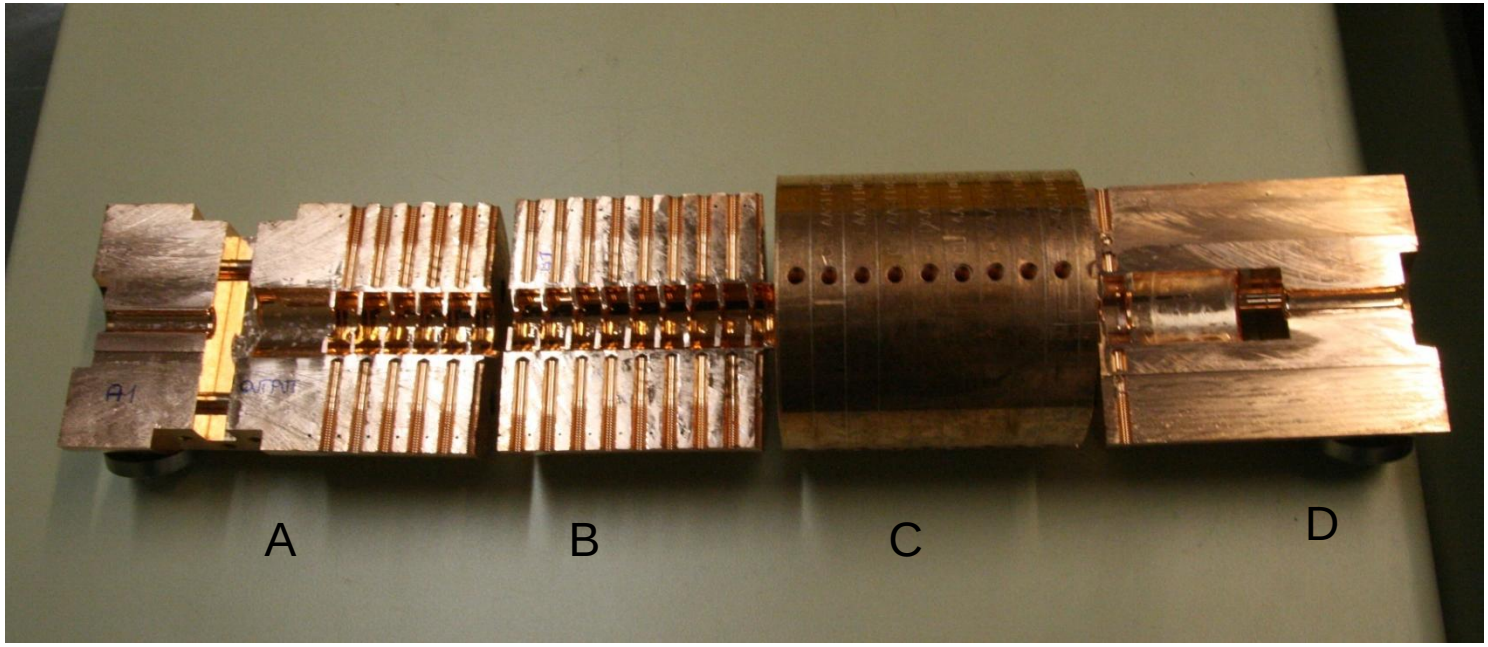
T24 - 11WNSDvg1.8Cu

Post mortem SEM inspection

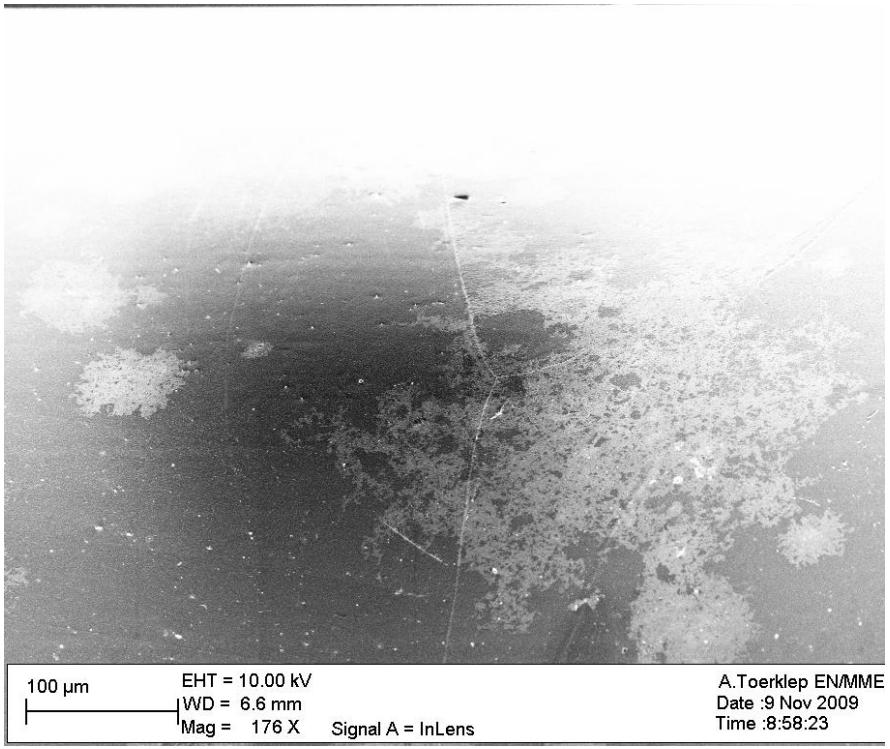


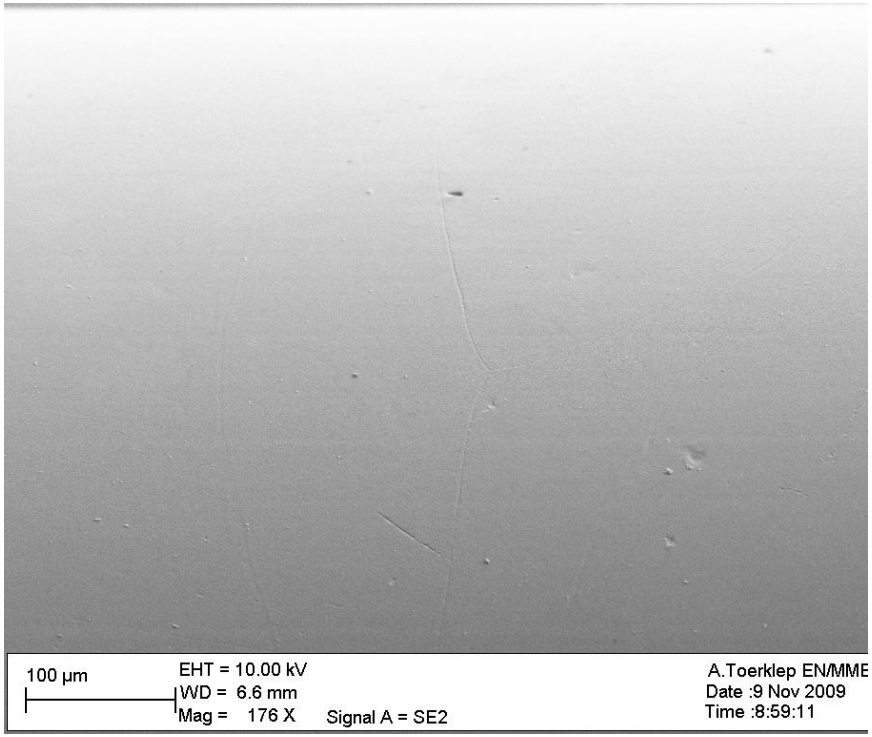
A. Toerklep EN/MME
G. Arnau Izquierdo EN/MME

