CERN

A15 materials thin films and HiPIMS progress at CERN for SRF cavities

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CERN

Outline

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  - Principle
  - Setup
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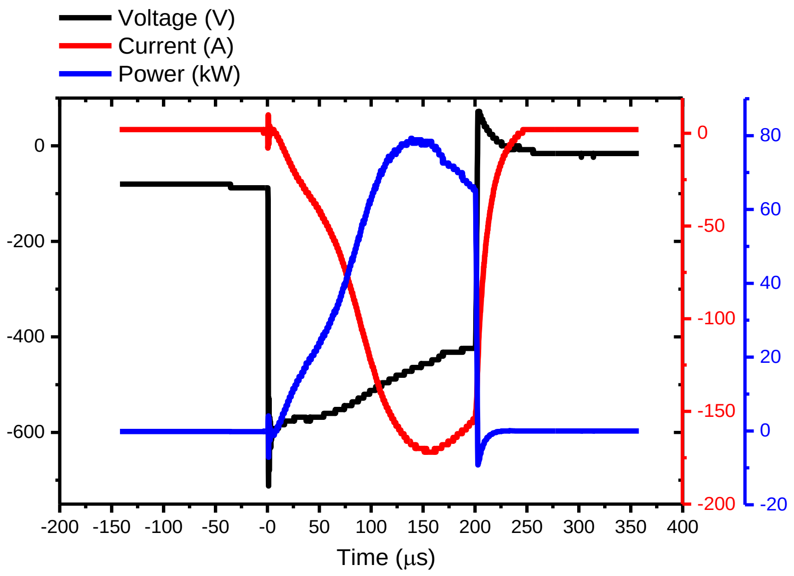
- A15
  - Goal
  - Setup
  - Results
  - Next steps
- Conclusion

HiPIMS coatings progress

Principle

- **HI**gh **P**ower **I**mpulse **M**agnetron **S**puttering
  - Pulsed power supply (~100μs pulses, 1% duty cycle up to 1kHz)
  - Power density
    - DC: 12 $W.cm^{-2}$
    - HiPIMS: ~1$kW.cm^{-2}$
  - Ionization of sputtered species up to 90%
  - Better coating conformity
  - Lower substrate heat-up
  - Lower coating rate : ions captured at the cathode
  - Very sensitive to cathode surface state (roughness) → arcing



Motivation

Systematic Q-slope degradation when lowering cavity beta value

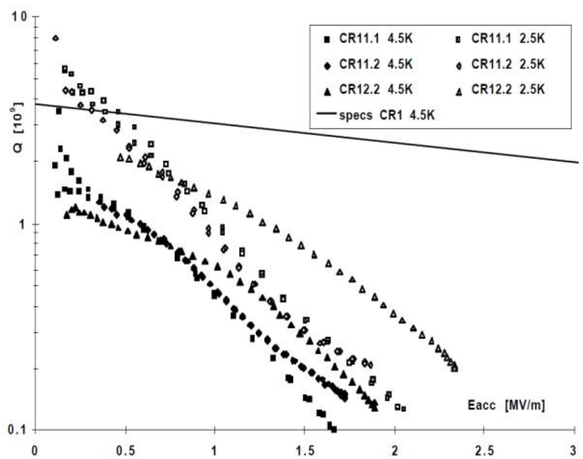


Fig. 2: Q(E) of the *two* ß=0.48 cavities at 4.5 K (full) and 2.5 K (open)

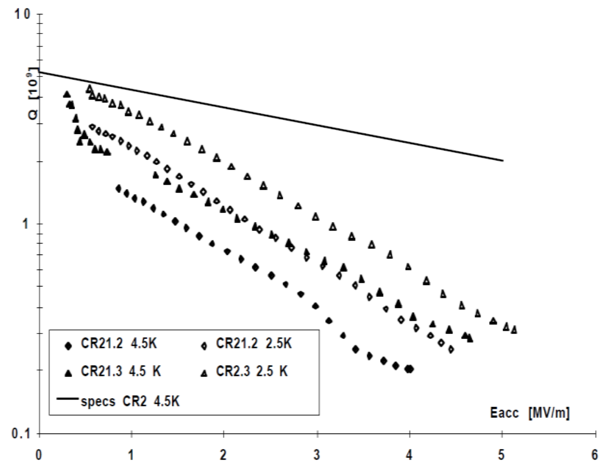


Fig. 3 : Q(E) of the ß=0.625 cavity at 4.5 (full) and 2.5 K (open)

