Controlled Light EP
The Icing on the Cake?

Charles Reece

SRF Materials Mtg, February 2010

Or just stimulating

Informal association of ideas that may be helpful.

The goal in Nb cavity surface preparation is simple:

Make attaining fundamental material limits routine at the lowest possible cost.

Present practices don't fit this bill

Wouldn't it be nice if all that is needed is a single light chemical polish after mechanical polish ?

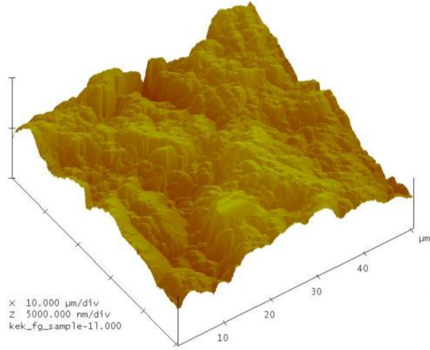
Not yet proven, but suggestive hints exist…

Consider some *samples* and some *cavities* each given light, controlled EP, and then tested:

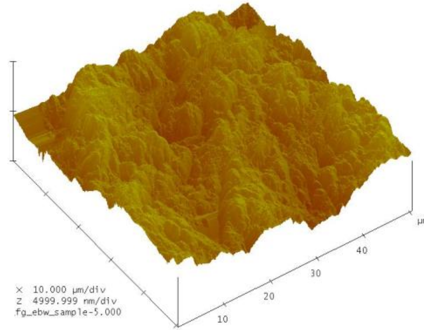
KEK_ Fine Grain

Rough stone , 6hrs

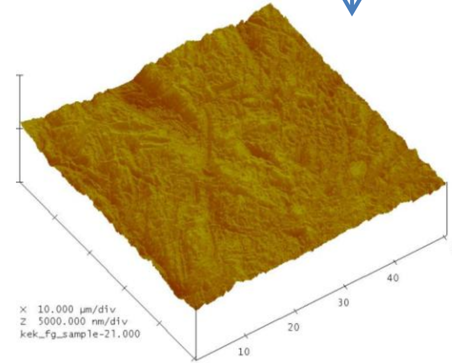
Rough stone (6hrs) + middle stone1 (6hrs) +middle stone2 (6hrs) + fine stone (6hrs)



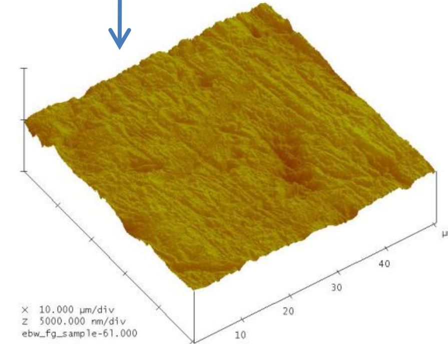
767.98+/-131.15 nm



889.66+/-172.53 nm

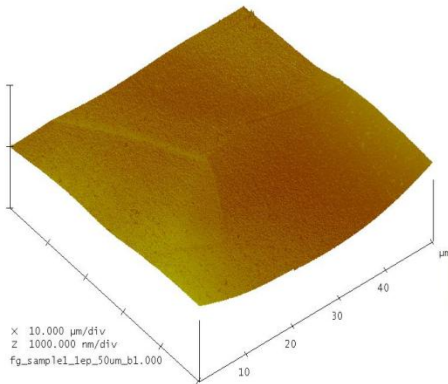


183.75+/-13.15 nm

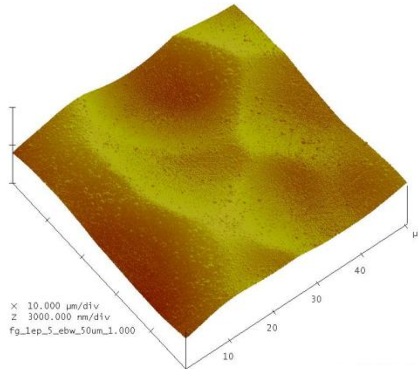


203.32+/-11.22 nm

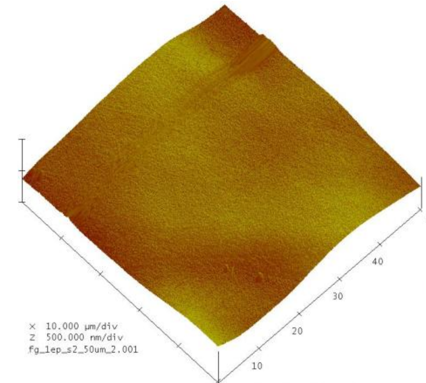
After 100 mins EP (30 µm removal) at 30 +/- 1 °C , 10 V



