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Biased HiPIMS technology for superconducting rf accelerating cavities coating

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BIASED HiPIMS TECHNOLOGY FOR SUPERCONDUCTING RF ACCELERATING CAVITIES COATING

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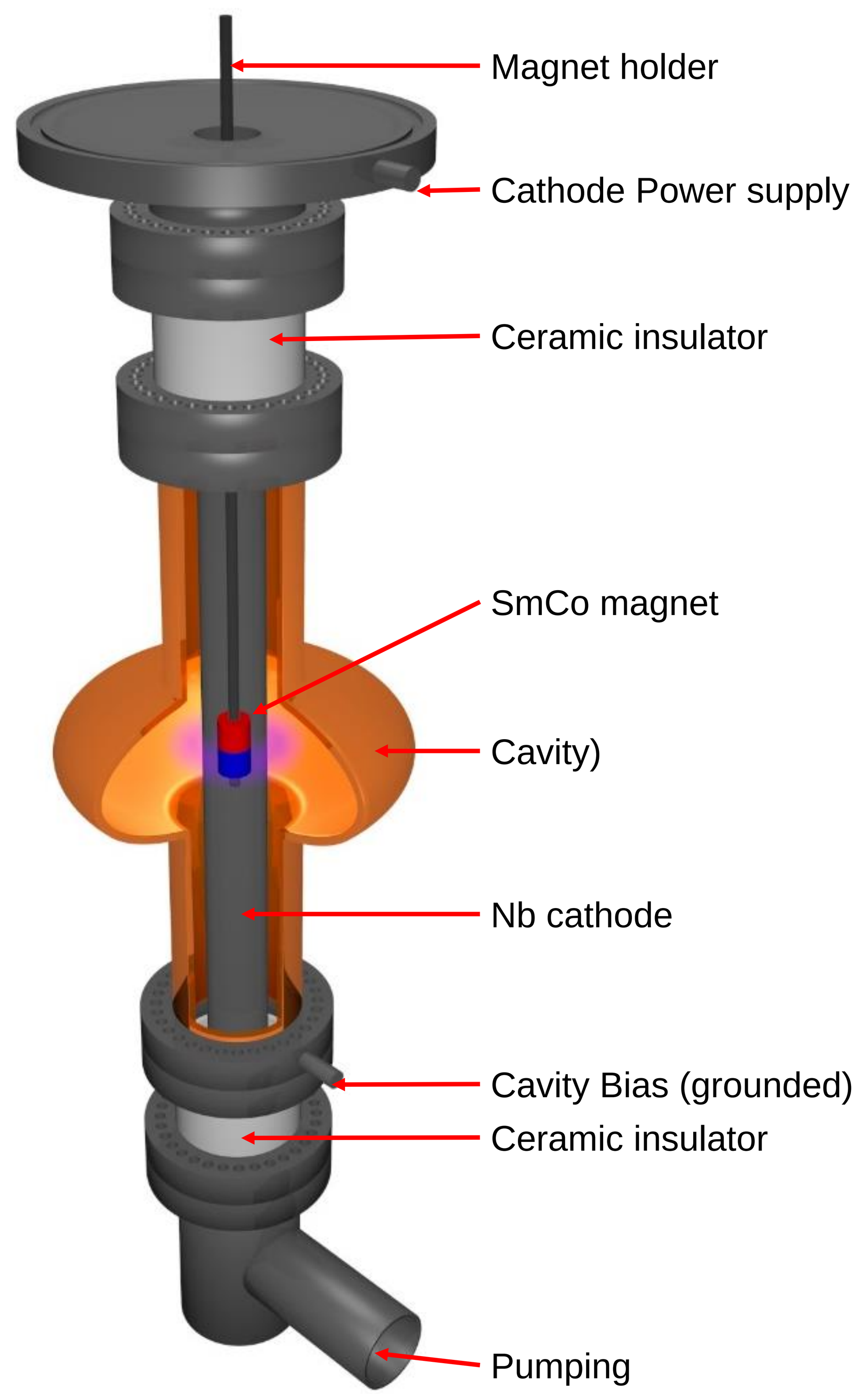
Abstract