Outline

- Low magnification cartography of the irises
  - A1 section
  - B1 section
  - B2 section
  - C1 section
- Reference surface
- Catalogue of features related with breakdown activity
  - Random distribution in the regions of high electric field
  - Patches with small craters only
  - Patches with (relatively) large craters in the centre
  - Patches with halos giving higher carbon signal
  - Worm-like very superficial activity
  - Other contaminants
- Extra features apparently not related with breakdown activity
  - Scratches on the flat top of the irises
  - Smaller recrystalised grains in regions deformed by tuning
  - Localised Al contamination in the surfaces of couplers
  - Brazing filler metal drop off the joint coupler/disk (confirms suspicion reported in EDMS 1000659)

In-lens detector vs standard Everhart-Thornley detector

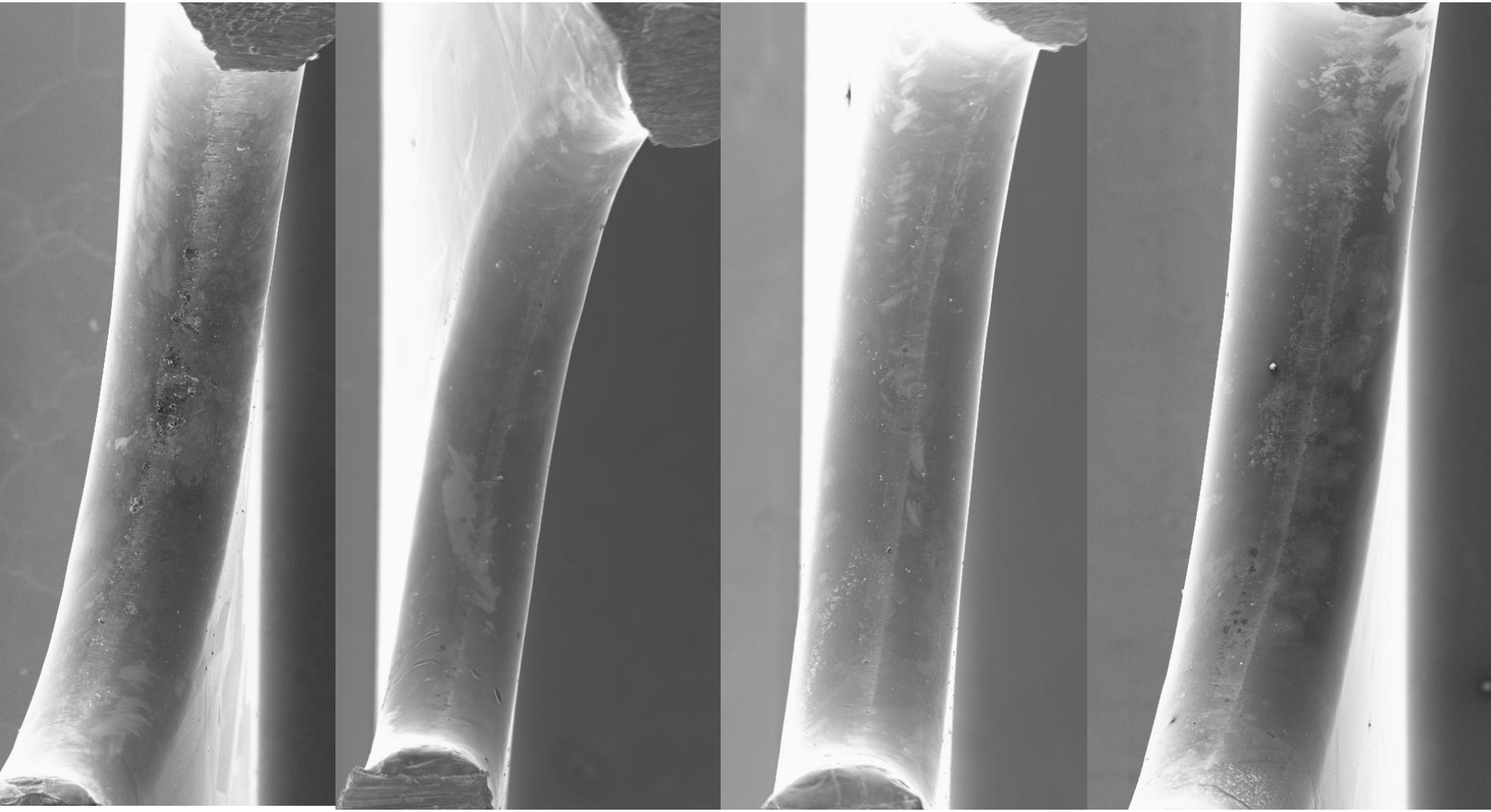




Outline

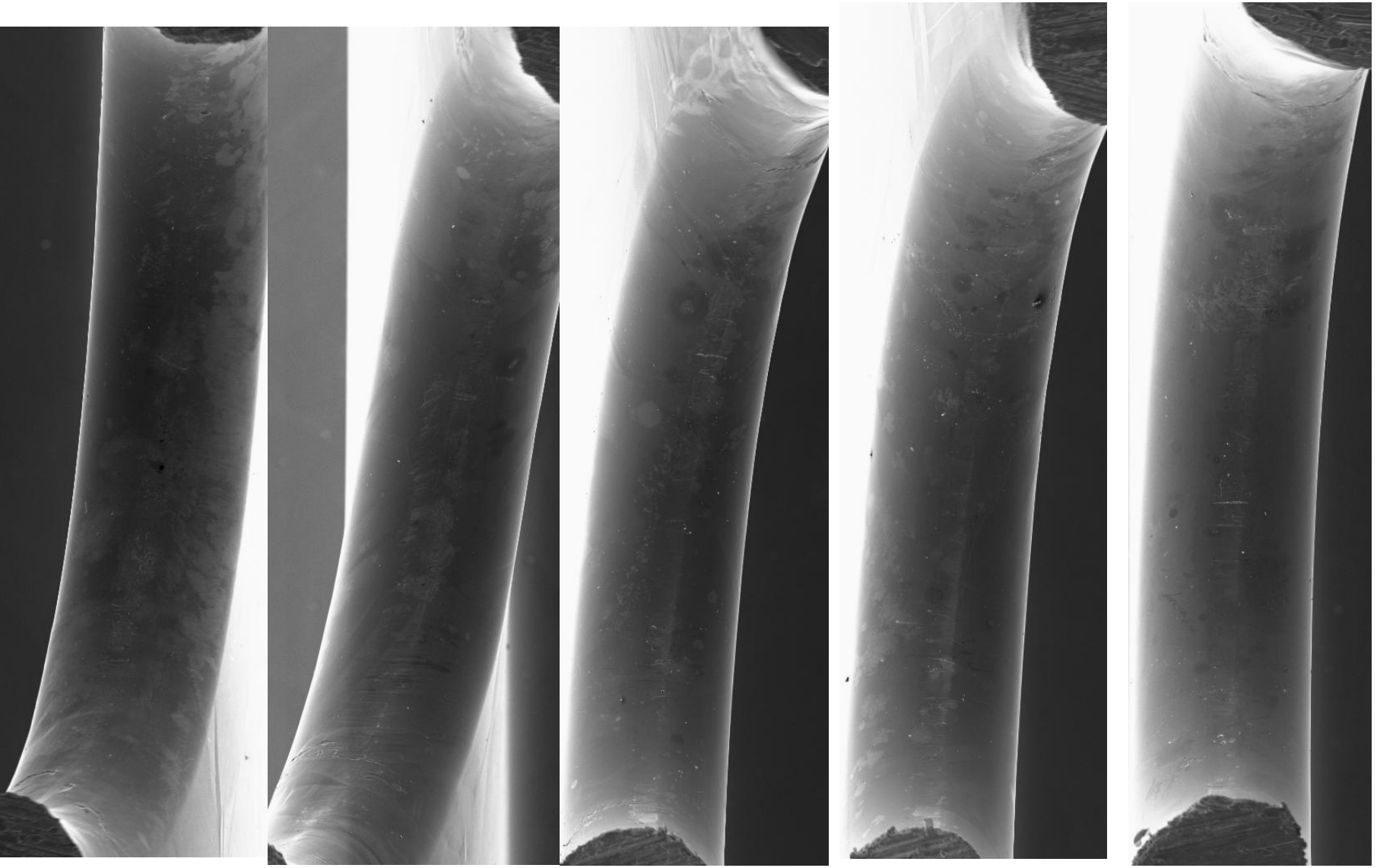
- Low magnification cartography of the irises
  - A1 section
  - B1 section
  - B2 section
  - C1 section
- Reference surface
- Catalogue of features related with breakdown activity
  - Random distribution in the regions of high electric field
  - Patches with small craters only
  - Patches with (relatively) large craters in the centre
  - Patches with halos giving higher carbon signal
  - Worm-like very superficial activity
  - Other contaminants
- Extra features apparently not related with breakdown activity
  - Scratches on the flat top of the irises
  - Smaller recrystalised grains in regions deformed by tuning
  - Localised Al contamination in the surfaces of couplers
  - Brazing filler metal drop off the joint coupler/disk (confirms suspicion reported in EDMS 1000659)

