UNIVERSITY OF TARTU

1632

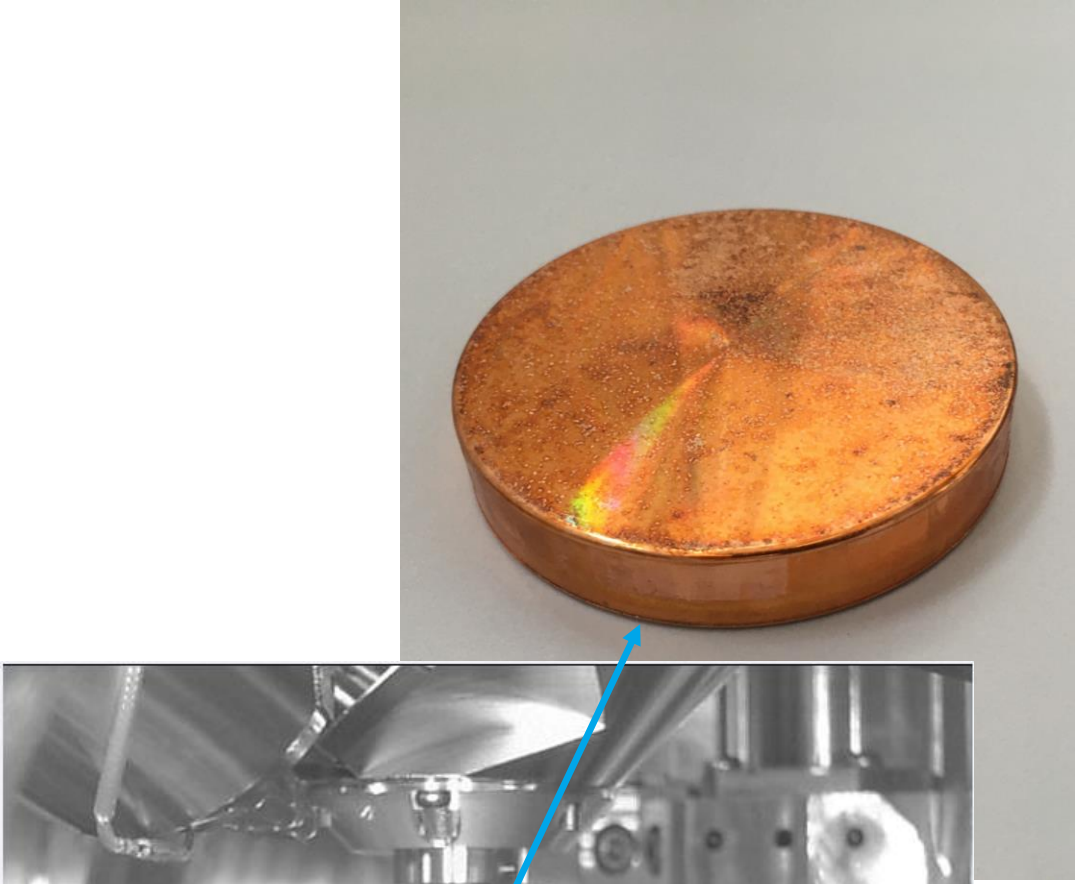
MATTER

Characterization of Cu electrodes after vacuum breakdown with AFM and SEM

1st CERN Baltic Conference (CBC 2021)

Sven Oras

POSTDOCTORAL RESEARCHER



Introduction

We have received two pairs of Cu electrodes from Helsinki.

Hard Cu

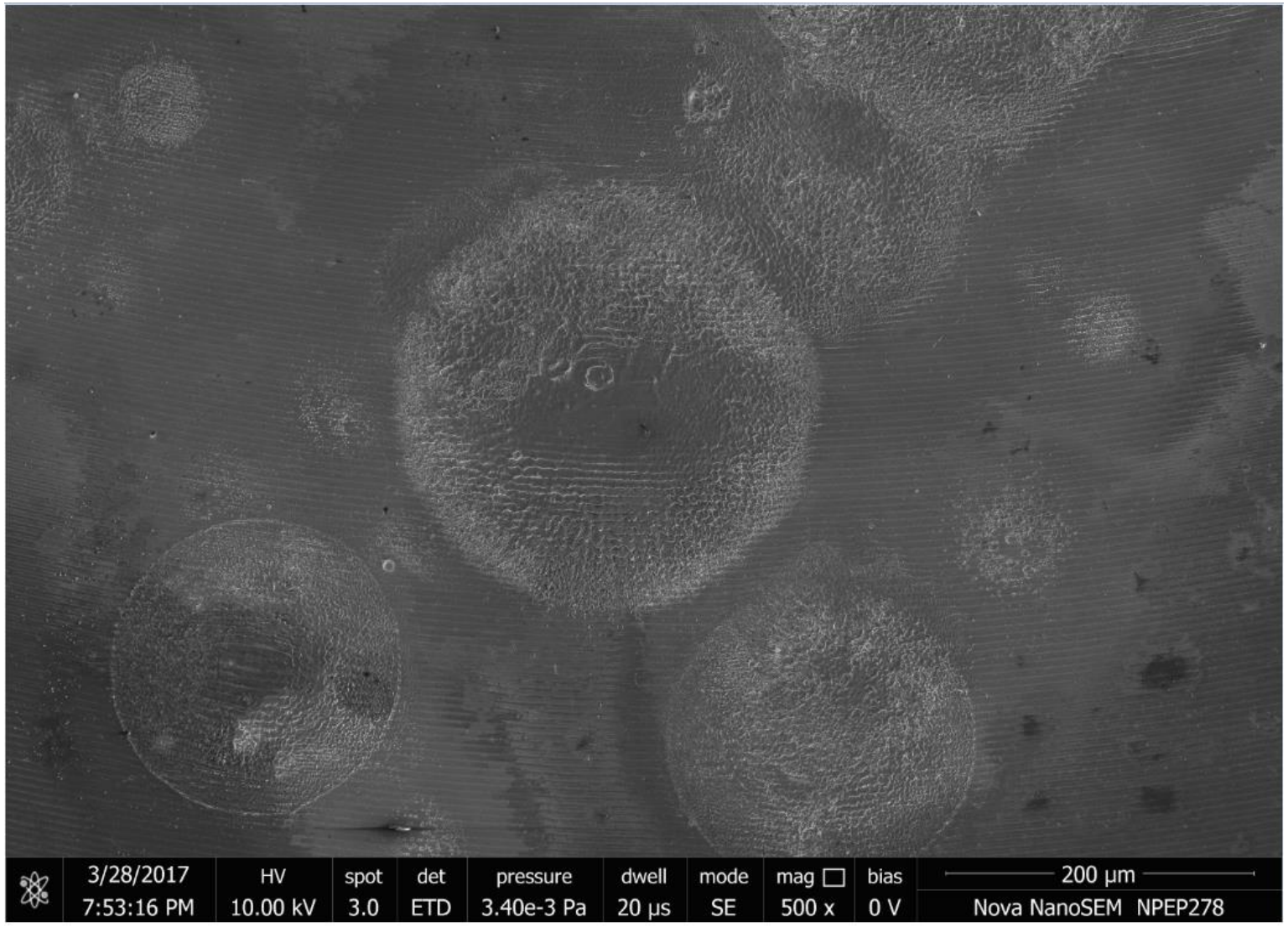
Soft Cu

All electrodes have been plasma treated.

Aim was to characterize with SEM and AFM.

SEM images

Craters

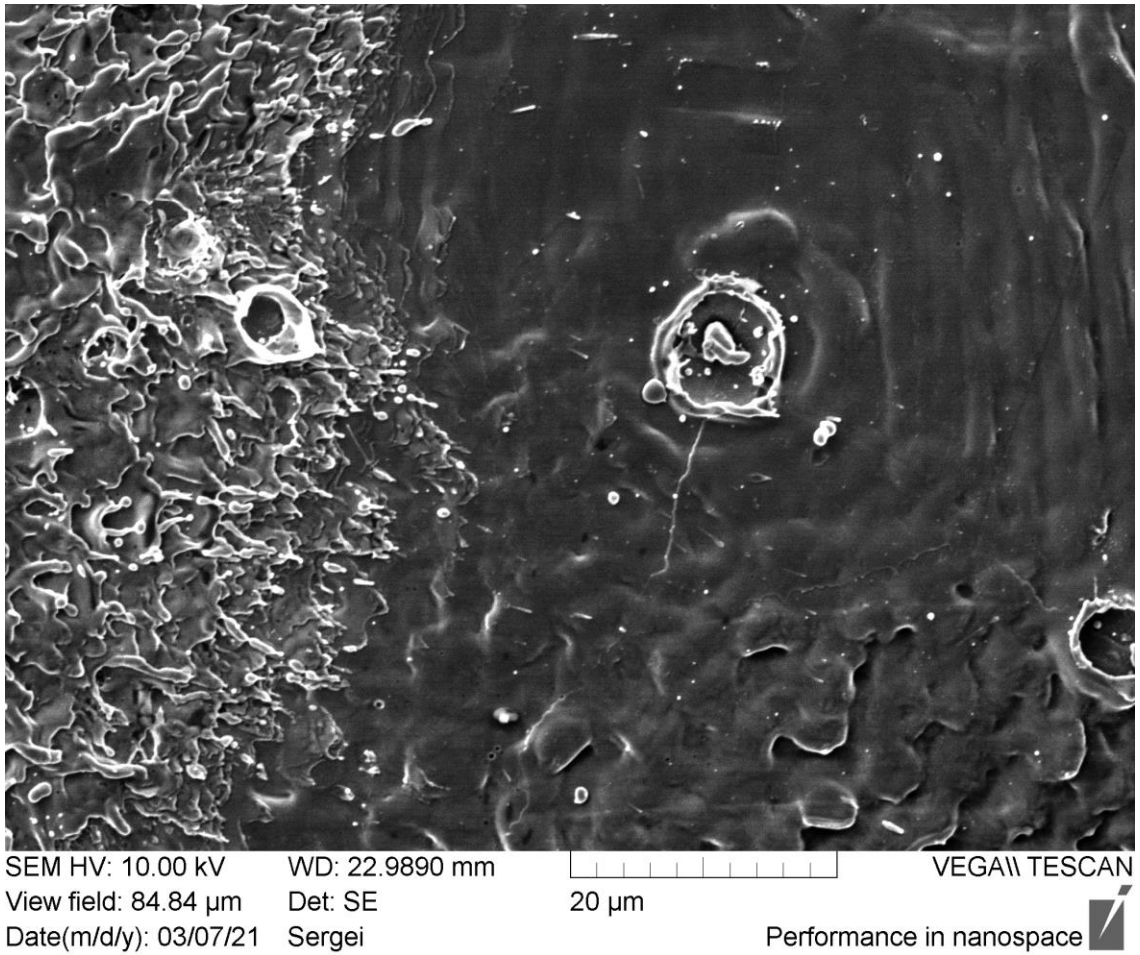

3/28/2017
7:53:16 PM
HV
10.00 kV
spot
3.0
det
ETD
pressure
3.40e-3 Pa
dwell
20 µs
mode
SE
mag
500 x
bias
0 V
200 µm
Nova NanoSEM NPEP278

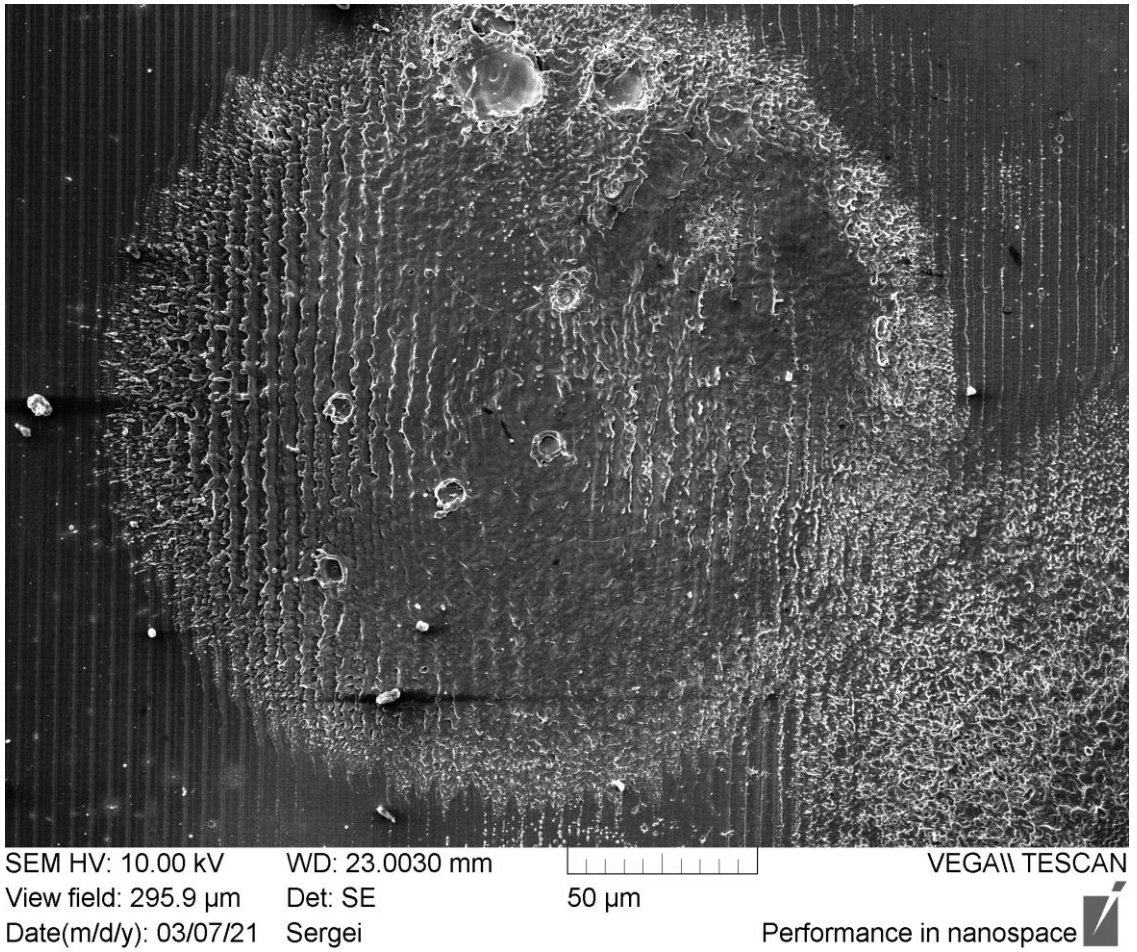
Center structure

A particle like structure in the middle of the crater.