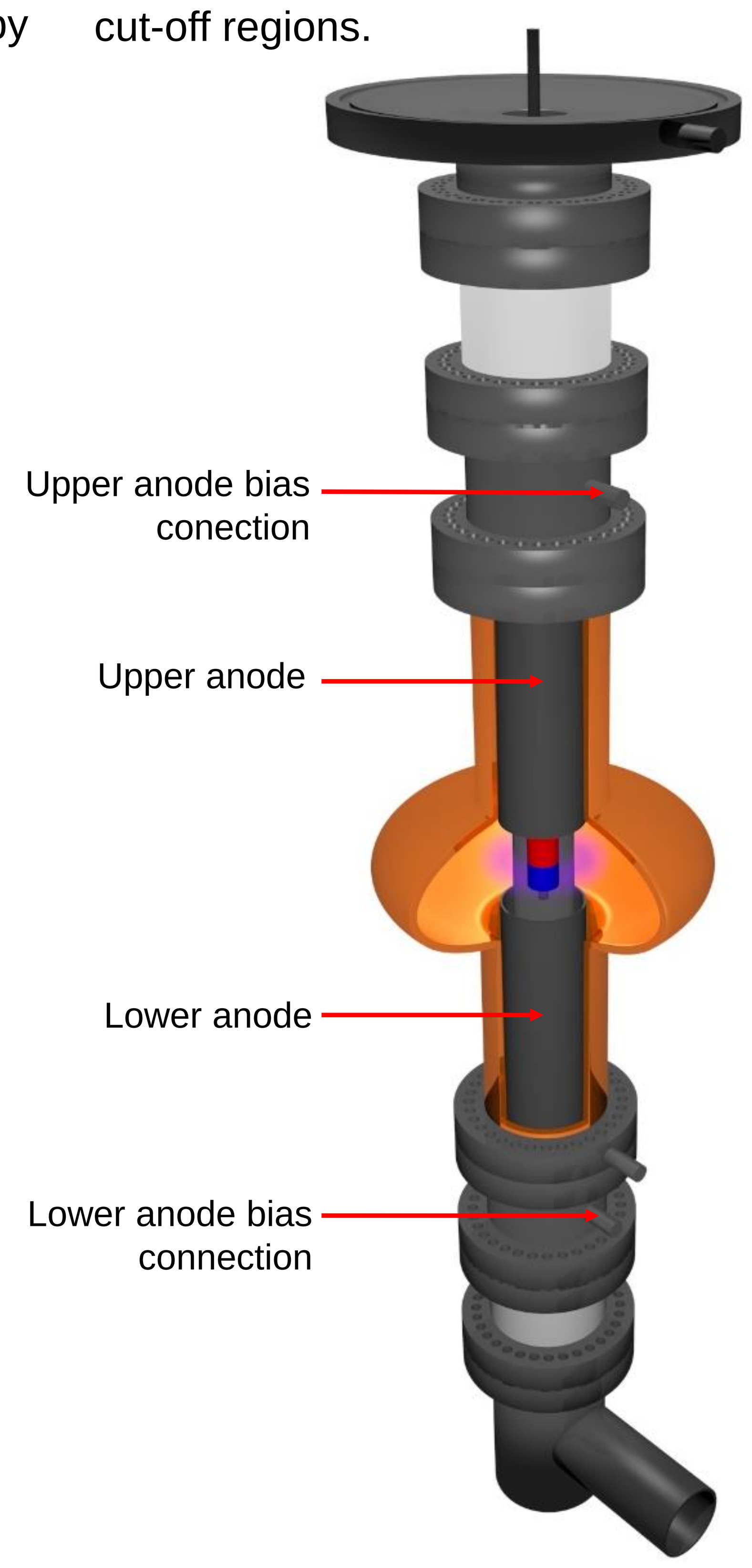
In the last few years the interest of the thin film science and technology community on High Impulse Power Magnetron Sputtering (HIPIMS) coatings has steadily increased. HIPIMS literature shows that better thin film morphology, denser and smoother films can be achieved when compared with standard dc Magnetron Sputtering (dcMS) coating technology. Furthermore the capability of HIPIMS to produce a high quantity of ionized species can allow conformal coatings also for complex geometries. CERN already studied the possibility to use such a coating method for SRF accelerating cavities. Results are promising but not better from a RF point of view than dcMS coatings. Thanks to these results the next step is to go towards a biased HiPIMS approach. However the geometry of the cavities leads to complex changes in the coating setup in order to apply a bias voltage. Coating system tweaking and first superconducting properties of biased samples are presented.