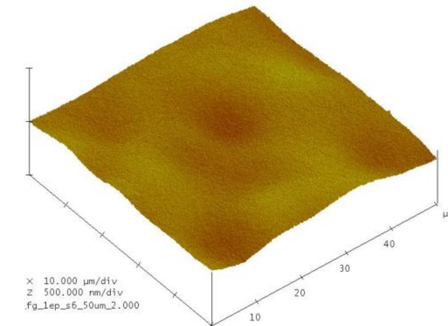
104.61+/-55.82 nm



253.58+/-62.55 nm

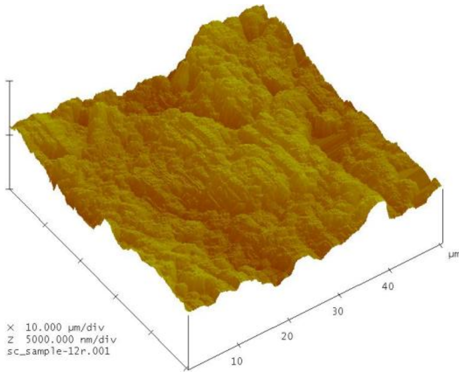


48.67+/-8.83 nm

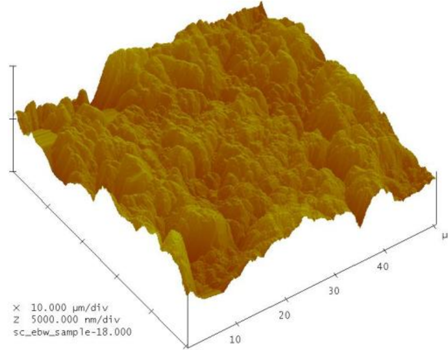


40.78+/-12.99 nm

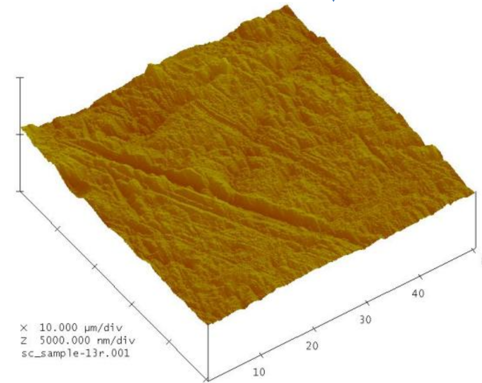
KEK_ Single Crystal



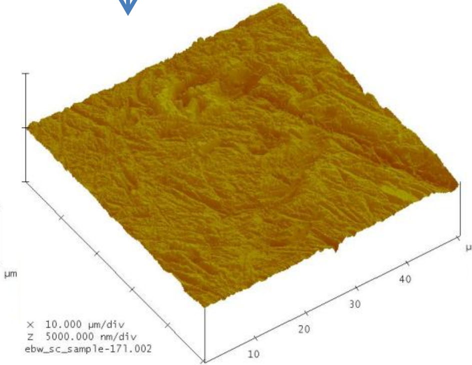
734.47+/-127.93 nm



763.46+/-121.35nm

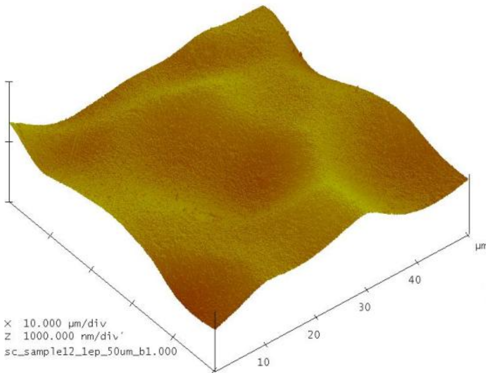


177.35+/-41.52 nm

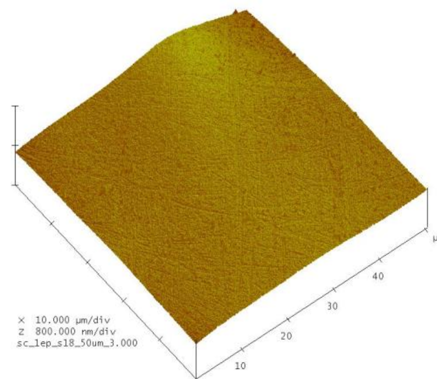


175.07+/-18.42 nm

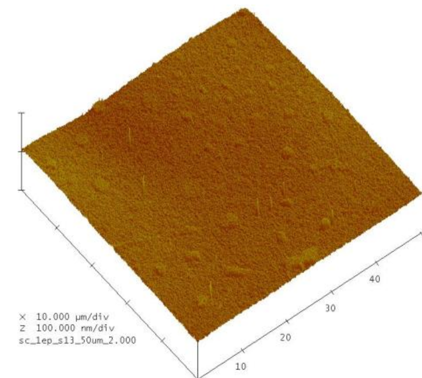
After 100 mins EP (30 µm removal) at 30 +/- 1 °C , 10 V



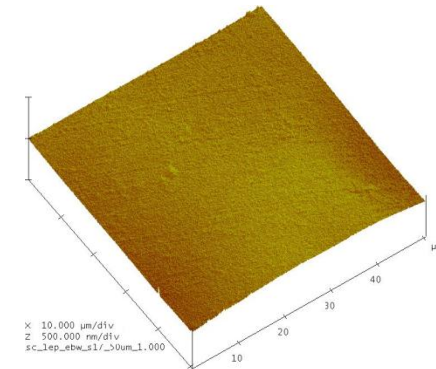
157.66+/-48.03 nm



66.32+/-11.41nm



7.13+/-5.34 nm



21.99+/-0.23 nm

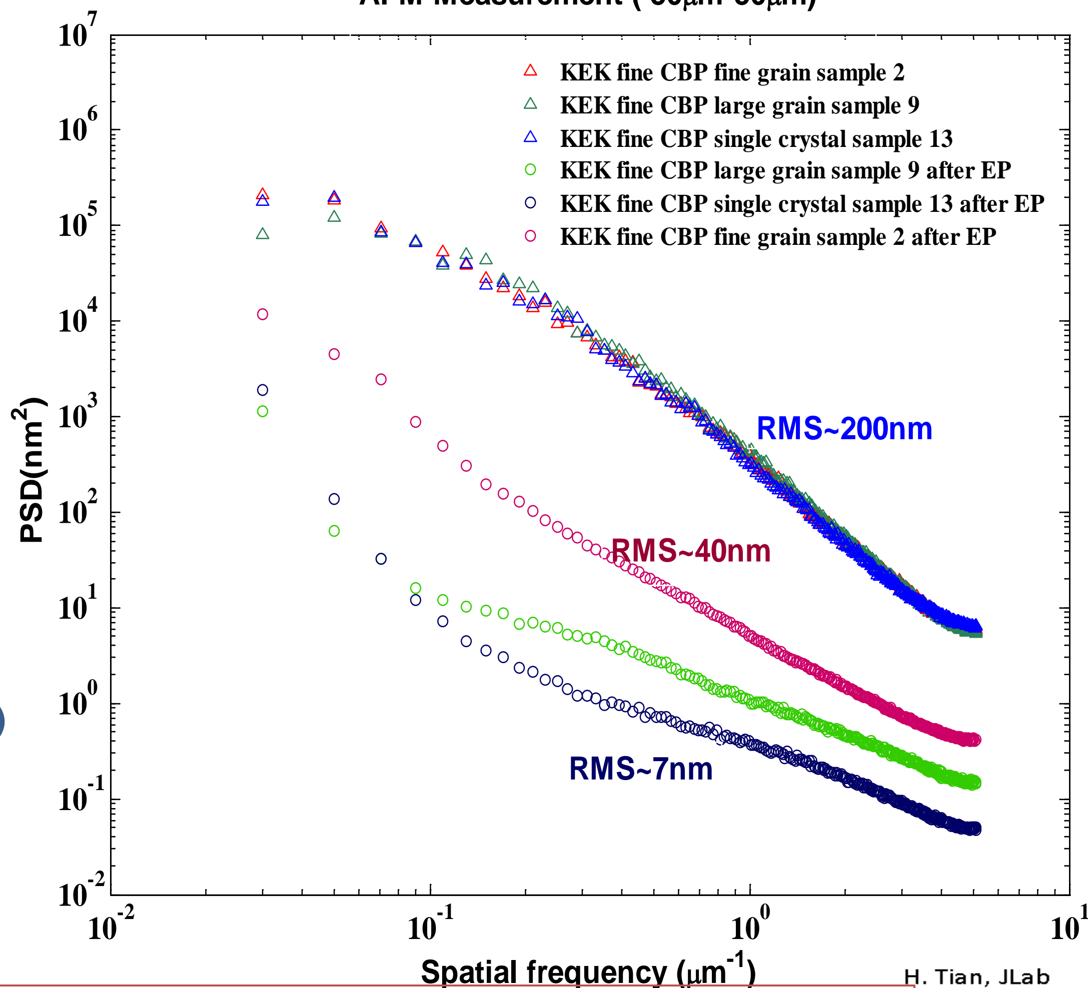
Not all Nb "EPs" the same

Showed this previously

With "standard"1:10 HF/H_2SO_4 Electrolyte at 30°C Nb crystallography affects the polishing effectiveness.

With identical starting topography from CBP, given identical 100 min "EP" at 30°C, single-crystal material was significantly smoother.