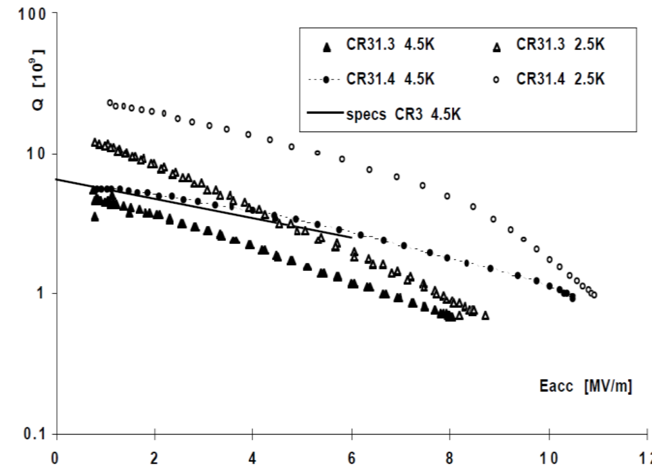
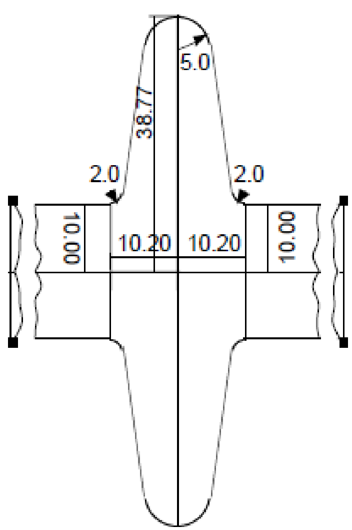
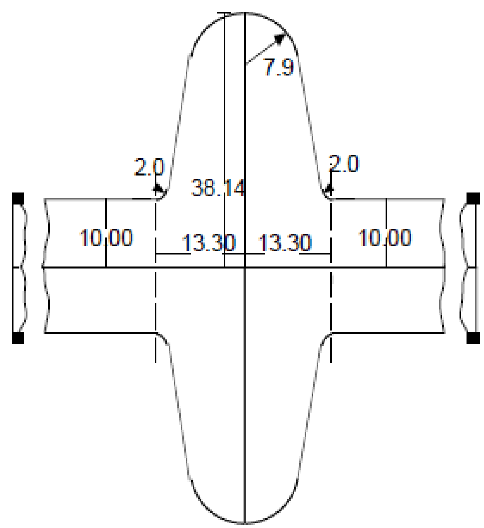
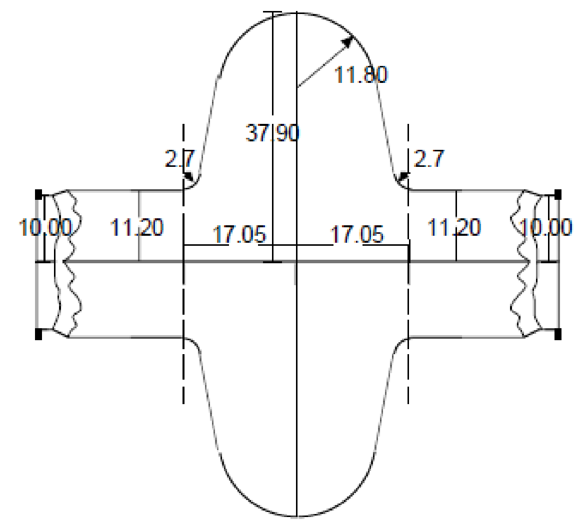


