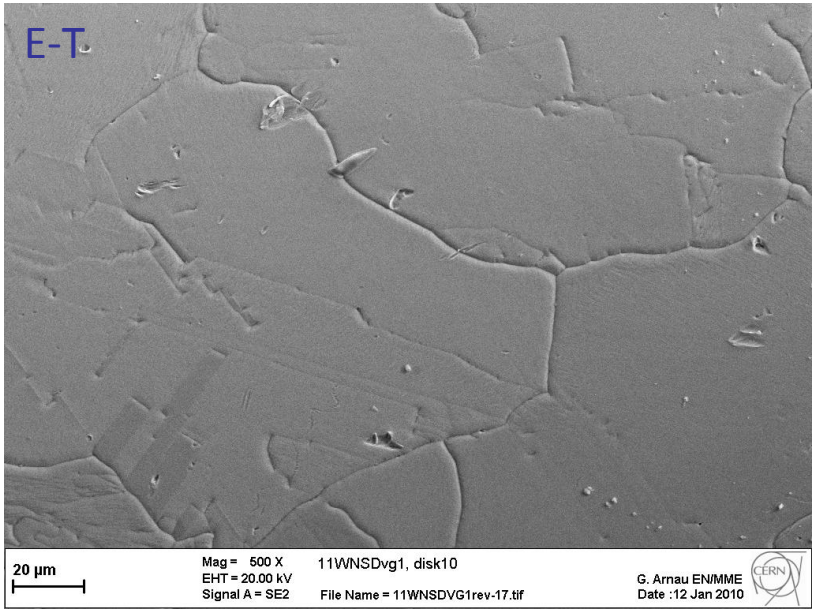
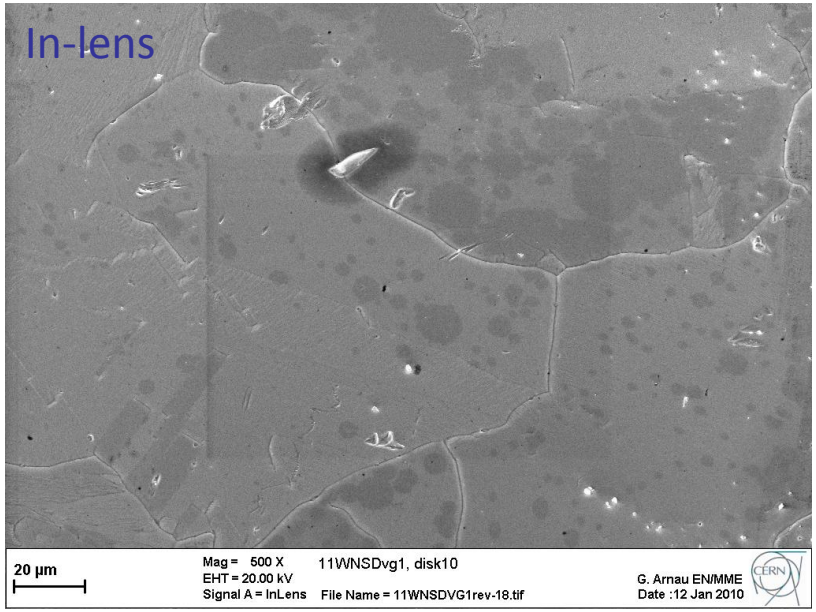
New features observed with SEM in-lens detector in the vicinity of breakdown craters.

- SE contrasts in LV-SEM. Different features observed by In-lens and E-T detector.
- Examples of worm-like, flowers, spaghetti, filamentary features… (better) observed with In-lens detector
  - RF tested structure. T24 - 11WNSDvg1.8Cu
  - DC spark sample. Cu 45 - 7N-LG

SE contrasts in LV-SEM. Different features observed by In-lens and E-T detector.

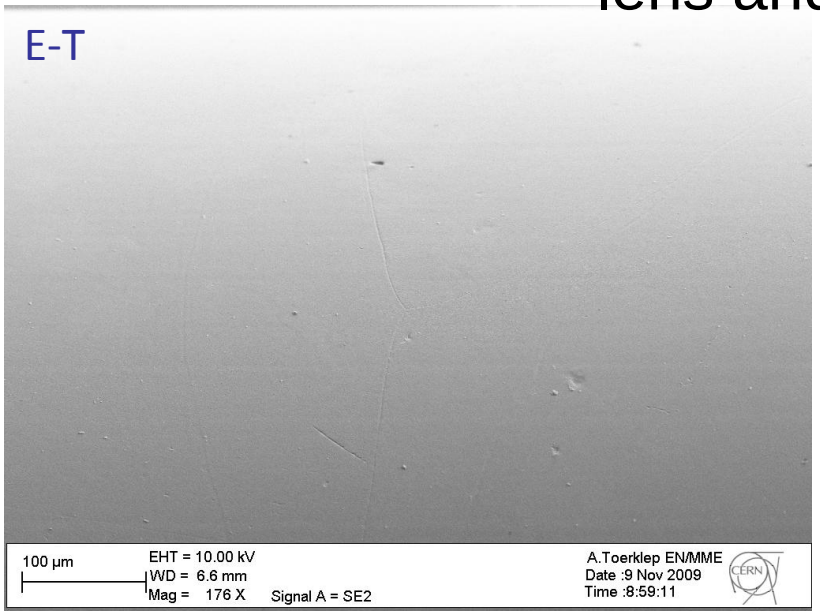


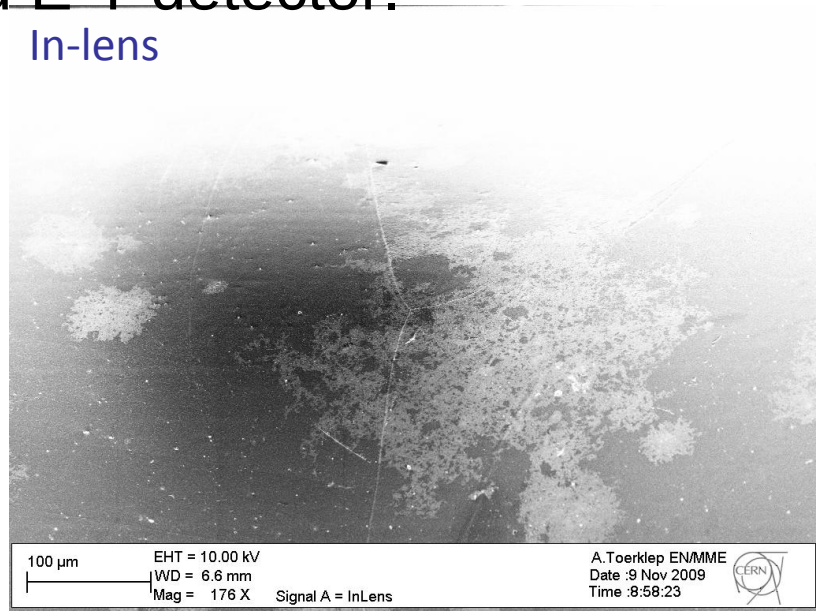


Images taken simultaneously and at the same location

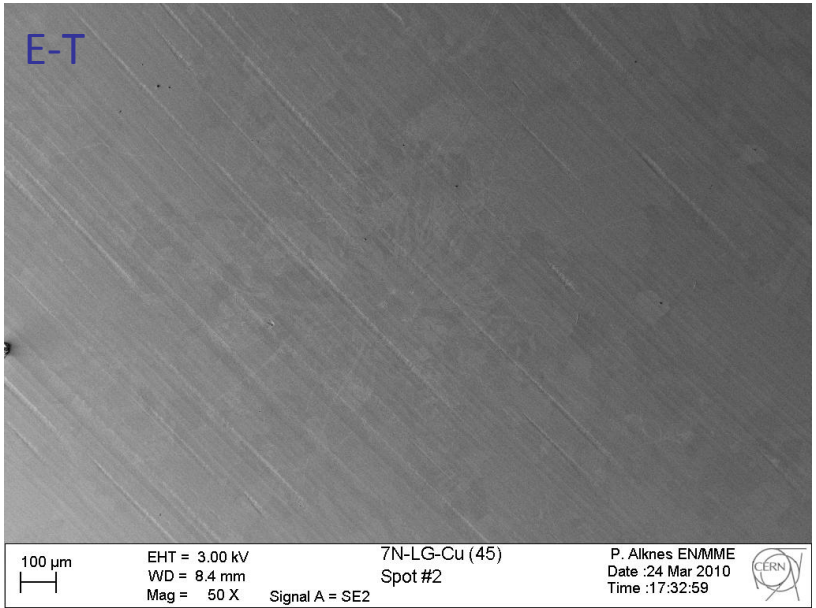
→With In-lens detector superficial contaminations become visible.

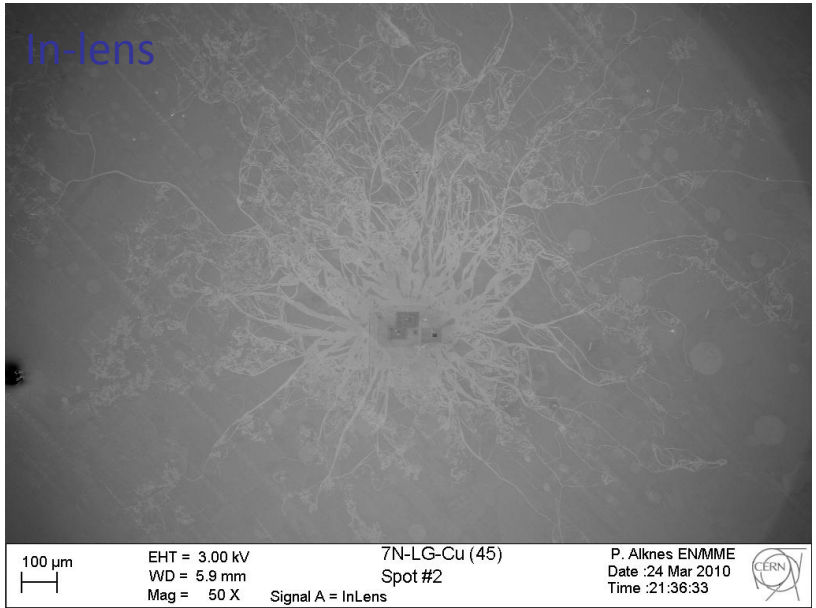
SE contrasts in LV-SEM. Different features observed by In-lens and E-T detector.





Cur structure after RF test





Cur sample after DC sparktest

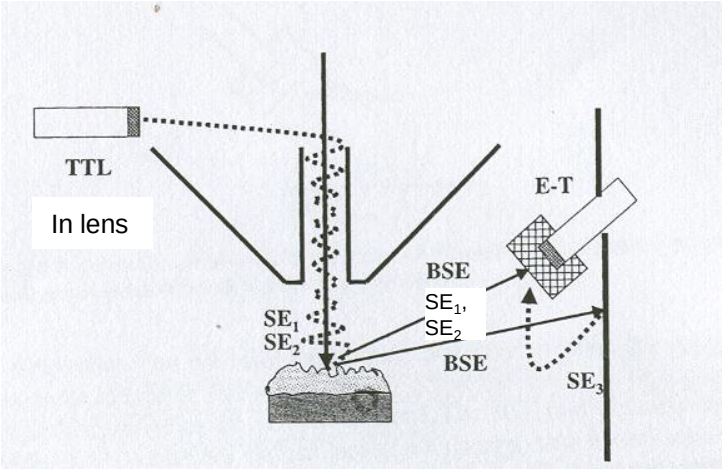
SE contrasts in LV-SEM. Different features observed by In-lens and E-T detector.

