Studies on the Electro-Polishing process with Nb sample plates at KEK

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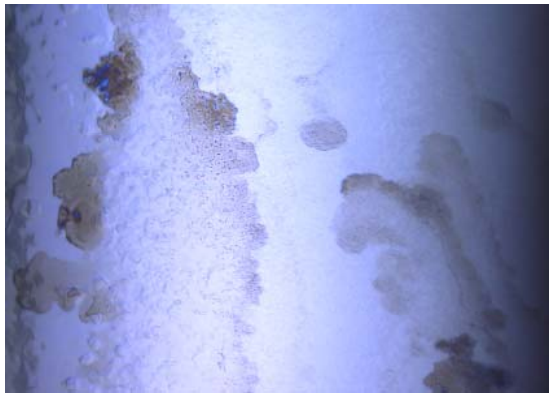
Introduction: Stain problem at STF/KEK

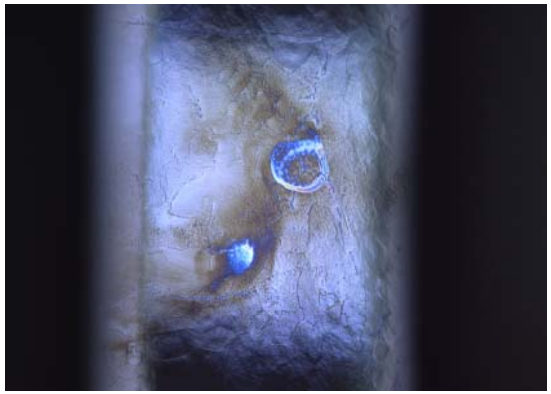
We replaced the EP acid of EP-tank at STF/KEK recently. After the replacement, cavity performances (MHI#6, MHI#7, MHI#8) become very bad (Eacc<20 MV/m) limited by heavy field emissions.

We observed brown spots and traces inside the 9-cell cavities (MHI#6, MHI#7, MHI#8);
Examples: (red indicates bad)
MHI#06 : spot or traces on BP-#1, cell#1, cell#2, cell#3, cell#4, cell#8, cell#9, #9-BP
MHI#07 : BP-#1, cell#1, cell#2, cell#3, cell#4, cell#5, cell#6, cell#7, cell#8, cell#9, cell#9-BP

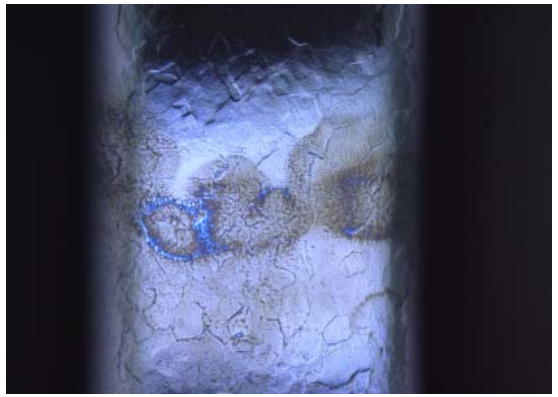
MHI#6 1-cell equator, t = 306 deg.
Downstream : Outside weld area



MHI#6 #9-BP, t = 241 deg. -1



MHI#6 #9-BP, t = 241 deg. -2

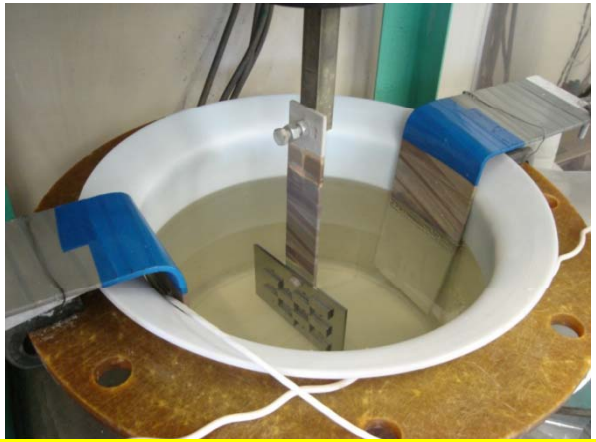


Kyoto-camera pictures using new LED illumination

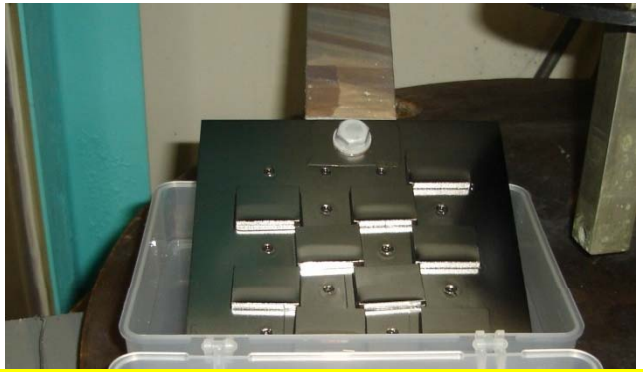
For more details about the vertical test results of these cavities, see the presentation ID: 1309 - TUPPO057 by Y. Yamamoto (KEK), and about the observation of cavities by Kyoto-camera, see ID: 1188 - TUOBAU01 by K. Watanabe (KEK).