Sometimes a plateau in the middle.

Hard Cu cathode

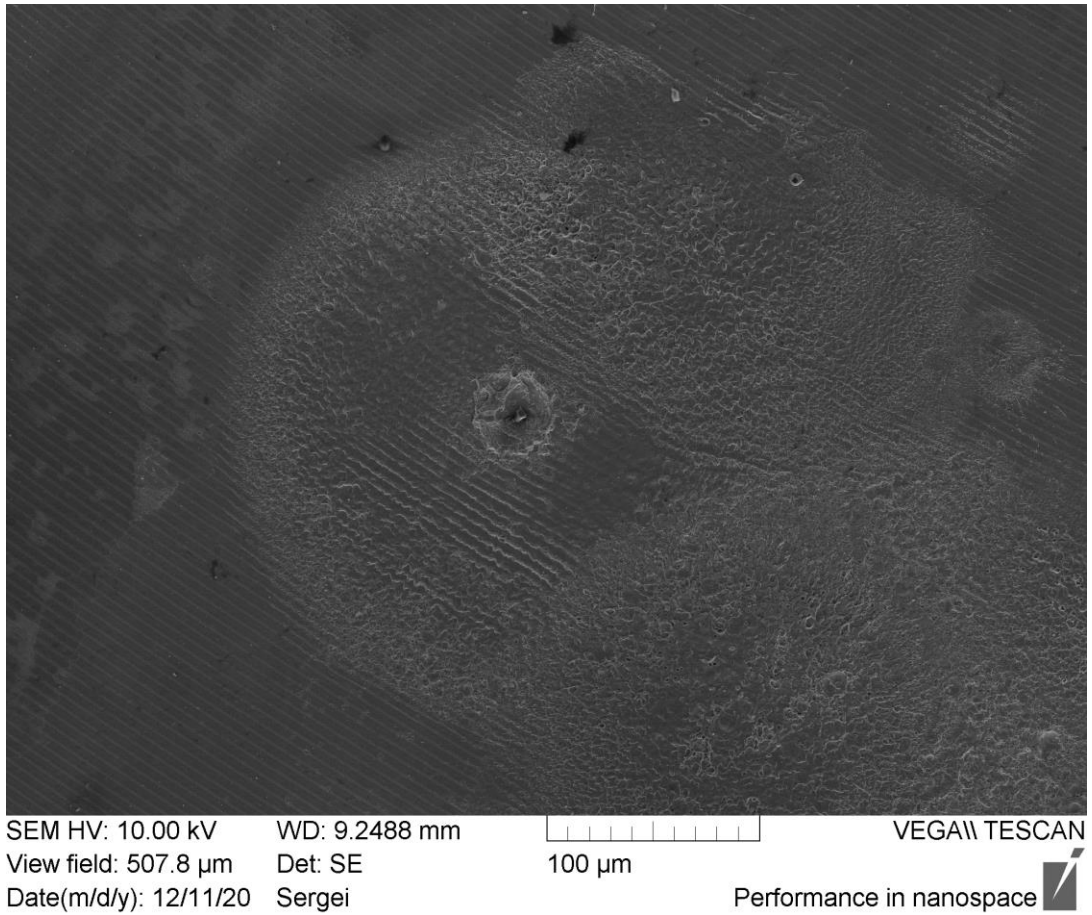




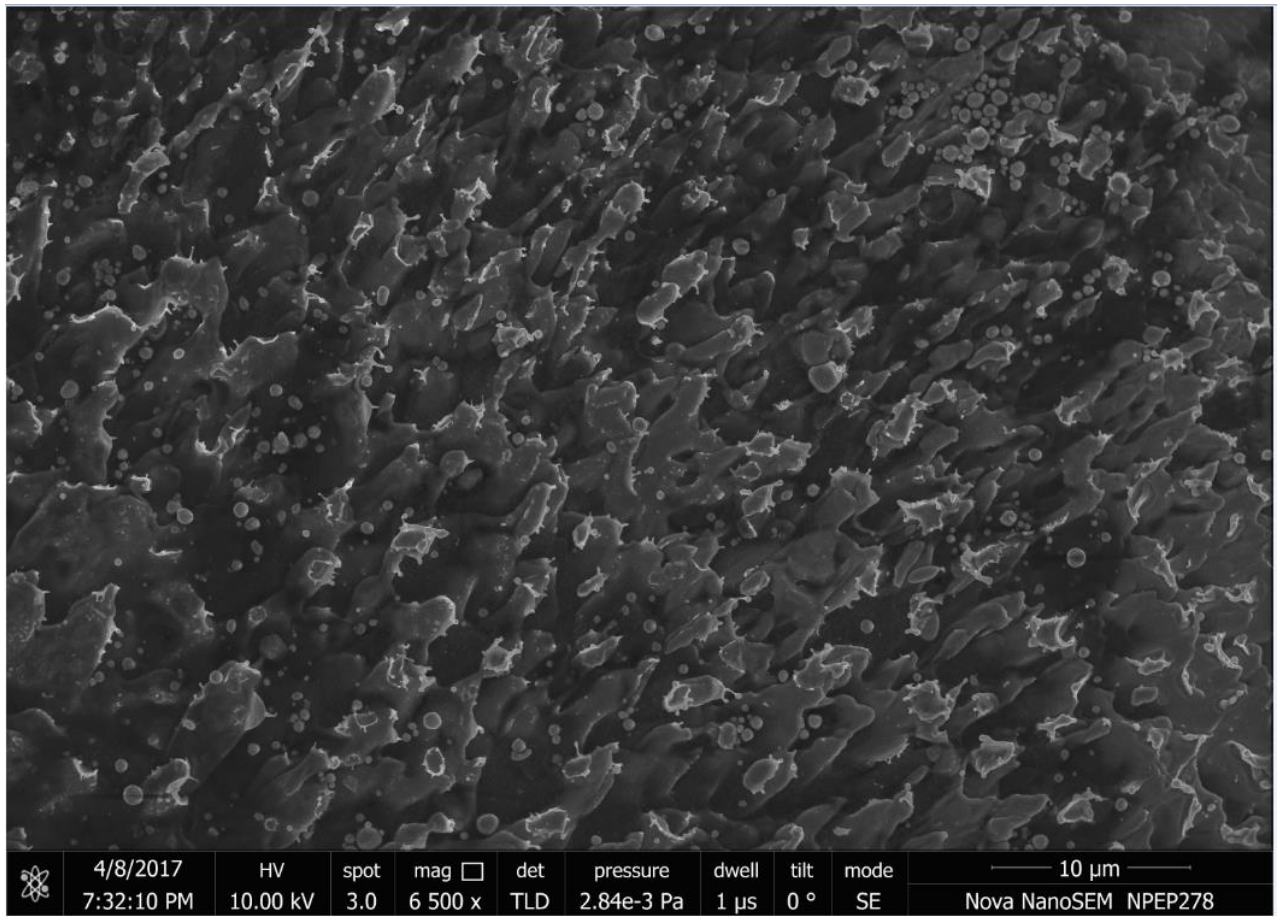
Protrusions

The sides of the crater are filled with various protrusions.