→SE signal very sensitive to surface condition and slight chemical differences

"The emission coefficient of SE is very sensitive to the condition of the surface because the low kinetic energy severely limits their range…dependence upon composition can be influenced by the nature of molecular bonds…this dependence should alert the microscopist to the possibility of unexpected contrast effects in SEM images were SE form a large part of the signal such images prepared with the In-lens detector."

→ In-lens less background of indirect SE produced on walls.

"The positive biased E-T has a strong BSE component in its signal from the SE_3 (SE electrons produced when the BSE hit the pole piece and chamber walls).



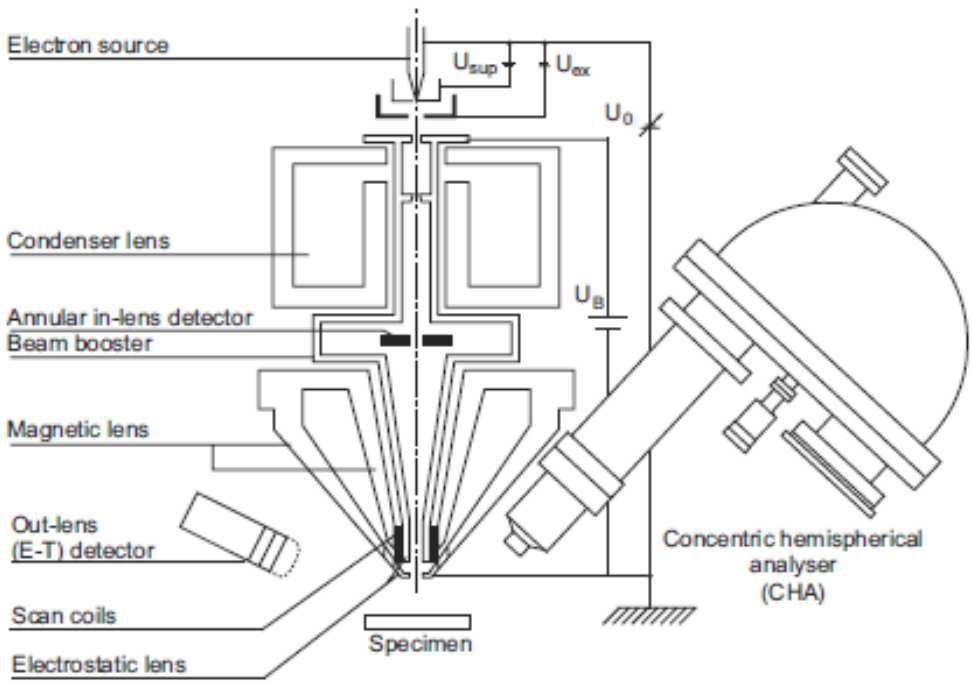
Scanning Electorn Microscopy and X-Ray Microanalysis. Third Edition. J. Goldstein and alt.

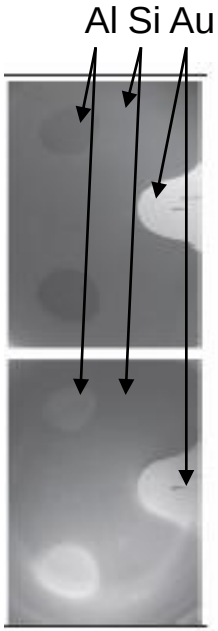
SE contrasts in LV-SEM. Different features observed by In-lens and E-T detector.

→ In-lens image is more sensitive to lower energy SEs.

The In-lens image is mainly composed of low energy electrons whose energy is less than 40 eV and are easyly atracted by the electrostatic field generated by U_B. This can be the reason why SE images of in-lens detector have high surface sensitivity. For the out-lens the main portion of the SEs have higher energy, thus images contain much (bulk) material information.

Sharing of secondary electrons by in-lens and out-lens detector in low voltage canning electorn microscope. K. Kumagai T. Sekiguchi. Ultramicroscopy 109 (2009) 368-372.





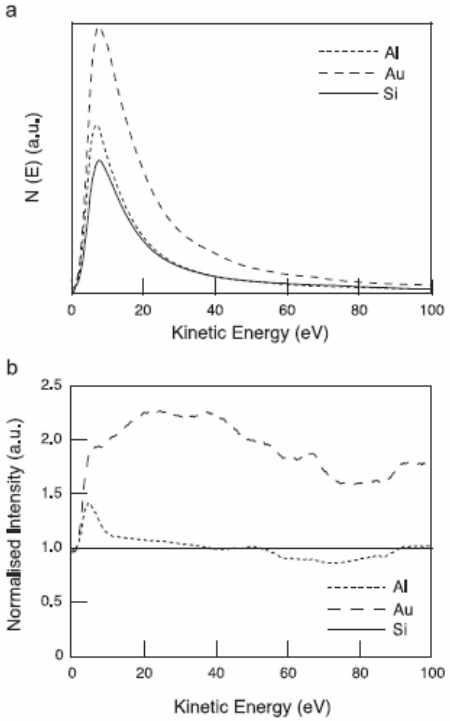
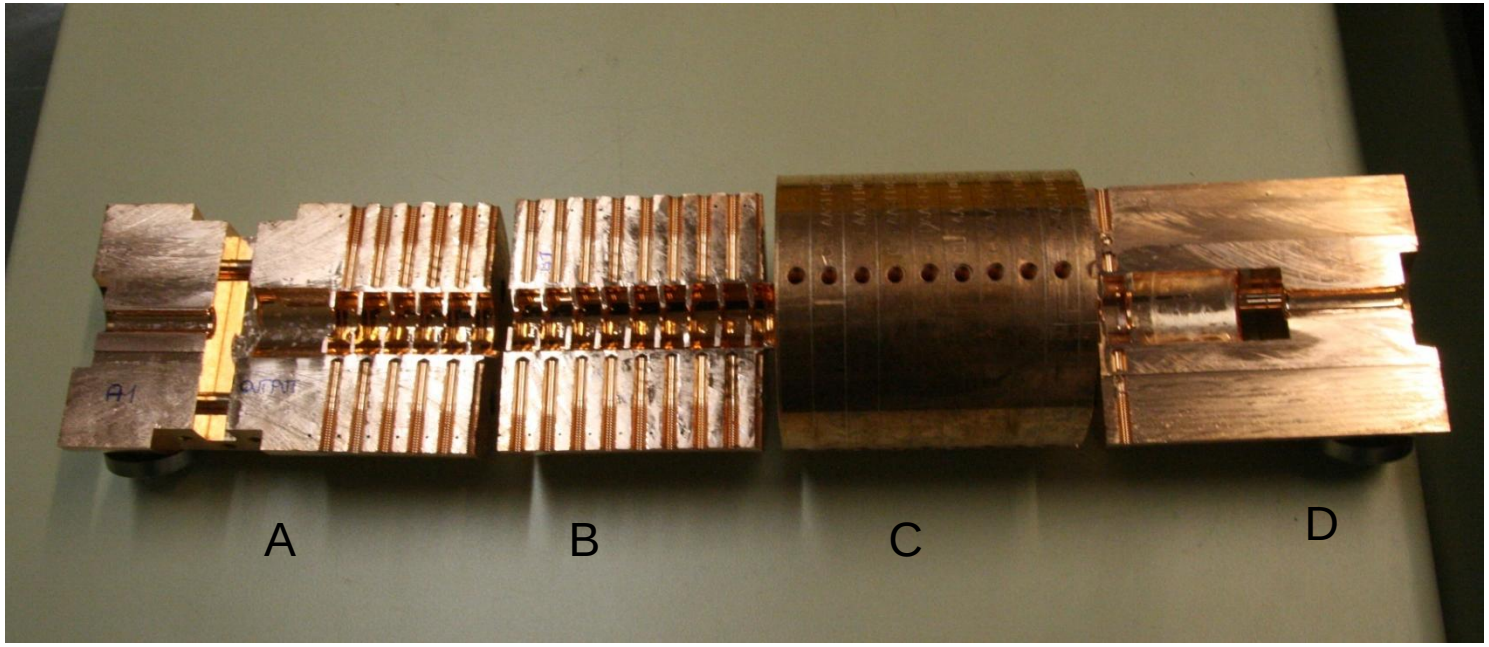


Fig. 3. (a) N(E) spectra on model specimen. (b) Plots of normalised intensity of Al and Au by that of Si. Dotted line, represents Al; dashed, Au; and solid, Si.