Labo-EP of samples at Nomura

11 Aug. 2009



Labo-EP (20 um) with new EP acid ([Nb] = 0 ~ 0.4 g/L) at Nomura

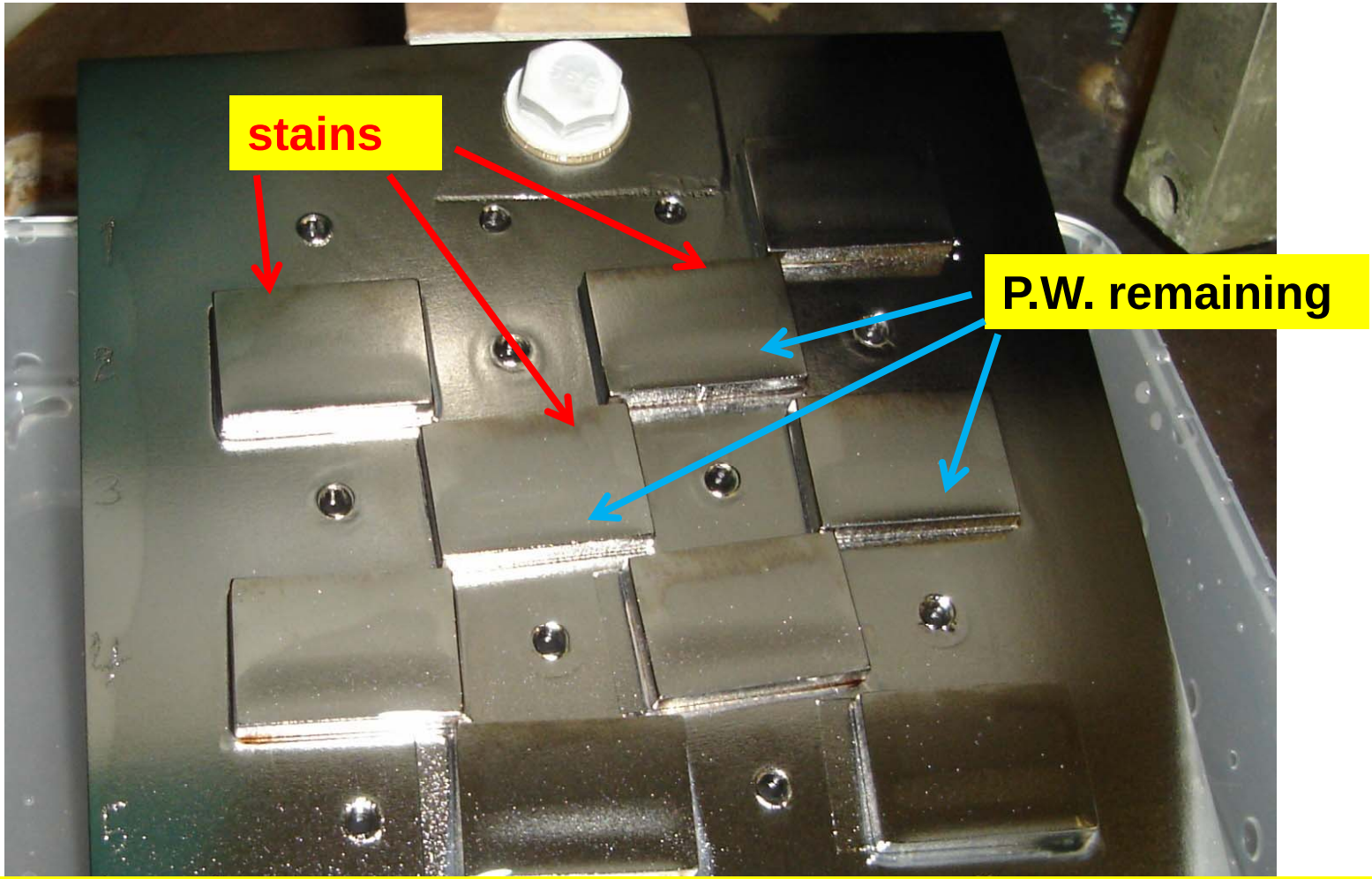


Exposing the samples to the air for 70 min. w/o Pure-Water (P.W.) rinse. No stain appeared.

Light P.W. rinse for a few 10's seconds.

Stains appeared within a minute after exposing the samples to the air.