Evidence for a significant etching activity at 30°C



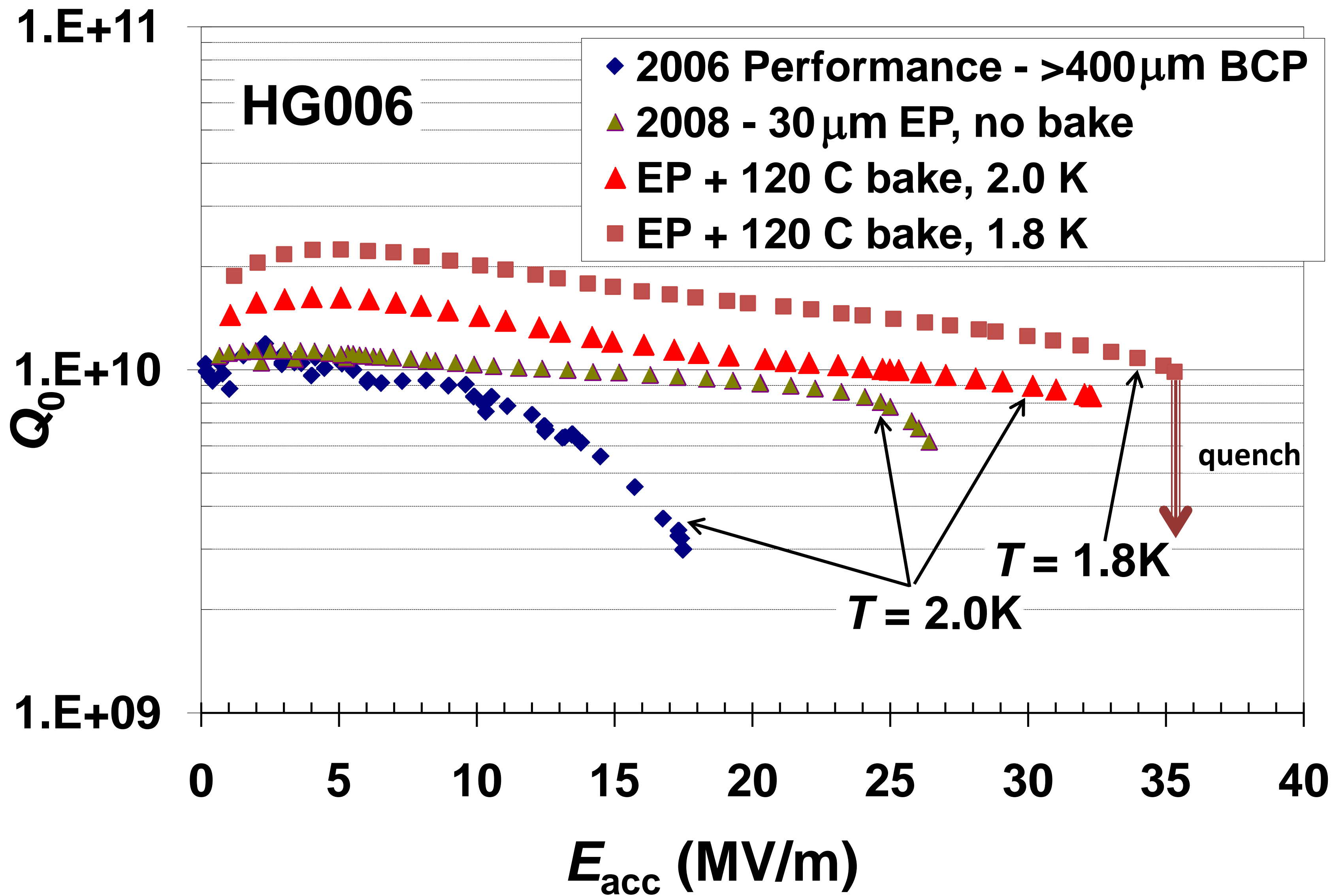
Suppose we consistently went from 200 nm roughness to 7 nm consistently and uniformly – with < 30 μm removal in less than 2 hours?... Attractive idea?

Clearly, there is room yet to optimize the EP process, but we may already see avenues to reduce cost and improve consistency.

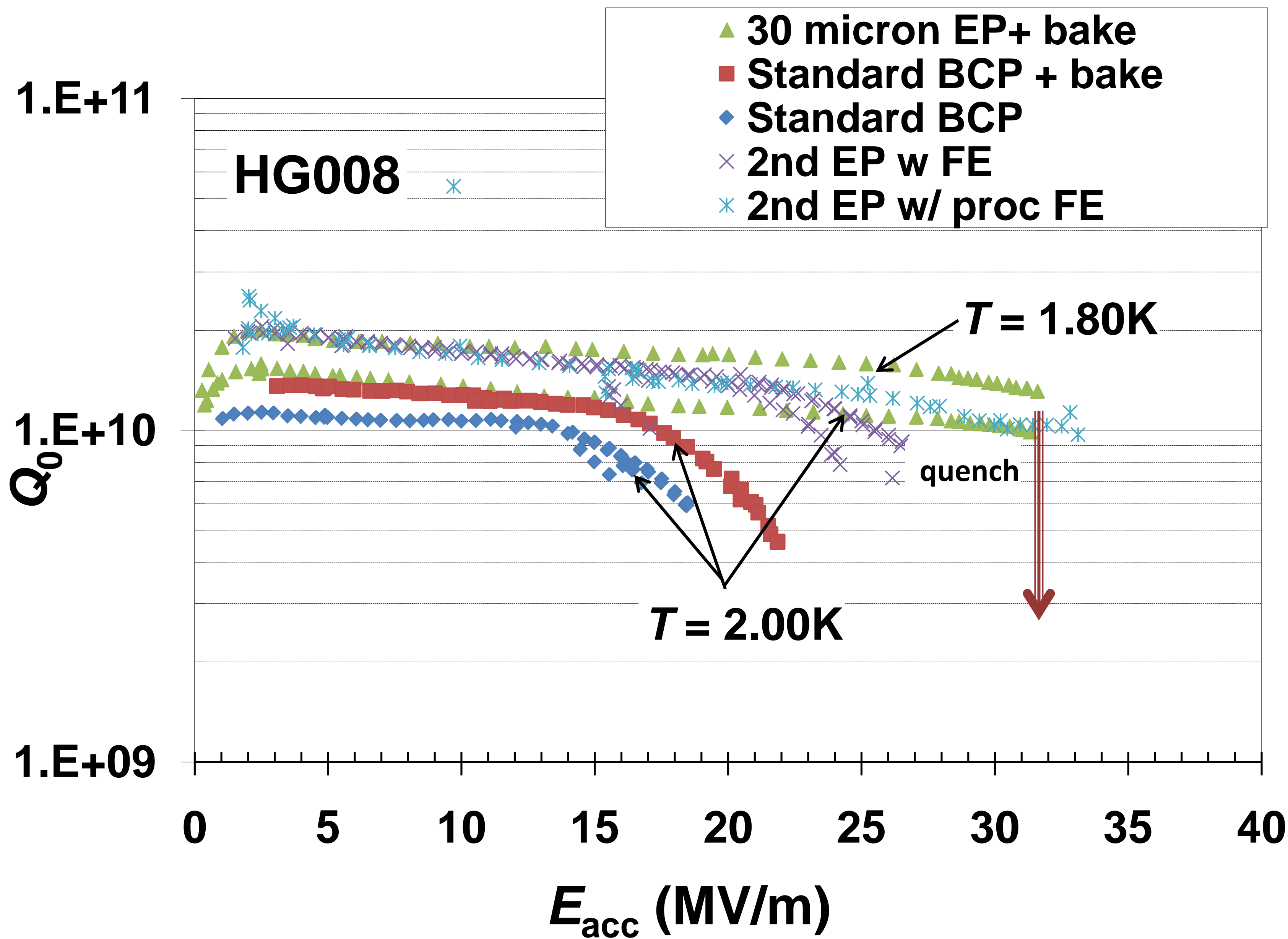
While ILC may be locked into a given procedure to minimize near-term yield risks, JLab presently has some freedom to explore how little EP will still fill the need.

Results to date are very encouraging.