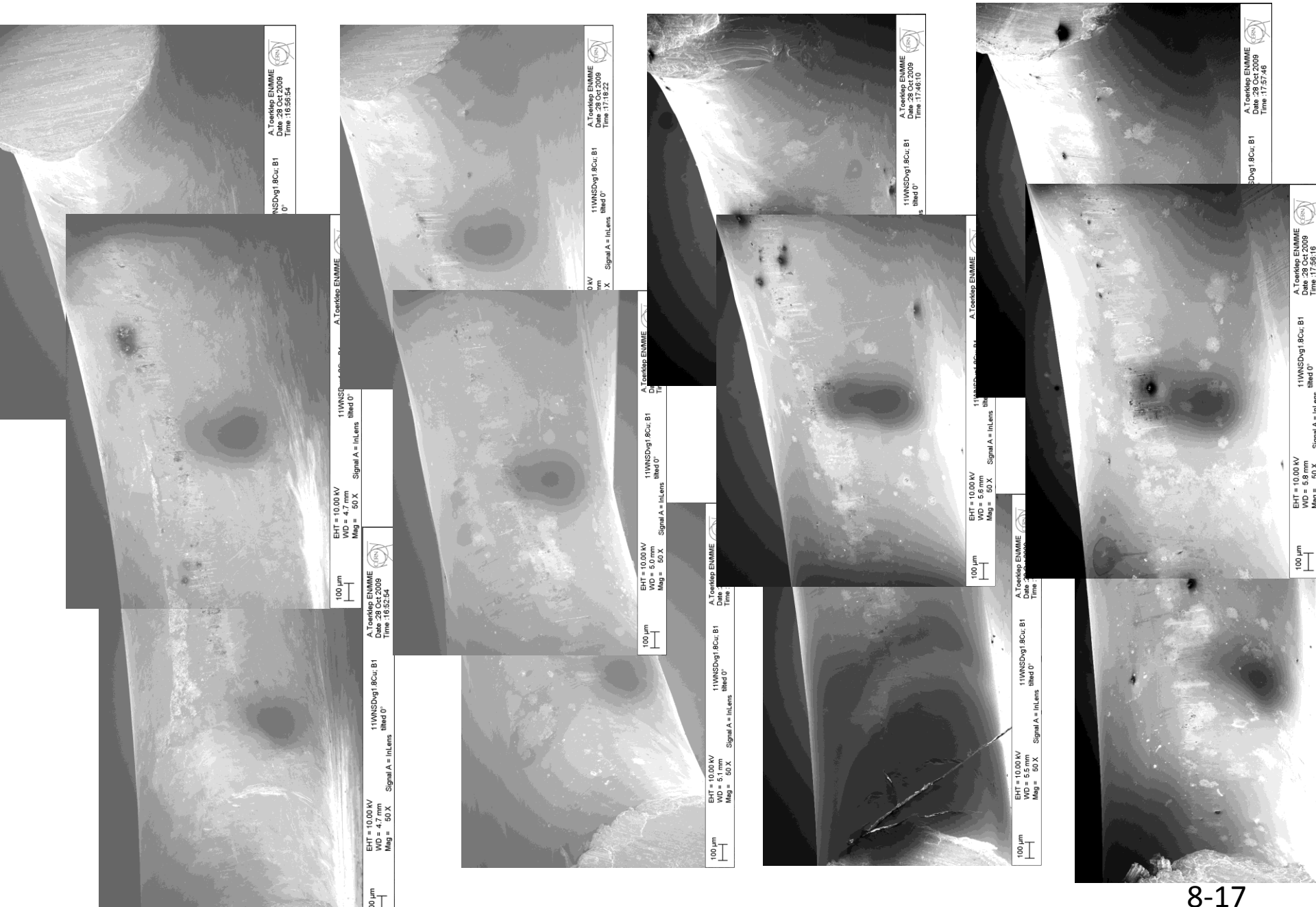
T24 - 11WNSDvg1.8Cu

Post mortem SEM inspection



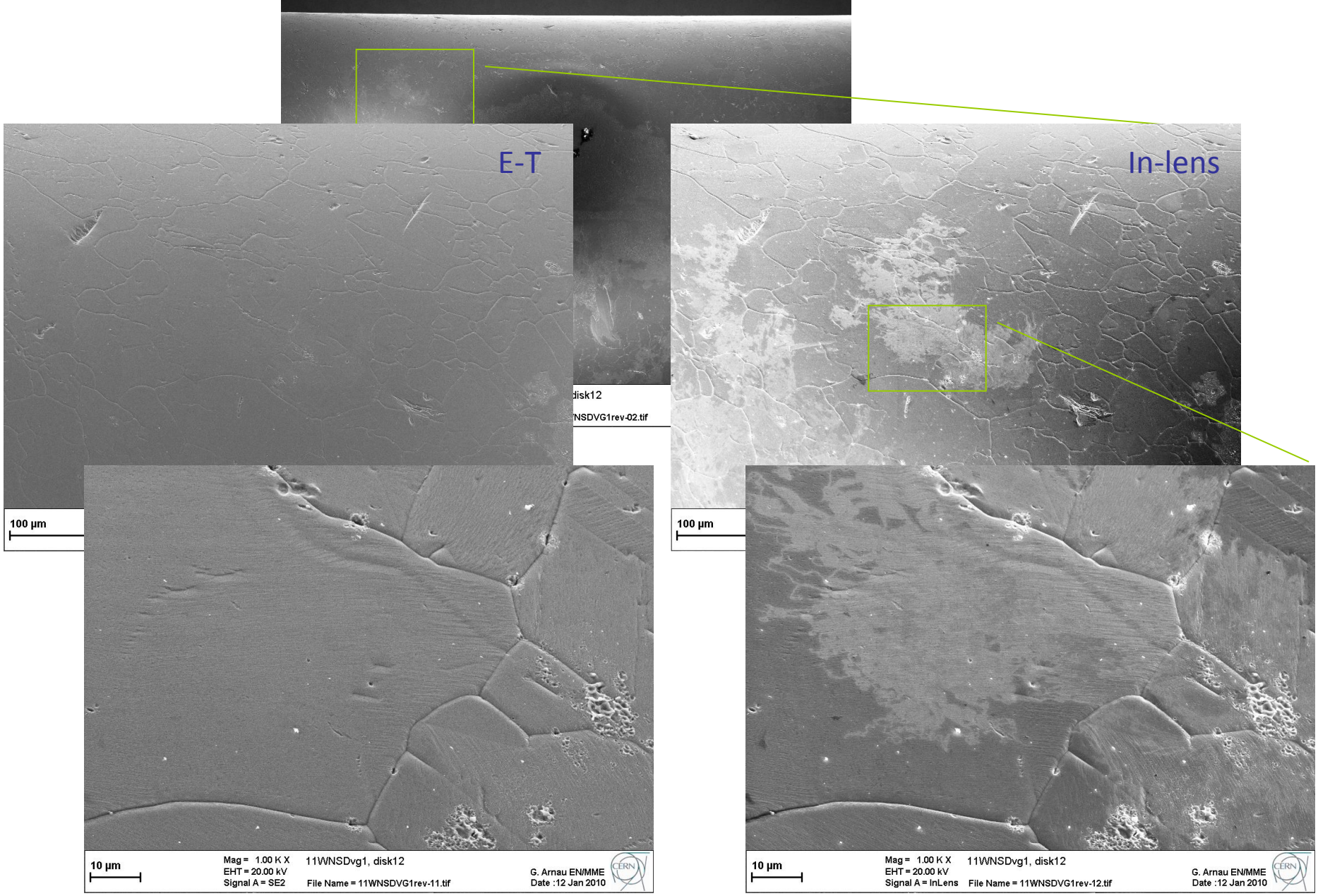
A. Toerklep EN/MME
G. Arnau Izquierdo EN/MME

B1


100 µm
EHT = 10.00 kV
WD = 4.7 mm
Mag = 50 X
11WNSDvg1.8Cu; B1
tilted 0°
Signal A = InLens
A.Toerklep EN/MME
Date :28 Oct 2009
Time :16:52:54
100 µm
EHT = 10.00 kV
WD = 4.7 mm
Mag = 50 X
11WNSDvg1.8Cu; B1
tilted 0°
Signal A = InLens
A.Toerklep EN/MME
Date :28 Oct 2009
Time :16:56:54
100 µm
EHT = 10.00 kV
WD = 5.0 mm
Mag = 50 X
11WNSDvg1.8Cu; B1
tilted 0°
Signal A = InLens
A.Toerklep EN/MME
Date :28 Oct 2009
Time :17:18:22
100 µm
EHT = 10.00 kV
WD = 5.1 mm
Mag = 50 X
11WNSDvg1.8Cu; B1
tilted 0°
Signal A = InLens
A.Toerklep EN/MME
Date :28 Oct 2009
Time :17:46:10
100 µm
EHT = 10.00 kV
WD = 5.6 mm
Mag = 50 X
11WNSDvg1.8Cu; B1
tilted 0°
Signal A = InLens
A.Toerklep EN/MME
Date :28 Oct 2009
Time :17:57:46
100 µm
EHT = 10.00 kV
WD = 5.5 mm
Mag = 50 X
11WNSDvg1.8Cu; B1
tilted 0°
Signal A = InLens
A.Toerklep EN/MME
Date :28 Oct 2009
Time :17:58:18
100 µm
EHT = 10.00 kV
WD = 5.8 mm
Mag = 50 X
11WNSDvg1.8Cu; B1
tilted 0°
Signal A = InLens
A.Toerklep EN/MME
Date :28 Oct 2009
Time :17:59:42

8-20

8-17

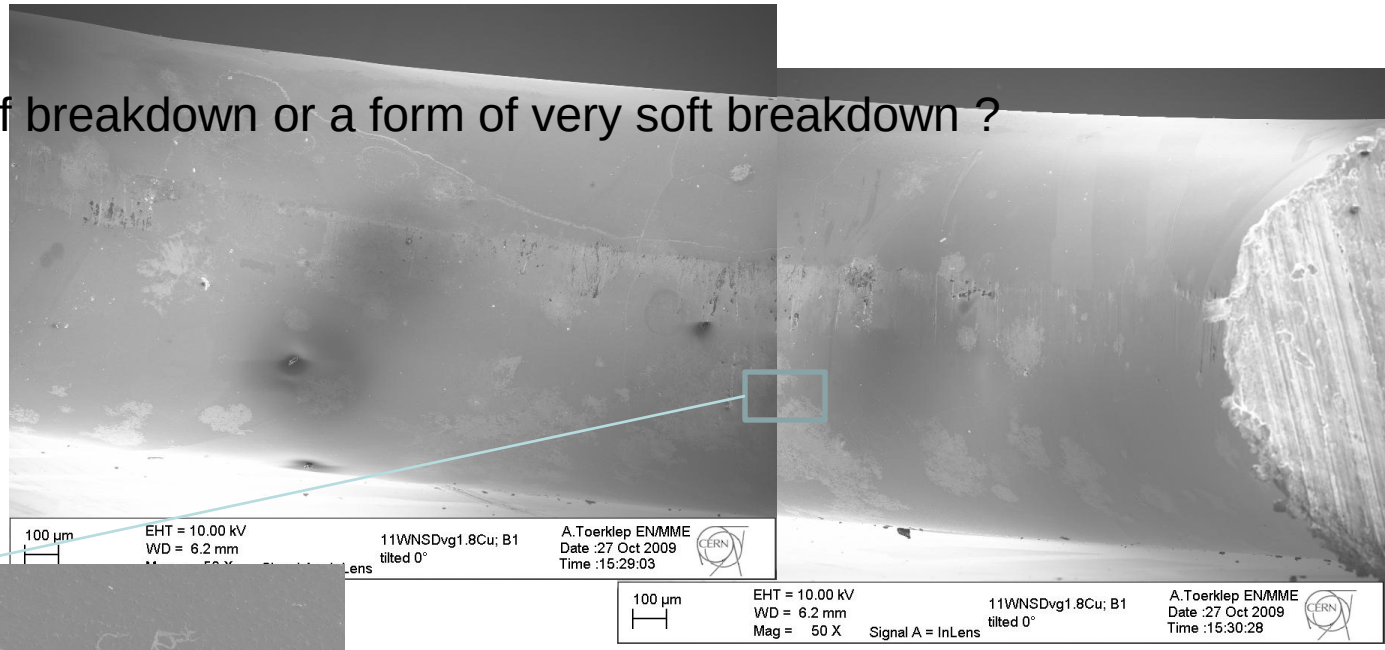


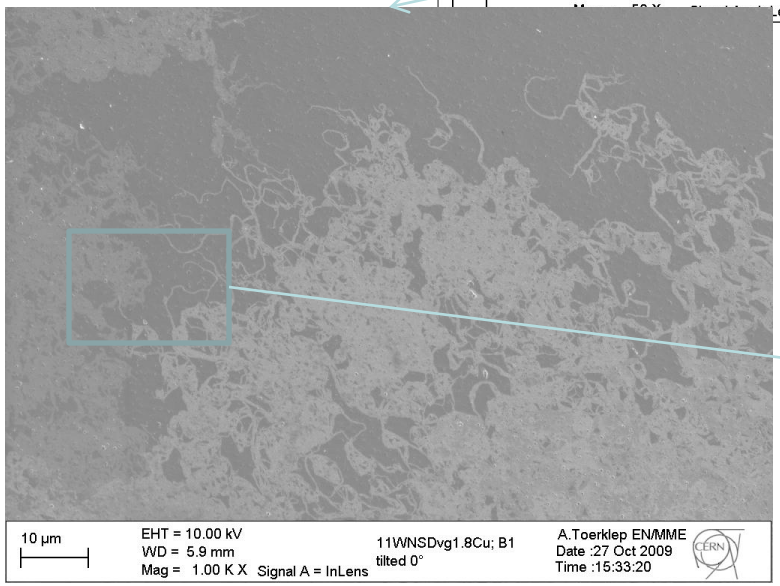
→ presence of worm-like features around some craters close to the big region with the dirt

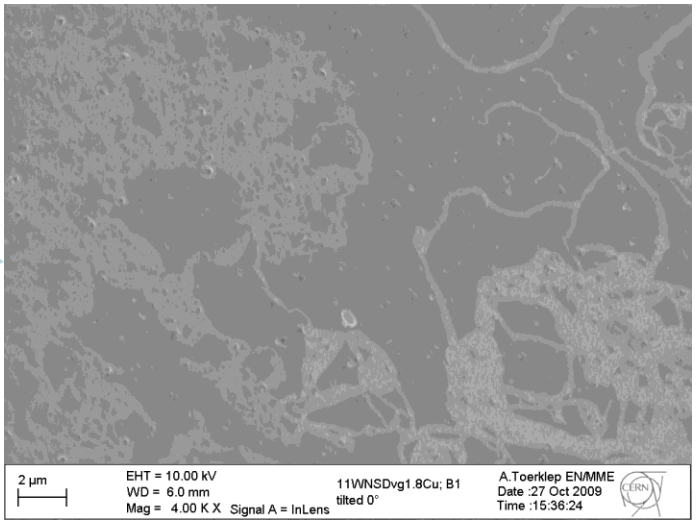
Worm-like features

In most of the patches of activity the edges are not sharp but seem to be made of a mess of wrinkled lines

Is it a kind of prelude of breakdown or a form of very soft breakdown ?