A1 – Leo 430i, E-T detector



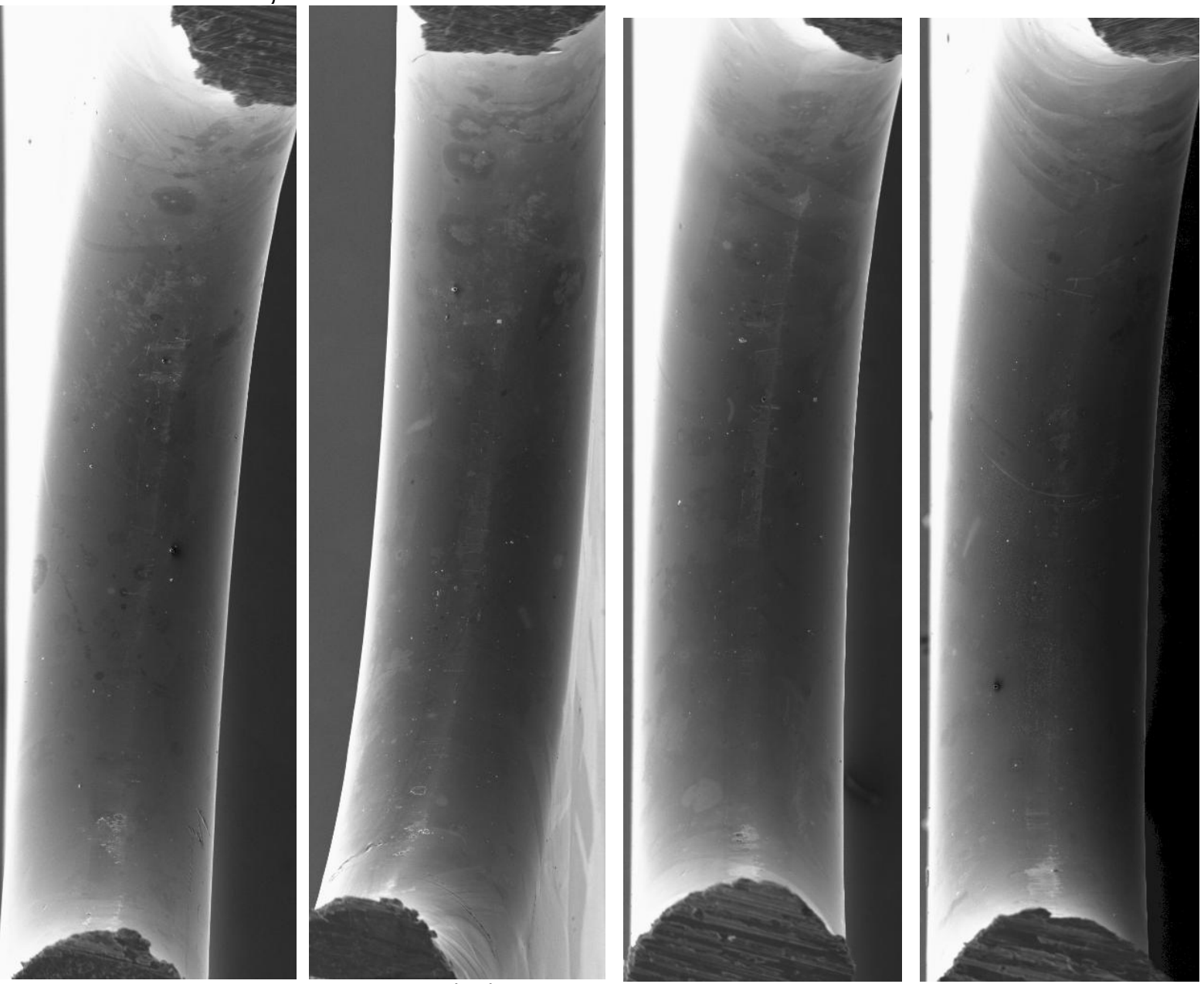
8-26 8-25 8-24 8-23

B1 – Leo 430i, E-T detector



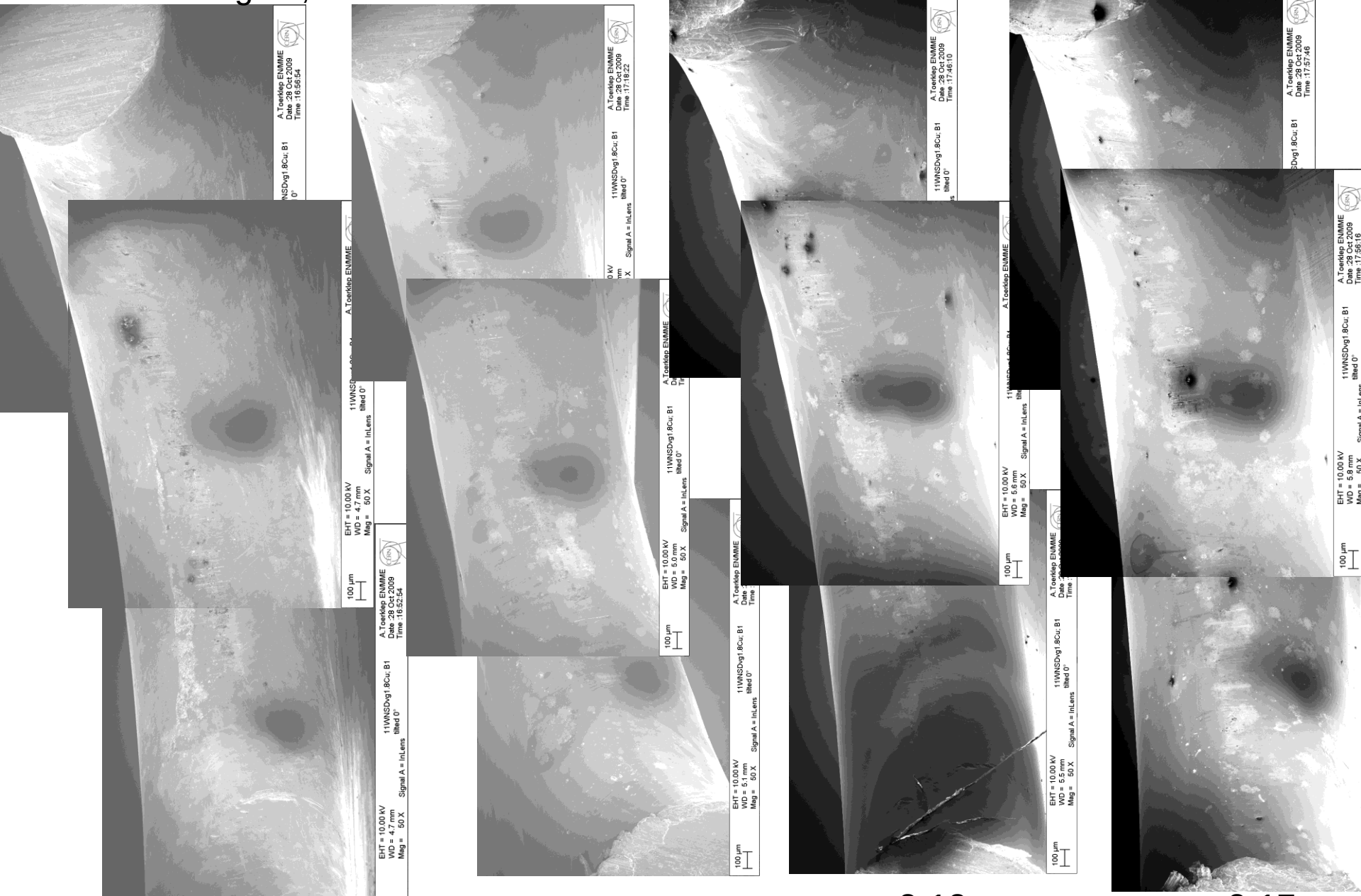
8-20 8-19 8-18 8-17 8-16

B1 – Leo 430i, E-T detector



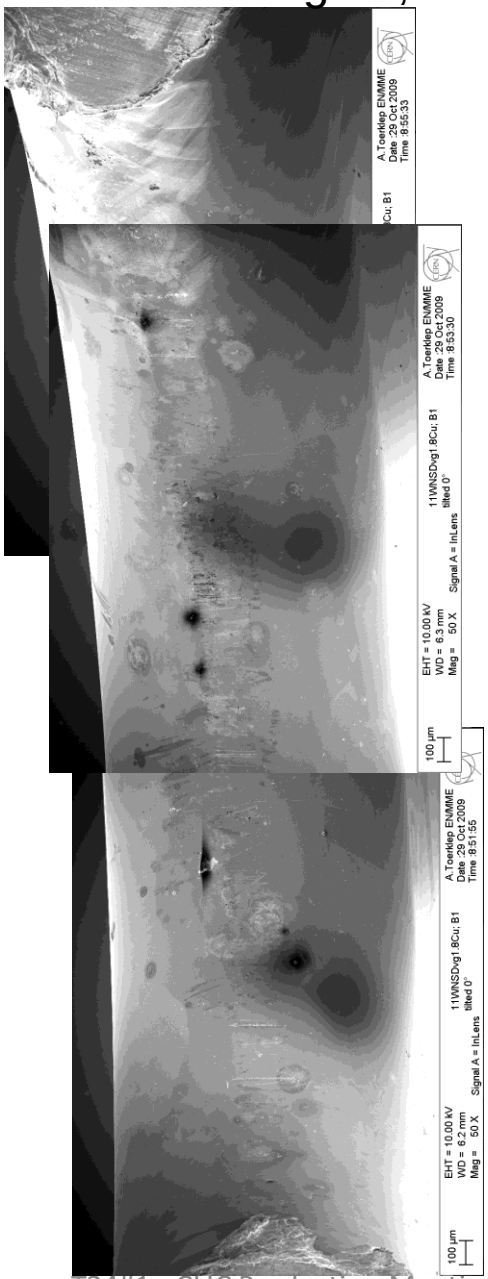
8-15 8-14 8-13 8-12

B2 – Zeiss Zigma, In-lens detector

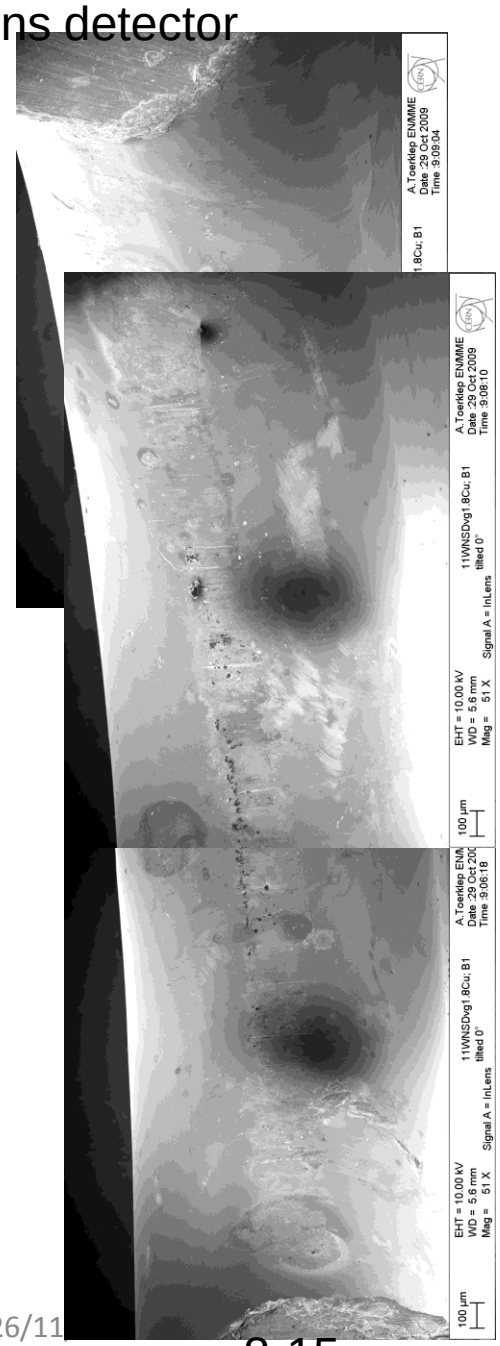