Fig. 4 : Q(E) of the ß=0.8 cavity at 4.5 (full) and 2.5 K (hollow)



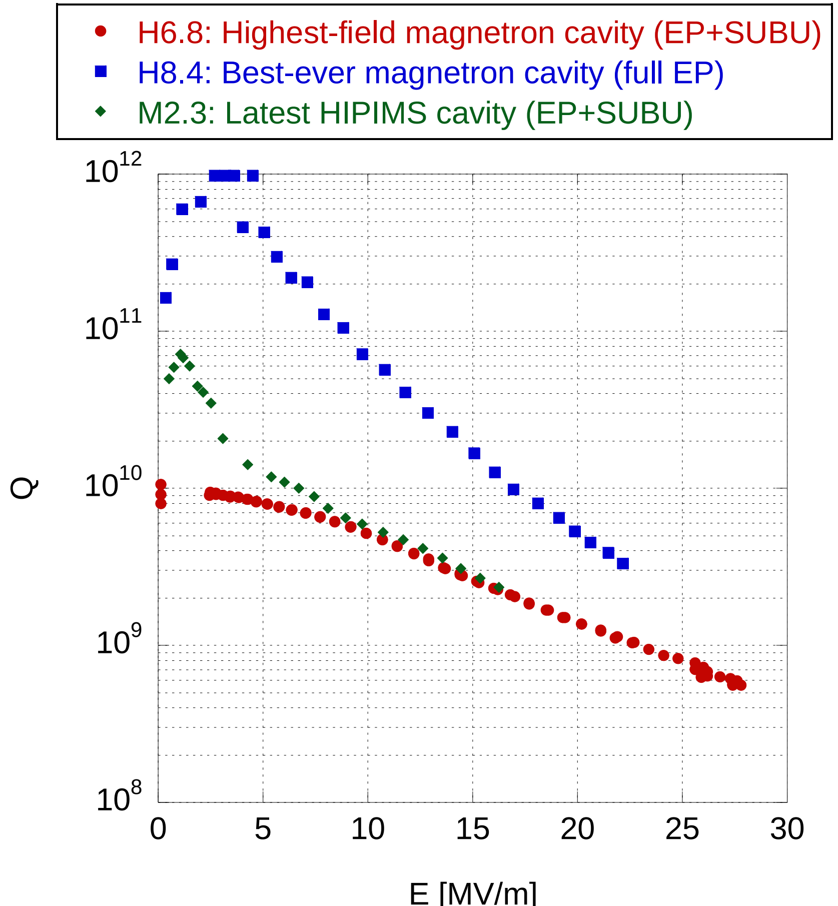




C. Benvenuti et al, Production and test of 352 MHz niobium sputtered reduced beta cavities, 1997

Motivation

- Encouraging first coating (G. Terenziani)



HiPIMS performs close to the best ever achieved magnetron coated cavities.

How to go farther?

CERN Setup

Kr process gas
Differential pumping RGA (process quality control and leak detection)
Bakeout system (base pressure ~ 5.10^{-10} mbar)
Controlled venting: Dry Air