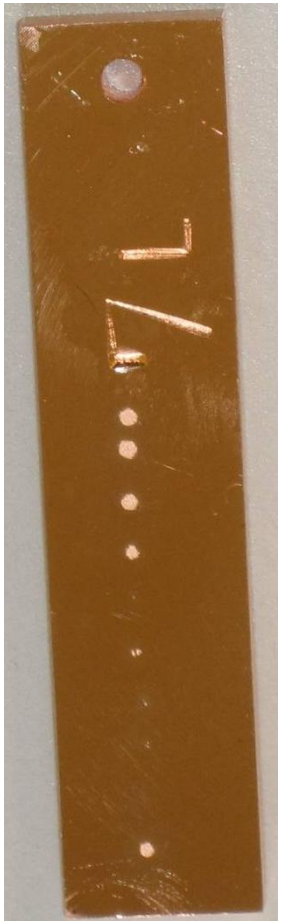






DC spark – Cu45

7N-LG



EDMS: **1070707**

12/04/2010 P.Alknes EN/MME

Sample: 7N-LG Cu (45)
99.99999 % purity

Sample processing

1. Rough shaping by WDM from blank of 140mm diameter with 20mm thickness.
2. Light etching with acid for removing contamination by WDM.
3. Diamond turning
4. Annealing at 600 deg C./2 hours in vacuum.

Object

-Observe and take SEM images of the sampled spots on sample Cu 45
-Measure the size of all spots.
-BSE image for estimation of grain size and location of craters with respect to grain boundaries

Results

All spots observed and meassured
Worm like features visible only in the small spots (2 – 6) with the inlens detector

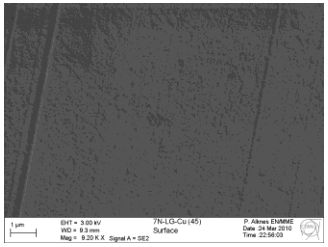
Sample parameters

Spot #	spot z	meas. Type	Tot. #sparks	Initial beta	Last beta	Gap measurement (Final distance confirmation)	measurement Term		Pressure	Pressure	Comments (Sample Install Date 26/01/2010)
1	4.05	Beta-BDF-cond-BDR	>100	-	40.44	No	2/22/2010 17:36:03	2/24/2010 20:47:39	7.1E-10	7.4E-10	
2	4.15	Beta-BDF	1	/	/	No	2/24/2010 21:14:25	2/24/2010 21:29:25	7.2E-10	7.1E-10	
3	4.25	Beta-BDF	2	16.72	59	No	2/24/2010 22:13:22	2/24/2010 22:54:22	7.6E-10	7.3E-10	
4	4.35	Beta-BDF	5	21.81	38.7	No	2/25/2010 11:02:14	2/25/2010 14:00:14	6.6E-10	7.0E-10	
5	4.45	Beta-BDF	22	11.7	54.75	No	2/25/2010 14:18:18	2/25/2010 21:07:18	7.0E-10	7.0E-10	
6	4.55	Beta-BDF	1	9.23	/	No	2/26/2010 08:01:10	2/27/2010 00:34:10	6.5E-10	6.7E-10	A cable from HV-PS had a bad connection
7	4.65	Beta-BDR-cond-BDR	>100	6.57	-	No	2/27/2010 13:50:04	3/01/2010 21:48:04	6.8E-10	6.8E-10	A cable from HV-PS had a bad connection
8	4.75	Beta-BDF	>100	9.54	56.31	No	3/01/2010 22:05:00	3/03/2010 13:52:00	6.7E-10	6.1E-10	sparks at 450 MV/m by Jan //A cable from HV-PS had a bad connection
9	4.85	Beta-BDF-cond-BDR	>100	11.26	46.48	No	3/03/2010 14:16:30	3/06/2010 13:06:30	6.0E-10	6.4E-10	
10	4.95	Beta-BDR-cond-BDR	>100	43.67	48.56	No	3/06/2010 13:21:45	3/08/2010 07:48:45	5.8E-10	4.9E-10	

Shown here after

TOC

surface



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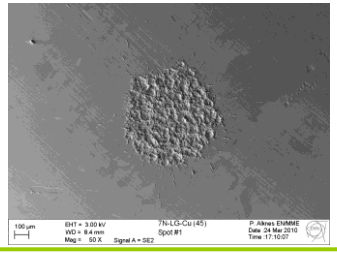
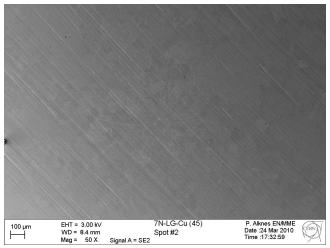


#2



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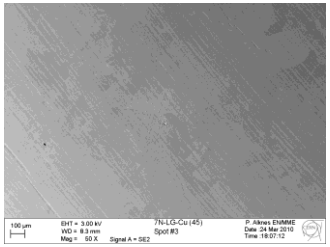

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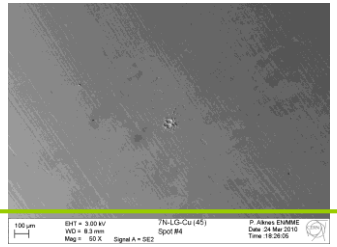

Shown here after

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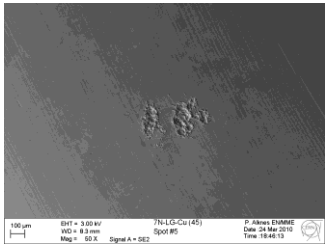

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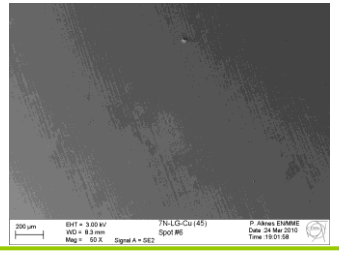

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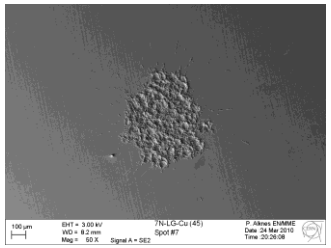

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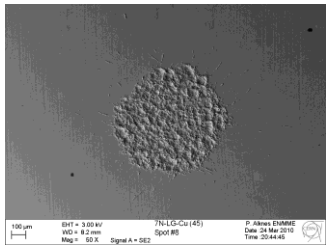

