Nb COATED HIE-ISOLDE QWR SUPERCONDUCTING ACCELERATING CAVITIES: FROM PROCESS DEVELOPMENT TO SERIES PRODUCTION

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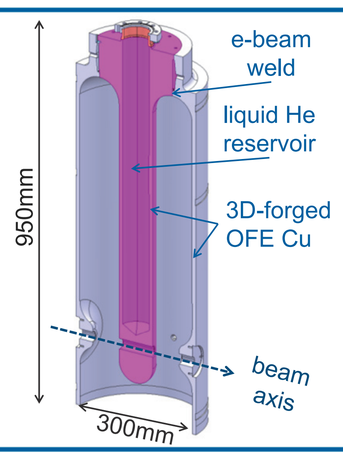
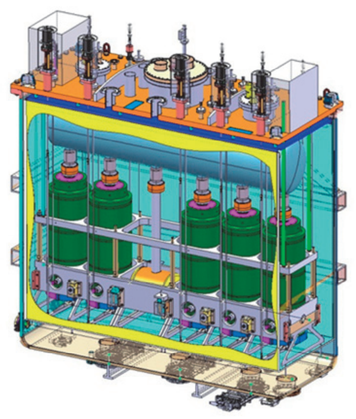
Introduction

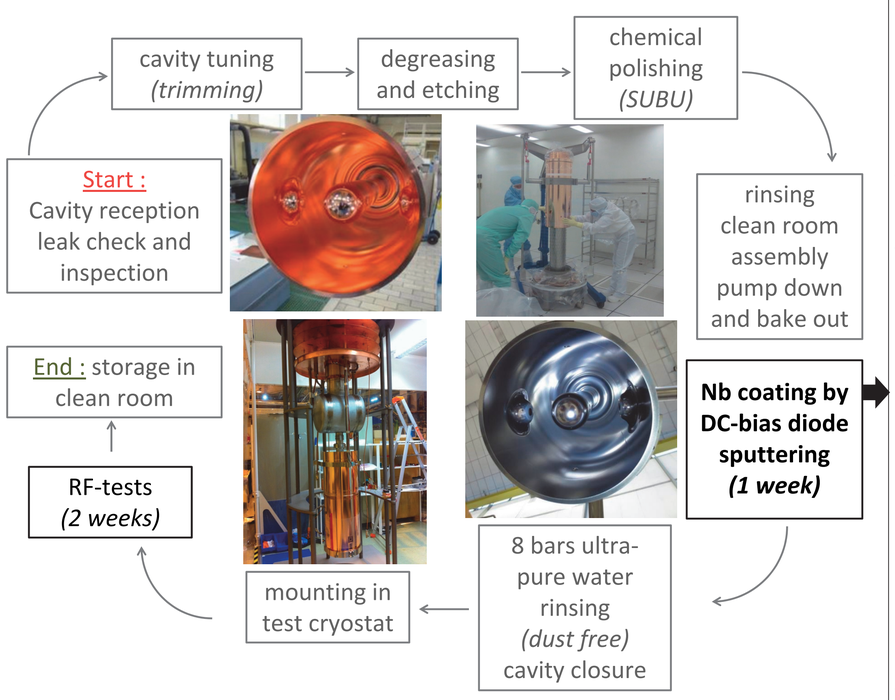
In the frame of **High Intensity and Energy (HIE) ISOLDE project**, the **niobium coating of the high beta superconducting quarter-wave resonators (QWR)** entered series production. The QWR cavities are made of OFE 3D-forged copper and are coated by DC-bias diode sputtering with a thin superconducting layer of niobium. Development of the sputtering setup and process has been conducted along the last years at CERN to meet the HIE-ISOLDE specifications: operation at **4.5K** with an accelerating field of **6MV/m** at **10W RF losses**, **Q_0=4.7x10^8** and an average surface resistance of 65 nΩ. In a first phase two cryomodules of 5 high-β cavities each are scheduled. The series production of these cavities has started.
The assembly of the first cryomodule is foreseen for the end of 2014.