8-20 8-19 8-18 8-17

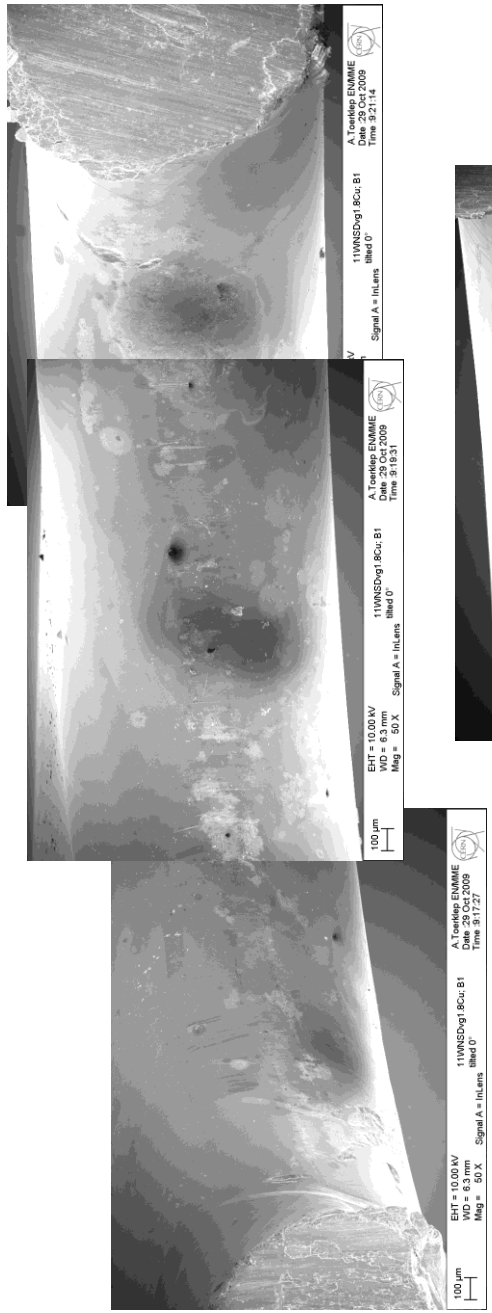
B2 – Zeiss Zigma, In-lens detector



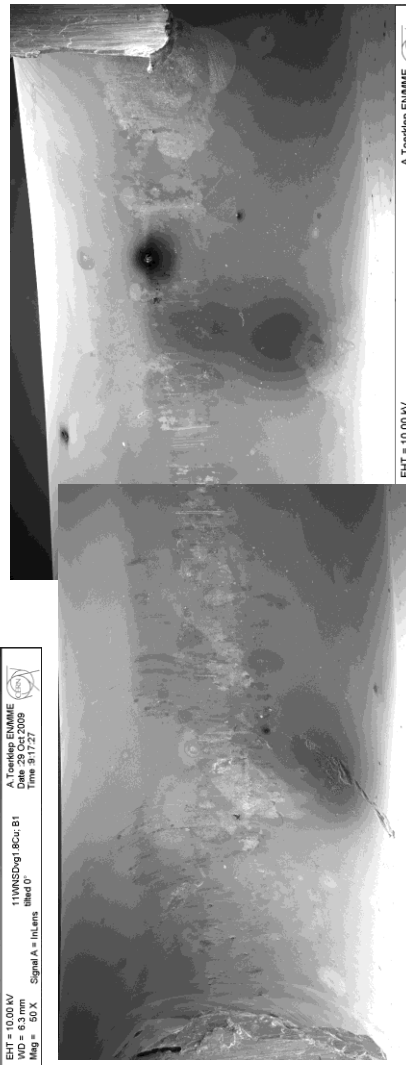
8-16



8-15

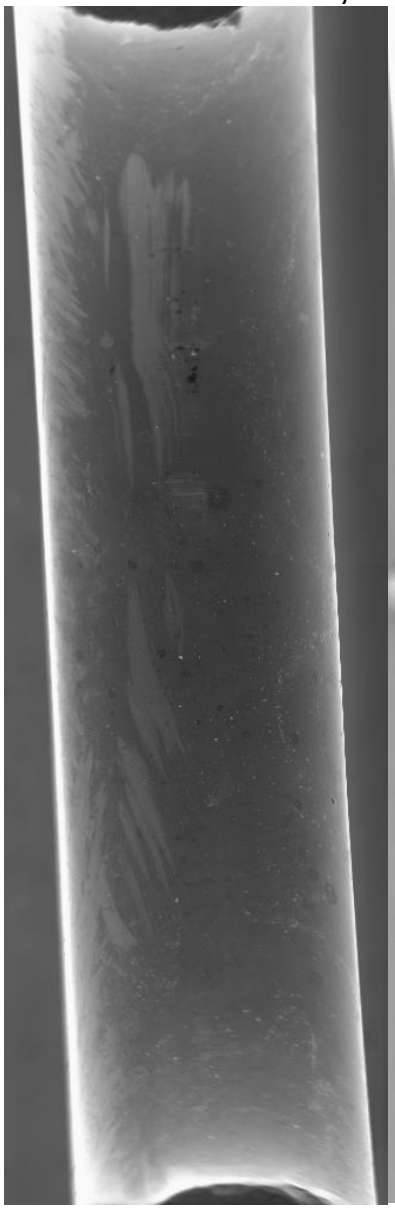


8-14

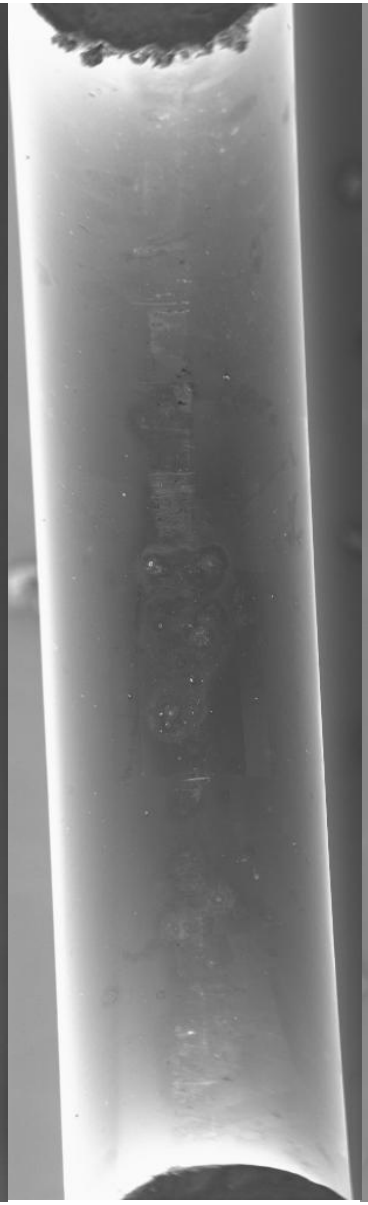


8-13

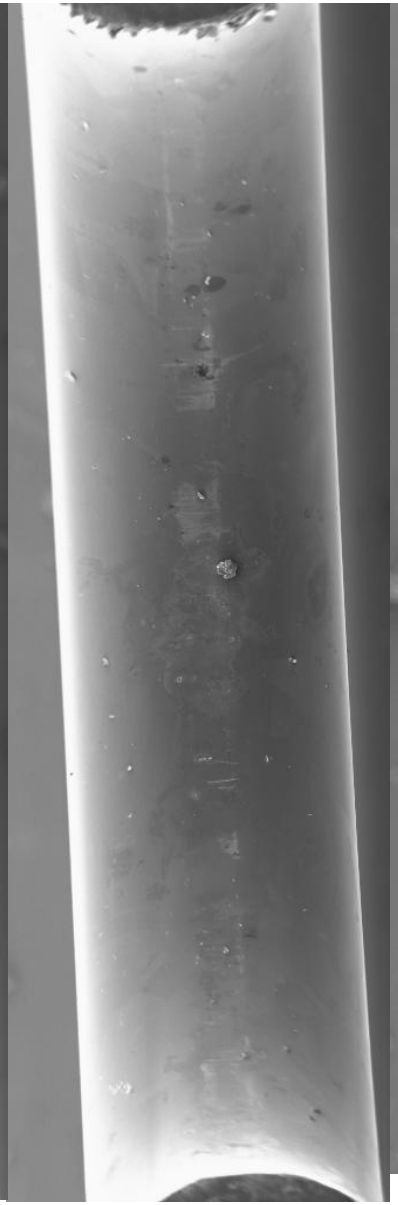
C1 – LEO 430i, E-T detector



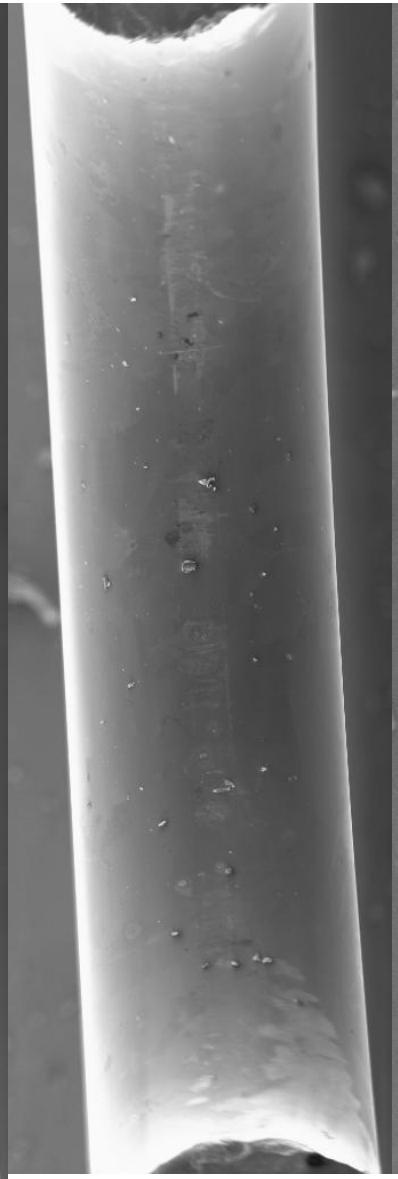