Hard Cu cathode

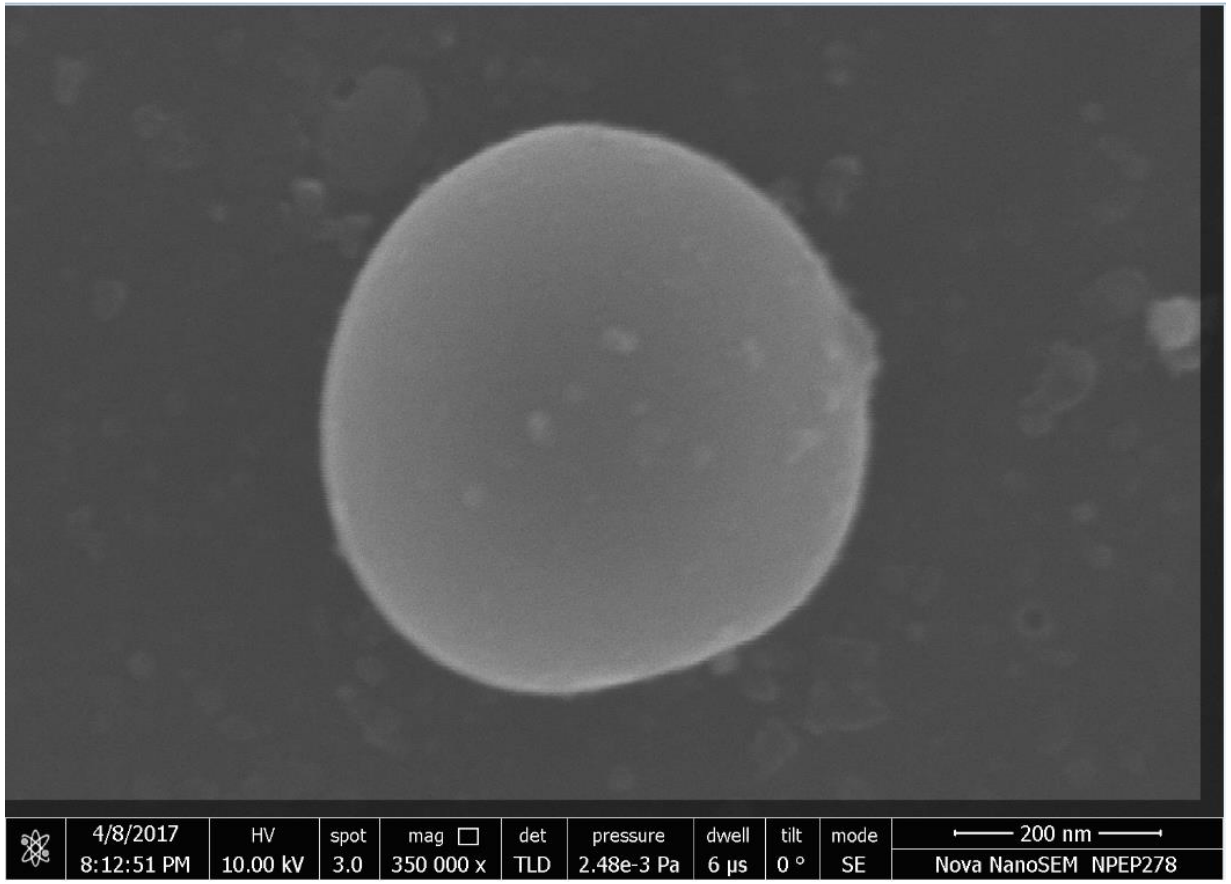


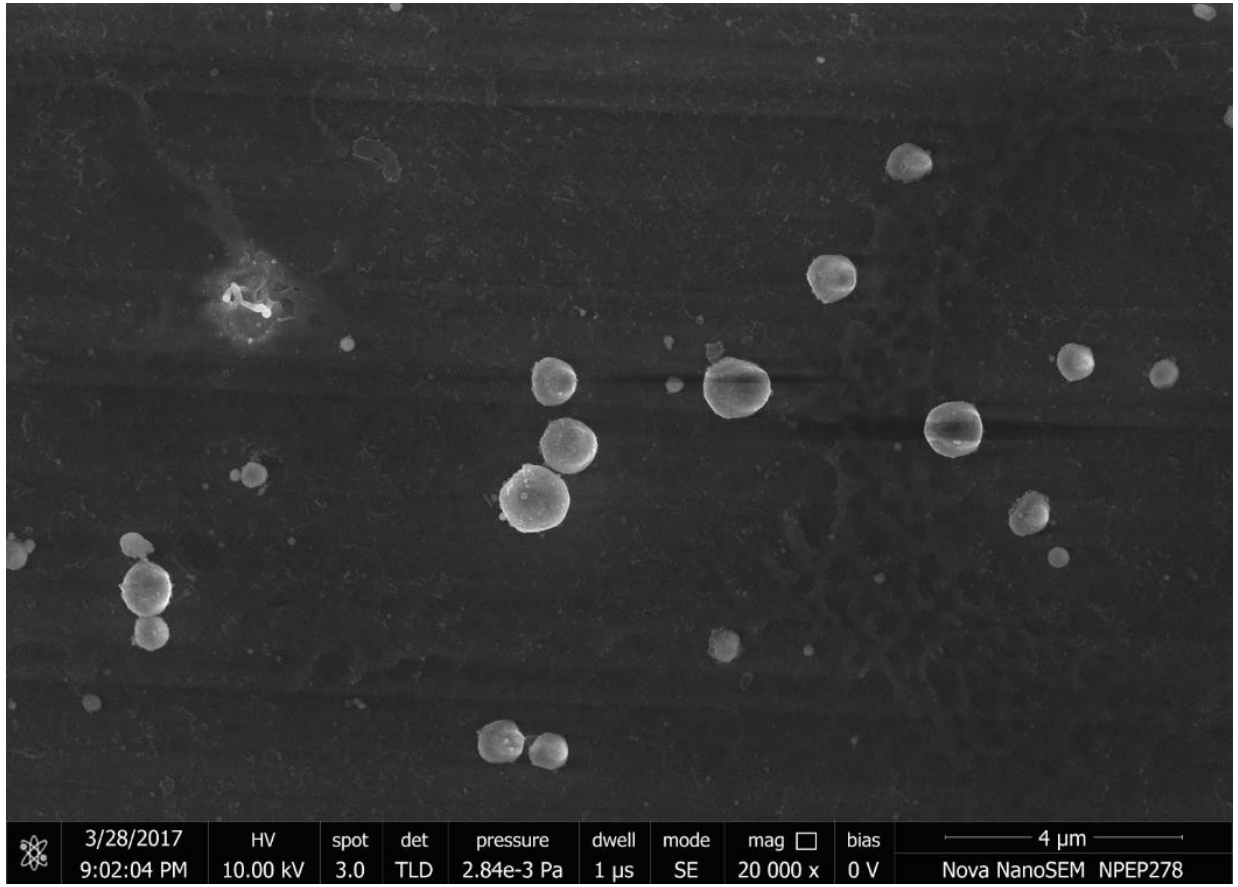
Hard Cu anode



Particles

Hard Cu cathode





Hard Cu cathode

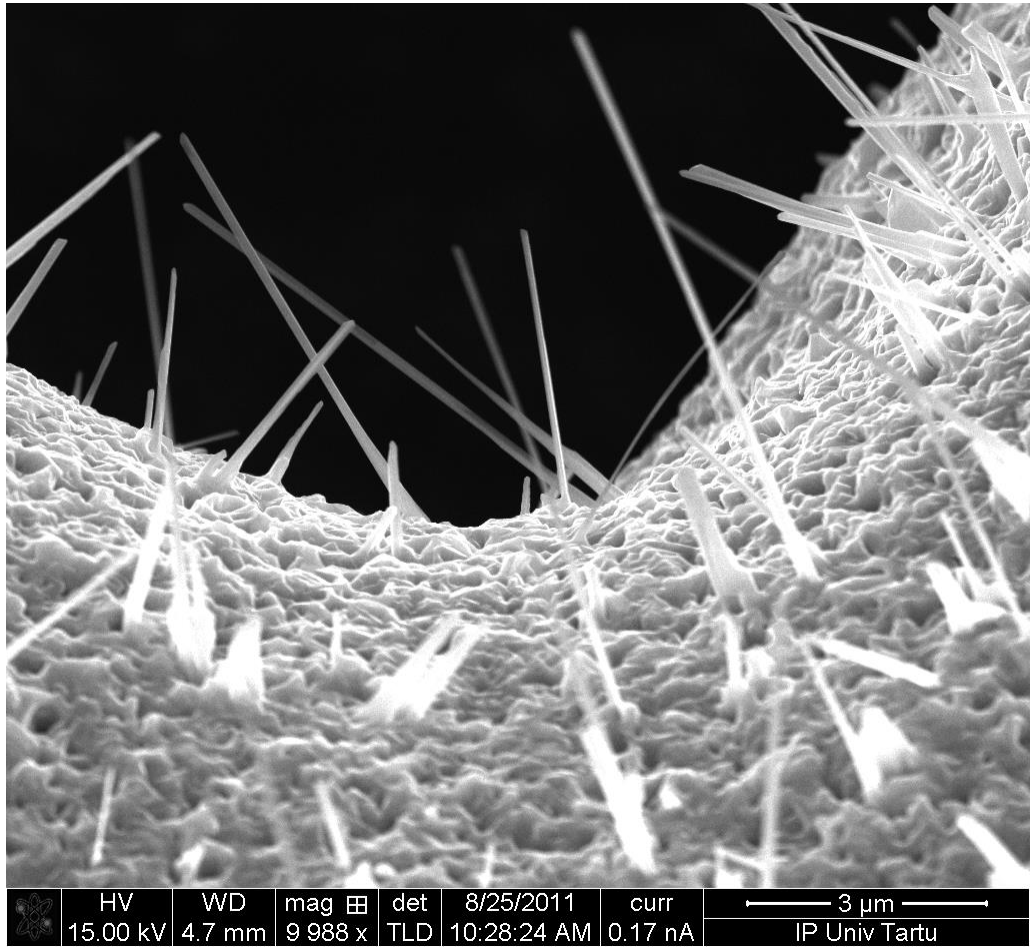
Growth of CuO nanowires

Another candidate for protrusions:

CuO NWs can be synthesized by heating Cu in air. **Nano Lett., Vol. 2, No. 12, 2002**

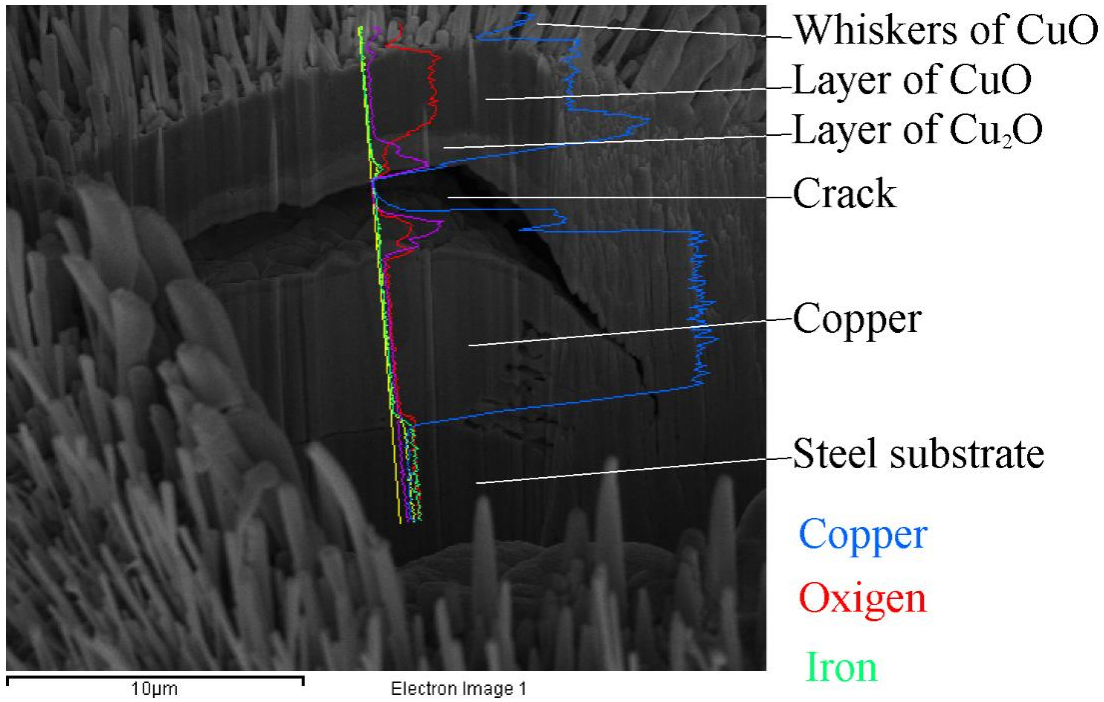
Temperatures 400°-700° results in NWs.

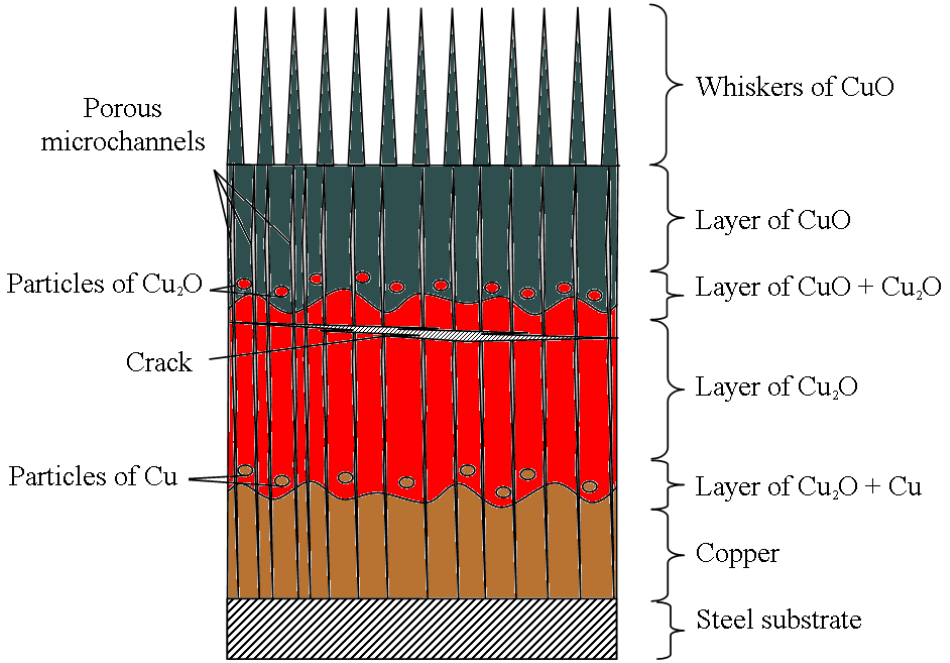
Higher temperatures produces particles.



Cu sample with CuO nanowires:

inner structure after heat-treatment
Cut by FIB, analysed by EDX (NSFL, IPUT)