Exposing samples to the air after P.W. rinse

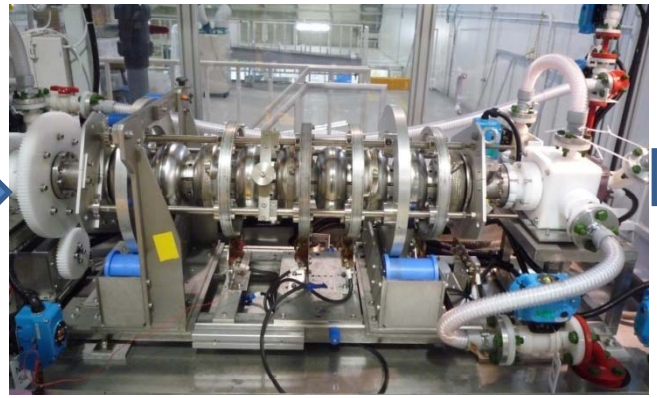


Stains appeared within a minute after exposing the samples to the air.
The stains appeared in the area where P.W. dried. (EP acid of [Nb] = 0.4 g/L)

Modification of first U.P.W. rinse process

First U.P.W. rinse duration after EP-acid-draining at STF/KEK was extended.

Drain EP acid for 15 min.



Horizontal for 5 min.

Drain EP acid for 10 min.
Then UPW rinse starts.

The first U.P.W. rinse was extended with overflow for a longer time.
Original sequence: [pouring U.P.W. for 7 min. + draining for 5 min.] x 5
Modified sequence: [pouring U.P.W. for 60 min. + draining for 10 min.] + [pouring U.P.W. for 20 min. + draining for 7 min.] x 3.

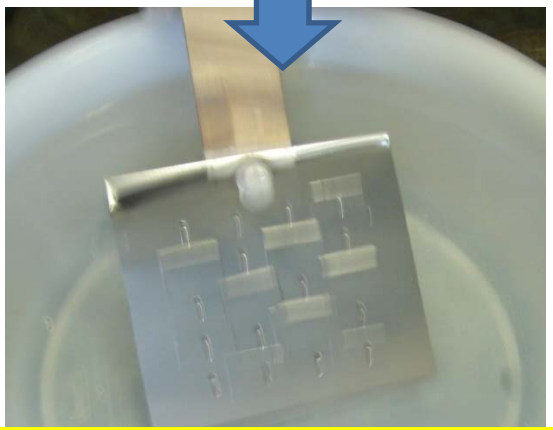
MHI#9 (9-cell cavity) was processed with this modified sequence and reached Eacc = 27 MV/m at Q0 = 9x10^9 (quench), even with some field emission.
More details about the results, see **ID: 1309 - TUPPO057 by Y. Yamamoto (KEK)**.

Labo-EP of samples at Nomura

8 Sept. 2009

Labo-EP (20 um) with EP acid ([Nb] = 4.4 ~ 4.8 g/L) at Nomura

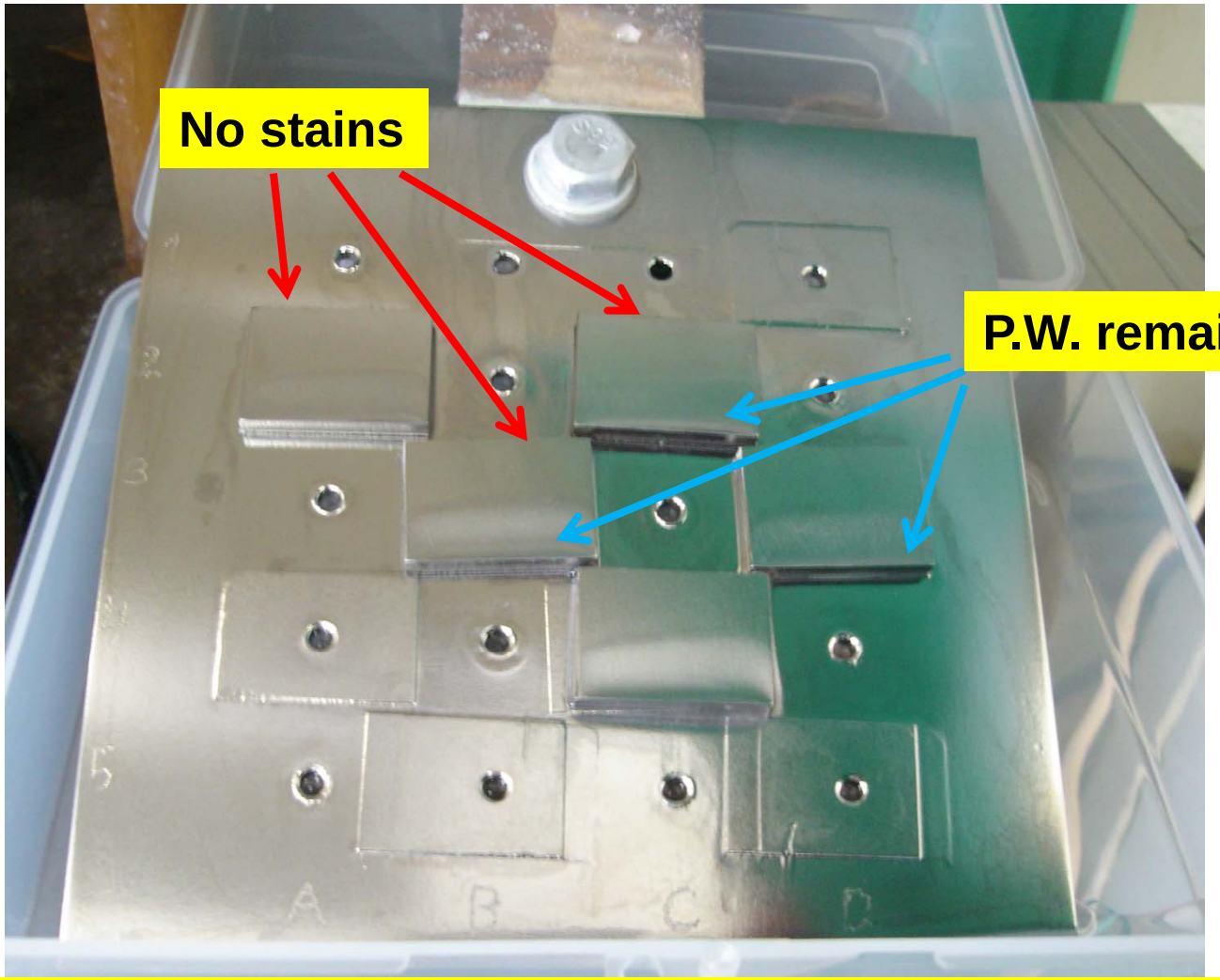
Exposing the samples to the air for 30 min. w/o Pure-Water (P.W.) rinse. No stain appeared.