8-11



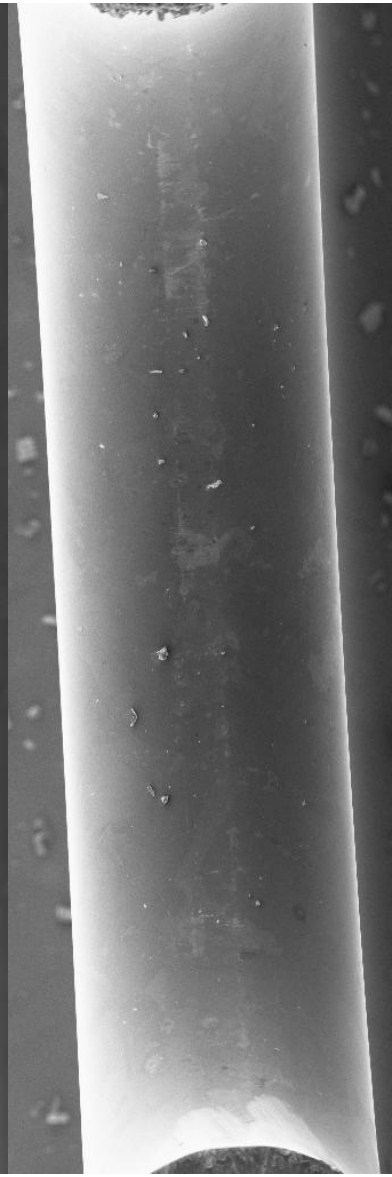
8-10



8-9

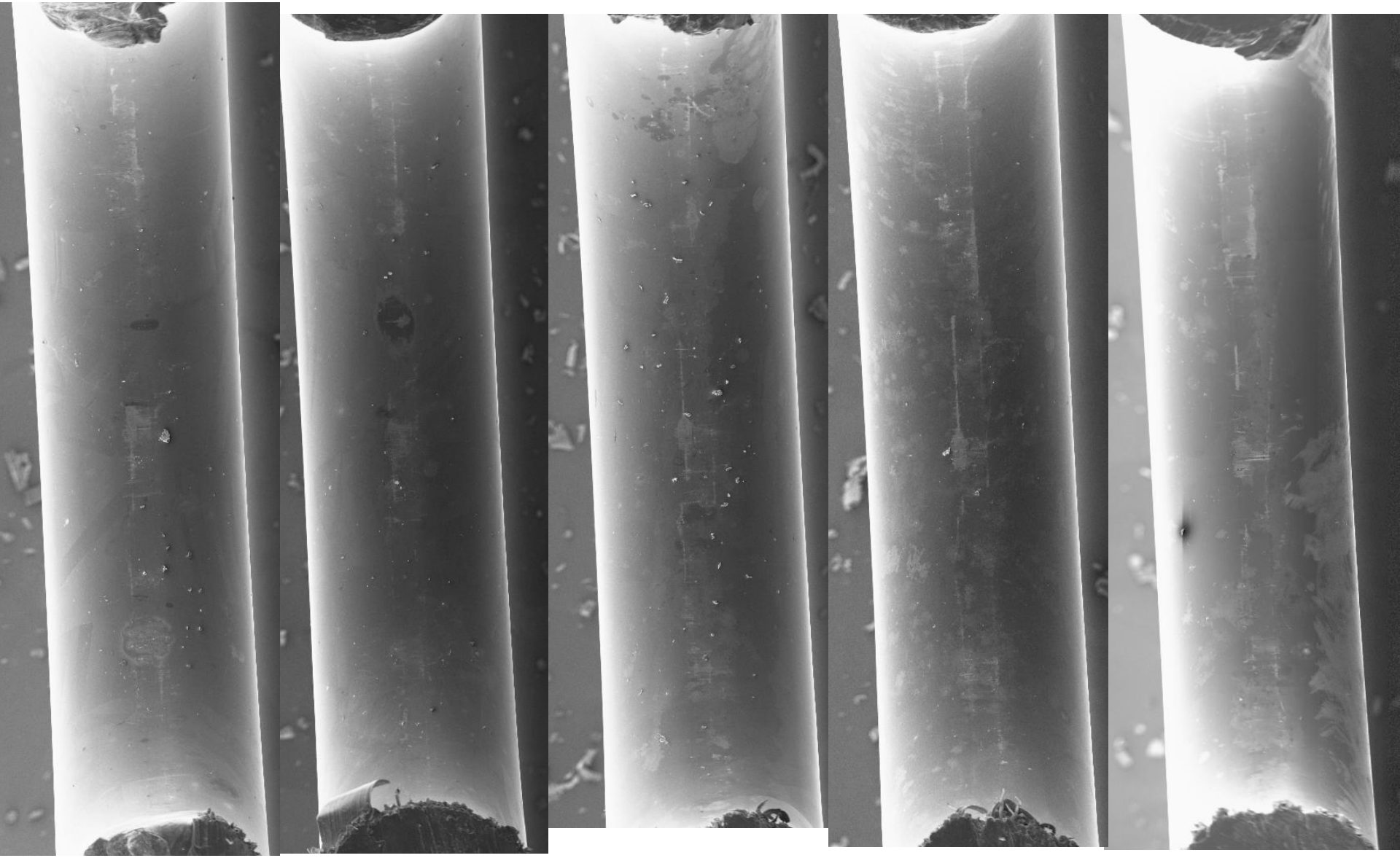


8-8



8-7

C1 – LEO 430i, E-T detector



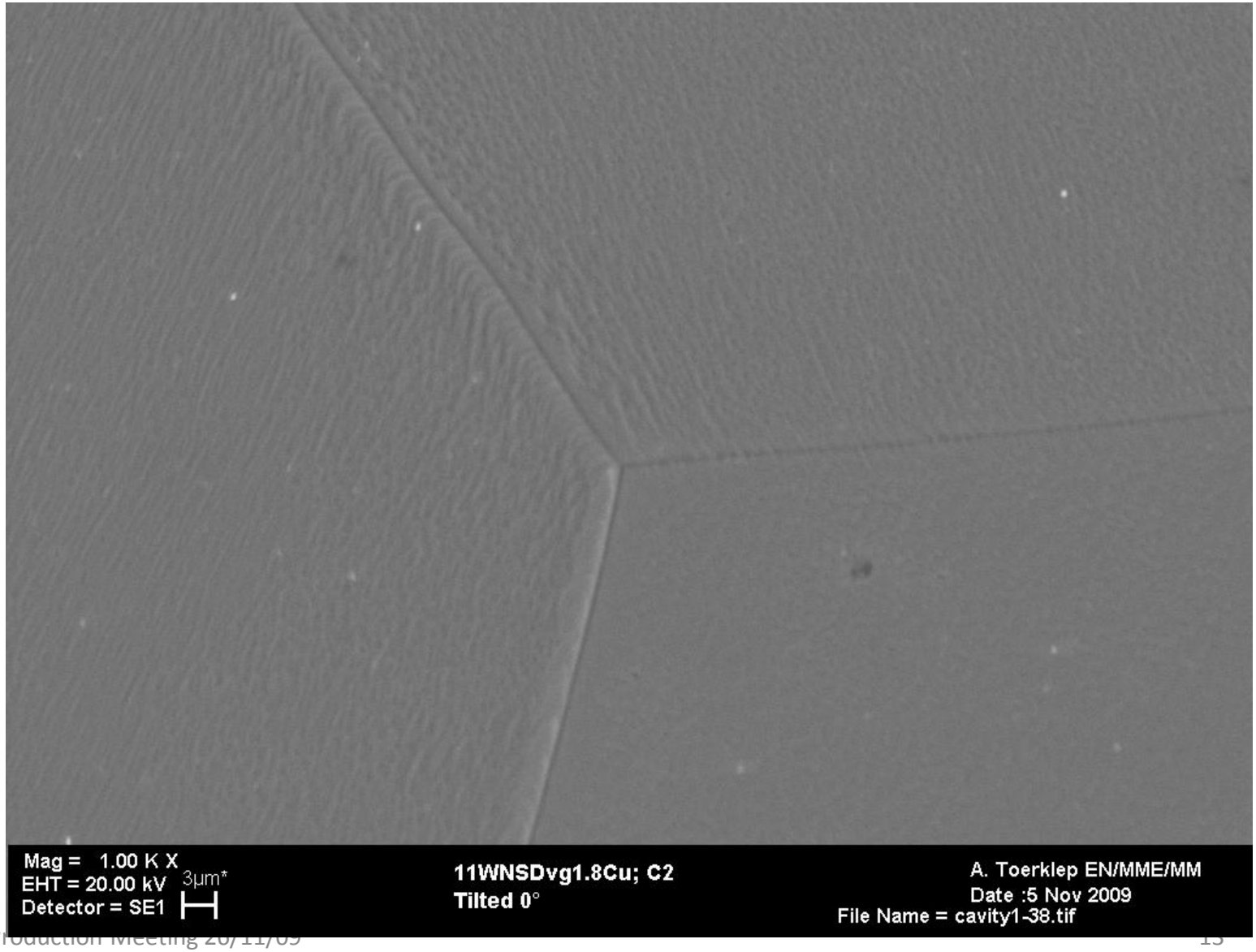
8-6 8-5 8-4 8-3 8-2

Outline

- Low magnification cartography of the irises
  - A1 section
  - B1 section
  - B2 section
  - C1 section
- Reference surface
- Catalogue of features related with breakdown activity
  - Random distribution in the regions of high electric field
  - Patches with small craters only
  - Patches with (relatively) large craters in the centre
  - Patches with halos giving higher carbon signal
  - Worm-like very superficial activity
  - Other contaminants
- Extra features apparently not related with breakdown activity
  - Scratches on the flat top of the irises
  - Smaller recrystalised grains in regions deformed by tuning
  - Localised Al contamination in the surfaces of couplers
  - Brazing filler metal drop off the joint coupler/disk (confirms suspicion reported in EDMS 1000659)

Reference surface (cavity wall away from iris tip):