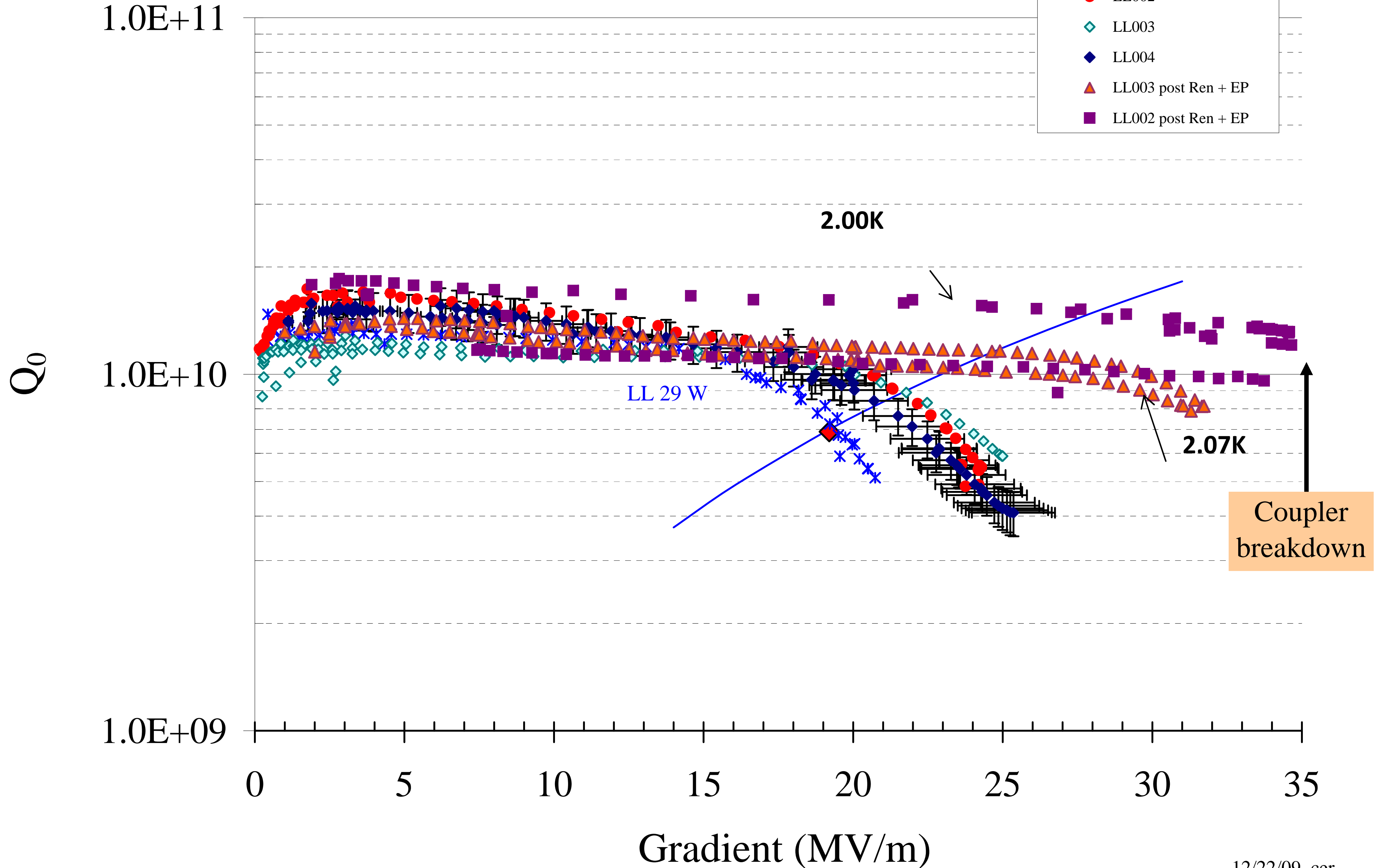
“Light” EP being applied to JLab 7-cell cavities.

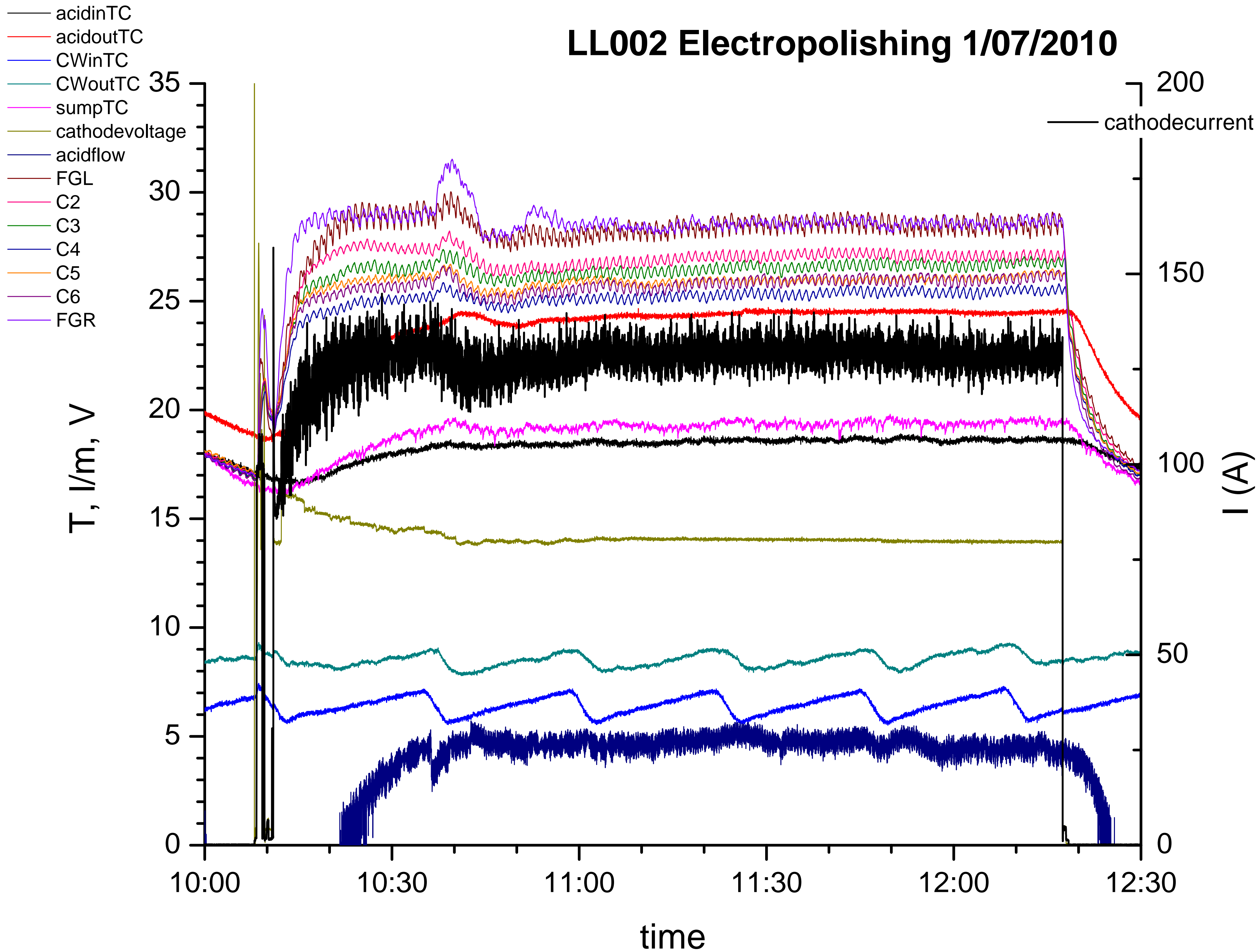


HG006
2006 Performance - >400μm BCP
2008 - 30μm EP, no bake
EP + 120 C bake, 2.0 K
EP + 120 C bake, 1.8 K
1.E+11
1.E+10
1.E+09
Q0
0
5
10
15
20
25
30
35
40
Eacc (MV/m)
quench
T = 1.8K
T = 2.0K