Light P.W. rinse for a few 10's seconds.

No stains appeared after exposing the samples to the air.

Exposing samples to the air after P.W. rinse



No stain appeared after exposing the samples to the air.
(EP acid of [Nb] = 4.8 g/L at the end)

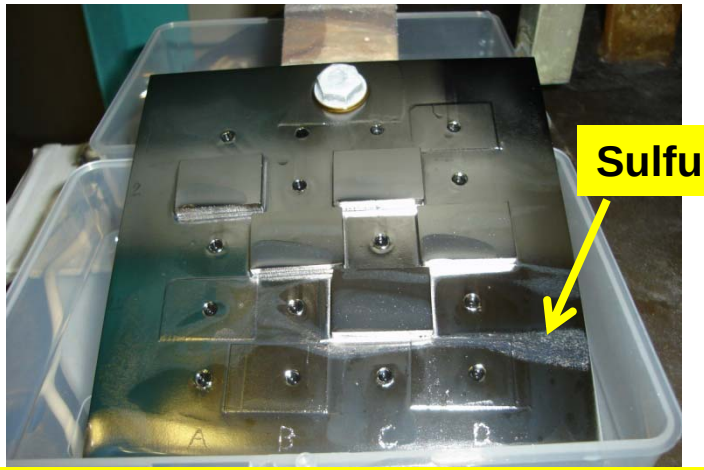
Labo-EP of samples at Nomura

11 Sept. 2009

Labo-EP (20 um) with EP acid ([Nb] = 8.2 ~ 8.6 g/L) at Nomura

Exposing the samples to the air for 30 min. w/o Pure-Water (P.W.) rinse. No stain appeared.

Light P.W. rinse for a few 10's seconds.



No stains appeared after exposing the samples to the air.