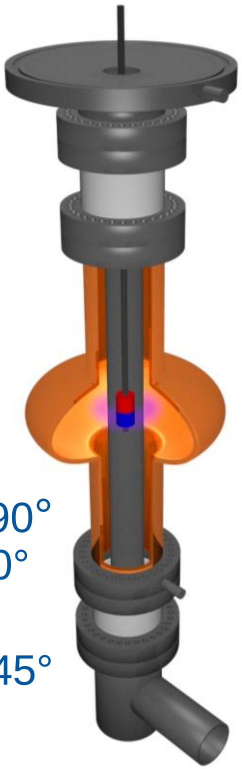
HiPIMS Power supply + capacitors bank

Bias power supply

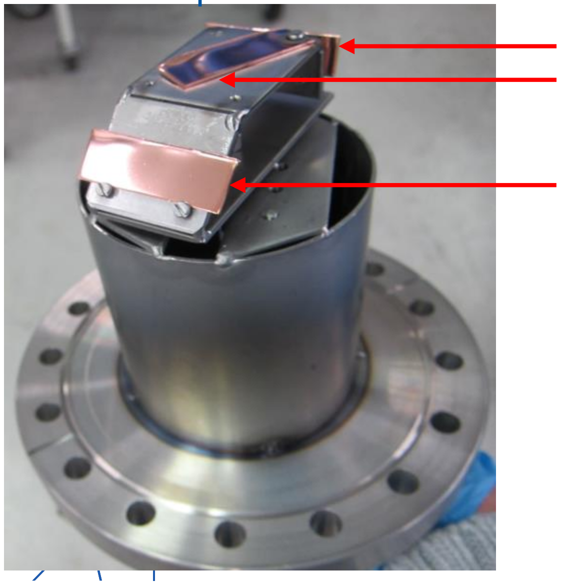
CERN Setup

Standard

- Single Nb cathode
- Cavity grounded
- LHC-like coating setup

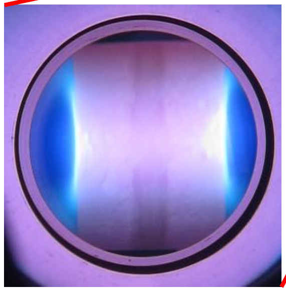


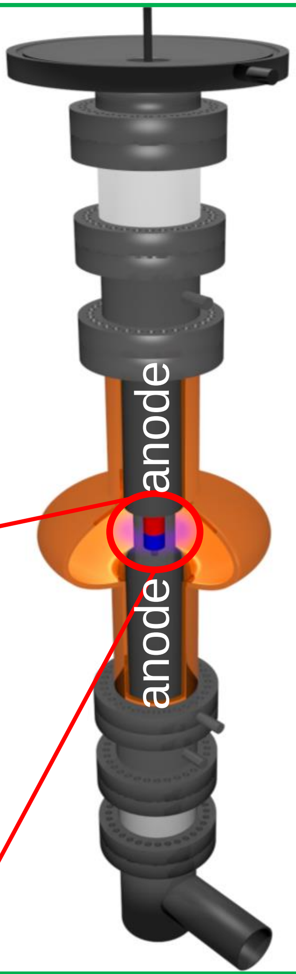
Sample Holder



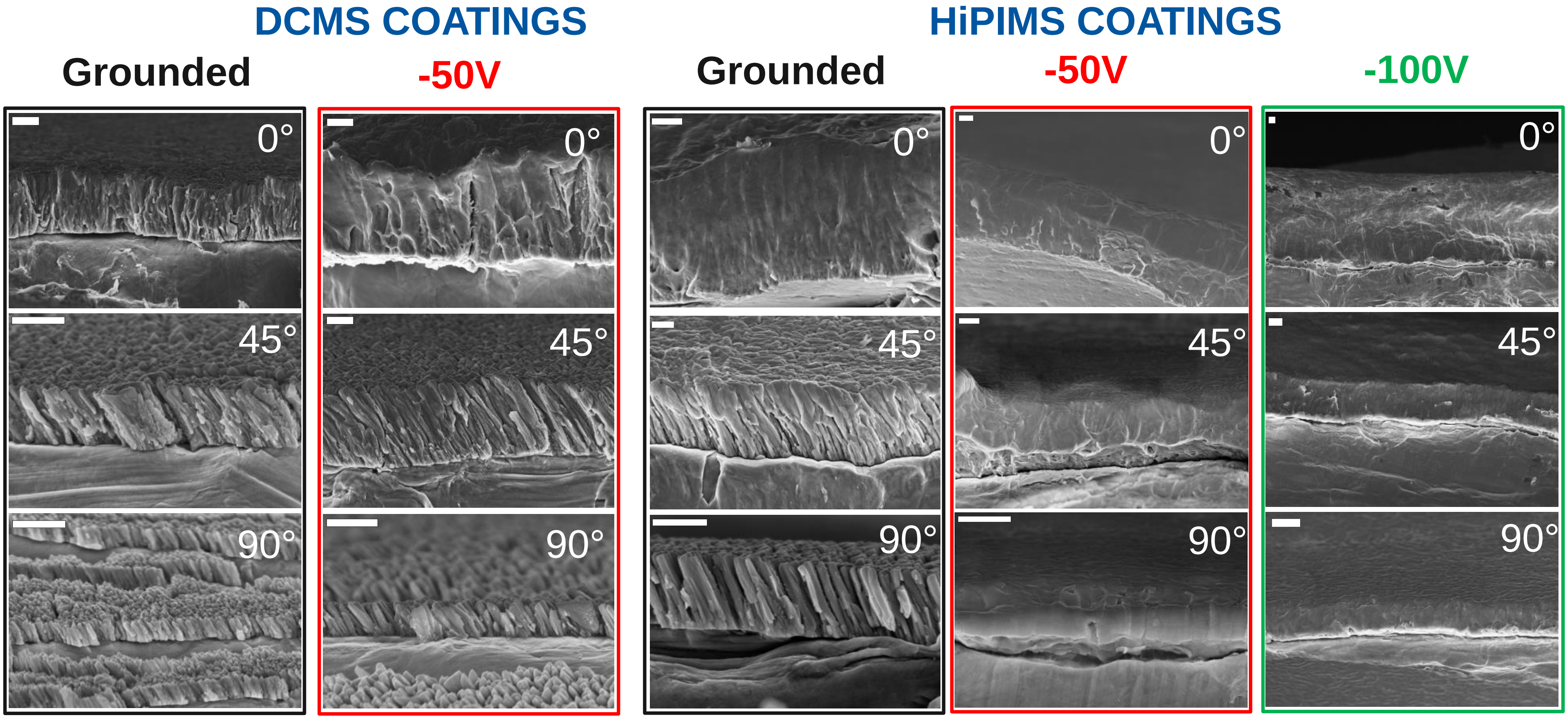
Bias

- Three Nb electrodes
  - Can be used as anode or cathode