Baseline process

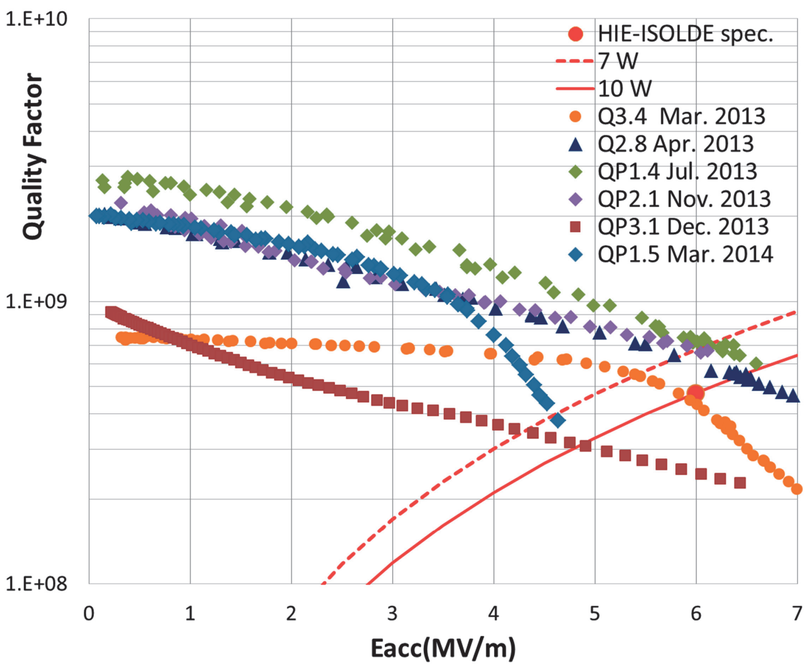
9 weeks process from Cu-substrate reception to cavity storage:



COATING PARAMETERS

- **Temperature:**
  Inner conductor:
  315°C to 620°C
  Outer conductor:
  300°C to 430°C
- **Pressure:** 0.2mbar
- **Sputtering gas:** Ar
- **Nb-cathode power:** 8kW
- **Cavity bias:** -80V
- **14 runs:**
  25' coating
  + 5h35' cool down to 300°C each

RF test results



Linear fitting:

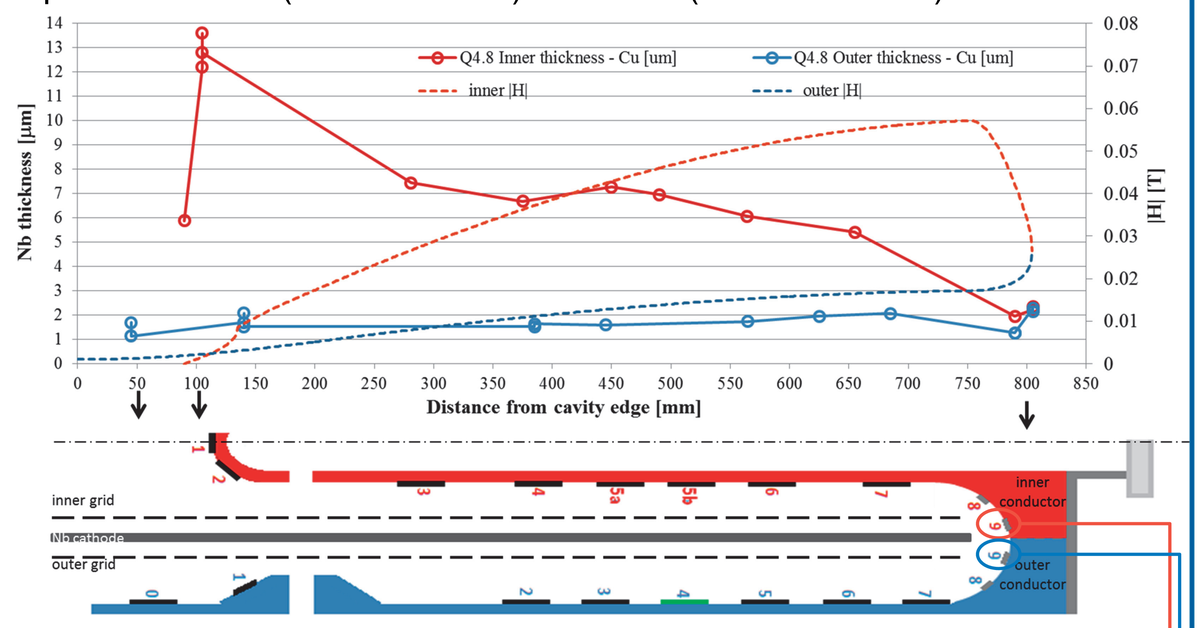
$$Rs = Rs0 + Rs1 \cdot E_{acc}$$

	Rs0 [nΩ]	Rs1 [nΩ/(MV/m)]
Q3.4	40.4	1.6
Q2.8	14.4	3.4
QP1.4	11.1	1.5
QP2.1	12	4.7
QP3.1	30.6	13.3
QP1.5	14.9	2.1

→ **The HIE-ISOLDE specifications have been reached and overtaken by three cavities** (Q2.8, QP1.4 and QP2.1). The best cavities offer up to 30% margin on cryogenic power, being 7W dissipation at 6MV/m

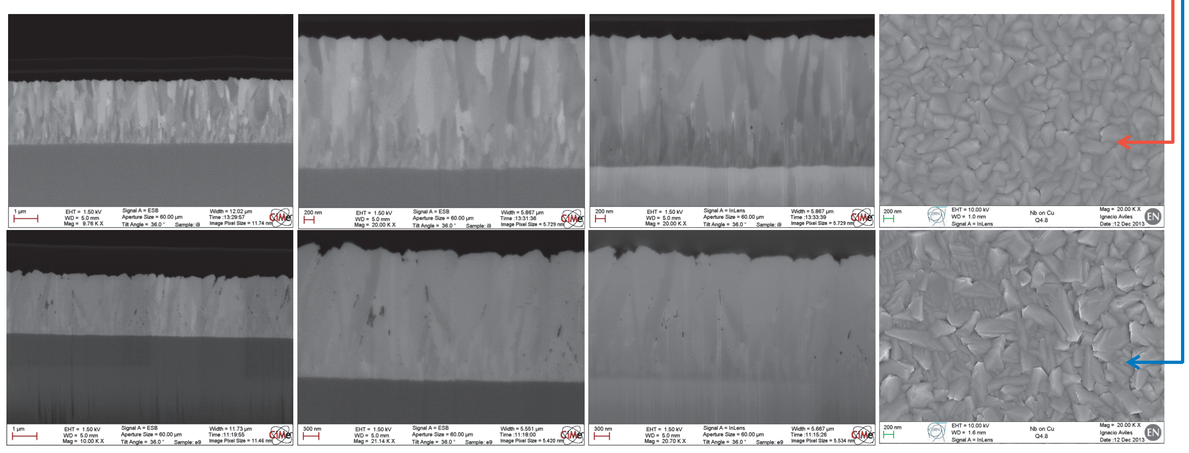
Niobium film characteristics

1. **Niobium film thickness profiles** along the cavity inner (red line) and outer (blue line) conductors together with calculated surface magnetic field profile on inner (dotted red line) and outer (dotted blue line) conductors.



→ Though the film thickness is not uniform along the cavity and especially between the inner and outer conductor, the layer is thick enough and its quality is good enough to match RF needs

2. **Niobium film structure** at the top of the cavity, sample 9 (SEM-FIB/SEM)



→ Although the coating is done in 14 runs with cool down in between, the film is not composed of "layers"
→ There is no interface layer observable along the coating profile that could result from the effect of residual gas in the vacuum chamber during the cool down step in between two runs or a different surface mobility with temperature.
→ This confirms that the film grows in a continuous way along the 14 runs, with grain size growing accordingly (300-500nm).

Conclusion

The HIE-ISOLDE cavities production process is now well established at CERN and the production has started. The first production cavity manufactured by industry will be coated at the end of June. The production rhythm is fixed to one cavity per month coated and RF-tested with target assembly of five cavities in the first cryomodule for October 2014.
In parallel of the production, thin film characterization and magnetron sputtering development activities are underway.

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