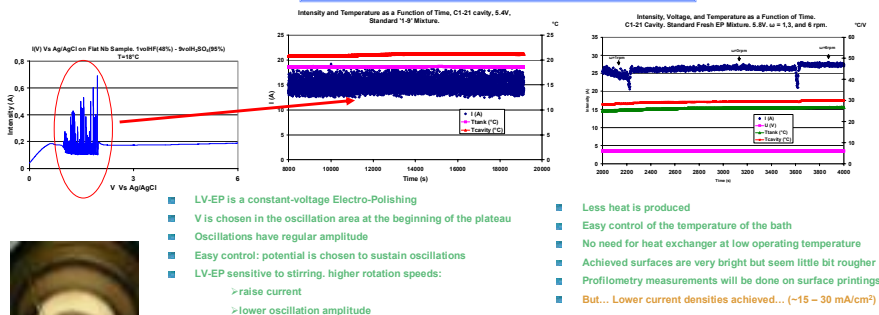


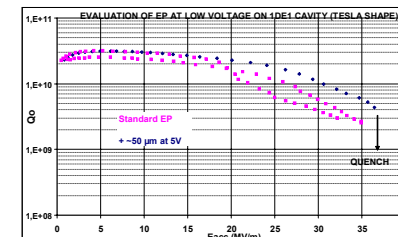
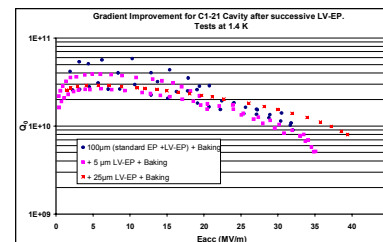
Introduction: Electro-polishing (abbreviated as EP) is believed to be the most desirable treatment for SRF cavities. EP is an anodic electrochemical treatment carried out in HF-H₂SO₄ electrolytes. The characteristic I(V) curve of the process shows a diffusion plateau and in the SRF community, the potential is commonly chosen at the end of the plateau for the polishing of elliptical cavities. 17 V is for example used at DESY for EP of XFEL cavities. We have pursued the investigation work about influence of EP parameters, initiated in the CARE SRF program and have focused on influence of voltage. We intend to prove that RF results after Low Voltage Electro-Polishing (LV-EP), that is to say, EP in a current oscillation area, at 5 V, are similar compared to standard EP. LV-EP would provide in addition numerous advantages. First analyses indicate that it should generate a decreased particulate contamination. We will also demonstrate that chloroform rinsing of cavities should be considered as an efficient step prior to High Pressure Rinsing.

CHARACTERISTICS OF LOW-VOLTAGE EP (LV-EP)



LV-EP ESPECIALLY ADAPTED TO LARGE CAVITIES (proton) TREATMENT OR/AND VERTICAL PROCESS

TEST OF 1-CELL SRF CAVITY AFTER LV-EP



TESTS AFTER LOW-V EP ARE SIMILAR COMPARED TO EP. SRF PERFORMANCE DOES NOT DEPEND ON THE VOLTAGE USED DURING EP

INCREASED SULFUR GENERATION AT HIGH VOLTAGE

Reduction Reactions at the Cathode
 Reduction of H⁺: 2 H⁺ + 2 e⁻ → H₂ Eq. 1 (Predominant)
 Reduction of SO₄²⁻: SO₄²⁻ + 8 H⁺ + 6 e⁻ → S + 4 H₂O Eq. 2



Sample A, 20 Volts: 9.18 g removed, 51 hours EP
 Sample B, 5 Volts: 9.11 g removed, 115 hours EP

What about Hydrogen in niobium after LV-EP?

EXPERIMENT	20 V	3V
Removal	150 μm	150 μm
H Content	2 ppm	1 ppm

No increased H contamination after LV-EP!