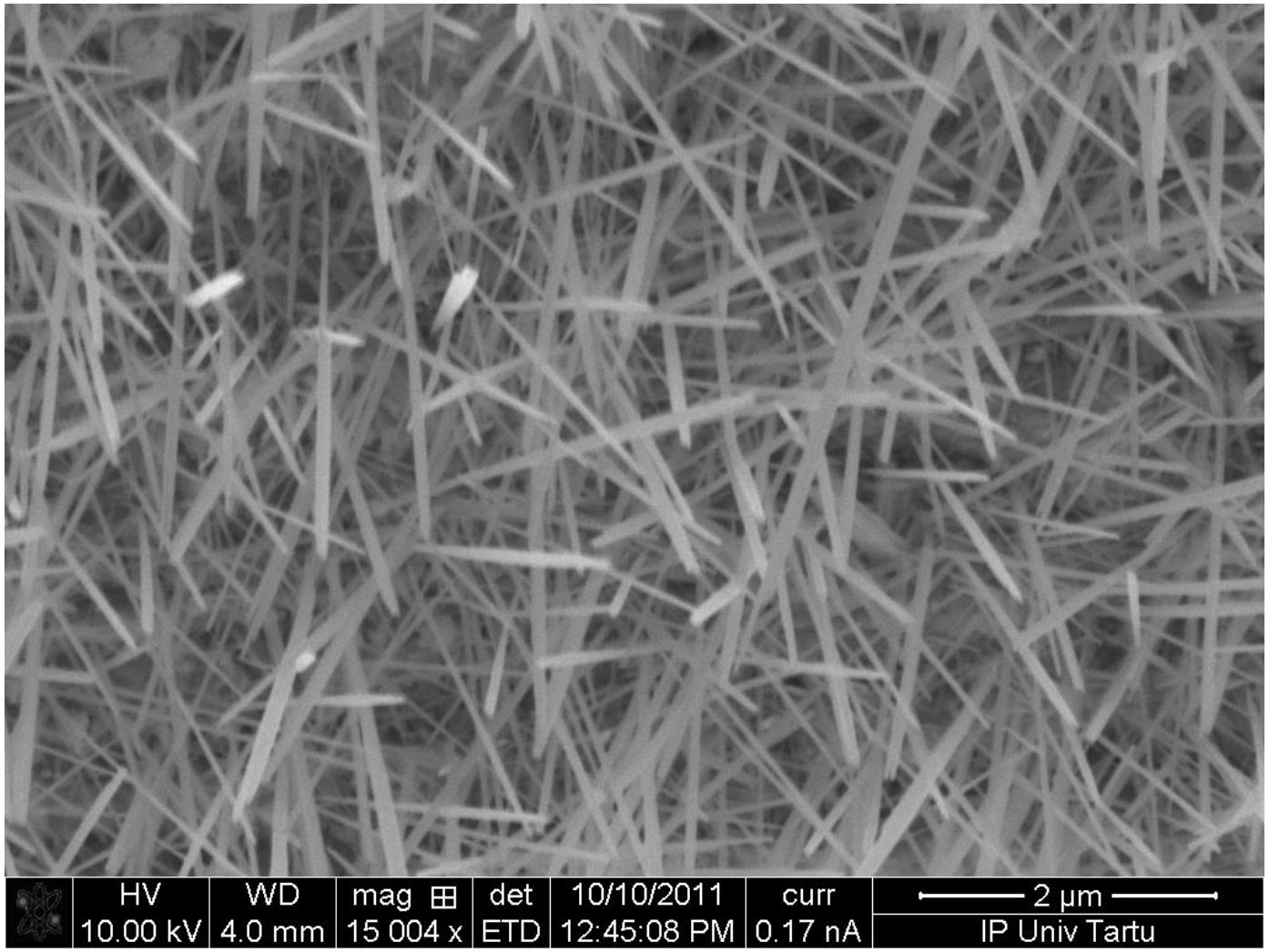




Dorogov, et. al, Appl. Surf. Sci. ***246****, 423 (2015).*

SEM tungsten filament

Tungsten Oxide NWs grown on burnt tungsten filament used in SEM



Estimating the amount of molecules in CLIC

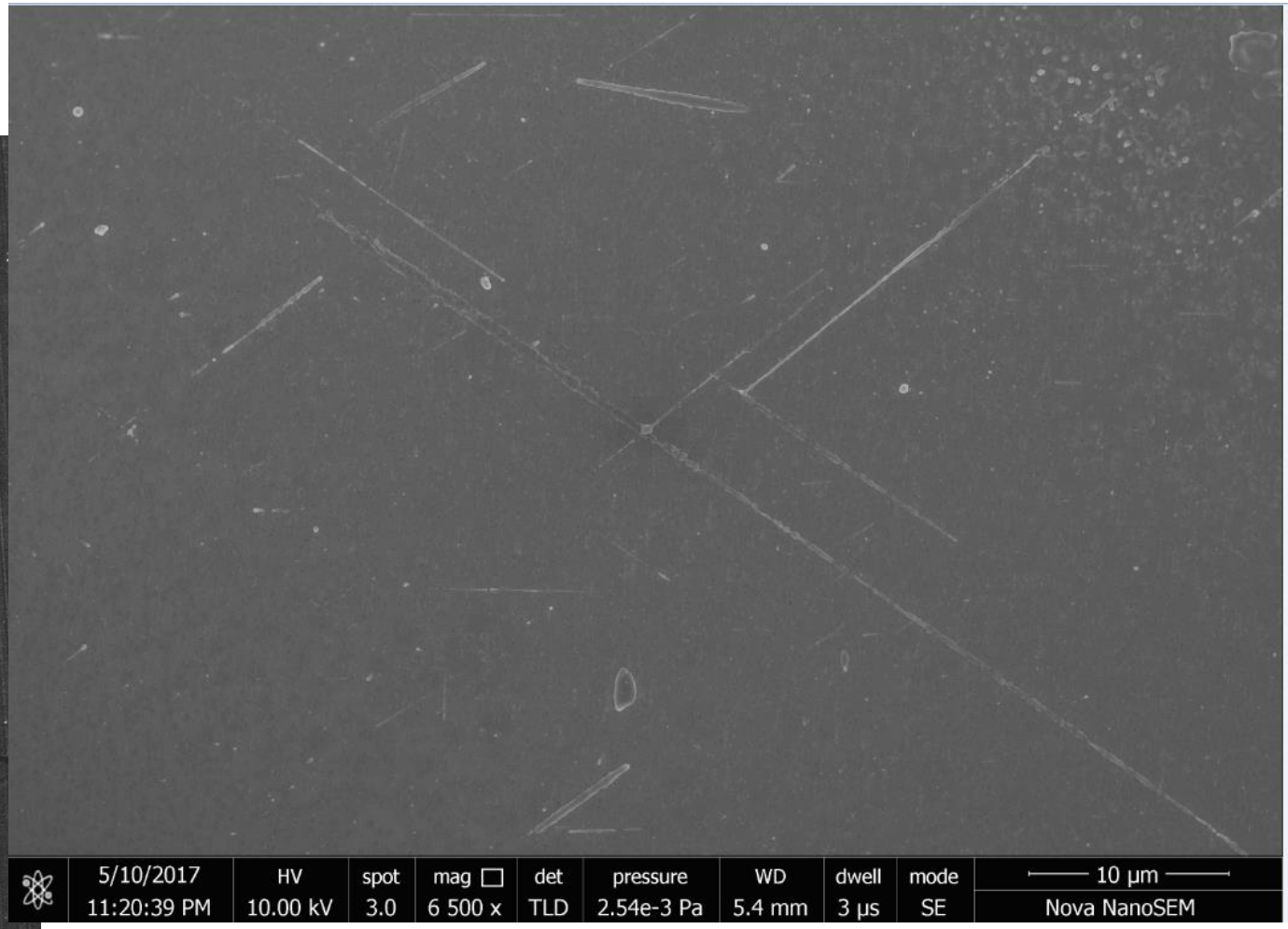
$$T = 293K$$

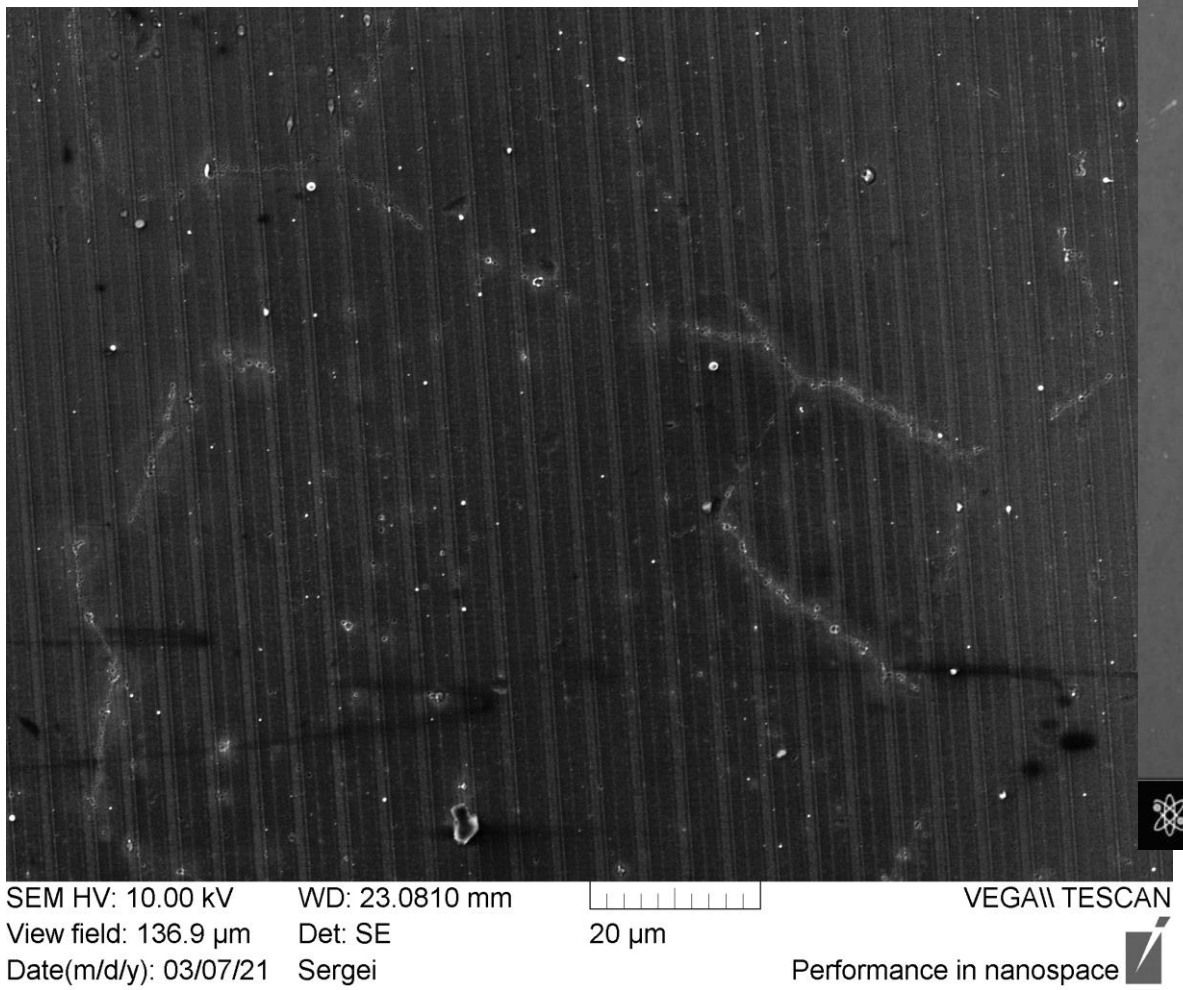