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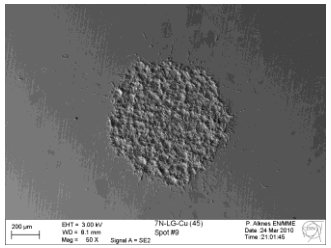
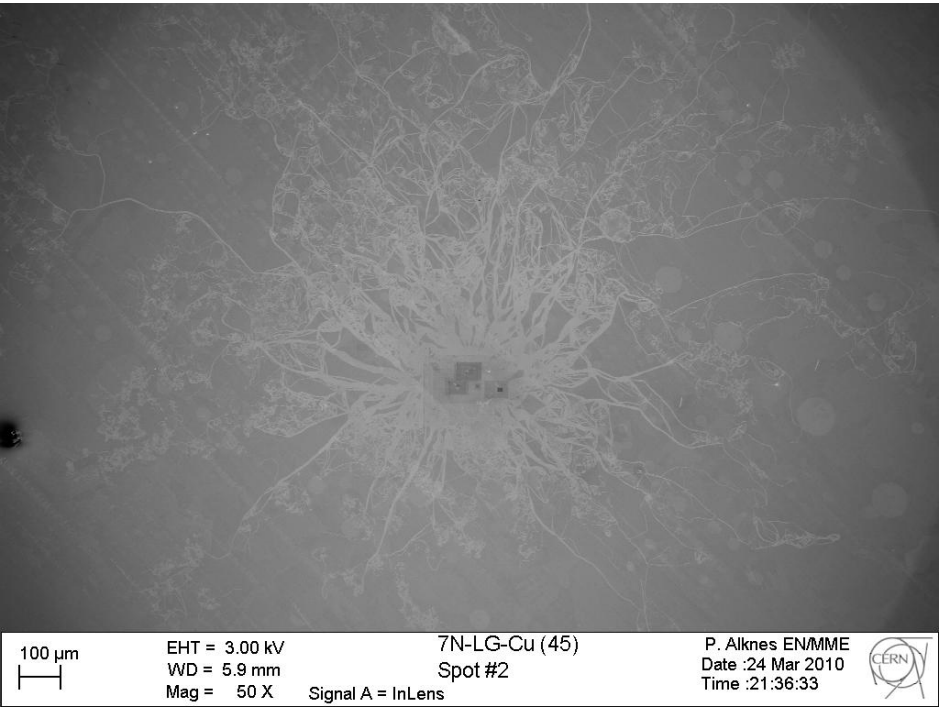
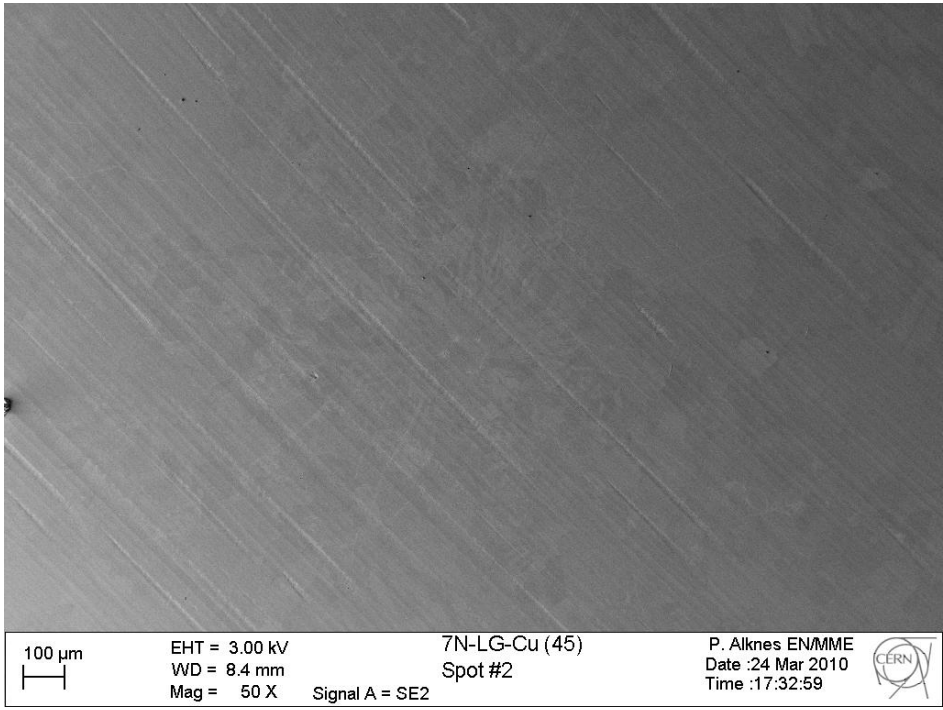
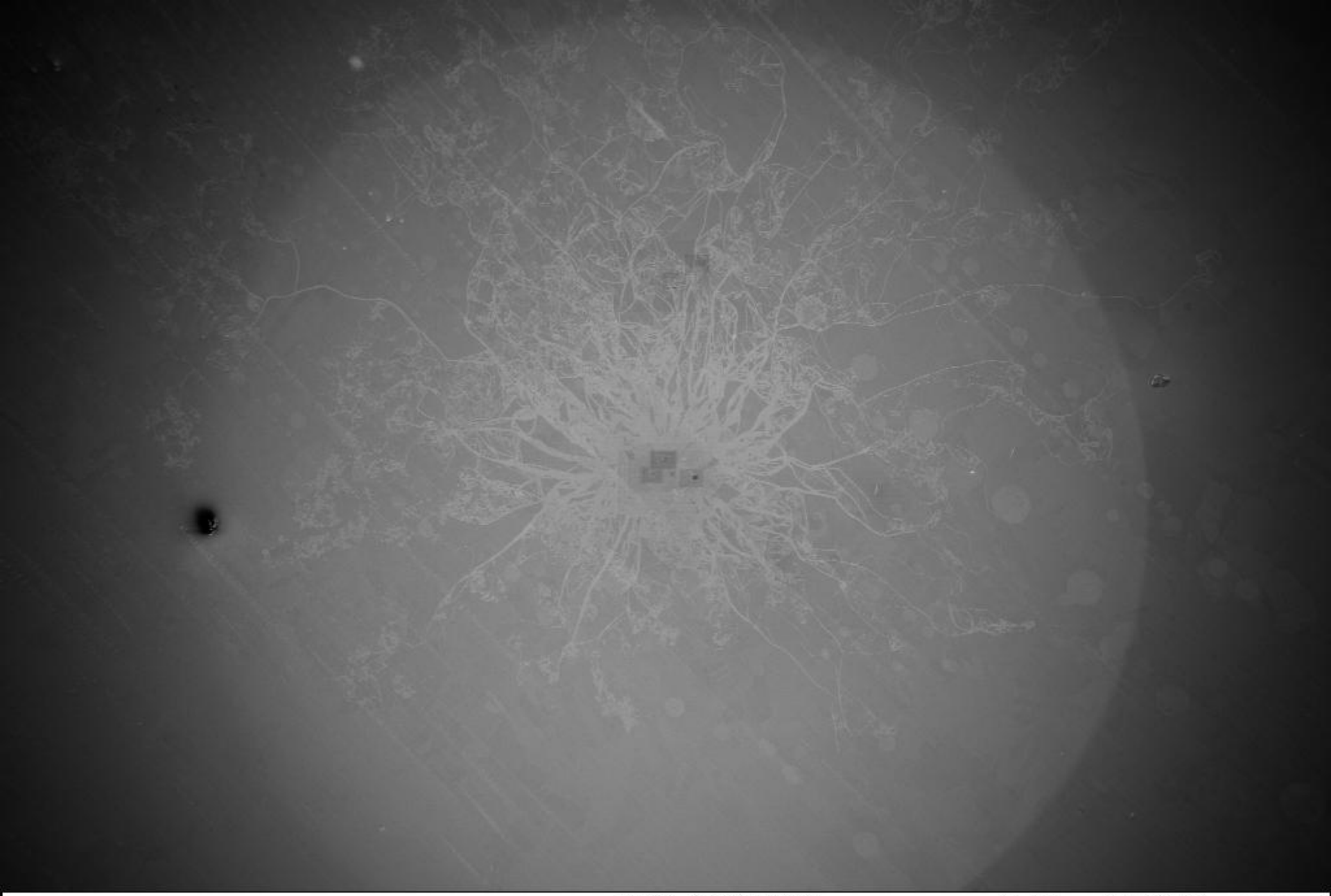