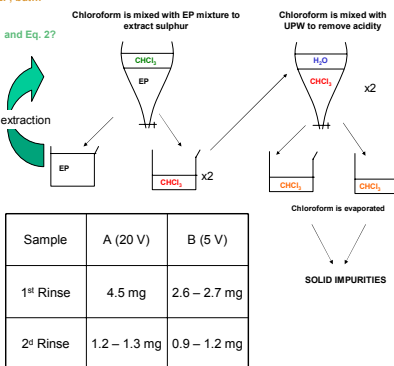
- H₂ mainly produced at the cathode during EP, but...
- Sulphur likely to form if [HF]/[H₂SO₄] is low
- Might cathodic overpotential change the balance between Eq. 1 and Eq. 2?
- Long time experiments have been carried out on two samples: A (EP at 20 V) and B (5 V)

After similar niobium removal:

- Sample B is bright
- Sample A is covered with yellow sticky spots
- Spot removed neither by ethanol rinsing, nor chloroform rinsing
- What about impurities in electrolytes A and B? (900 ml used)

Impurities in electrolytes A and B extracted with Chloroform CHCl₃

- 200 ml of both A and B have been rinsed with CHCl₃
- Two extractions are done on each sample
- The "dirty" chloroform obtained is rinsed with water to remove residual acidity
- After evaporation, impurities are weighed.
- More impurities found after EP at 20 V!



EXPERIMENTS ON SAMPLES SHOW THAT EP AT HIGH VOLTAGE IS INCLINED TO GENERATE MORE IMPURITIES IN THE ELECTROLYTE. THESE IMPURITIES MIGHT STRONGLY STICK ON THE NIOBIUM SURFACE. ANALYSIS ARE REQUIRED TO PRECISELY KNOW INVOLVED COMPOUNDS.

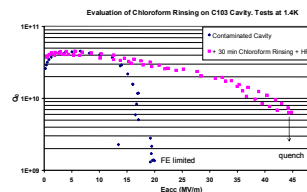
LV-EP DOES NOT INDUCE HIGHER H CONTAMINATION IN NIOBIUM

CHLOROFORM RINSING OF SINGLE-CELL CAVITIES

International Collaboration within ILC S0 Program has proved that ethanol rinsing was a good candidate to be included in the rinsing recipe, to avoid field emission and to obtain reproducible gradients.

We have decided at Saclay to test chloroform rinsing. Chloroform rinsing should be more efficient because of the very high solubility of sulphur in this solvent.

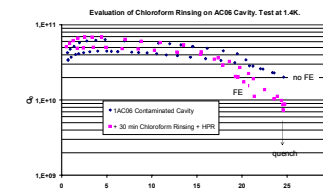
CHCl₃ rinsing has been successful to remove field emitters on different single cell cavities.



C1-03 EP'ed cavity has been heavily polluted after a failure during a pumping procedure. It reached excellent gradient after chloroform rinsing.



The same volume of chloroform has been successfully used for the rinsing of different cavities. However, if it is used for too many treatments, FE appears again. Lot of impurities are found in the incremented solvent. They will be analysed to determine if they come from the solvent itself, or from the process.



AC06 (DESY cavity) single crystal 1-cell cavity, has heavy field emission after standard BCP polishing. Ethanol rinsing removes field emission.

CHLOROFORM RINSING OF CAVITIES IS VERY EFFICIENT TO REMOVE FIELD EMISSION. IT MIGHT BE USED IN THE RINSING RECIPE PRIOR TO HPR

Conclusion: RF tests on single-cell cavities indicate that electro-polishing at low-voltage makes it possible to reach satisfactory gradients. Some resulting advantages should be put forward: higher lifetime of the electrolyte, easy control of the EP, no need for heat exchanger during process. Ongoing results tend to prove that LV-EP is liable to decrease the forming of impurities during the process. Furthermore, chloroform rinsing has been successfully tested out on 1-cell cavities as a cure to remove field emission. Characteristics of LV-EP make this process especially suited to the possible electrochemical treatment of large proton cavities. Printings of the inner surface have been made after LV-EP for profilometry measurements. If rougher surface after LV-EP is confirmed, voltage and surface finish would not influence superconductive properties of the surface. The only drawback of LV-EP is the decreased removal rate achieved. Studies are on going in order to find a counterbalance (use of vertical EP, of higher stirring and temperature of the electrolyte, of higher HF concentrations).