$$P = 10^{-9} mbar$$

$$\frac{n}{V} = \frac{P}{R \cdot T} = 2^{14} \frac{molecules}{m^3}$$

Lines

Soft Cu cathode

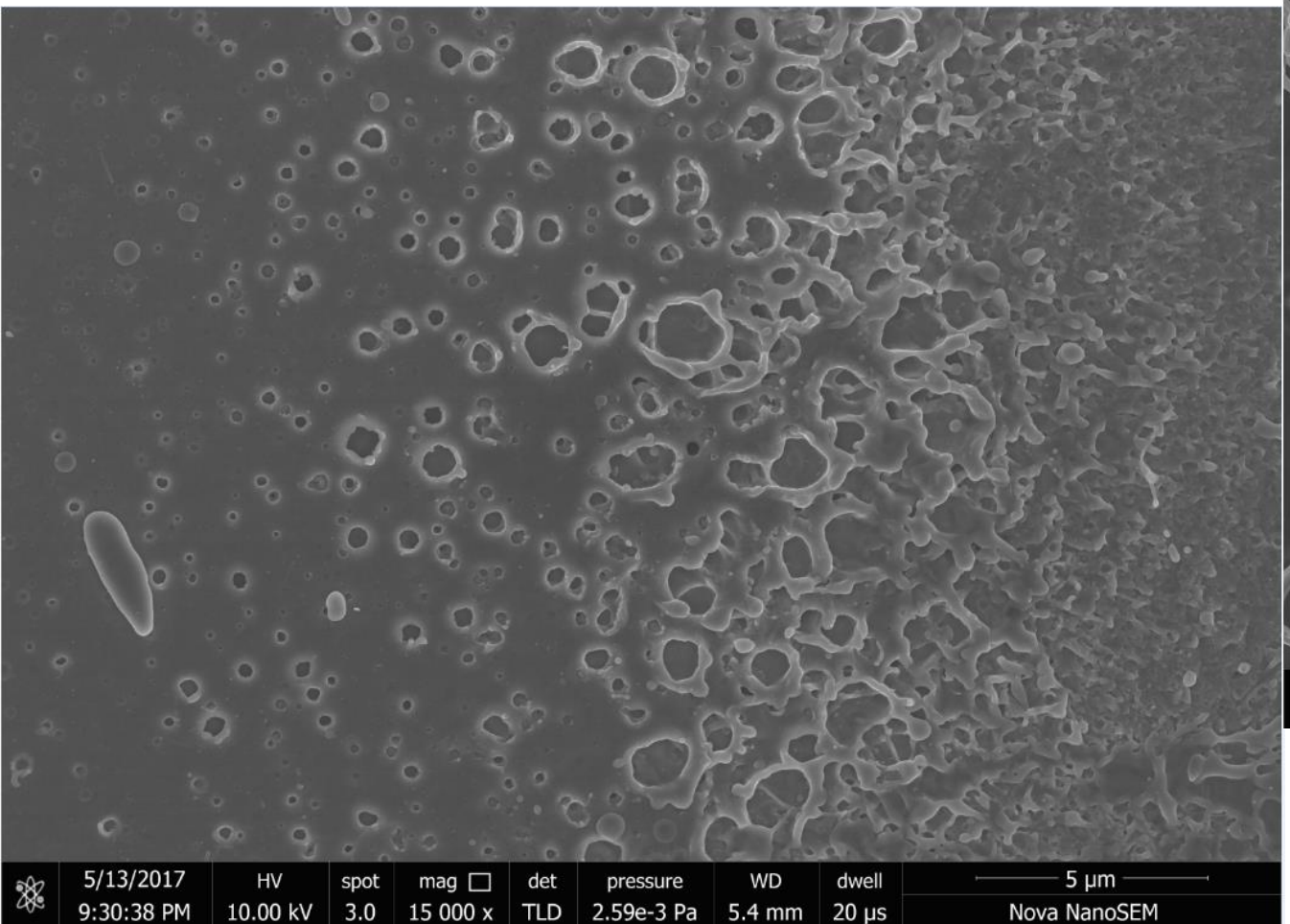


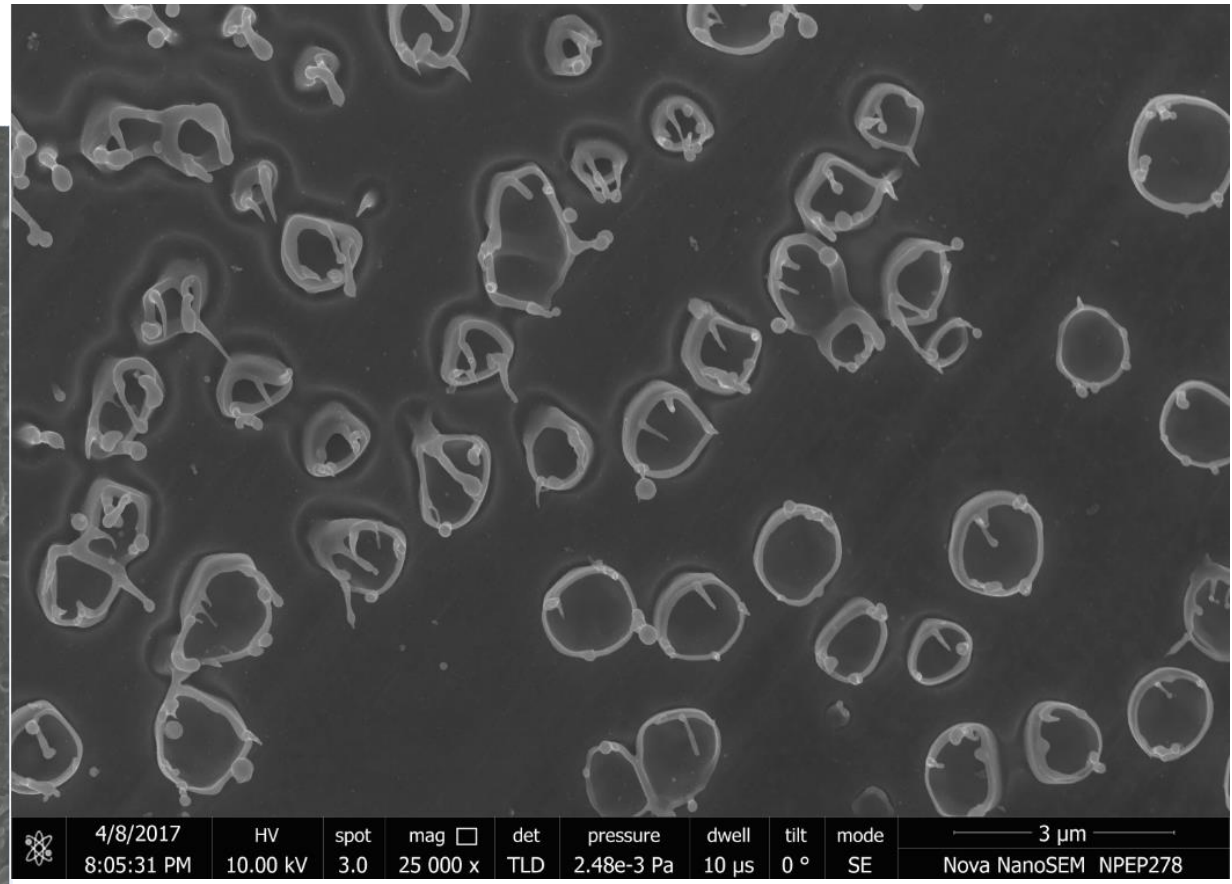


Hard Cu cathode

Rings on anode

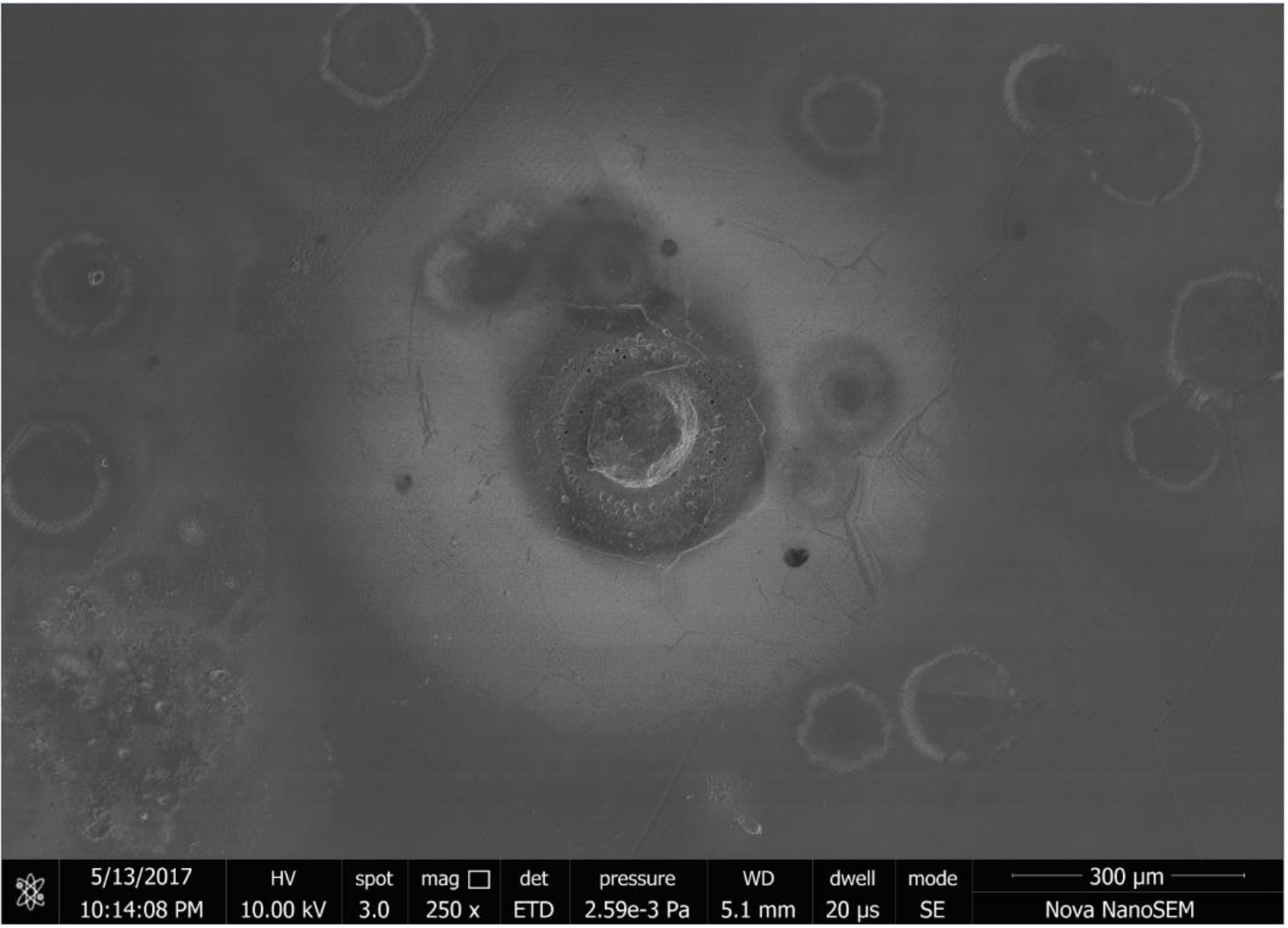
Soft Cu



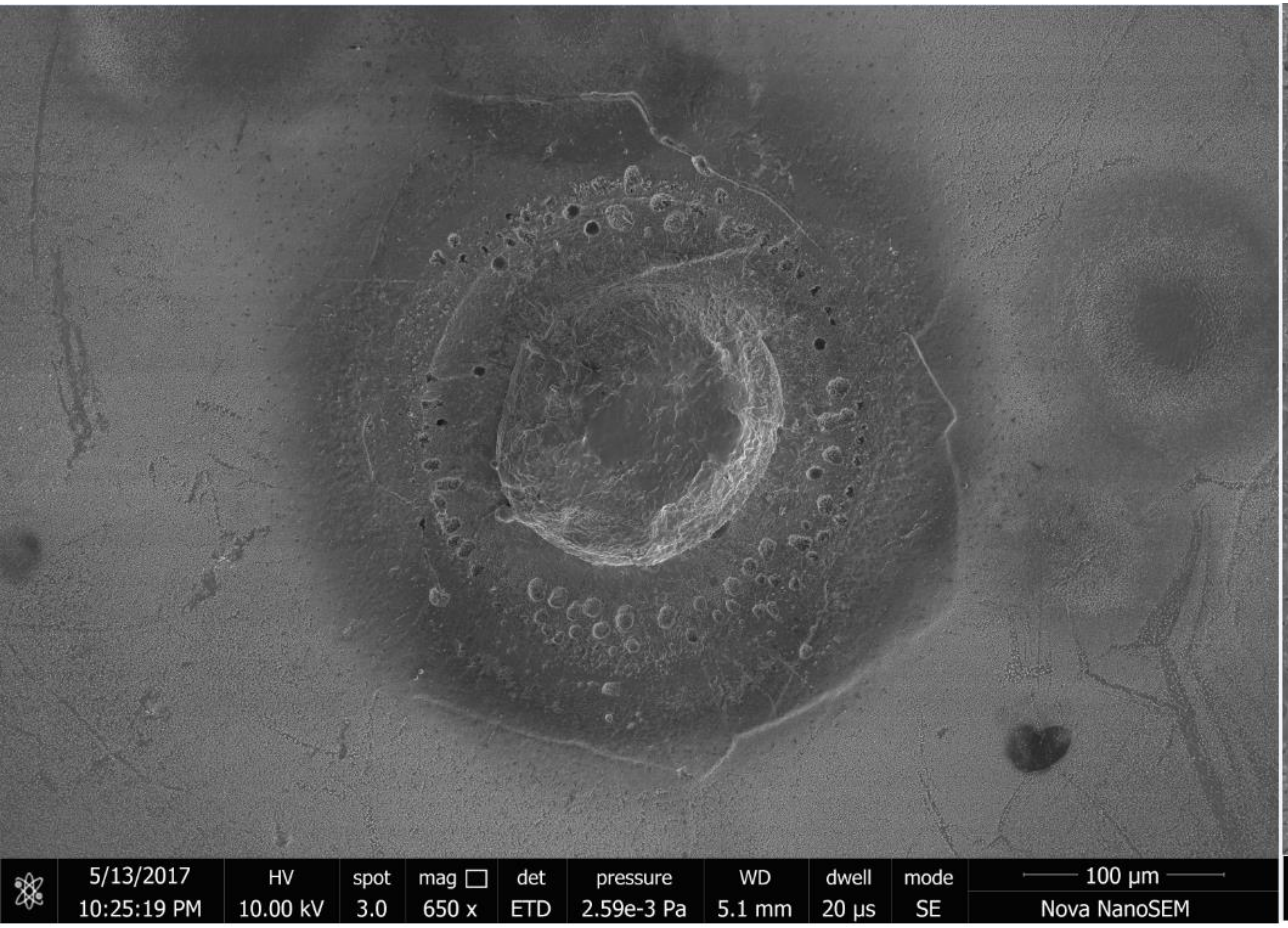