Worm like features





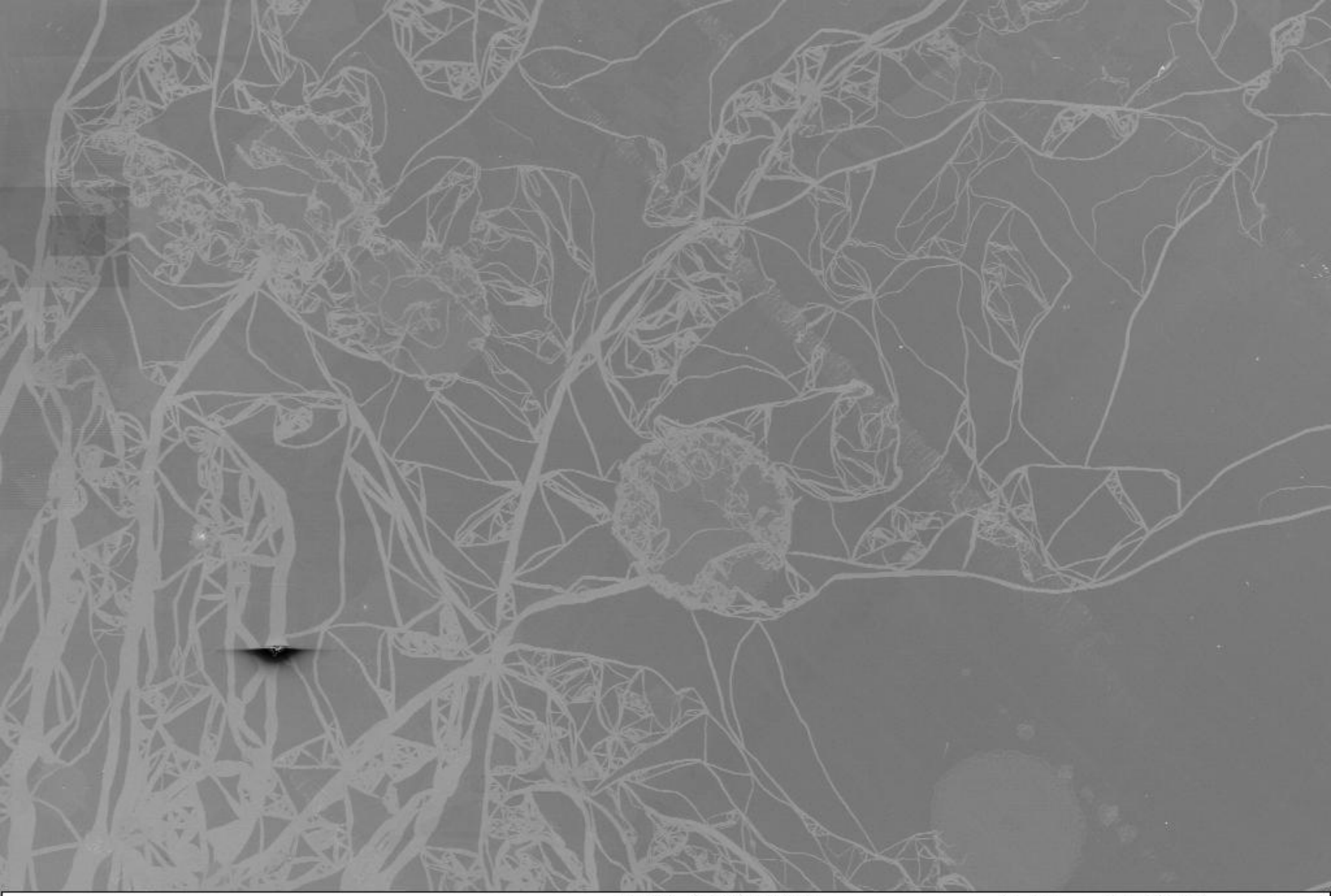


200 µm

EHT = 3.00 kV
WD = 5.9 mm
Mag = 35 X

7N-LG-Cu (45)
Spot #2
Signal A = InLens

P. Alknes EN/MME
Date :24 Mar 2010
Time :21:45:08

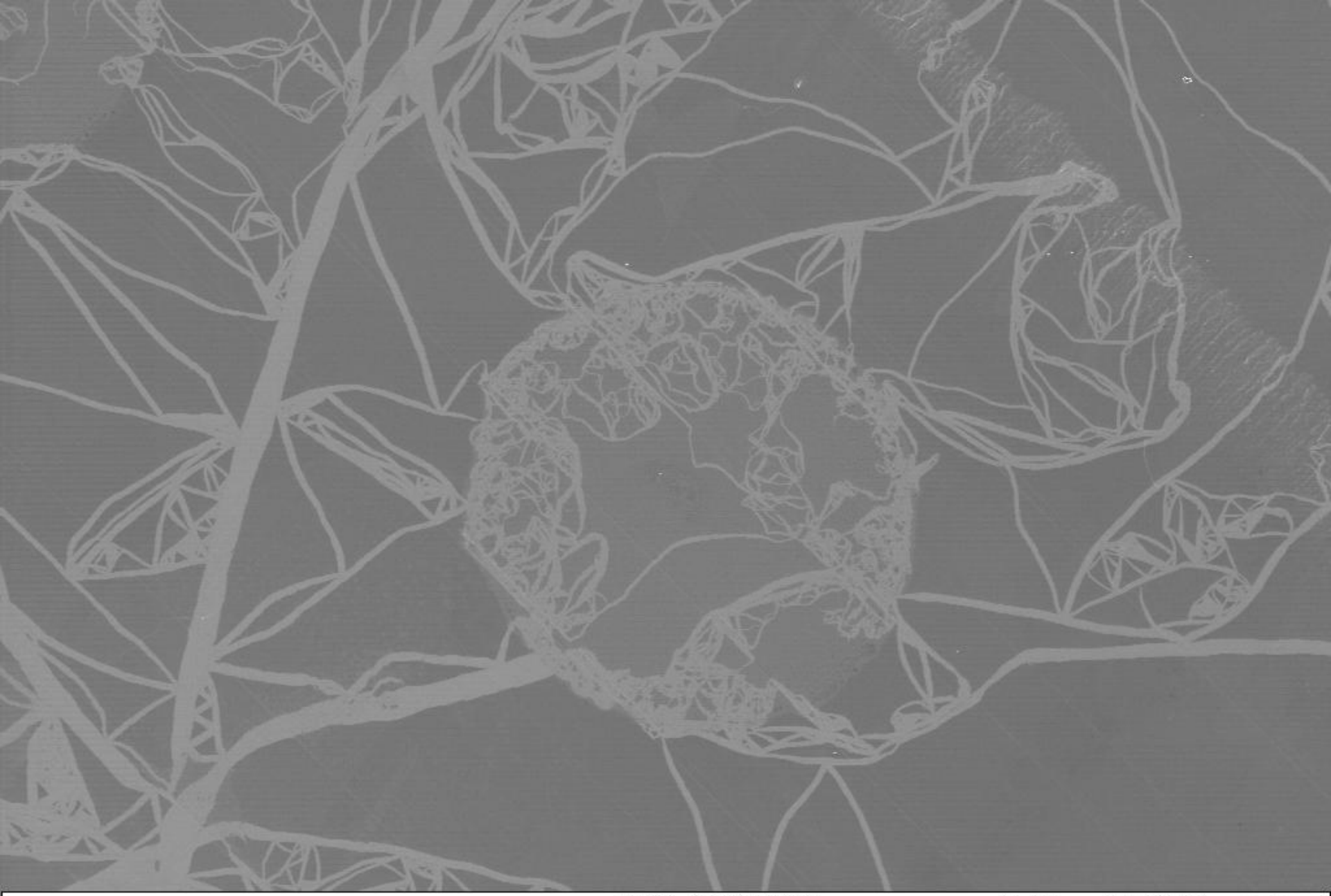


20 µm

EHT = 3.00 kV
WD = 5.9 mm
Mag = 200 X

7N-LG-Cu (45)
Spot #2
Signal A = InLens

P. Alknes EN/MME
Date :24 Mar 2010
Time :21:53:04

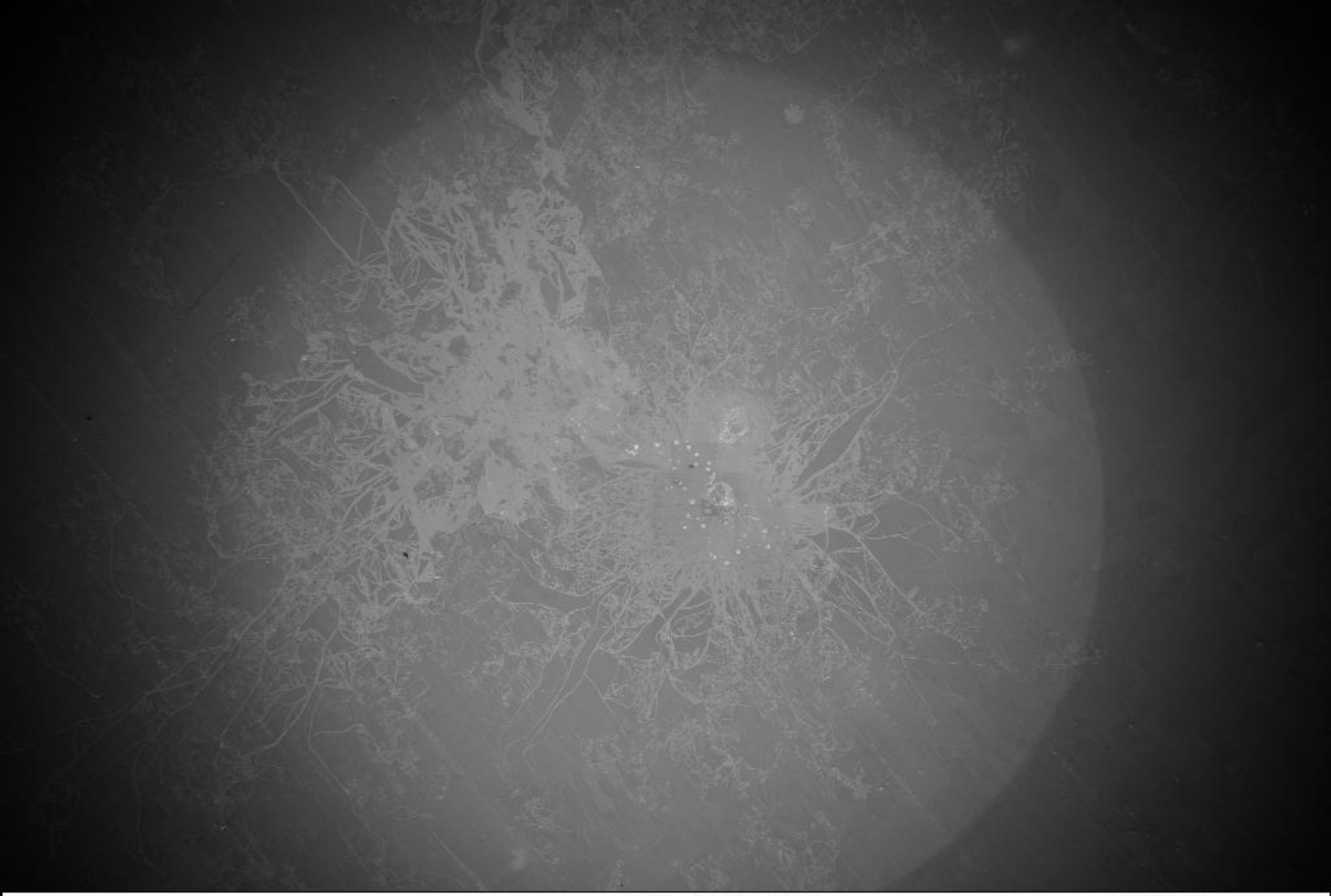


10 µm

EHT = 3.00 kV
WD = 5.9 mm
Mag = 500 X

7N-LG-Cu (45)
Spot #2
Signal A = InLens

P. Alknes EN/MME
Date :24 Mar 2010
Time :21:54:13



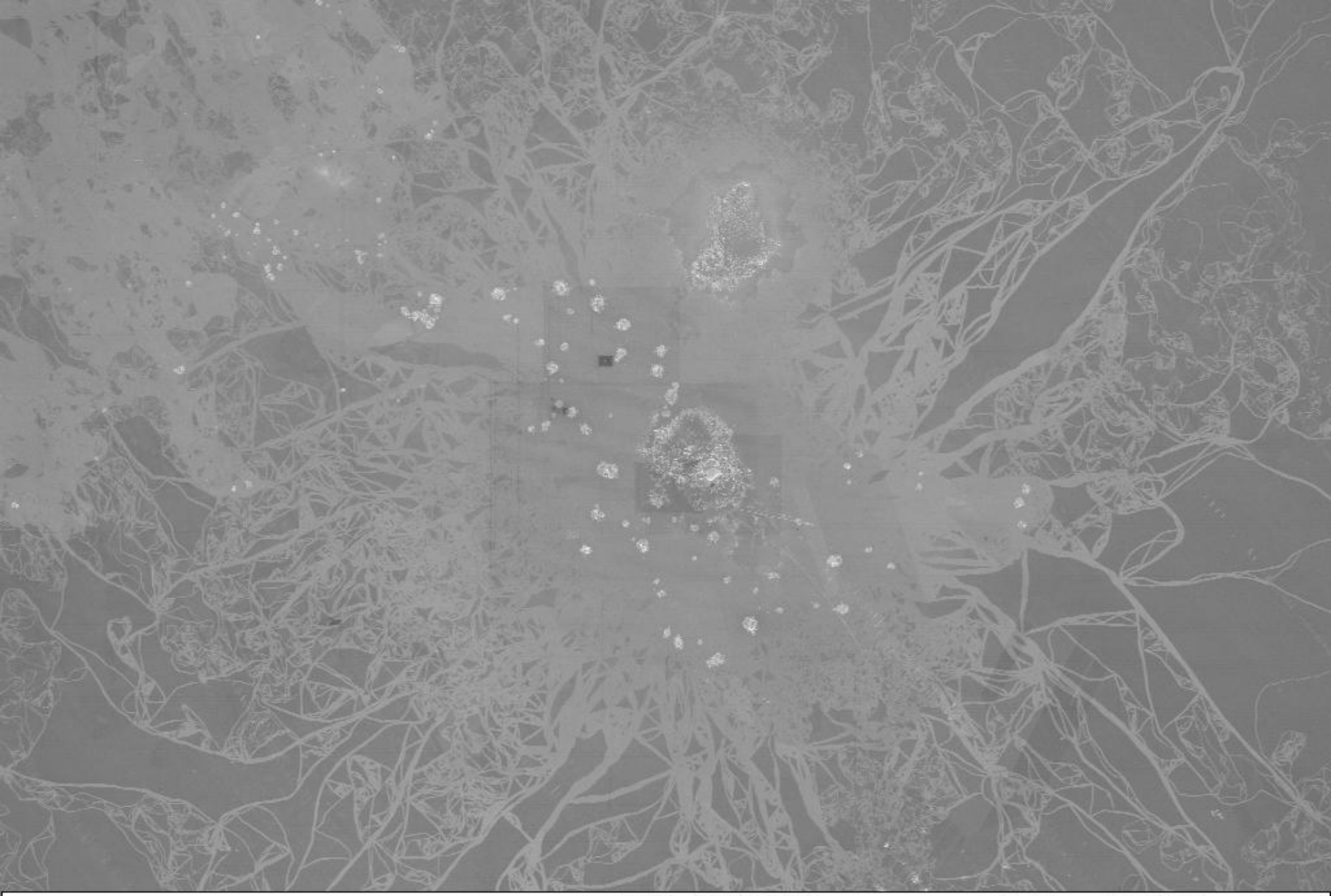
100 µm

EHT = 3.00 kV
WD = 5.9 mm
Mag = 33 X

7N-LG-Cu (45)
Spot #3

Signal A = InLens

P. Alknes EN/MME
Date :24 Mar 2010
Time :22:03:04