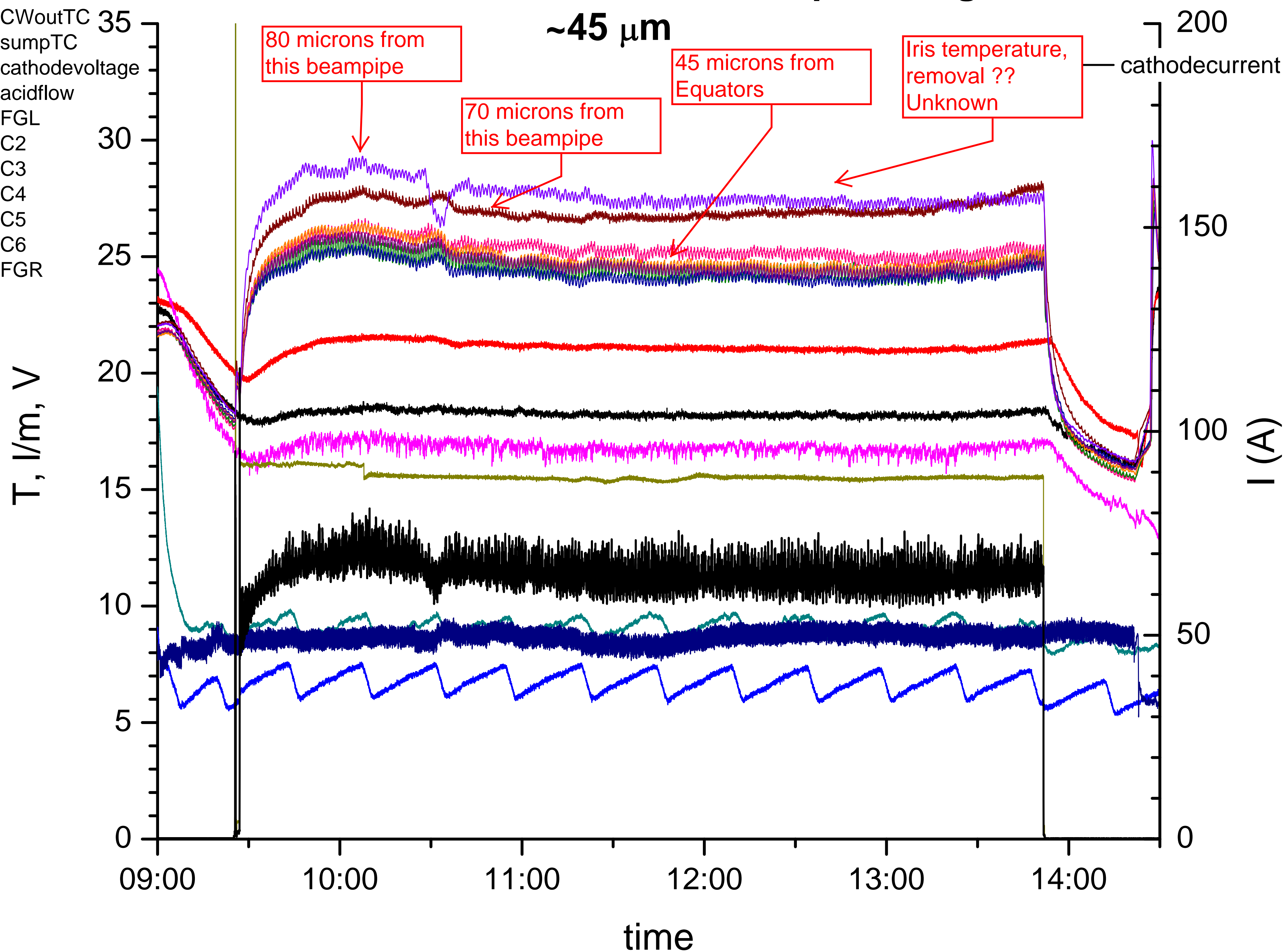


30 micron EP+ bake
Standard BCP + bake
Standard BCP
2nd EP w FE
2nd EP w/ proc FE
HG008
1.E+11
1.E+10
1.E+09
Q_0
T = 1.80K
T = 2.00K
quench
0
5
10
15
20
25
30
35
40
E_{acc} (MV/m)


LL Cavities for Renascence - VTA Performance
+ first EP of LL002 & LL003 post Ren extraction
12 GeV Project Spec
LL 29 Watts
LL001
LL002
LL003
LL004
LL003 post Ren + EP
LL002 post Ren + EP
1.0E+11
1.0E+10
1.0E+09
Q0
2.00K
2.07K
LL 29 W
Coupler breakdown
0
5
10
15
20
25
30
35
Gradient (MV/m)
12/22/09 cer



LL002 Electropolishing 1/07/2010
acidinTC
acidoutTC
CWinTC
CWoutTC
sumpTC
cathodevoltage
acidflow
FGL
C2
C3
C4
C5
C6
FGR
cathodecurrent
T, l/m, V
I (A)
time
0
5
10
15
20
25
30
35
0
50
100
150
200
10:00
10:30
11:00
11:30
12:00
12:30


LL003a Electropolishing 12/16/2009
~45 µm
acidinTC
acidoutTC
CWinTC
CWoutTC
sumpTC
cathodevoltage
acidflow
FGL
C2
C3
C4
C5
C6
FGR
cathodecurrent
80 microns from this beampipe
70 microns from this beampipe
45 microns from Equators
Iris temperature, removal ?? Unknown
T, l/m, V
I (A)
time
0
5
10
15
20
25
30
35
0
50
100
150
200
09:00
10:00
11:00
12:00
13:00
14:00

Implications:

- We should expect the best micropolishing for topographic features smaller than ~ 15 μm, so **start with surfaces that are consistently smooth to this scale**: CBP.
- "EP" has a temperature-dependent etching process present >> **minimize the temperature**.
- So far, 5 JLab 7-cell cavities previously heavily BCPd, and in ~~two~~ three cases used for beam ops, exceeded 30 MV/m after **~40 μm EP**. (More in the pipeline.)
- The 12 GeV Project has all-but-officially accepted a **change to a final light EP** for the 80 cavities for the CEBAF upgrade as cost and technical contingency boost.
- Stay tuned

Contributors:

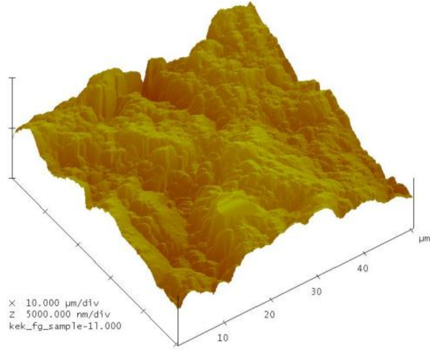
H. Tian	JLab, (W&M)
O. Trofimova	JLab
M. J. Kelley	JLab, W&M, VT
G. Ribeill	JLab (DOE SULI)
R. Geng	JLab
B. Golden	JLab
A. Reilly	JLab
J. Folkie	FNAL (JLab)
J. Davenport	JLab
S. Castagnola	Jlab
S. Brankovic	UH

Authored by Jefferson Science Associates, LLC under U.S. DOE Contract No. DE-AC05-06OR23177.

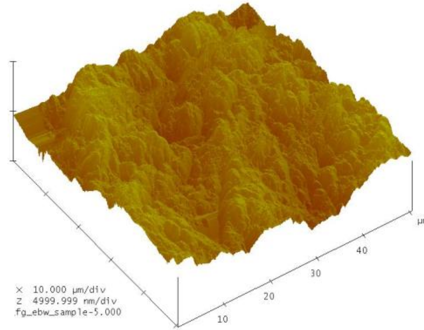
KEK_ Fine Grain

Rough stone , 6hrs

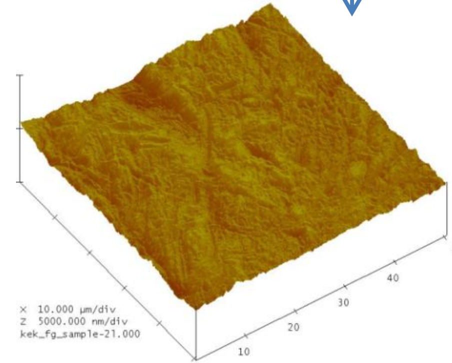
Rough stone (6hrs) + middle stone1 (6hrs) +middle stone2 (6hrs) + fine stone (6hrs)