EXPERIMENTAL SETUP

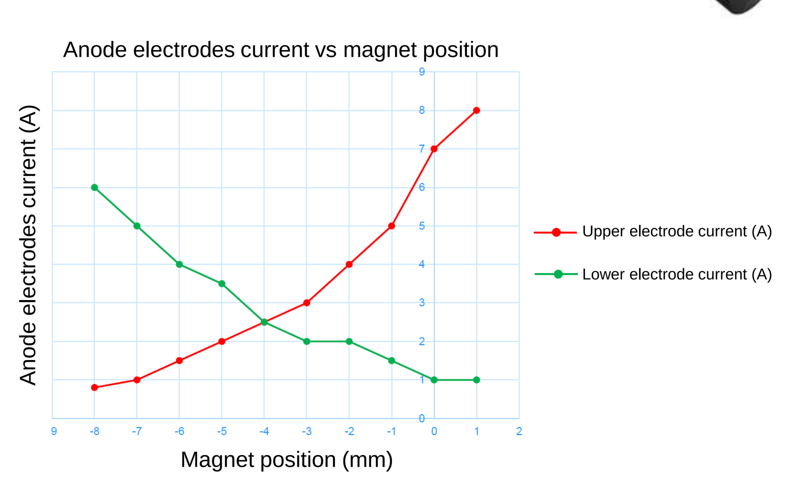
Standard HiPIMS/dcMS
The coating setup is based on a cylindrical magnetron sputtering configuration developed at CERN[1] and using the cavity as the vacuum chamber. A tube of niobium is used as a cathode and insulated from the cavity potential using a ceramic spacer brazed on two DN100 flanges. The magnetic field is applied using a permanent SmCo magnet axially magnetized. The area of the cavity to be coated is thus defined by the position of the magnet within the cathode by displacing it using a step motor.



Biased HiPIMS
The core setup remains the same. However because the cavity is now negatively biased one needs to get an anode within the coating setup. For that purpose two extra electrodes surround the extremities of the central cathode. These electrodes are used as anode (grounded) when coating the cell of the cavity and as cathode when coating the cut-off regions.

