracing algorithm) were run to study the sputtering rate on the internal conductor tip.

Response: the thickness degradation on the tip of the inner conductor is not due to the increasing distance with the cavity, but the niobium atoms rate is mainly limited by collision with the gas atoms.

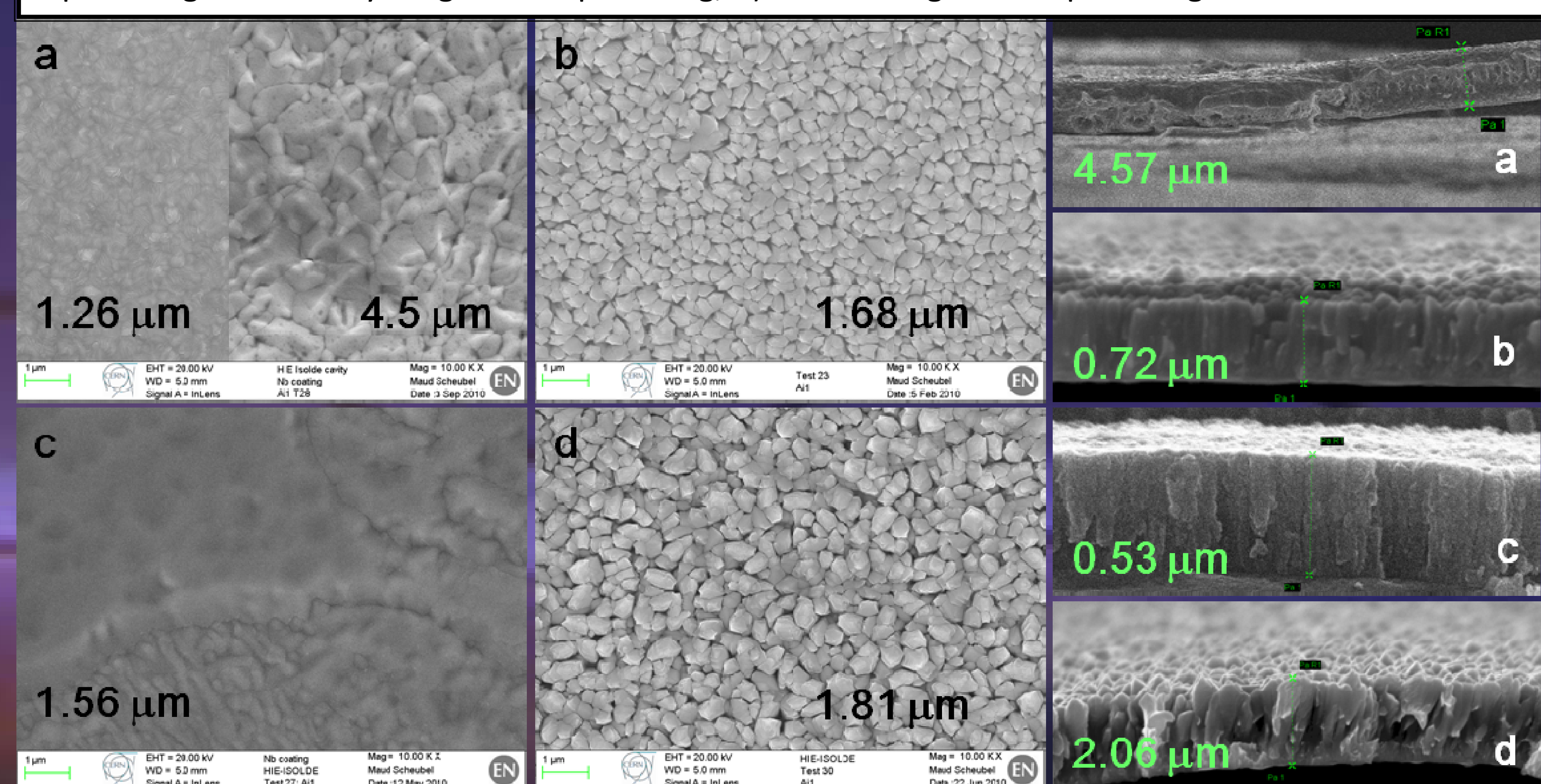
Test were performed reducing the coating pressure to 0.003 mbar.

RESULTS

Configuration Position	Diode	Magnetron High p	Combi	Magnetron Low p
Inner	4.5	6.5	2.9	10.6
Tip	0.6	1.4	1.0	3.7
Outer	2.4	1.4	4.1	1.9
Top	4.2	1.7	4.5	6.2

- In the diode configuration the deposition rate is higher on the external wall and on the top part of the cavity.
- The biased magnetron sputtering configuration has a higher sputtering rate inside the cathode. Decreasing the pressure increases the rate on the top and the tip but doesn't influence the rate on the outer wall.