- Coating in cut-offs: cavit grounded
- Cell coating: cavity can biased





Latest results as function of coating angle

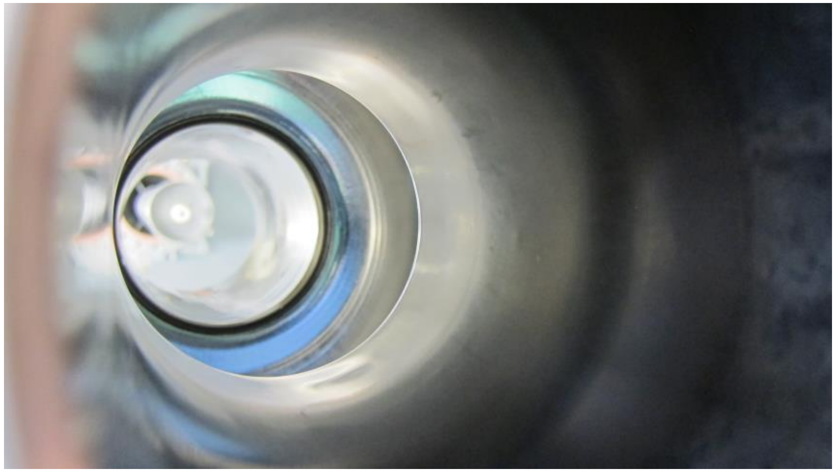


All scale bars are 400µm

- No major improvement from grounded to biased DCMS
- Grounded HiPIMS equivalent to DCMS
- Biased HiPIMS shows densification of the layer no matter the orientation

Next steps

- M2.10 (1.3 GHz) coated with HiPIMS/-100V bias. RF characterization pending.

