MOPTEV012

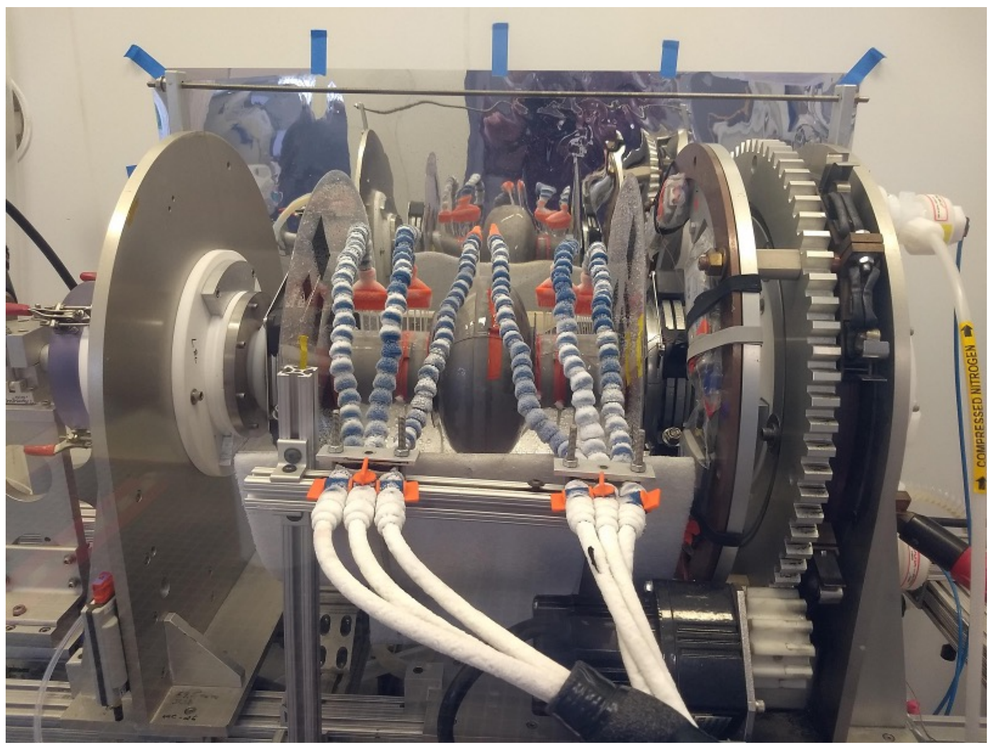
Extra-Cold EP process at Fermilab

F. Furuta, D. Bice, M. Martinello, T. Ring
Fermi National Accelerator Laboratory, Batavia, USA

SRF 2021
28 June 2021 – 02 July 2021

Abstract

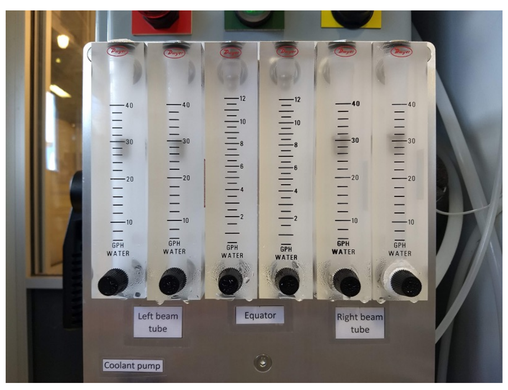
After the successes with Cold Electro-Polishing (EP) method on the single-/multi- cell SRF cavities with various frequencies, FNAL upgraded temp. control system of FANL EP tool and investigated feasibility and capability of EP process at very low temperature. Now the tool can perform EP at -4degC (equator outside) as the lowest. This Extra-Cold EP process below zero-degC was applied on 1.3GHz 1-cell cavity, and the cavity was evaluated in VTS. A compatible RF performance with cold EP method was demonstrated. The details of Extra-Cold EP and the cavity test results are presented in this poster



1.3GHz single cell on Extra-Cold EP process

Modified EP temperature control tools

- Re-arrange Chiller configurations.
  - Chiller #1; acid cooling and pre-cooling of returning coolant into chiller #2.
  - Chiller #2; cavity cooling, set around -14degC
- Use 40% propylene glycol as coolant.
- Separate coolant shower lines and install flow control valves on each line.
- Enlarge coolant line diameter for better flow.
- Add thermal insulation underneath of shower pan.



Flow control valves

Chiller #1 Chiller #2

Extra-Cold EP on 1.3GHz 1-cell

- Upgraded FNAL EP system succeeded to maintain EP process at -4degC (equator outside) as the lowest temp condition.
- After ~8hrs EP processing on 1-cell cavity at -4degC, 25±4um removal was measured over the cell with thickness gauge.
- Parameter comparisons are summarized in Table 1. No current oscillation was seen at -4degC with EP voltage of 18V. Current profiles with other conditions are also shown.
- The cavity also received std. 120C bake, then tested in VTS, and achieved Q of 1e10 at 43MV/m in 2K. The cavity was FE free and limited by quench.
- This was very similar with the result this cavity achieved before by Cold EP method.