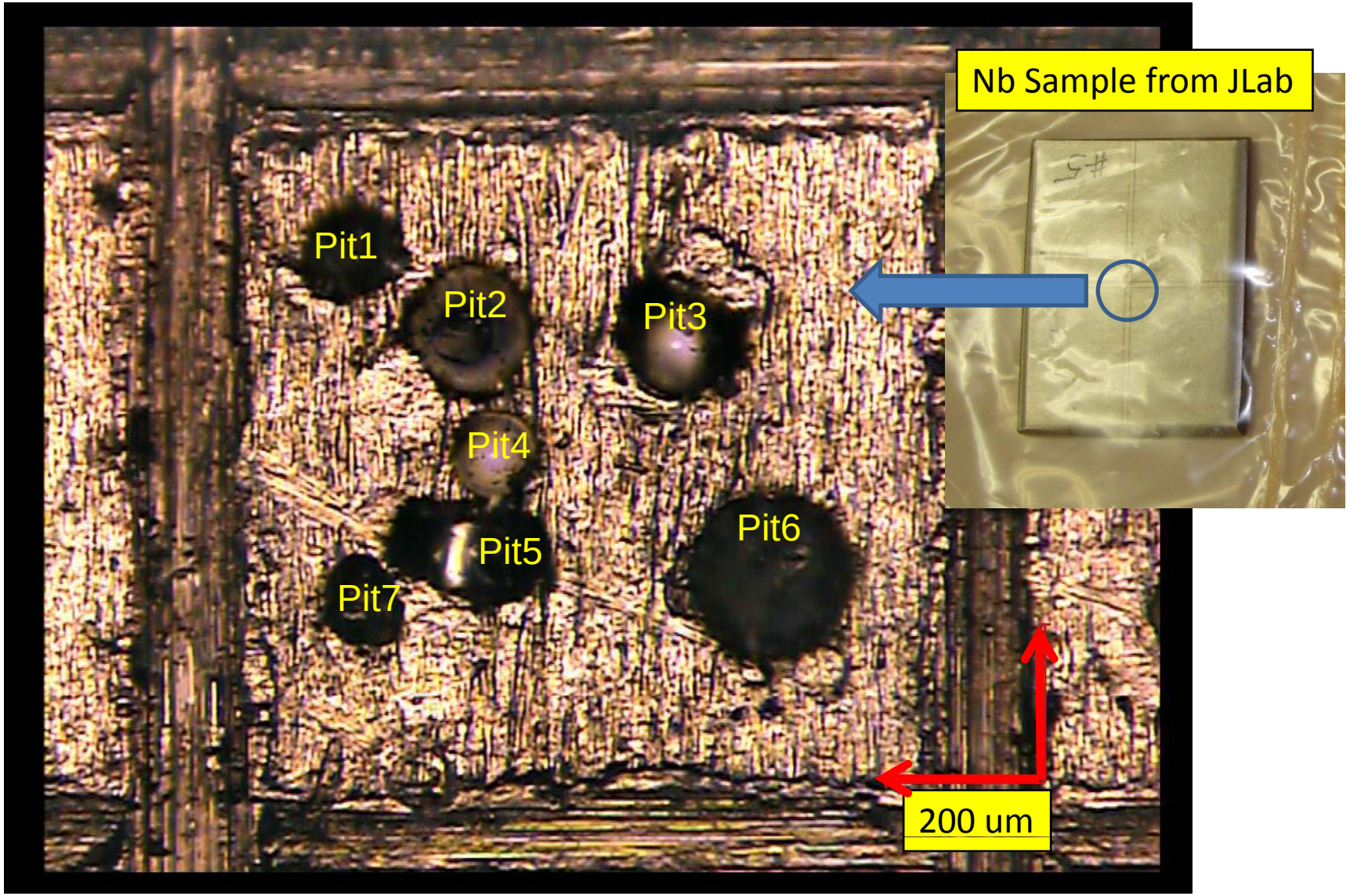
Summary

[Nb] of EP acid (at the end of EP)	Duration of exposure to the air. Stains?	Duration of light P.W. rinse	Duration of exposure to the air. Stains?
0.4 g/L	70 min. No stain	A few 10's sec.	Stains appeared within a min.
4.8 g/L	30 min. No stain	A few 10's sec.	6 min. No stains
8.6 g/L	30 min. No stain	A few 10's sec.	4 min. No stains

Considerations

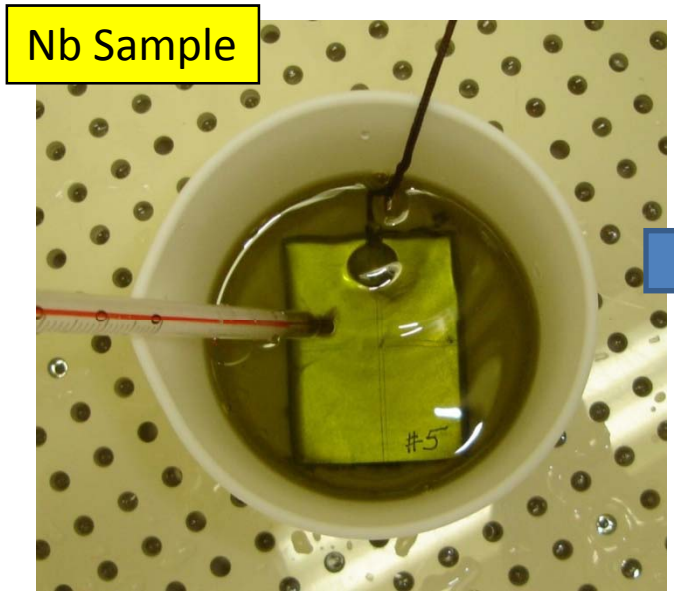
- KEK EP-facility has a big EP-tank of 1000L. When we replace the EP acid with new one, we will keep using new EP acid with some 9-cell cavities for a while.
- Should we change the amount of EP-acid in the tank? Or should we develop a new U.P.W. rinse method, like introducing N2 during first U.P.W. rinse duration?