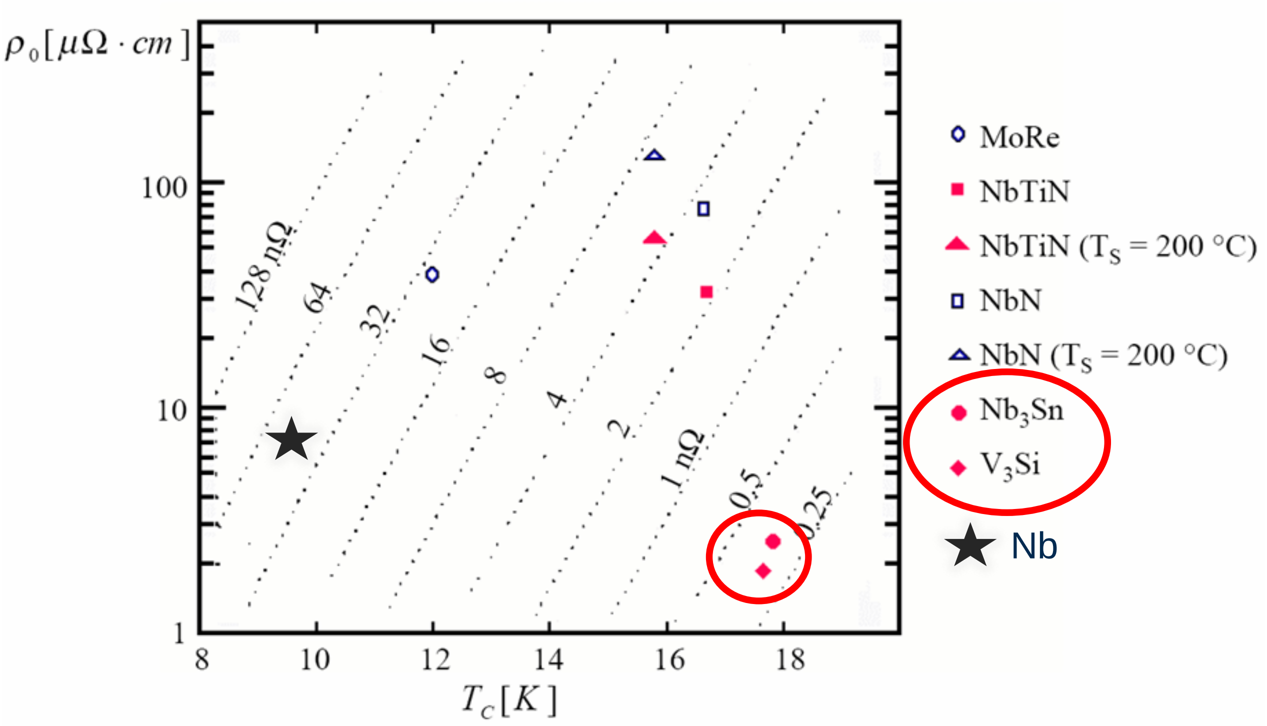


- Samples FIB preparation and analysis on going : Substrate/Nb layer interface, porosity evaluation…
- Pursue HiPIMS coatings to validate/exclude technological approach by end 2016.
- Propose new magnetic configurations to enhance Nb ions flux at the substrate.
- QPR to investigate the superconductive RF properties.
- Exploration of SC DC properties (magnetometer, T_C …)

A15 Materials

Goal

- Propose an alternative to Nb films for SRF accelerating cavities
- Candidates should have:



Low resistivity

Low surface resistance

"High" T_C

Single SC gap

Coating Setup

- Planar DC magnetron sputtering

150mm Nb/Sn and V/Si targets at 3:1 at. Ratio.