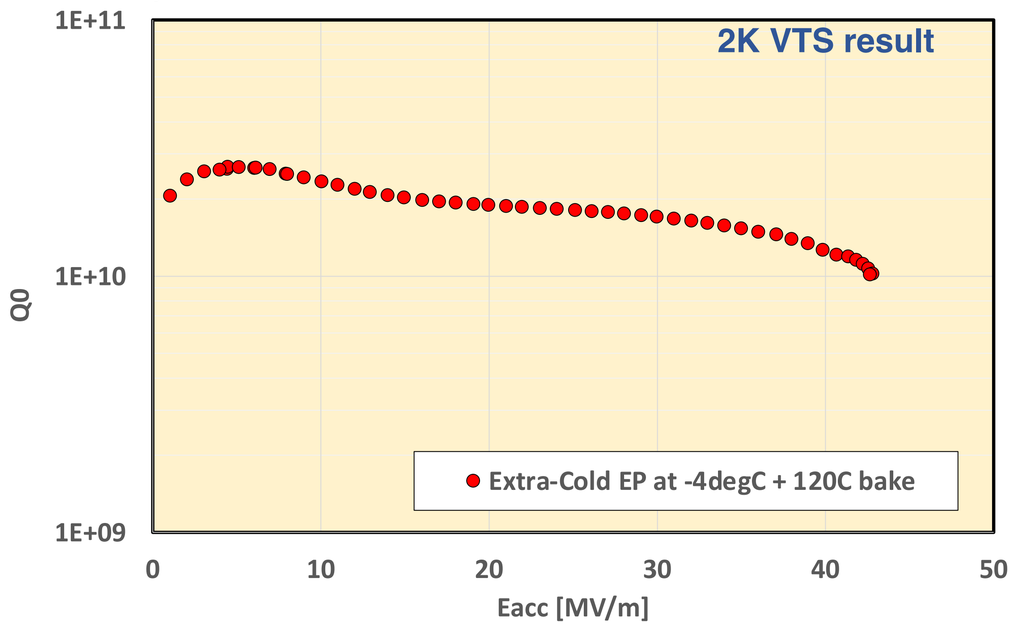
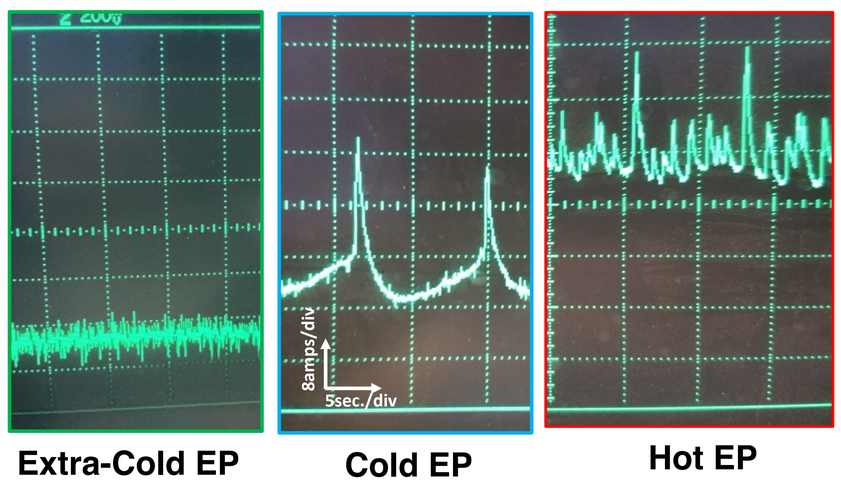


Table 1: Fermi EP conditions for 1.3GHz single cell

Parameters	unit	Extra Cold EP	Cold EP	Hot EP
EP voltage *1	[V]	18	18	18
EP current *1	[A]	8	15	40
Equator temp. *1	[℃]	-4	15	32
Beam tube temp. *1	[℃]	-8	0	5
Acid temp. *1, 2	[℃]	4	12	20
Removal rate *1	[μm/hour]	2~3	4~5	12~13
Acid circulation *1	[L/min.]	1.5~2.3	1.5~2.3	1.5~2.3
Cavity rotation	[RPM]	1	1	1
Nitrogen gas flow *1	[L/min.]	1	1	1

*1: average value, *2: in the acid tank



Extra-Cold EP Cold EP Hot EP

Current oscillation profiles

Summary

- Feasibility and capability of Extra-Cold EP method against high gradient 1-cell cavity was successfully demonstrated.
- Achieved VTS result suggested that very low temp EP (-4degC) or very low EP current density (~5mA/cm^2) did not cause damage to cavity RF surface up to 25um removal at least.
- N-doped 1-cell cavity plans to have Extra-Cold EP as final EP to investigate its impact on cavity RF performances.
- Coupon study is also in progress to investigate the impact of very low temp EP against Nb surface with and without N-dope.