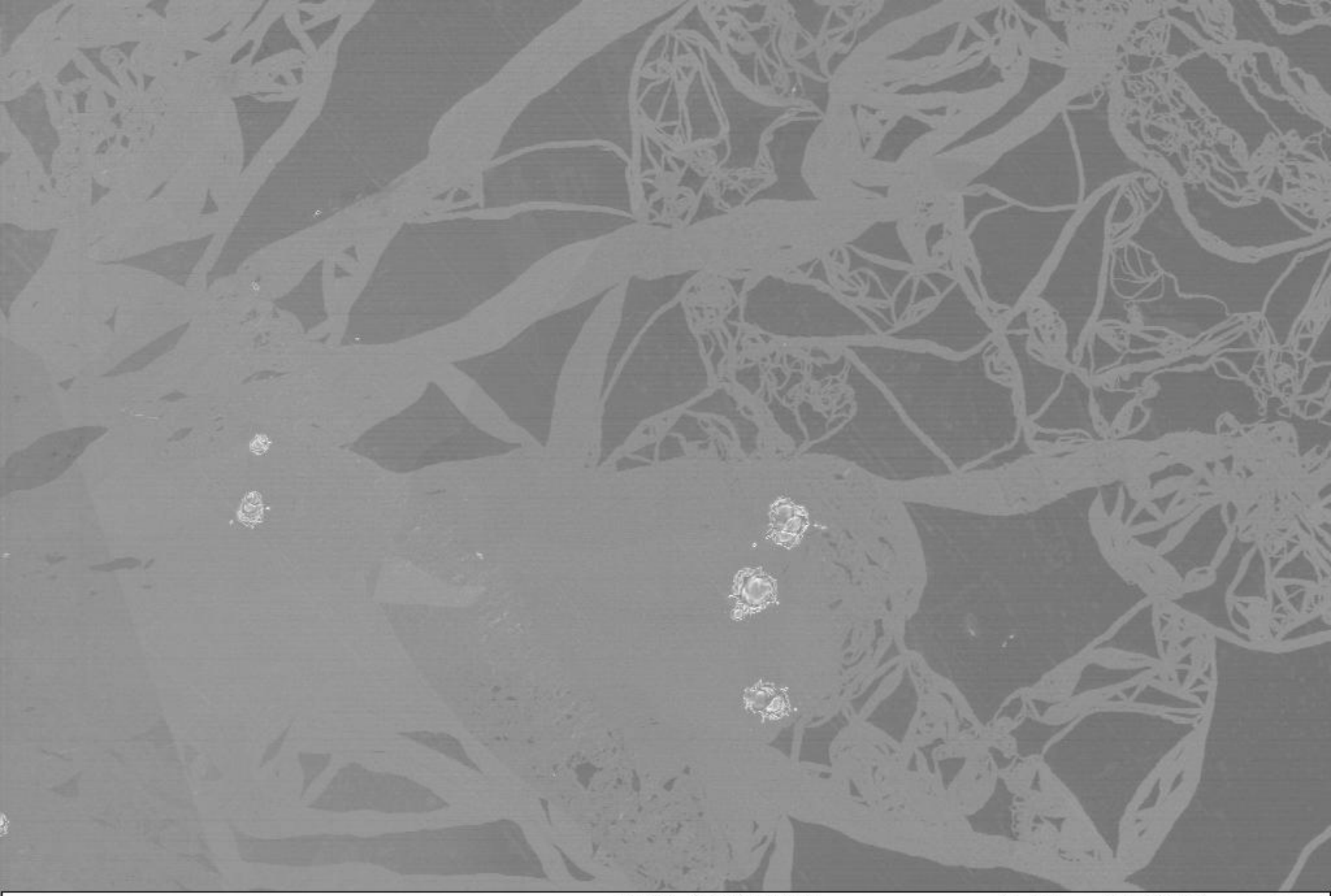
100 µm

EHT = 3.00 kV
WD = 5.9 mm
Mag = 100 X

7N-LG-Cu (45)
Spot #3

Signal A = InLens

P. Alknes EN/MME
Date :24 Mar 2010
Time :22:10:37

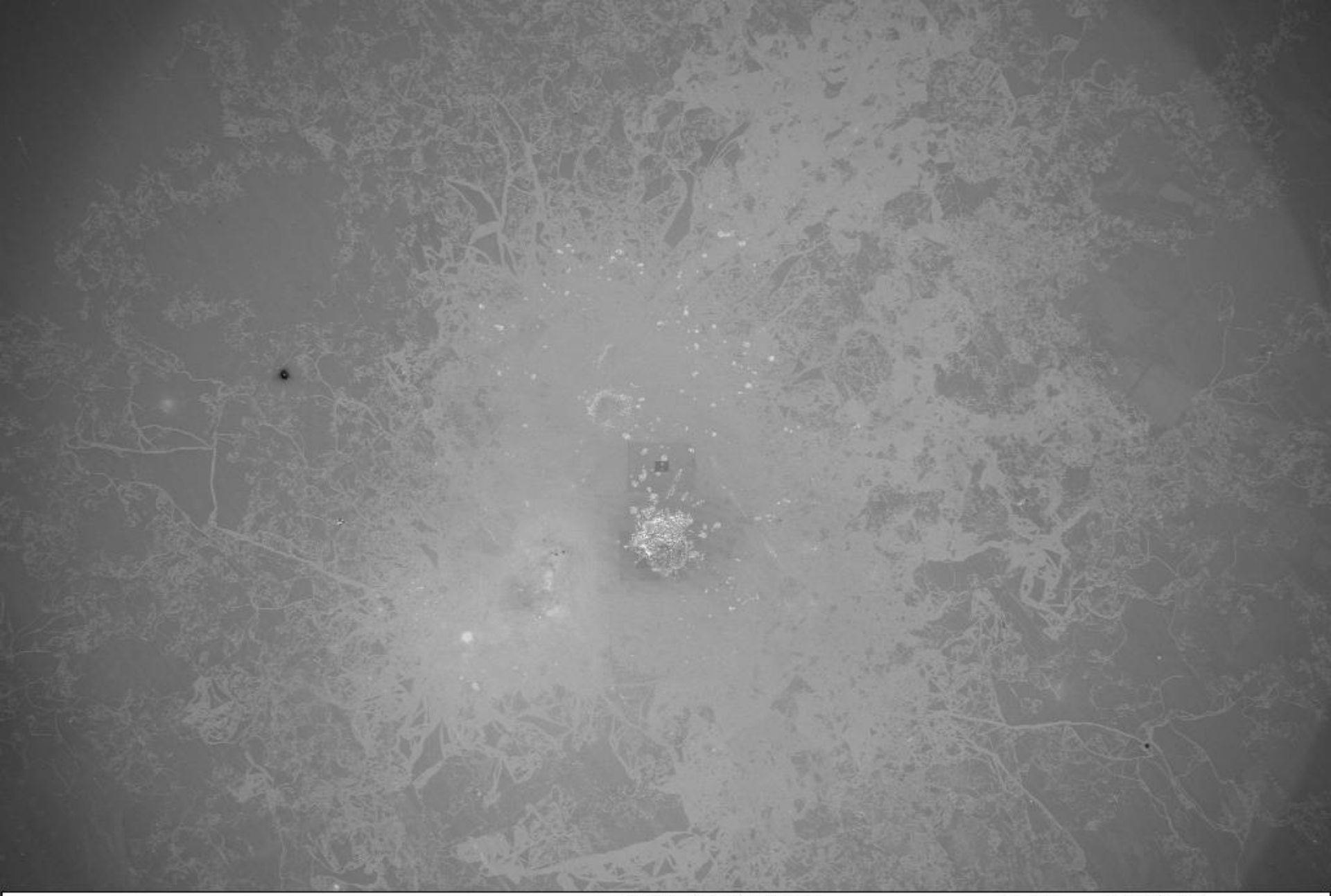


10 µm

EHT = 3.00 kV
WD = 5.9 mm
Mag = 500 X

7N-LG-Cu (45)
Spot #3
Signal A = InLens

P. Alknes EN/MME
Date :24 Mar 2010
Time :22:12:00



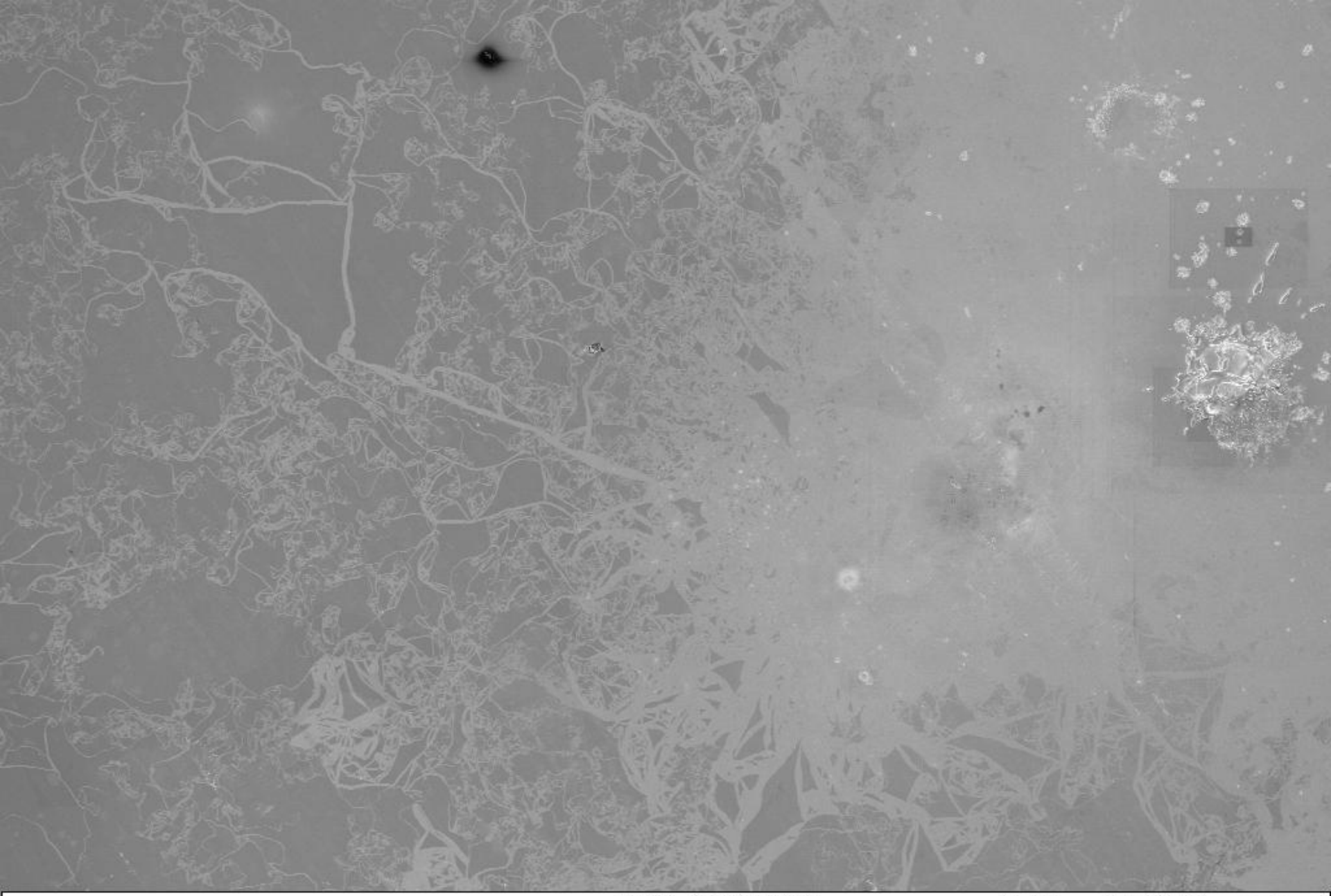
200 µm

EHT = 3.00 kV
WD = 5.8 mm
Mag = 50 X

Signal A = InLens

7N-LG-Cu (45)
Spot #4

P. Alknes EN/MME
Date :24 Mar 2010
Time :22:17:28



100 µm

EHT = 3.00 kV
WD = 5.8 mm
Mag = 100 X

7N-LG-Cu (45)
Spot #4
Signal A = InLens

P. Alknes EN/MME
Date :24 Mar 2010
Time :22:18:54

10 µm

EHT = 3.00 kV
WD = 5.8 mm
Mag = 500 X

7N-LG-Cu (45)
Spot #4