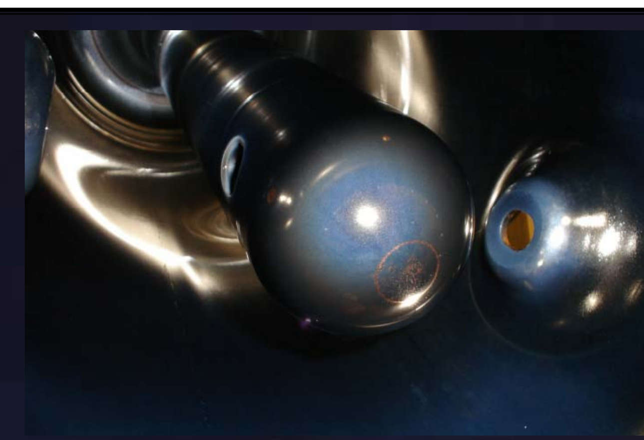
SEM images: a) Biased Diode sputtering; b) Biased Magnetron sputtering at 0.015 mbar; c) Diode Sputtering followed by Magnetron sputtering; d) Biased Magnetron sputtering at 0.003 mbar



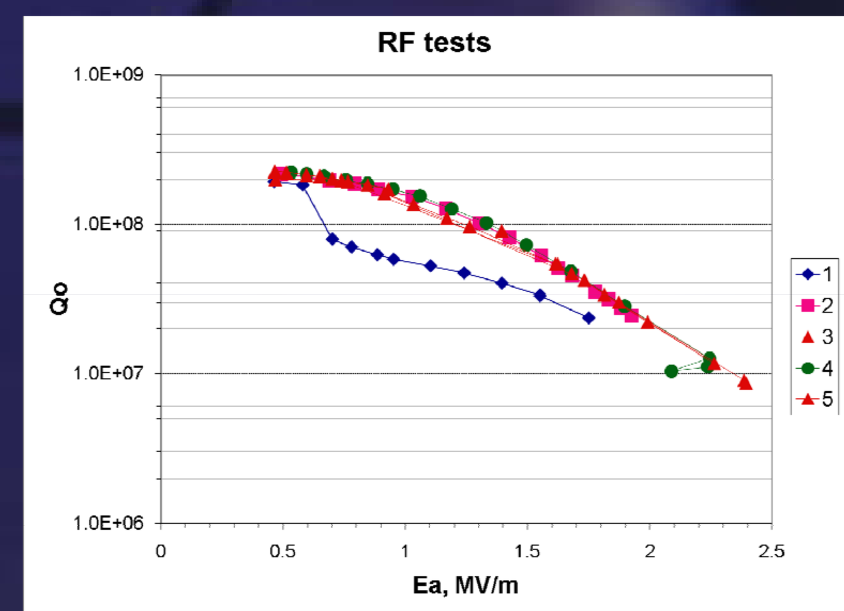
FIRST COATING RESULTS

RF tests were performed at **TRIUMF SCRF lab** in Vancouver, Canada.

During the rinsing a small fraction of a ring shape of the Nb coating peeled off in the high electric field region. It was anyway decided to proceed with the RF test.



- At first, a strong multipacting barrier at very low field was identified.
- A method to pass by this barrier was to warm up the cavity above 20K and cool down again. On the subsequent high power pulse the first multipacting level was overcome.
- The conditioning of the cavity was not very efficient and it was possible to pass through the low level barrier (50kV/m corresponding accelerating field) only with high power pulse.



- The measurements reveal a lower than expected Q-value at low field, and a steep slope.
- The first measurements showed a Q switch effect which has not been observed in the further tests
- A 2MV/m maximum gradient was reached.
- The achievable value was limited by the amount of power available in the amplifier.

CONCLUSIONS

Several test coatings have been performed,, with different configurations and parameters. Achieving a uniform coating thickness is possible and which guarantees a good RRR in all the "critical" position where the electromagnetic field is high.

The first cavity was tested in Vancouver. The performance was one order of magnitude lower than expected. The copper substrate proved to be a very good thermal stabiliser as even with the highest power pulse we could produce the cavity never quenched and different points of the cavity showed always quite stable temperatures.

The problem on the top of the cavity inner conductor was overcome with a change of sputtering parameters and the new coated cavity is ready to be tested. The production of a new copper cavity, dedicated entirely to the coating test, is under way and it will allow to focus directly on the correlation between the coating parameters and the cavity performances.

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