Ar sputtering gas

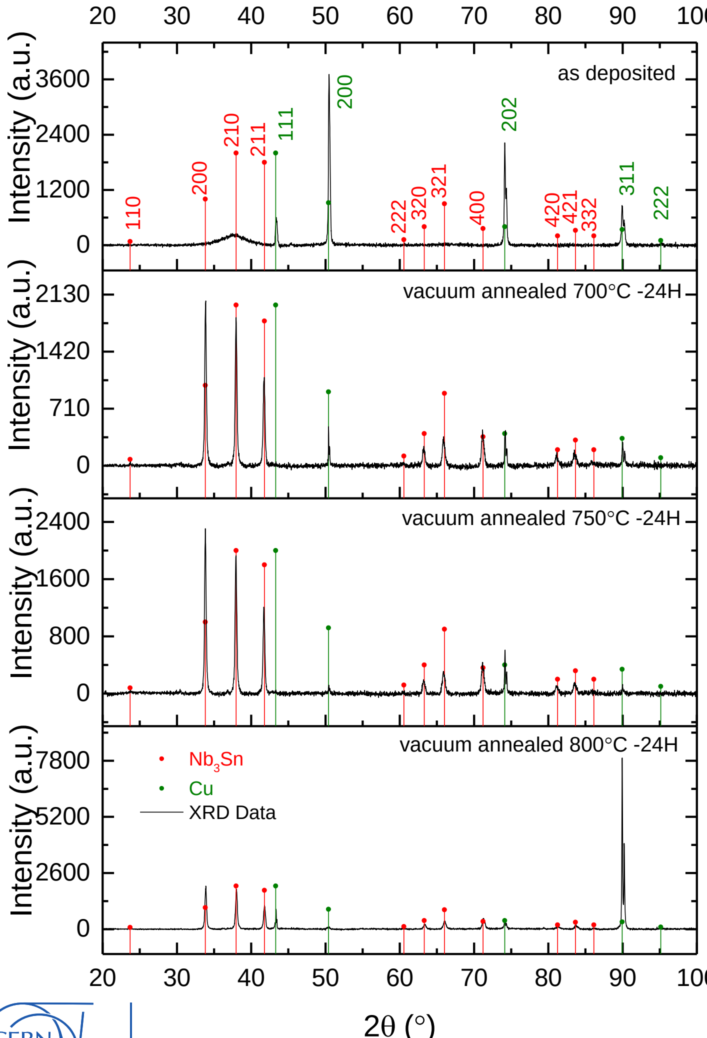
200W sputtering power

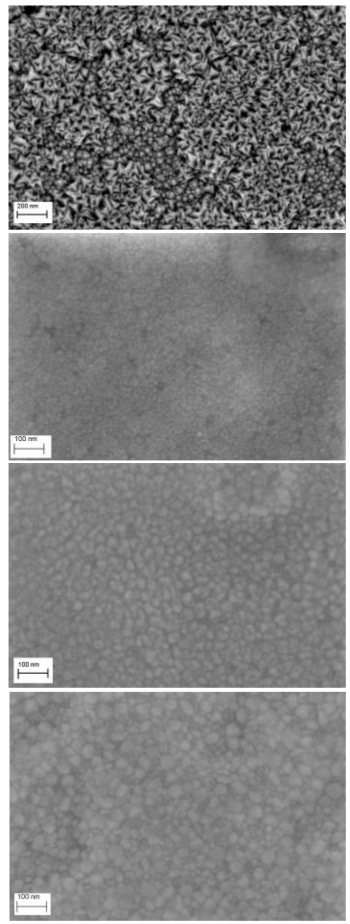
1.10^{-3} mbar up to 5.10^{-2} mbar working pressure