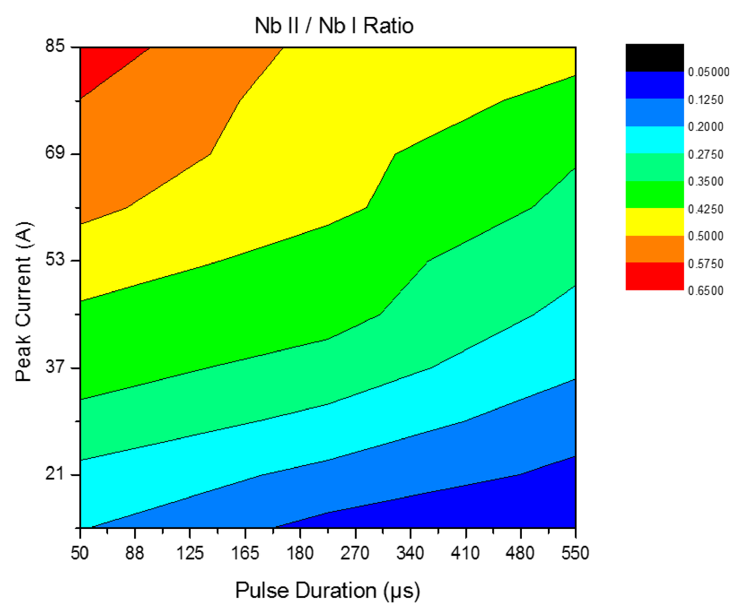


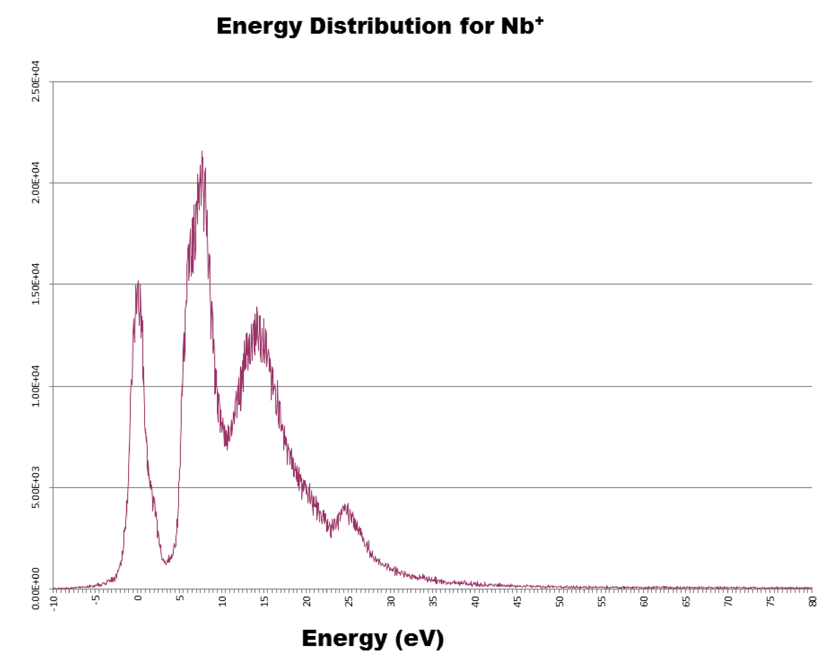
Magnet position monitoring:
In order to get an homogeneously distributed plasma it is necessary to control the magnet position with respect to the two anodes. This can be fine tuned by monitoring the current driven through both electrodes.