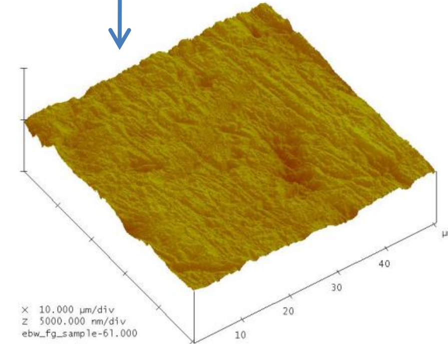
767.98+/-131.15 nm



889.66+/-172.53 nm

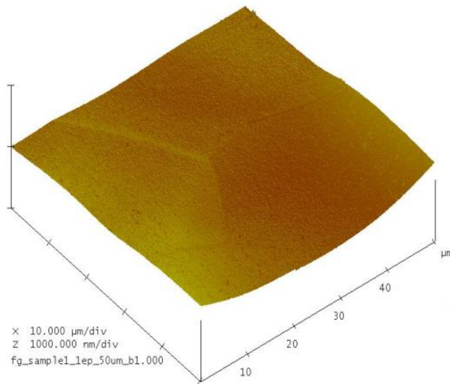


183.75+/-13.15 nm

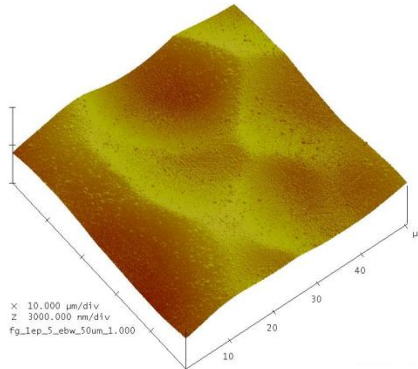


203.32+/-11.22 nm

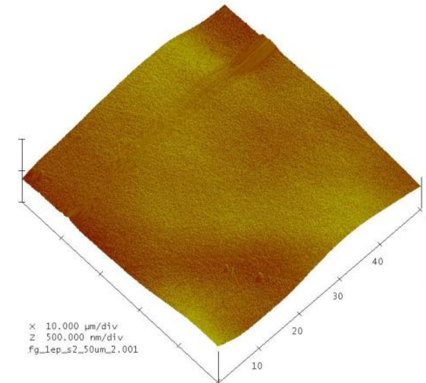
After 100 mins EP (30 µm removal) at 30 +/- 1 °C , 10 V



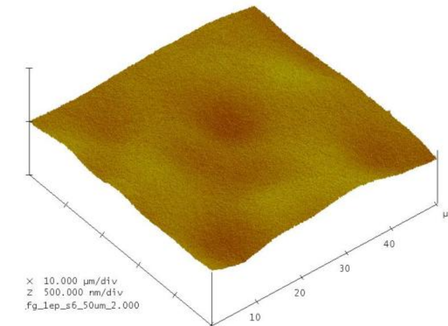
104.61+/-55.82 nm



253.58+/-62.55 nm



48.67+/-8.83 nm

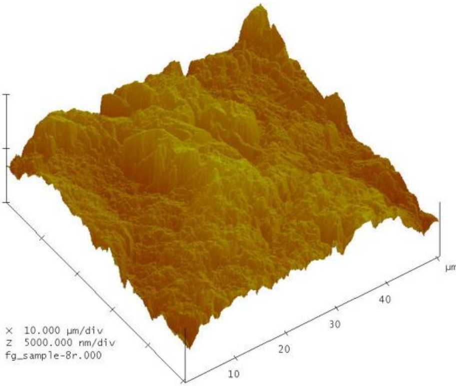


40.78+/-12.99 nm

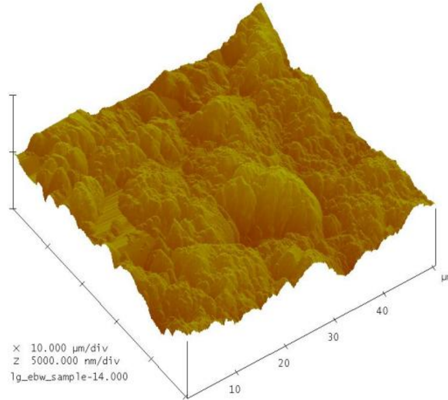
KEK_ large Grain

Rough stone , 6hrs

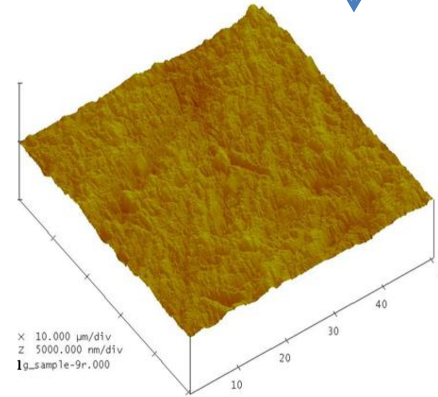
Rough stone (6hrs) + middle stone1 (6hrs) +middle stone2 (6hrs) + fine stone (6hrs)



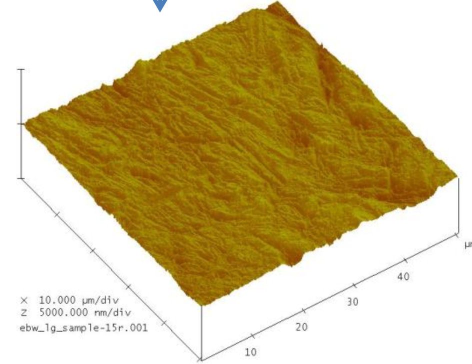
705.15+/-236.82 nm



656.28+/-76.75 nm

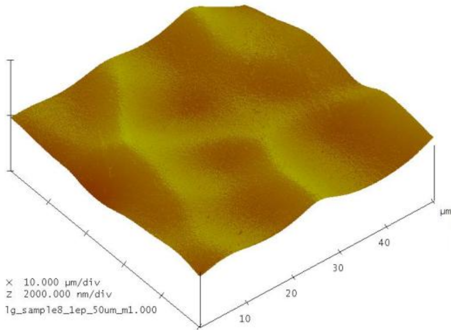


167.28+/-11.72 nm

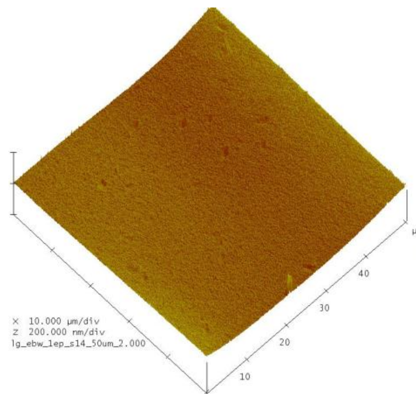


193.40+/-11.08 nm

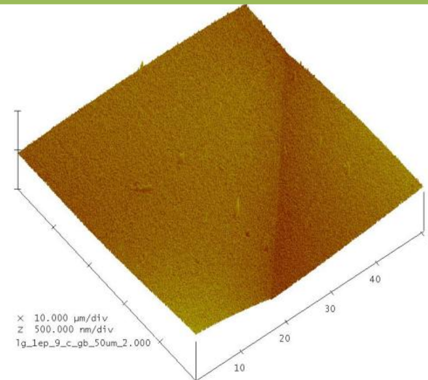
After 100 mins EP (30 µm removal) at 30 +/- 1 °C , 10 V