Nb sample with artificial pits from JLab

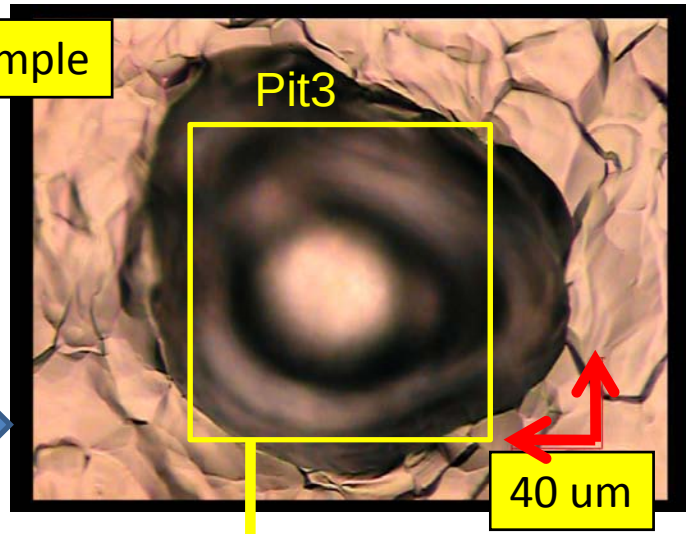


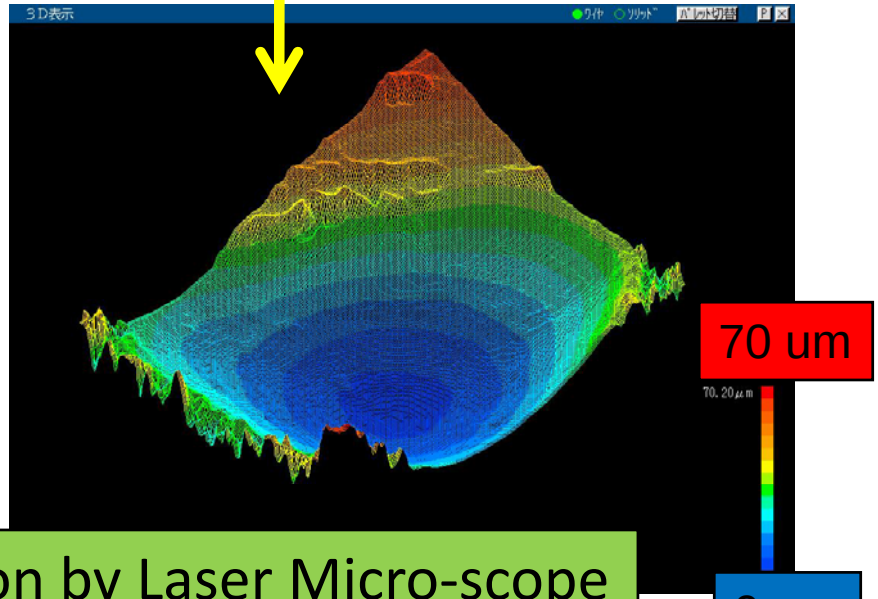
On interested surface of both samples, there are marked lines for purpose of location referencing.