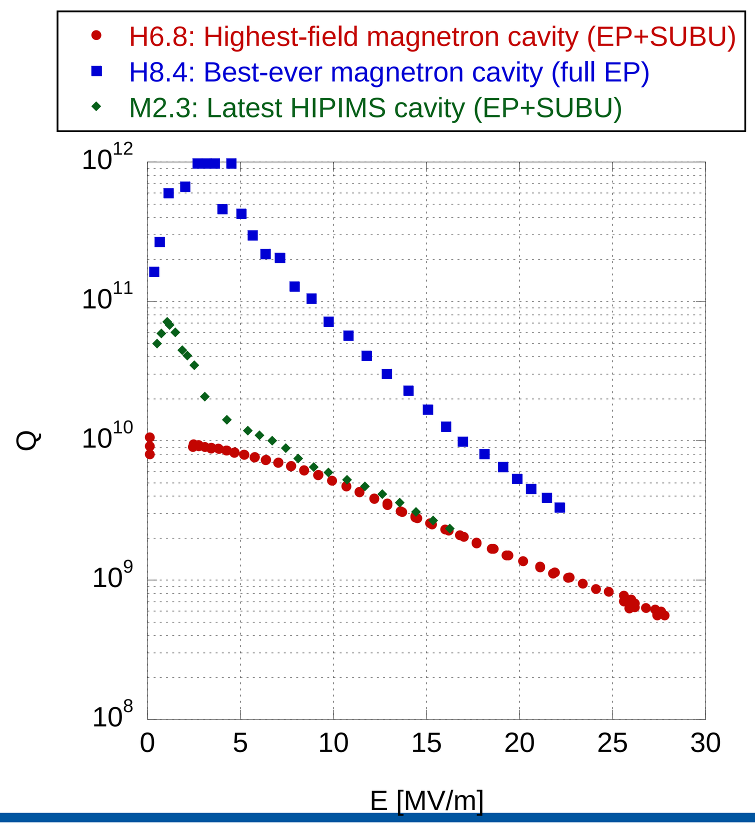
STANDARD HiPIMS RESULTS

Plasma Diagnostic
OES and MS measurements have allowed to investigate the impact of the pulse duration on the ion production. It has also been possible to study the energy spread of these ions.



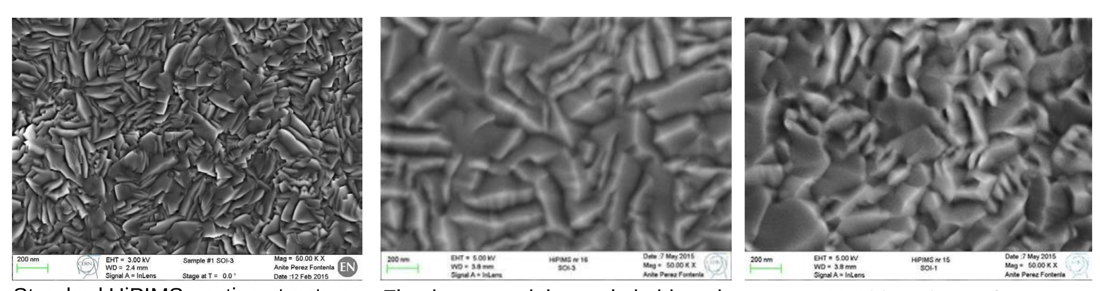


SRF cavities performances
HiPIMS coating shows that for an equivalent surface preparation the performances obtained are slightly better at low accelerating field than for a dcMS coating. However one can clearly see that a different surface preparation (EP only) still has a dominant effect over the coating technique.



FIRST BIASED HiPIMS RESULTS

Film structure
Biasing the sample and even letting it at floating potential enhances the size of the grains at the surface of the film leading also to an increase of the RRR value.
XRD analysis confirm that the films are polycrystalline but do not show any preferential orientation no matter the coating parameters.



Standard HiPIMS coating structure — Floating potential sample in biased type HiPIMS — -20V biased sample

Sample type	Thickness (µm)	RRR
HiPIMS standard	1.69	21
Biased / Floating	2.22	26
Biased / -20V	2.49	30

CONCLUSION AND PERSPECTIVES

HiPIMS technique is a promising approach in order to improve SRF cavities performances. Based on this observations a step forward has been done in order to control the cavity potential and thus to tune the energy of the impinging ions in order to get even much better film characteristics.
It as been shown that the film surface is clearly modified by applying a negative potential through the increase of the coating speed as well as the enhancement of the grains size.
A first superconducting parameter, RRR, as been characterized and exhibited a step up compared to standard HiPIMS coatings.
Further studies will be carried out such as the evaluation of the effect of using either a balanced or unbalanced magnetron configuration in order to tune the ion production and flow toward the substrate. OES and MS measurements will also be attempted in cavity geometry in the same way as for standard HiPIMS configuration in order to evaluate the changes of the plasma behaviour.
Finally SRF cavities will have to be coated so we can access the RF properties of such devices and get a link between the film structure and the accelerating structures performances.

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