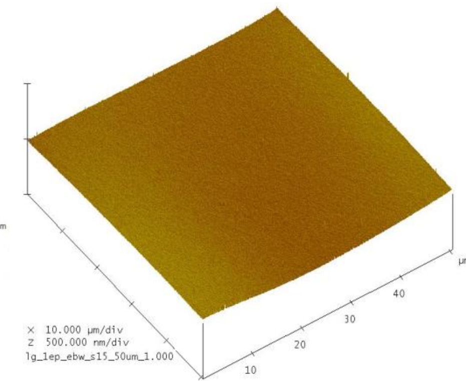
243.12+/-106.83 nm



20.88+/-3.96nm

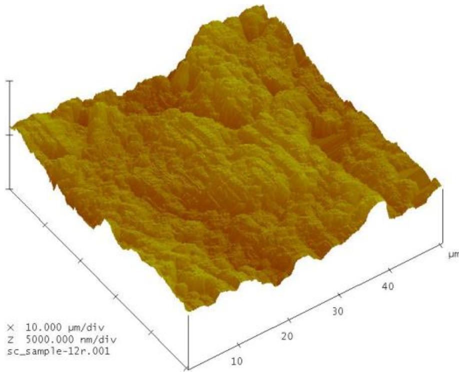


15.37+/-4.31nm

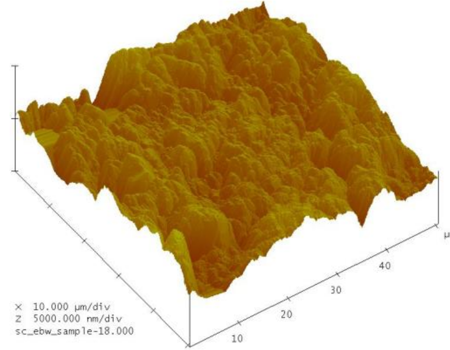


15.53+/5.45 nm

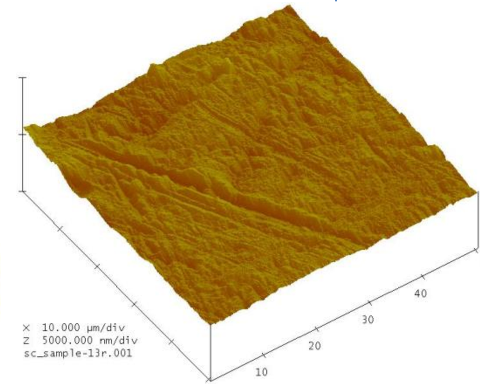
KEK_ Single Crystal



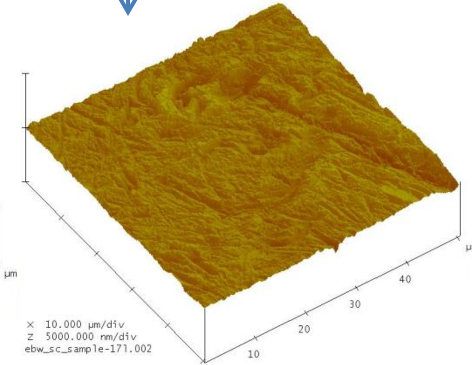
734.47+/-127.93 nm



763.46+/-121.35nm

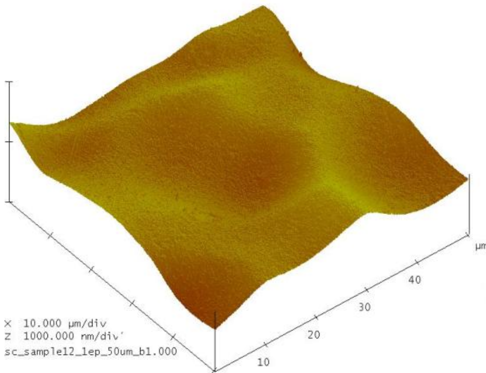


177.35+/-41.52 nm

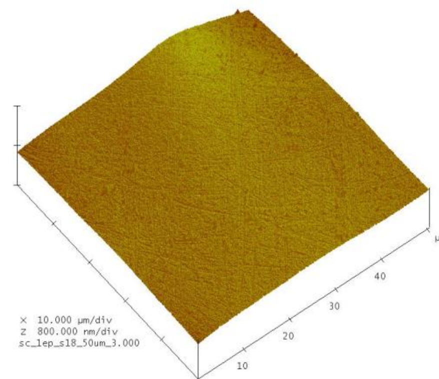


175.07+/-18.42 nm

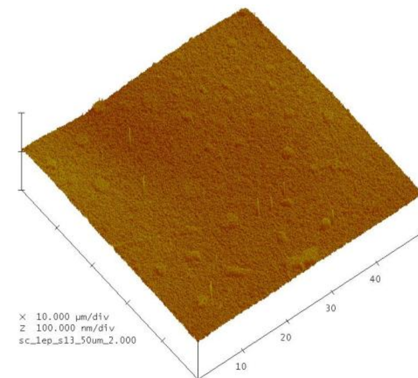
After 100 mins EP (30 µm removal) at 30 +/- 1 °C , 10 V