Alloyed target → possible scale-up to cavity size coatings

Results

- Nb_3Sn Room temperature coatings + annealing

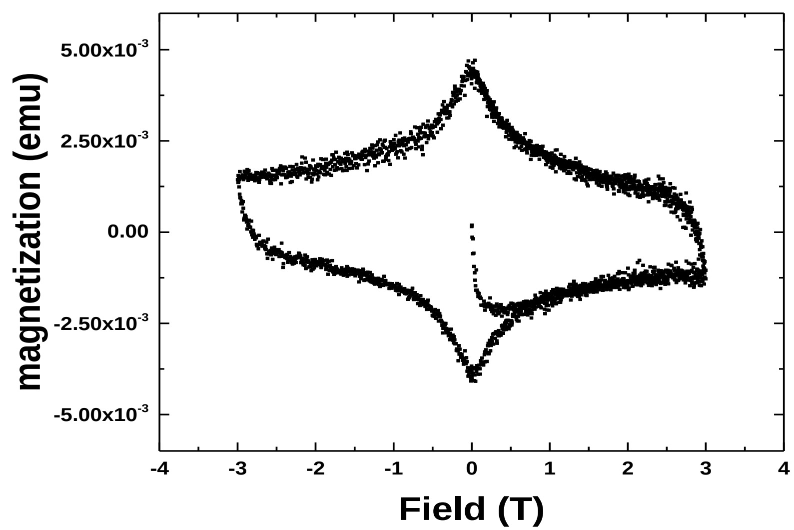




As deposited layer: nanocrystal but mainly amorphous

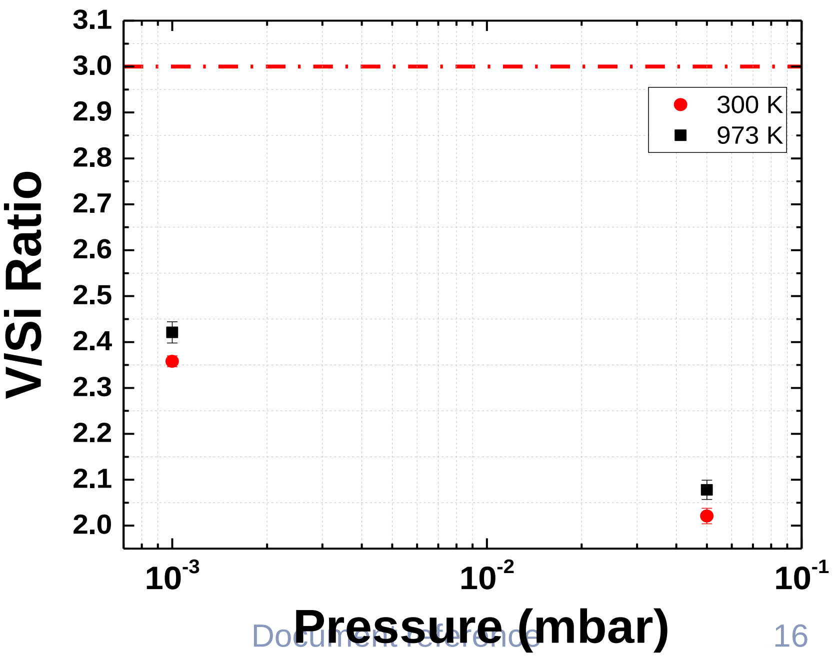
After annealing: A15 phase obtained even after annealing at low temperature.

DC measures confirm the obtention of a superconducting phase
Strong hysteresis suggests flux pinning



Next steps

- EUCARD-2 deliverable D12.5: **Postponed to Aug 2016 because of QPR system repair.**
- Understand the effect of surface preparation (surface energy measurements, roughness …)
- Recommissioning of the T_C measurement setup (induction)
- First promising results from high temperature coatings : to be investigated in depth.
- V_3Si coatings already started:
  - Stoichiometry issue : process gas?
  - XRD on going
- DC properties interpretation



Communications

2015

Poster at HiPIMS 2015, Braunschweig: BIASED HiPIMS TECHNOLOGY FOR SUPERCONDUCTING RF ACCELERATING CAVITIES COATING

DEVELOPMENT OF Nb3Sn COATINGS BY MAGNETRON SPUTTERING FOR SRF CAVITIES , G. Rosaz et al, SRF 2015 proceedings + POSTER

2016

Poster at FCC week, Rome : SUPERCONDUCTING SPUTTERED NB$_3$SN FILMS FOR SRF APPLICATIONS

CONCLUSION

- HiPIMS
  - Demonstrated very promising film morphology
  - First biased cavity coated – RF measures on-going

  - Study RF performances vs parameters (pulse duration, peak power, frequency…)
  - Plasma characterization

- A15
  - Nb_3Sn
    - A15 phase obtained after annealing. Superconductivity confirmed
    - High temperature coatings promising
  - V_3Si
    - First coatings done and under characterization
  - QPR coating by end Aug 2016
  - T_C measurement bench to be requalified