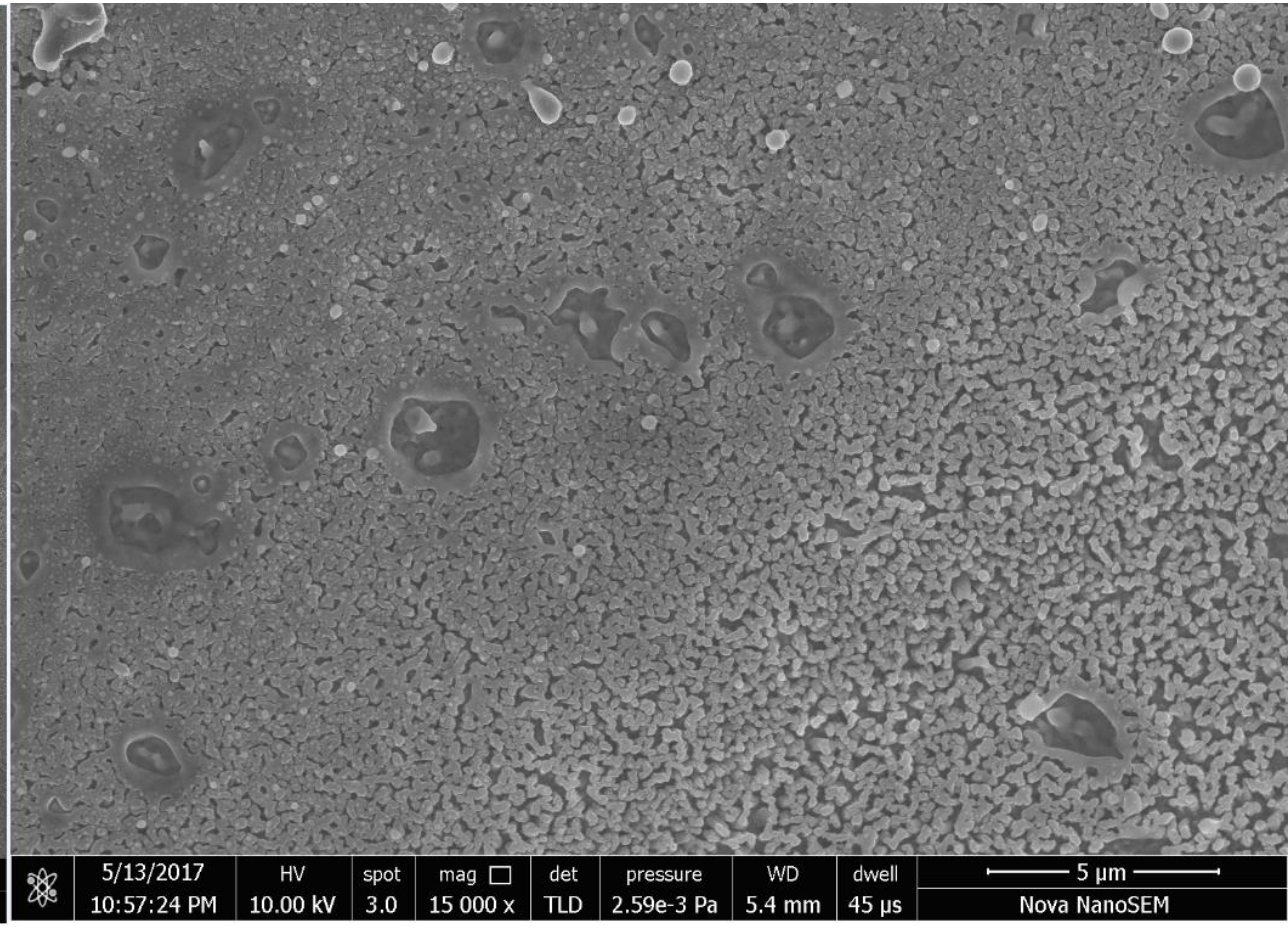
Hard Cu

Soft Cu anode 1

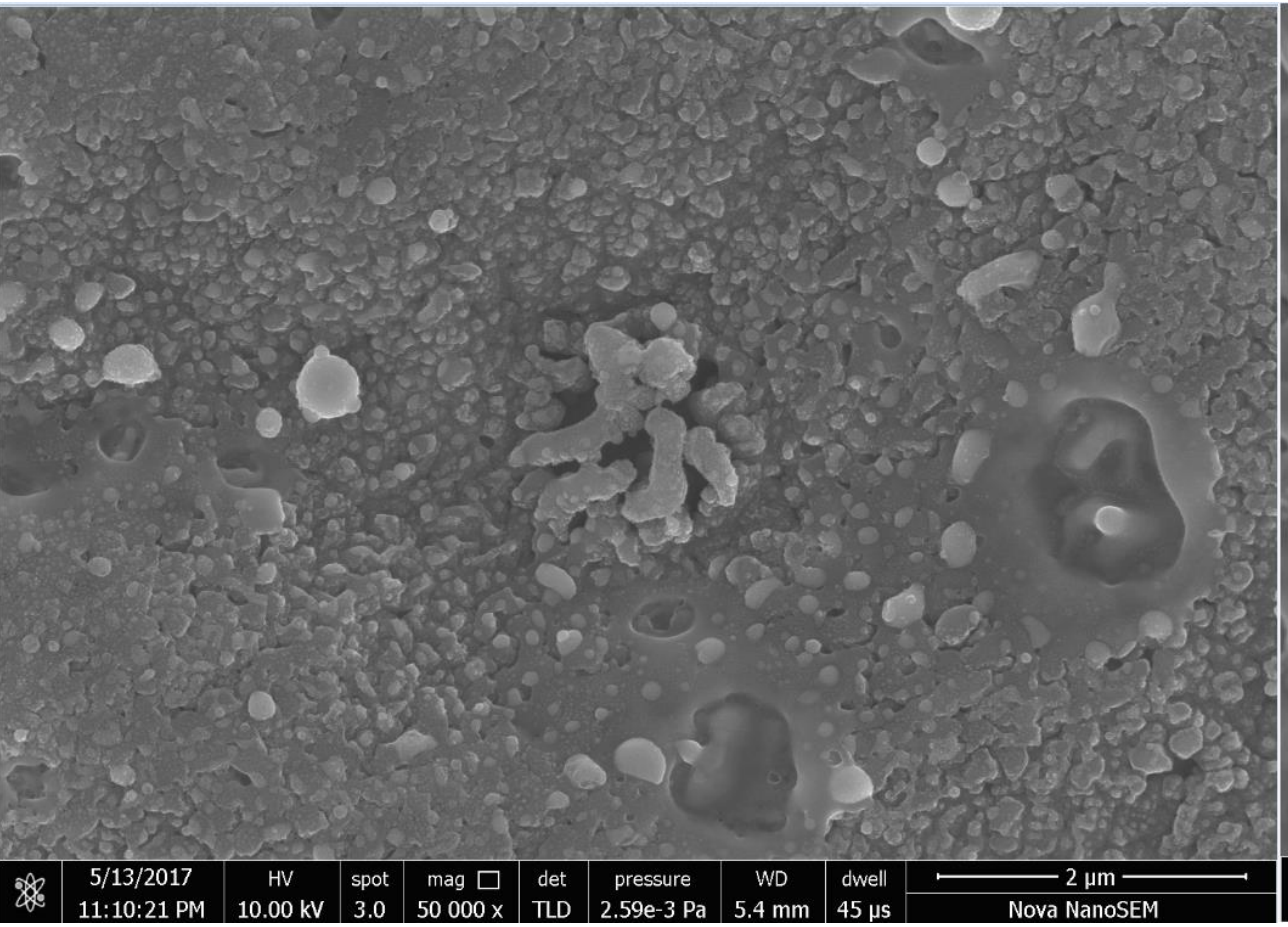


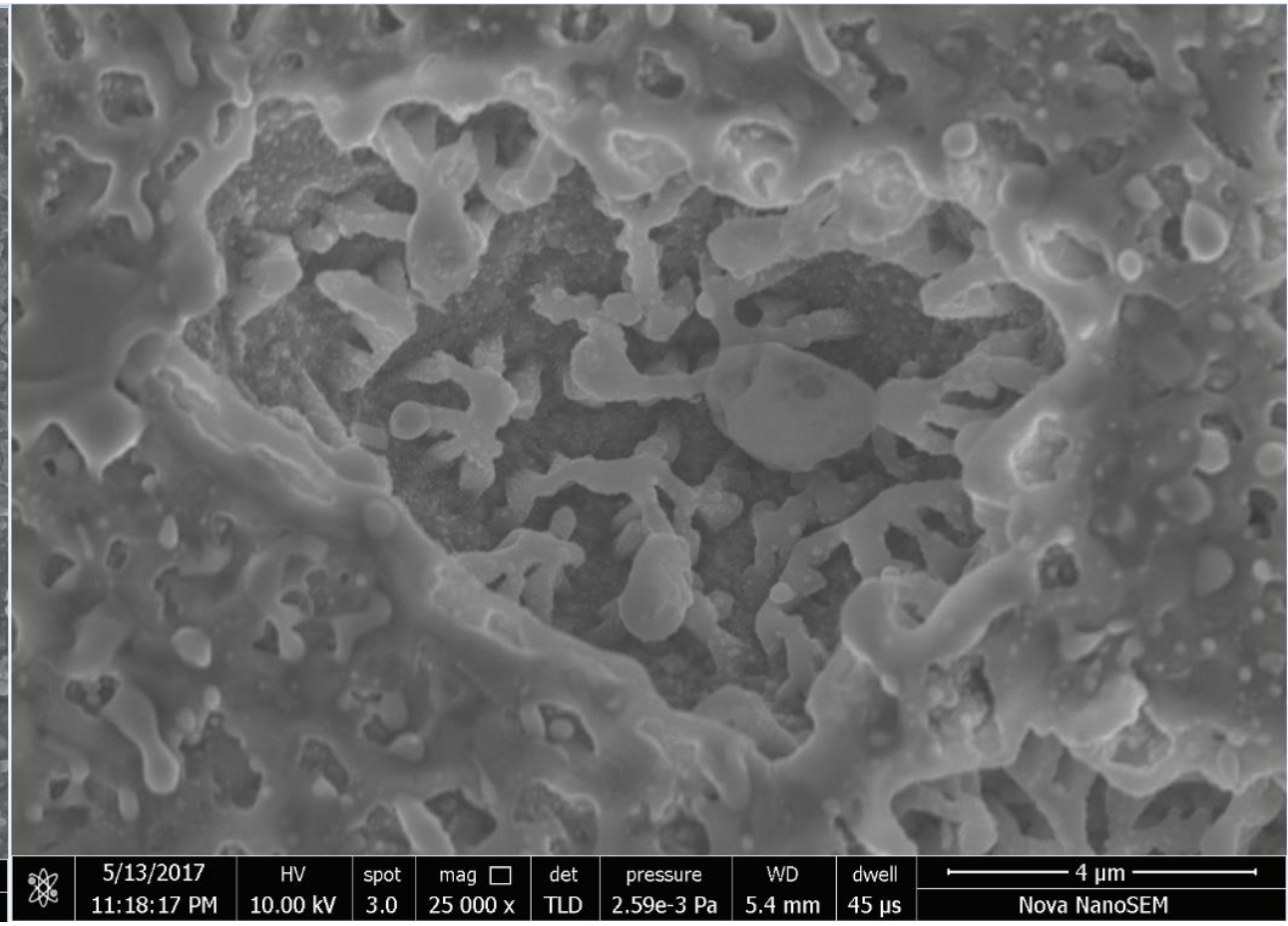
Soft Cu anode 2





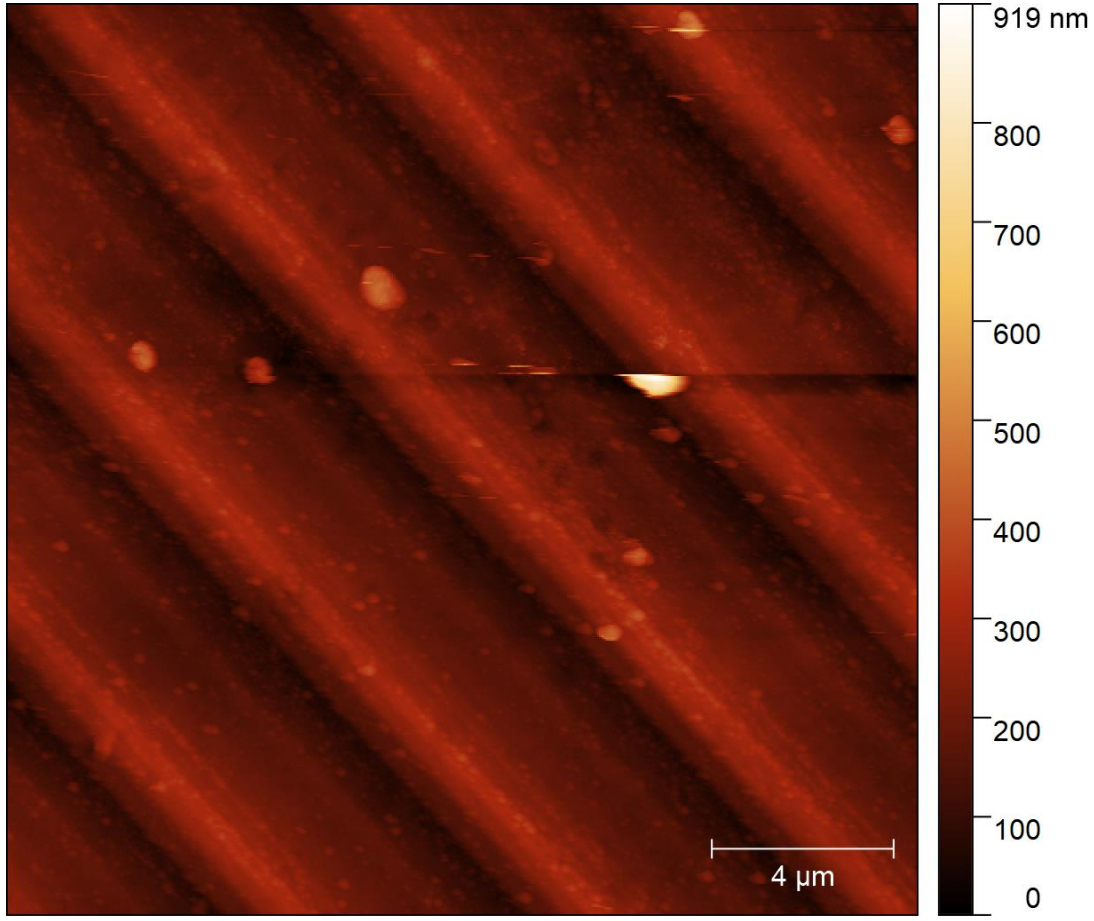
Soft Cu anode 3



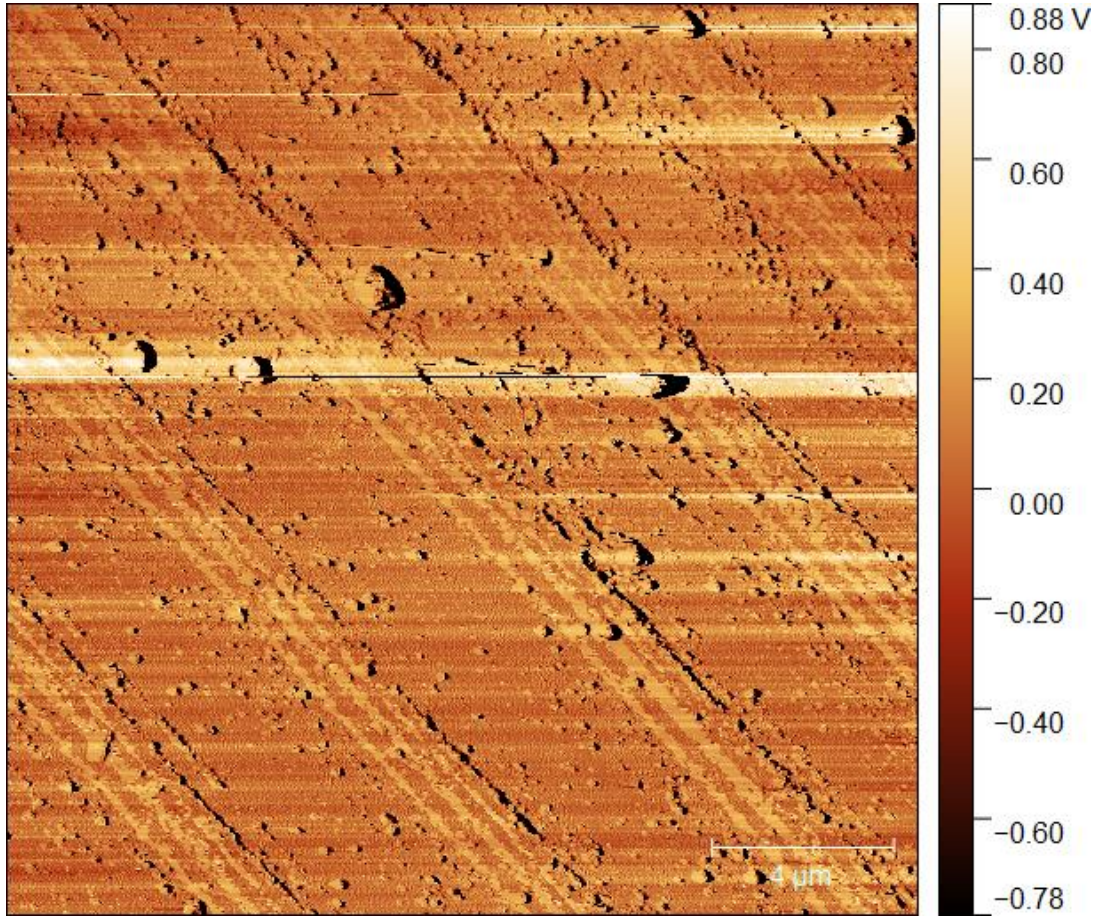


AFM images (only hard Cu cathode)