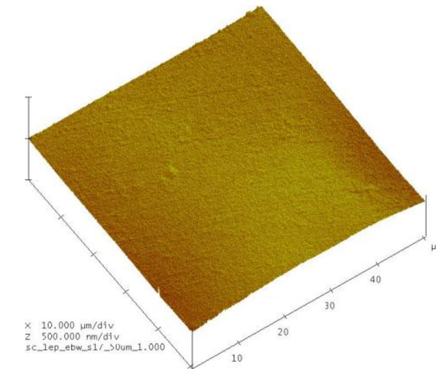
157.66+/-48.03 nm



66.32+/-11.41nm

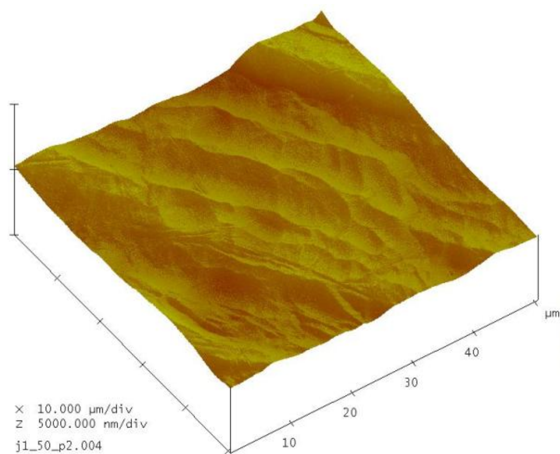


7.13+/-5.34 nm

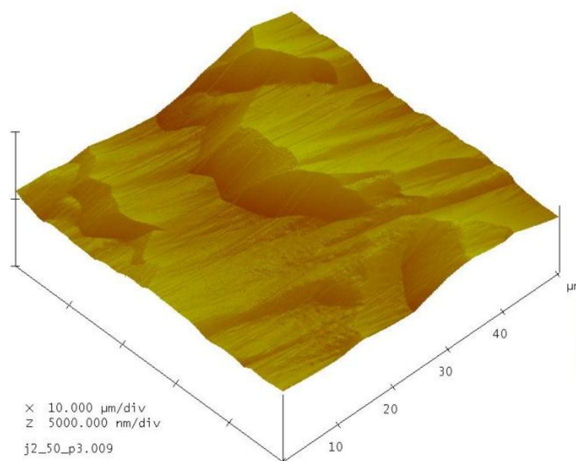


21.99+/-0.23 nm

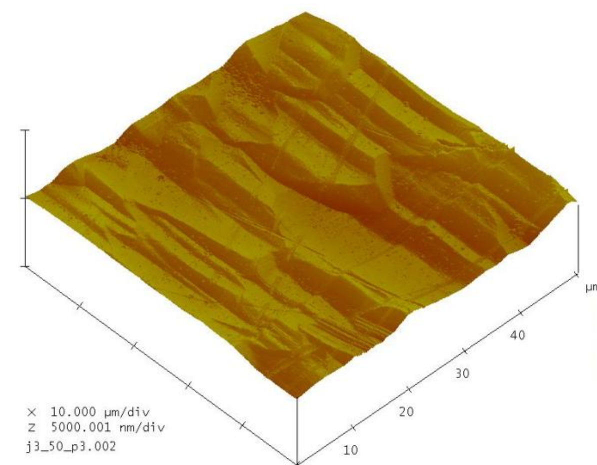
Jlab_ Light BCP



214.71+/-16.49 nm

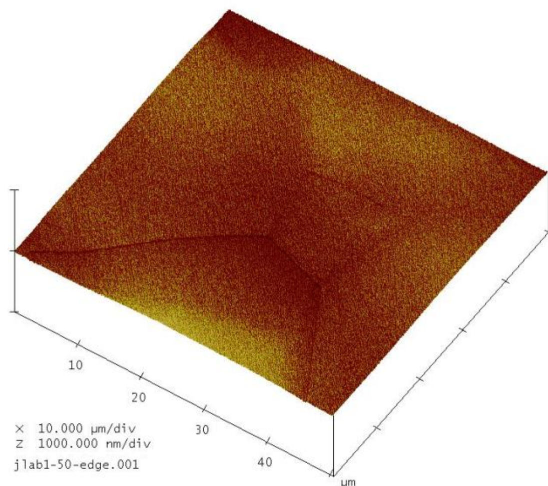


323.1+/-60.76 nm

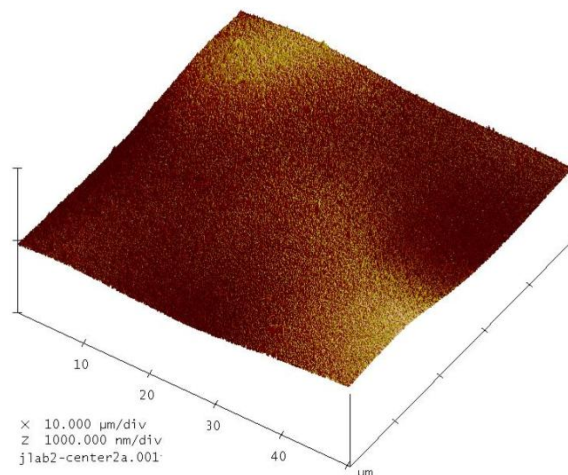


225.14+/-12.73 nm

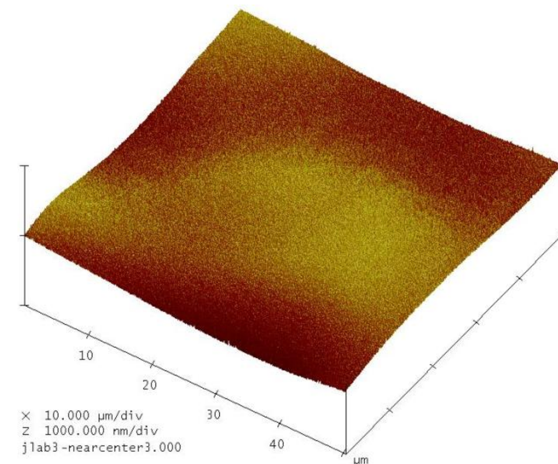
After 100 mins EP (30 µm removal) at 30 +/- 1 °C , 10 V



36.82+/-3.26 nm

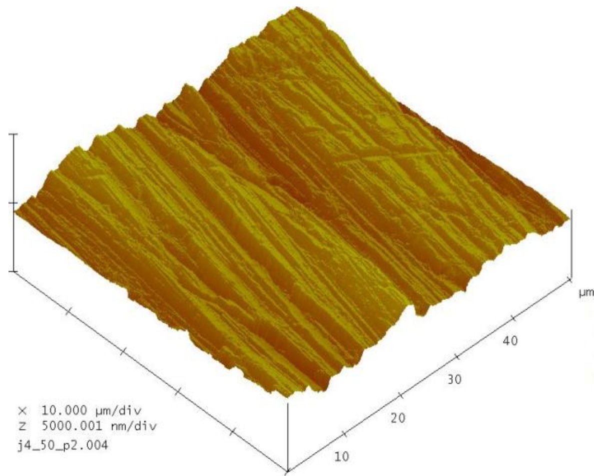


54.5+/-17.29 nm

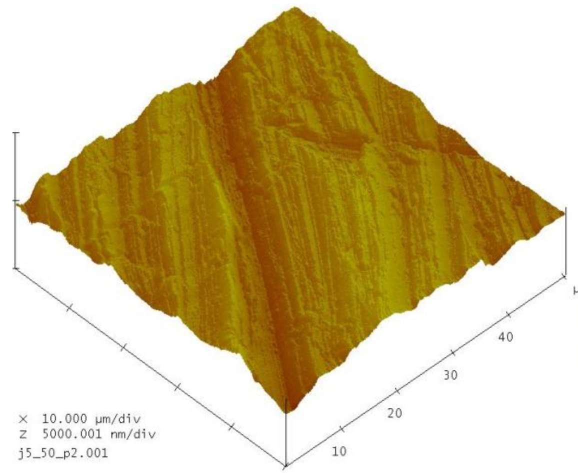


93.24+/-29.49 nm

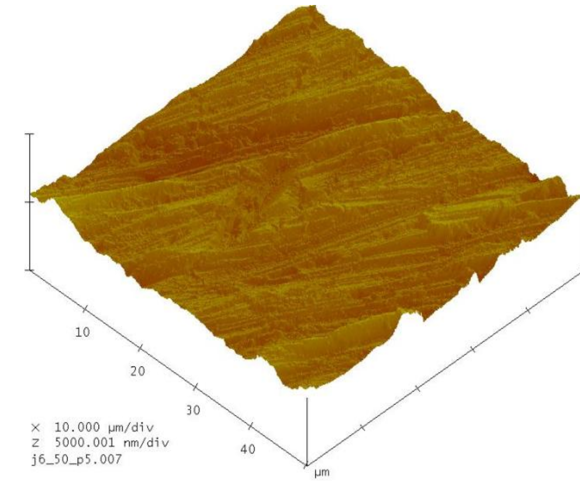
Jlab_ Ground



405.38+/-100.46 nm

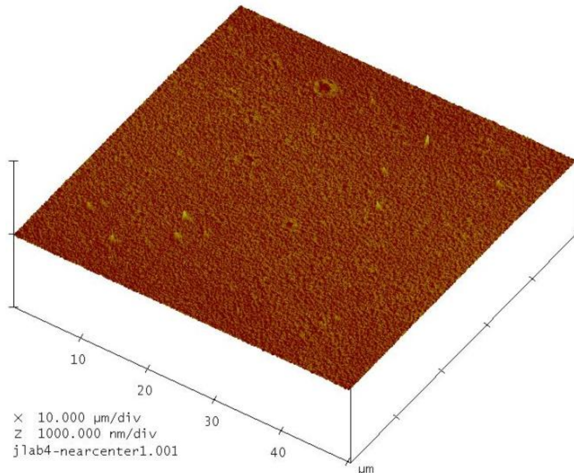


372.74+/-58.83 nm

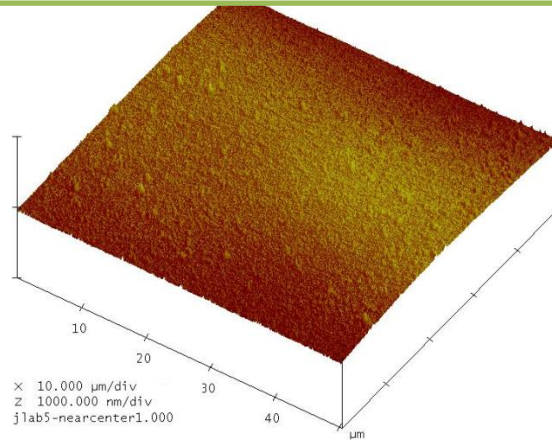


368.32+/-123.91 nm

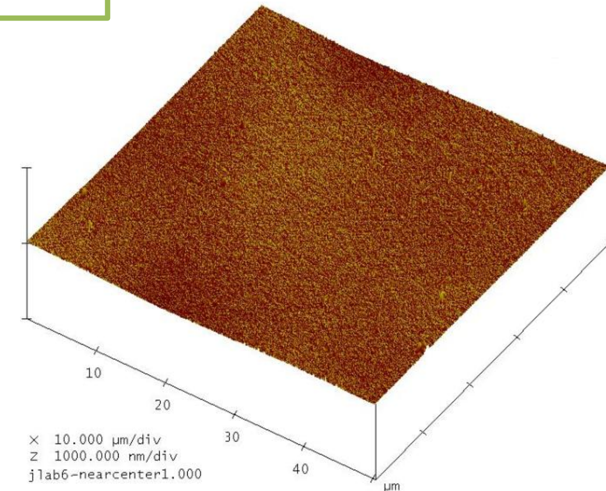
After 100 mins EP (30 µm removal) at 30 +/- 1 °C , 10 V



9.7+/-3.47 nm



18.62+/-11.74 nm



10.99 +/-4.49 nm