Jlab Nb sample with artificial pits



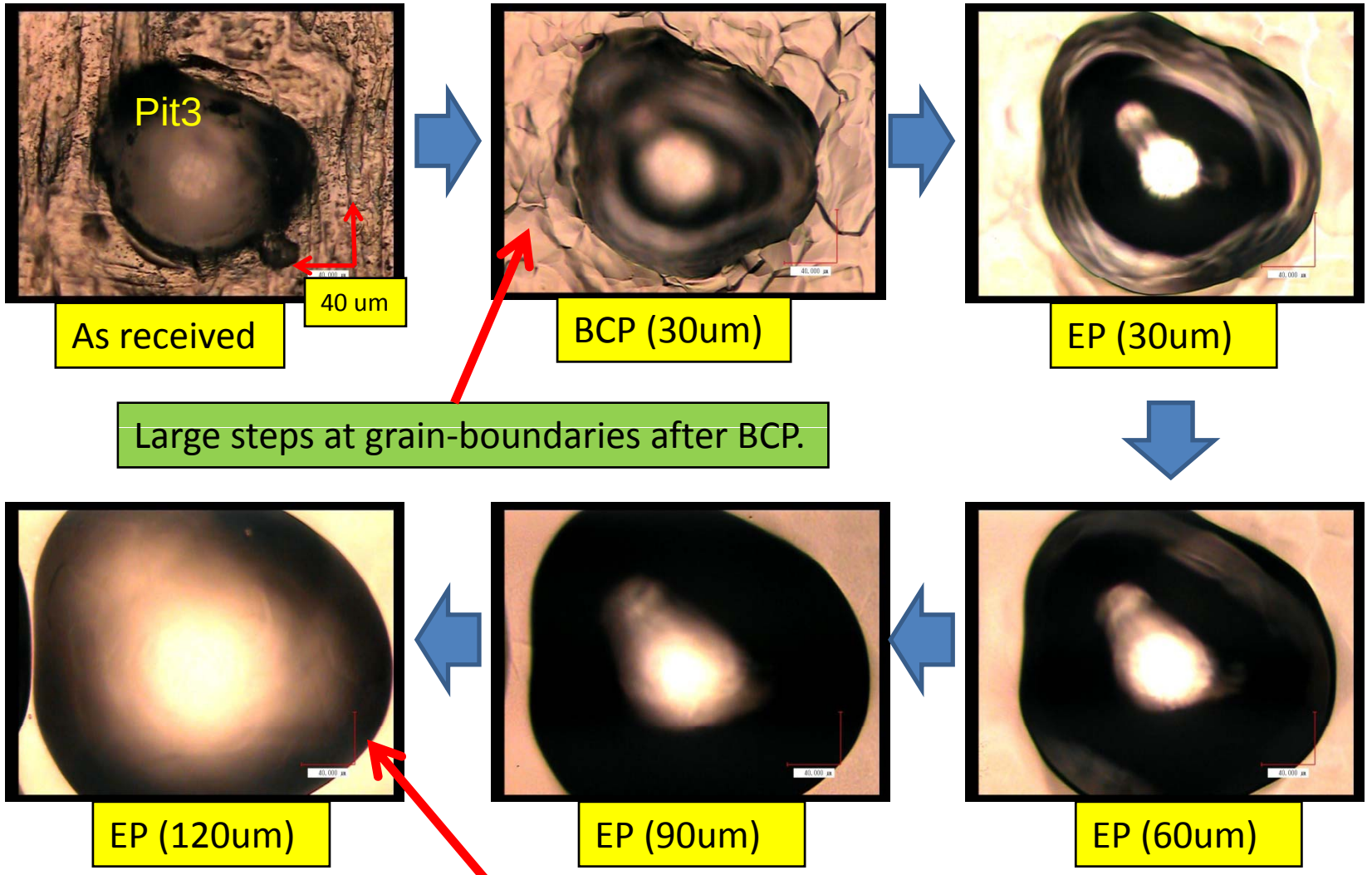
BCP (30um) at STF/KEK





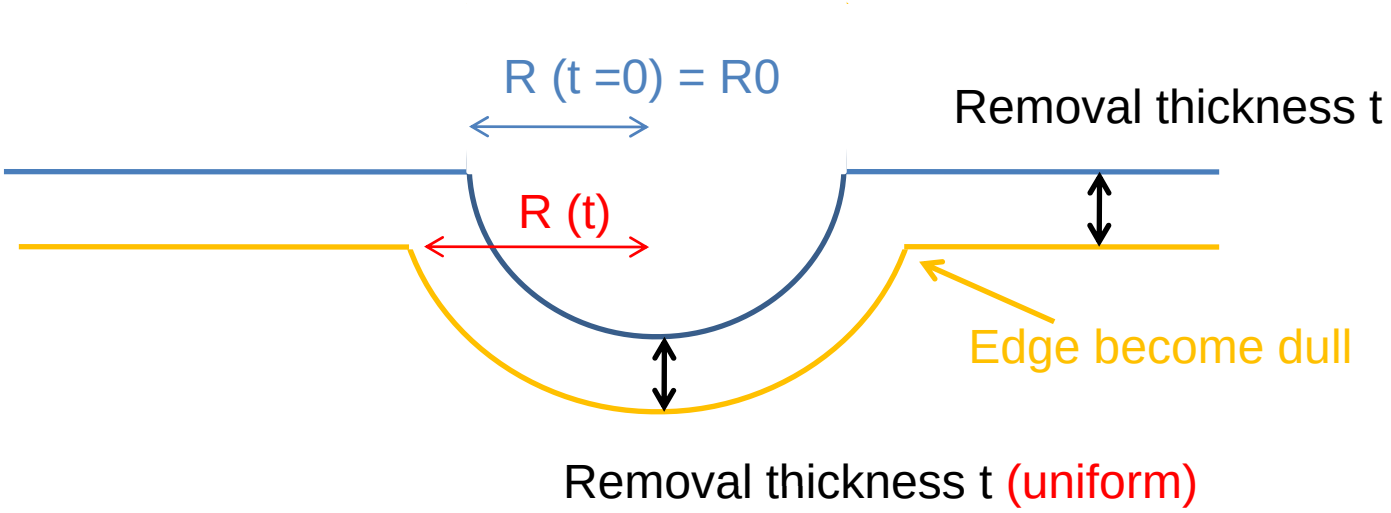
Observation by Laser Micro-scope

JLab Nb sample with artificial pits



Jlab Nb sample-1 with artificial pits

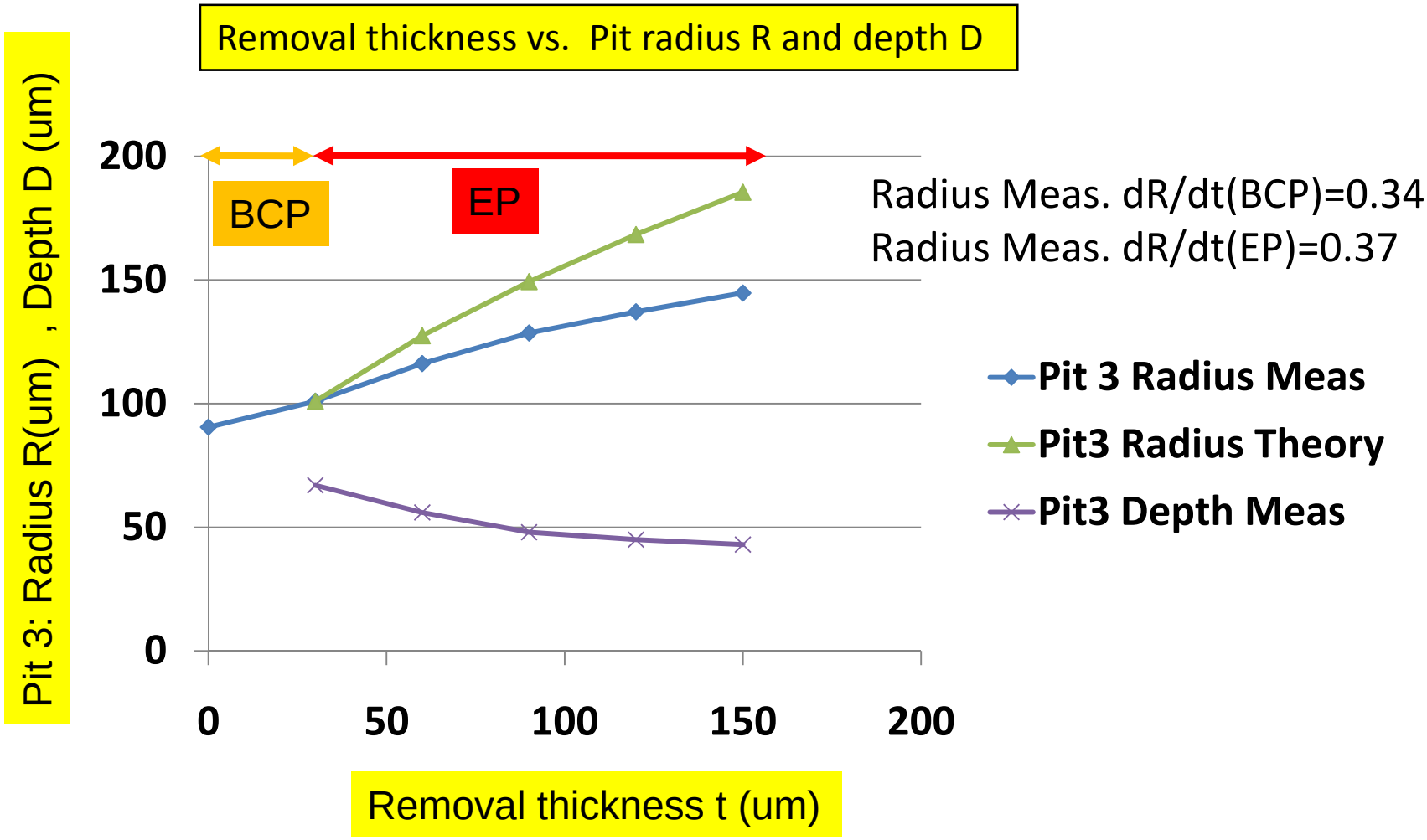
Radius for Uniform Removal (Theory)



$$R(t) = SQRT (R0 \times R0 + 2 \times R0 \times t)$$

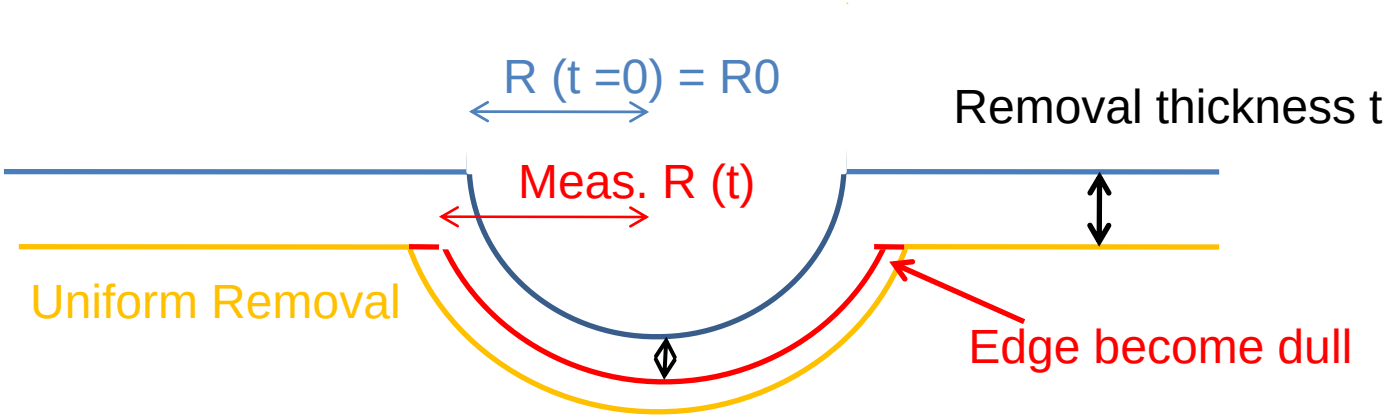
In this theory, the depth of pit is constant / no change.

JLab Nb sample with artificial pits



Jlab Nb sample with artificial pits

Measured Radius and Depth



Removal rate is less in the pit

Radius increases slowly and the depth becomes shallower.

However, EP seems not to round the edge of pit very effectively / selectively.
EP is not all mighty. All pits should be removed before EP process.

Summary of artificial-pit EP-process

- Nb sample with artificial pits were EP-processed and the shape of pit was observed with laser / optical micro-scope.
- EP process makes the steps at grain-boundaries smoother.
- The removal rate in the pit was smaller than that on the flat surface.
- The radius of pit increase slowly and the depth of pit becomes shallower while EP develops.
- In a result, the edge of pit became relatively dull, but EP process did not remove the edges of pits effectively / selectively.
- EP process is not almighty. All pits should be removed before EP process.
- More detailed information can be found at http://ilc.kek.jp/JFK-S0/