Plain surface topography & surafce potential

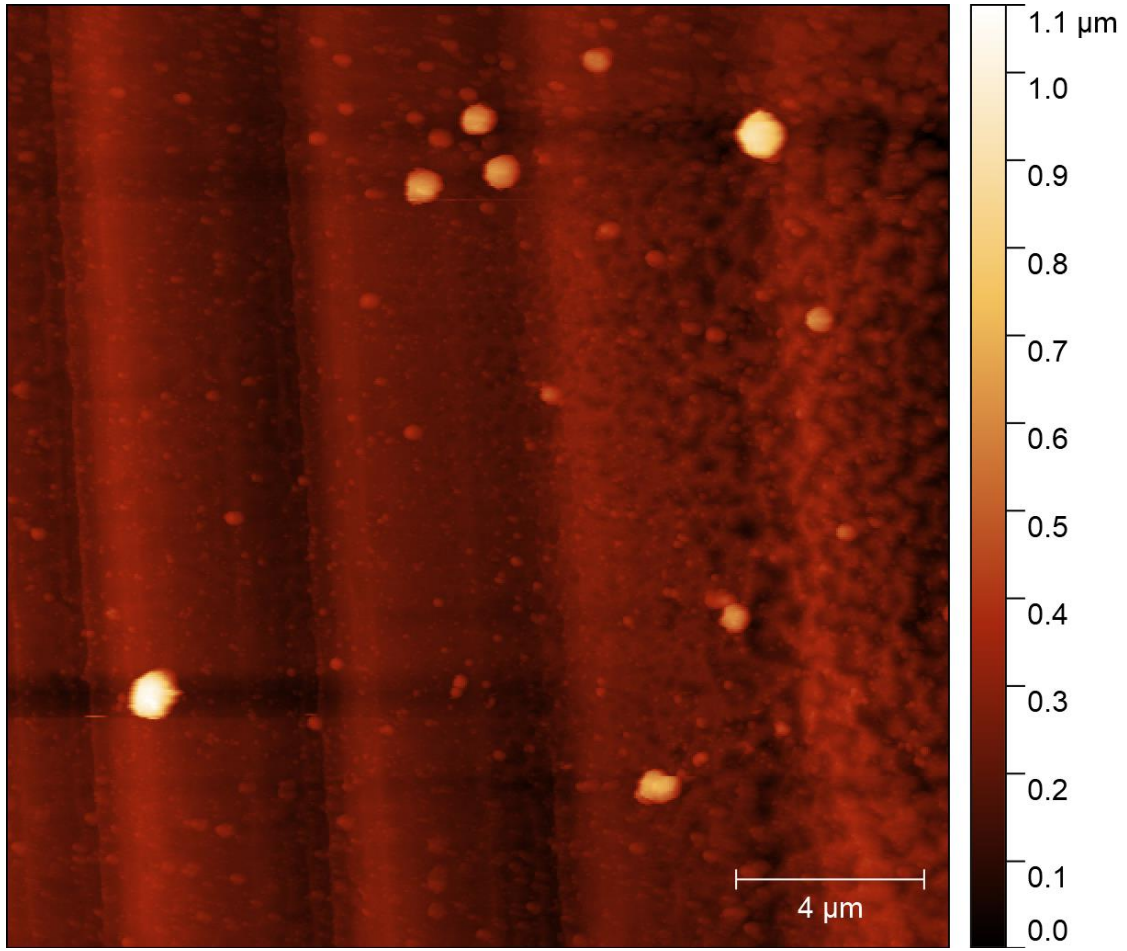


Topography

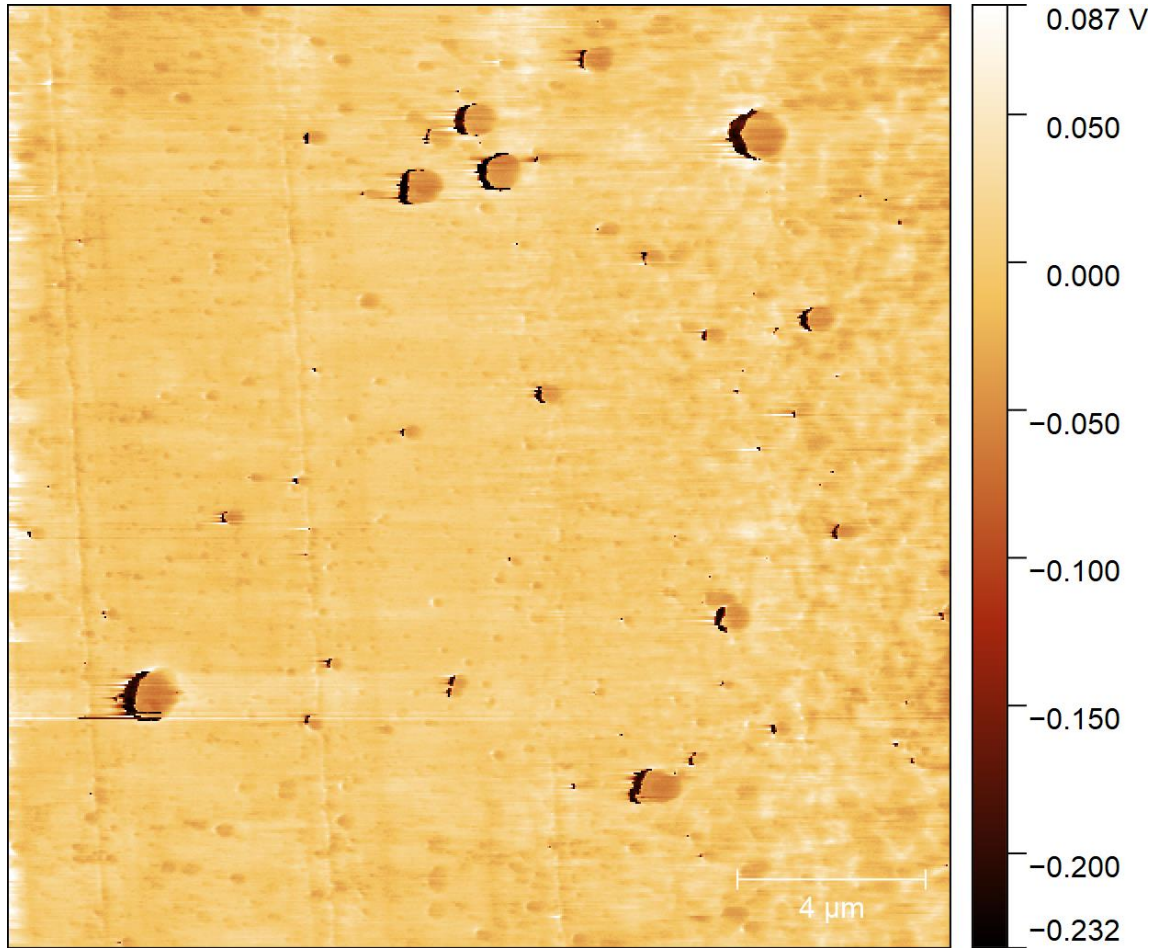


Potential image

Crater edge topography & potential

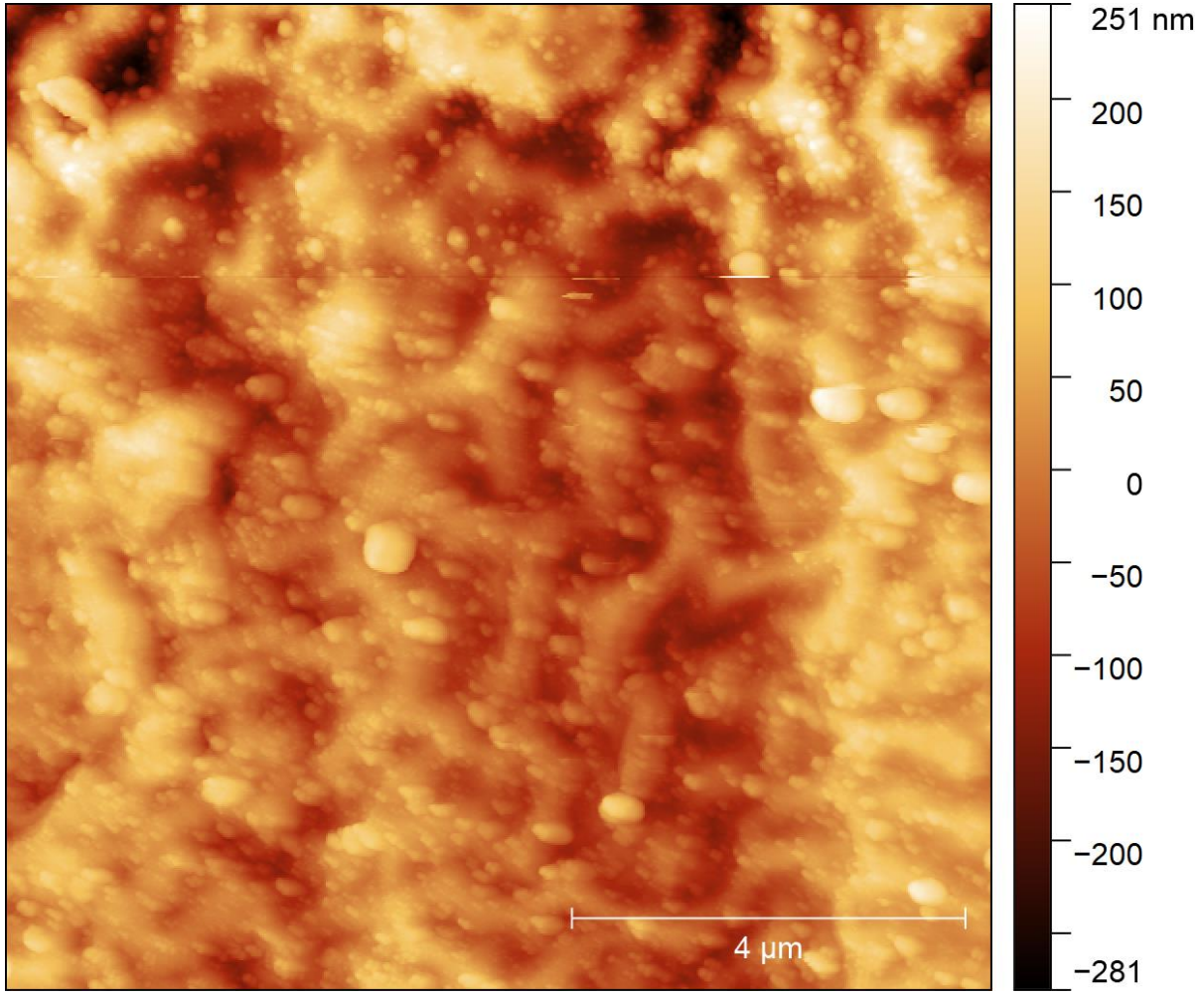


Topography

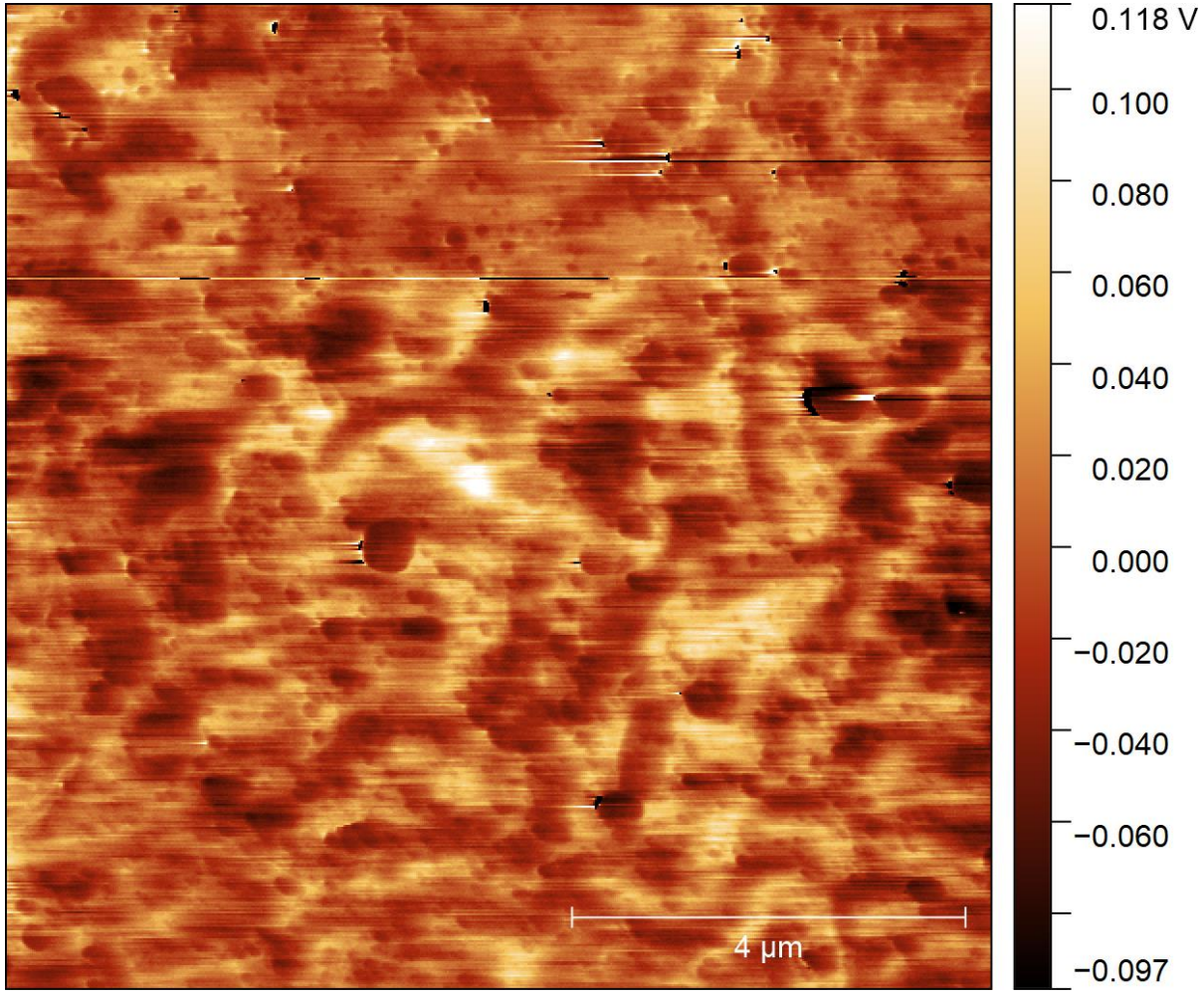


Potential image

Crater topo vs potential



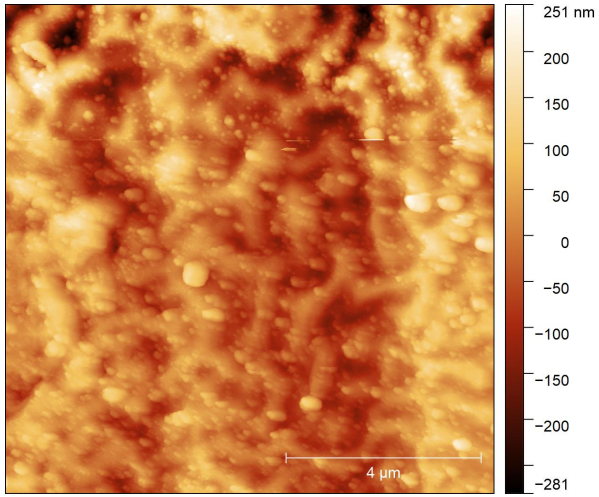
Topography

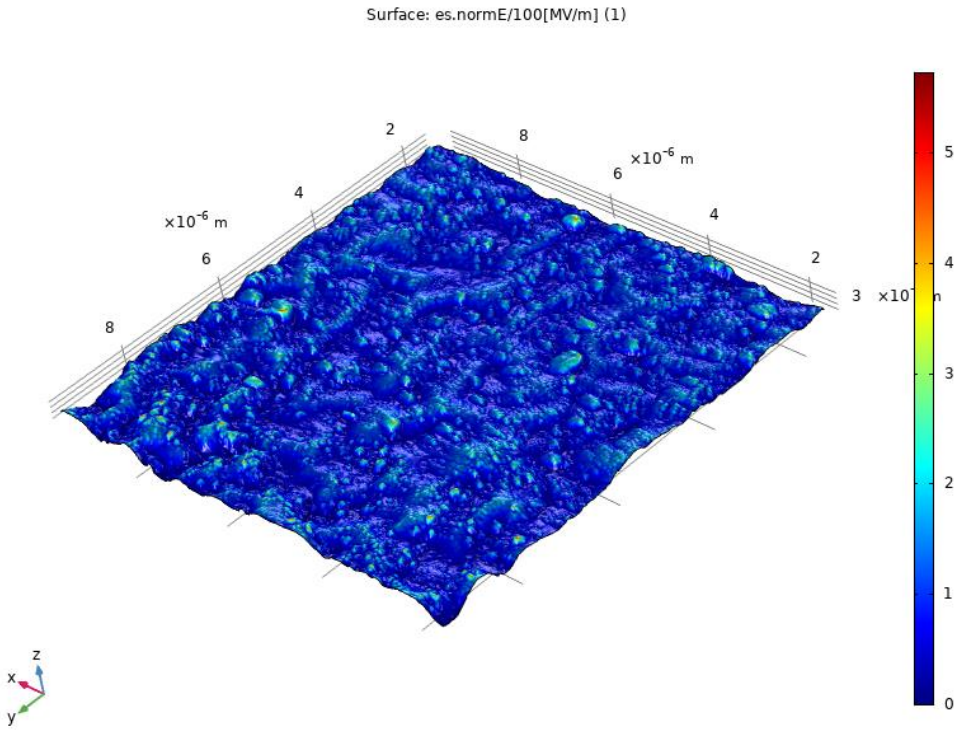


Potential image

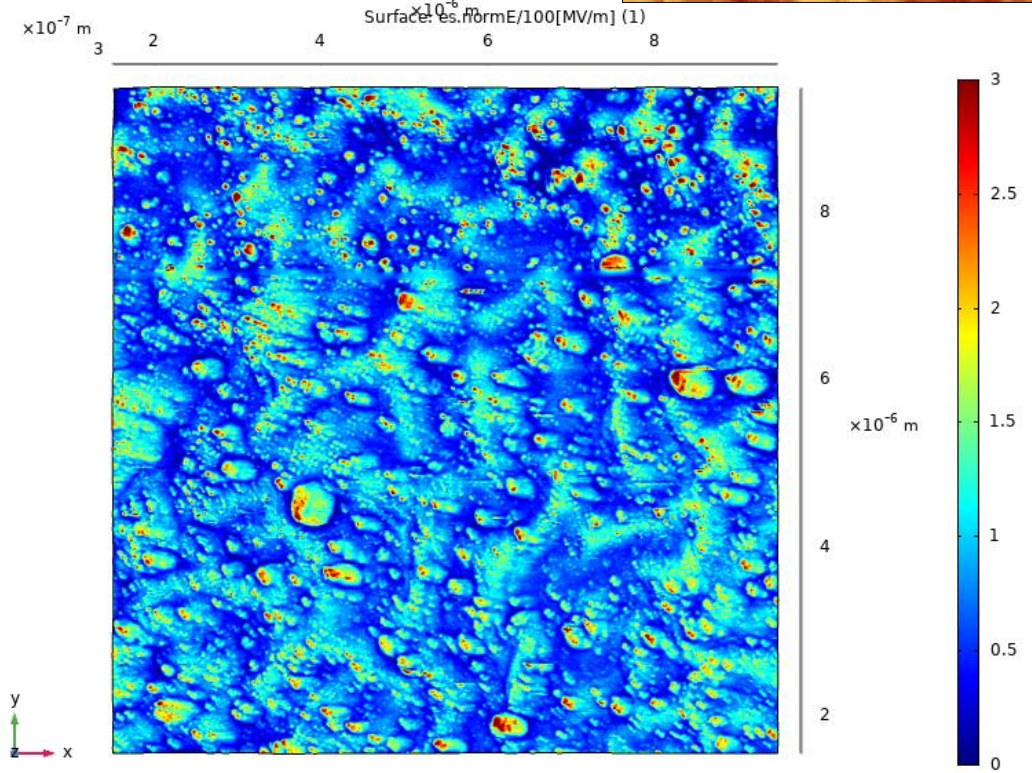
Field enhancement image

Field enhancement up to 5 times due to topology.





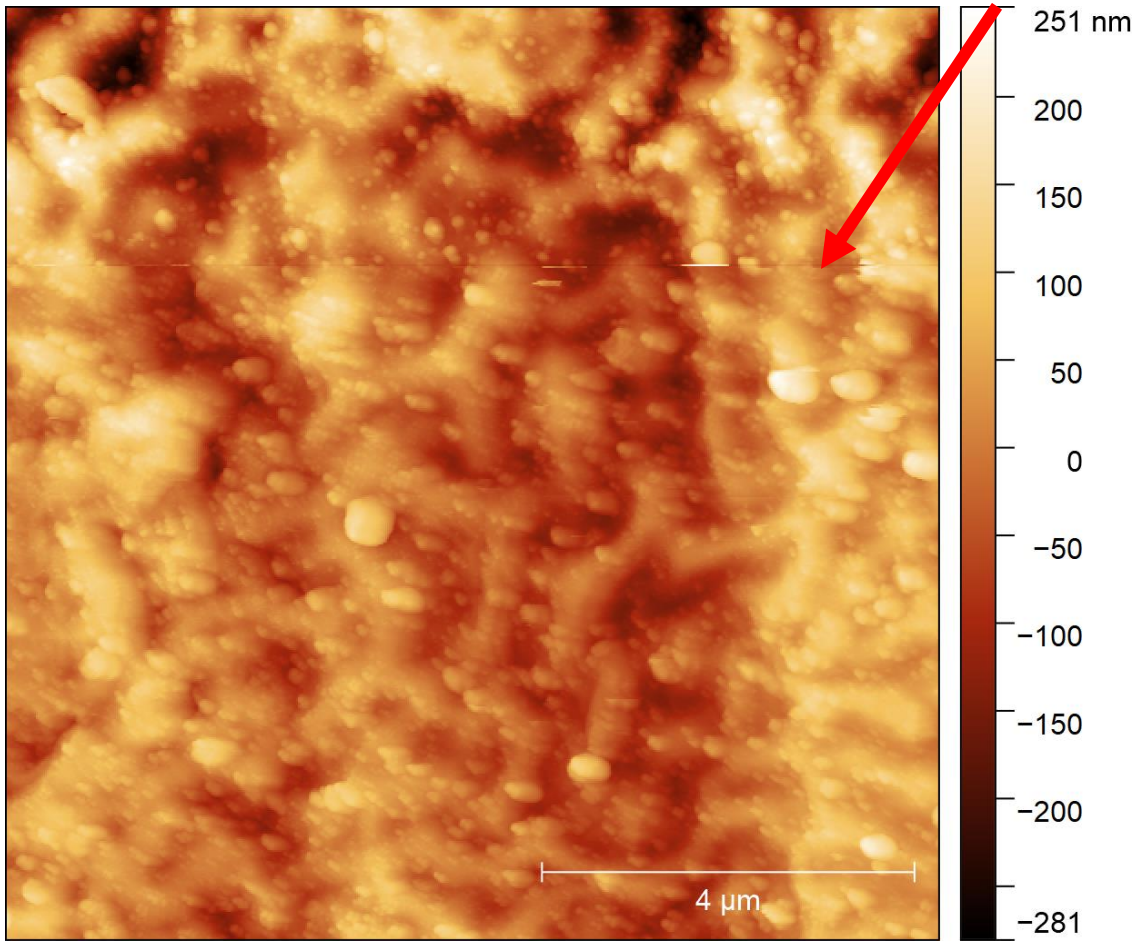
Field enhancement modeling