Signal A = InLens

P. Alknes EN/MME
Date :24 Mar 2010
Time :22:20:18

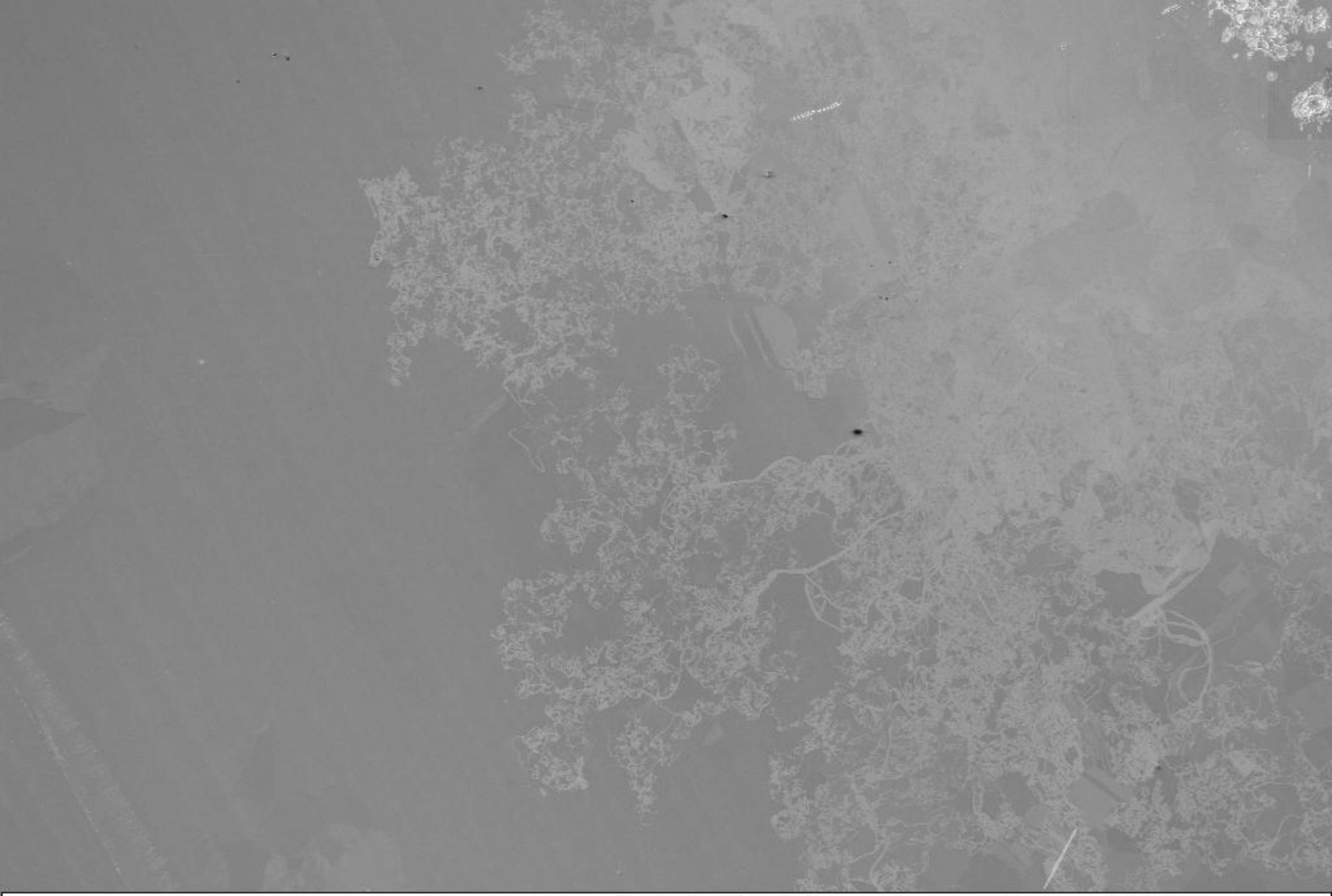
200 µm

EHT = 3.00 kV
WD = 5.8 mm
Mag = 44 X

Signal A = InLens

7N-LG-Cu (45)
Spot #5

P. Alknes EN/MME
Date :24 Mar 2010
Time :22:22:55

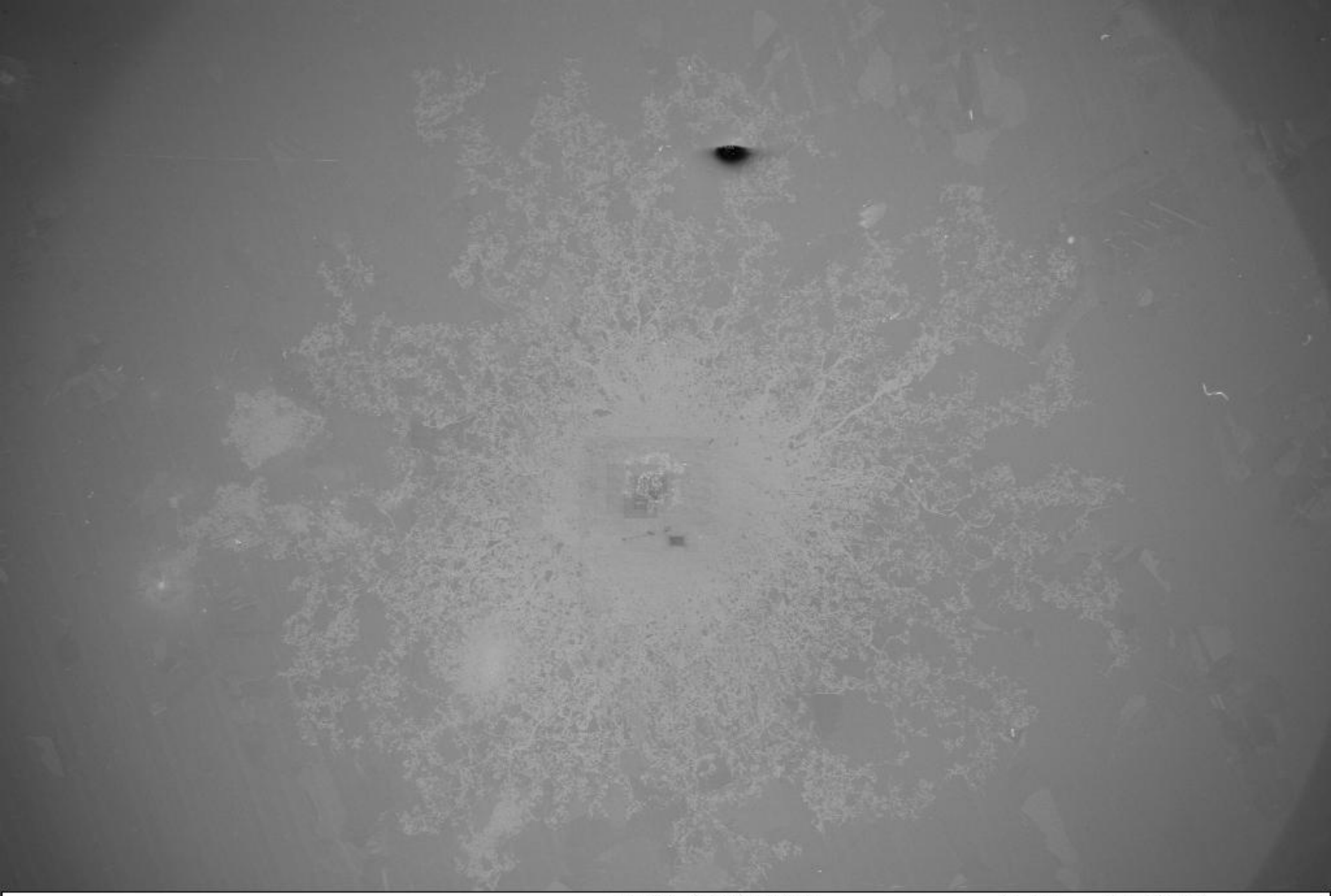


100 µm

EHT = 3.00 kV
WD = 5.8 mm
Mag = 100 X

7N-LG-Cu (45)
Spot #5
Signal A = InLens

P. Alknes EN/MME
Date :24 Mar 2010
Time :22:24:18



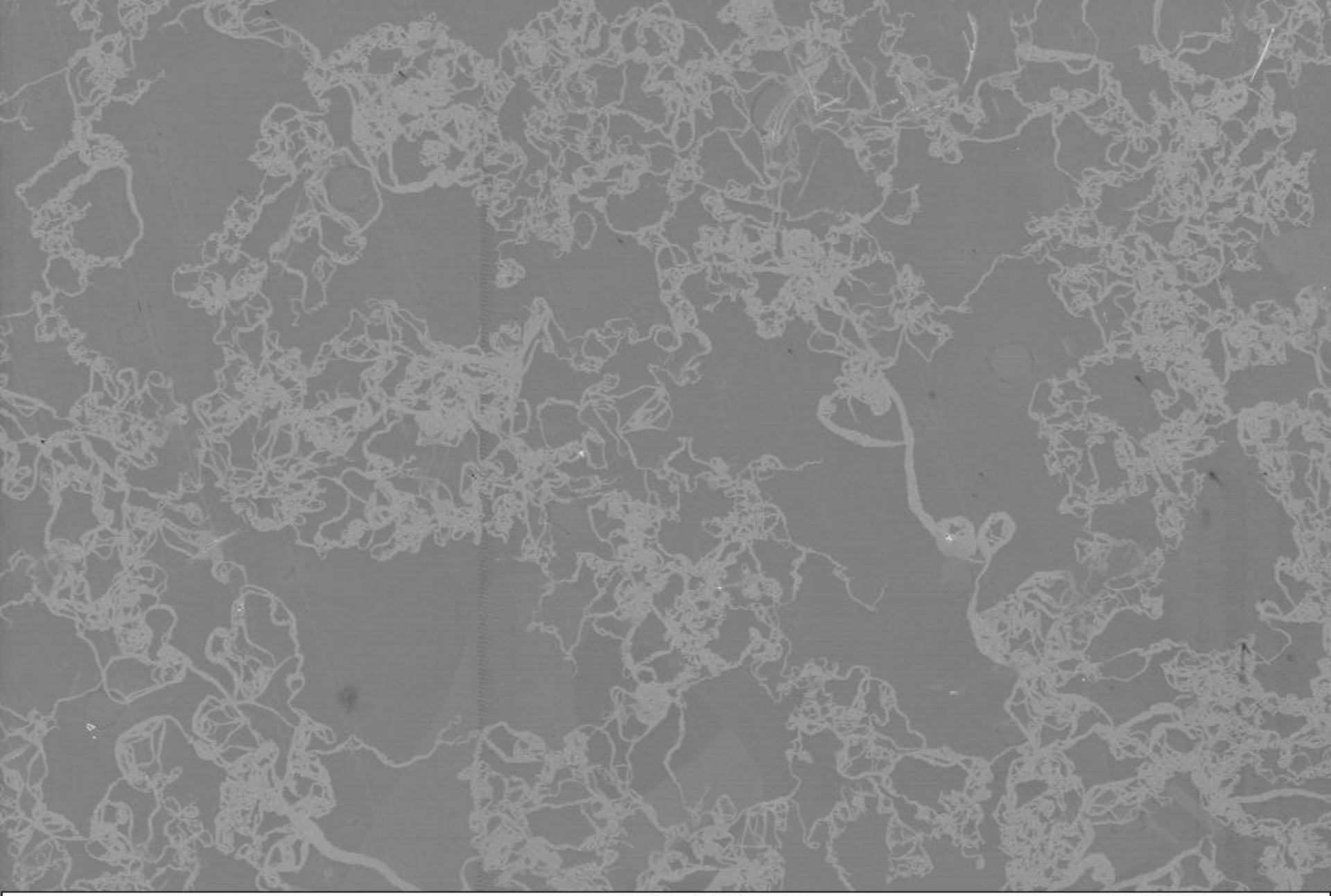
100 µm

EHT = 3.00 kV
WD = 5.7 mm
Mag = 50 X

Signal A = InLens

7N-LG-Cu (45)
Spot #6

P. Alknes EN/MME
Date :24 Mar 2010
Time :22:25:58



20 µm

EHT = 3.00 kV
WD = 5.7 mm
Mag = 500 X

Signal A = InLens

7N-LG-Cu (45)
Spot #6

P. Alknes EN/MME
Date :24 Mar 2010
Time :22:27:23