Field enchancement capped at 3

Mapping large craters

Mapping of the most interesing part is almost impossible.



¾ of image with dull tip

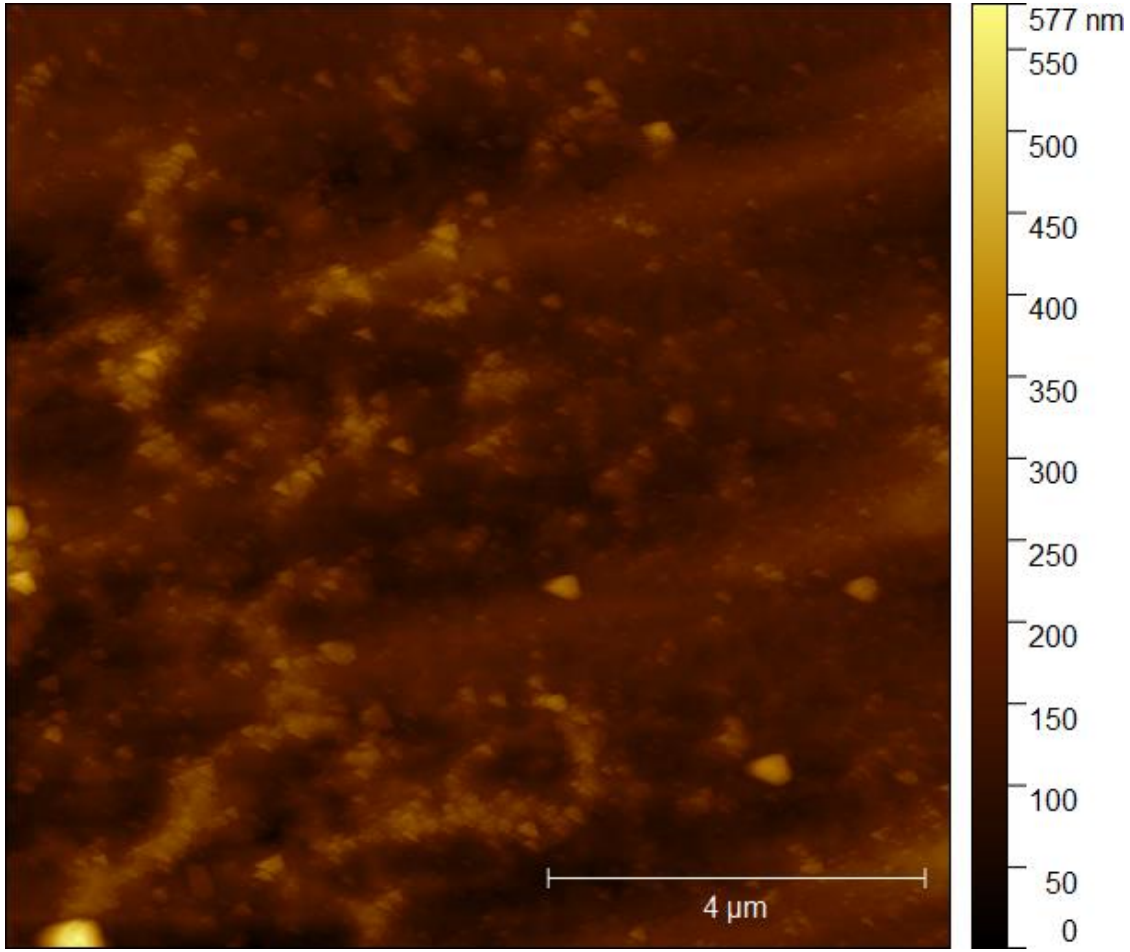


Image of crater with artefacts

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Conclusions & plans

The surface topology in craters is very rough, forming a lot of interesting structures.

The field enhancement of the protrusions can be at least up to 5.

Plans:

Also analyse Cu electrodes without plasma treatment.

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Haridus- ja Teadusministeerium
Estonian Ministry of Education and Research

Thank You!