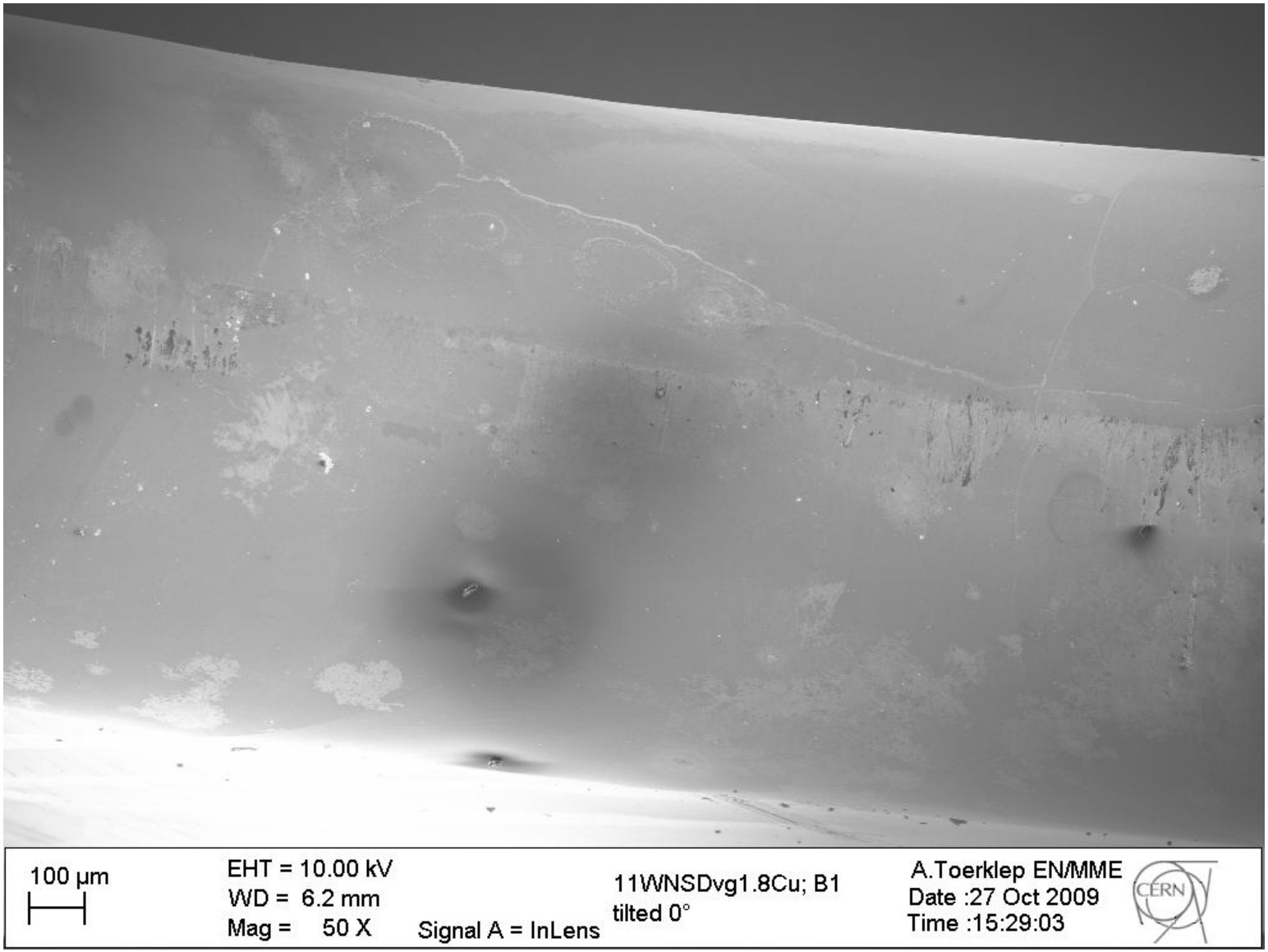
- Faceting, as expected after vacuum heat treatments
- No traces of sulfur rich precipitates at the grain boundaries



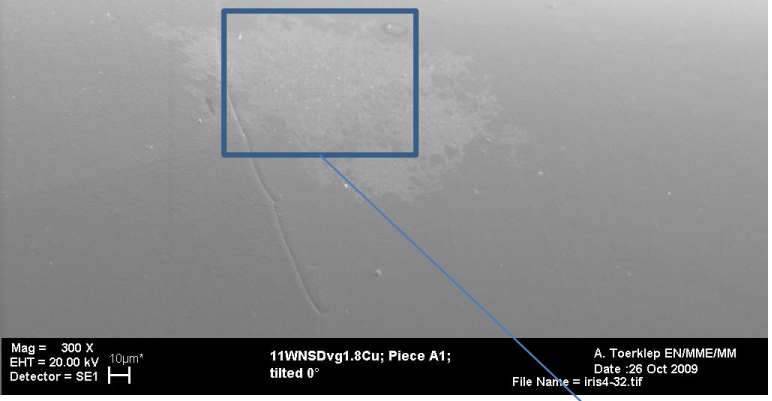
Outline

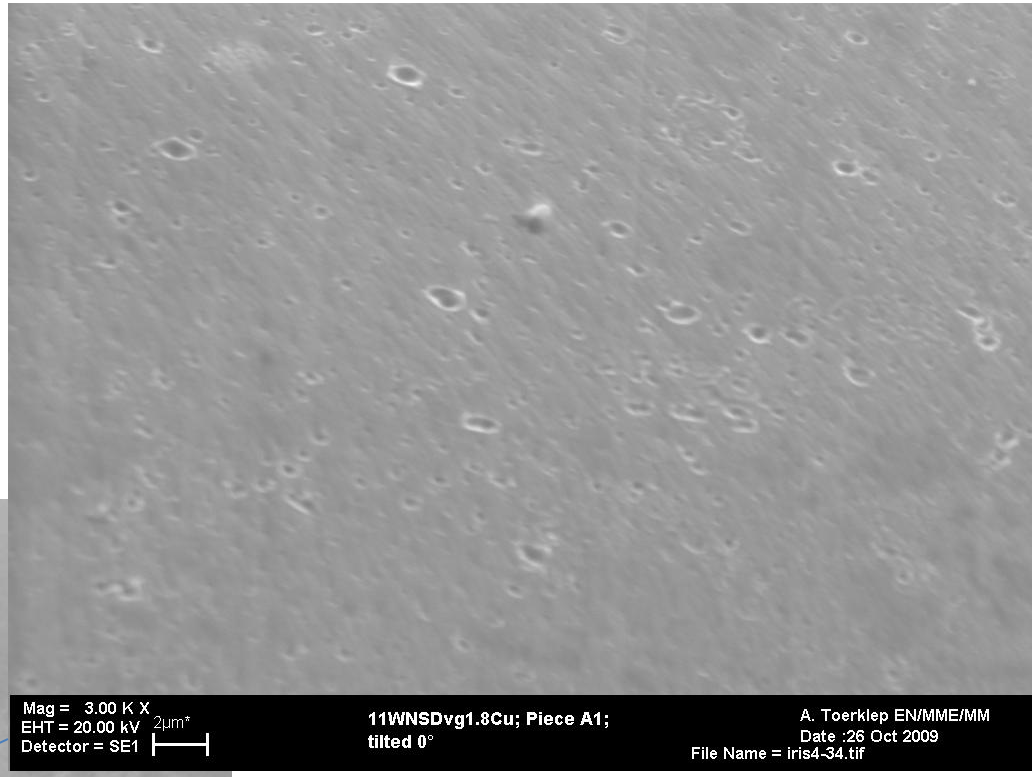
- Low magnification cartography of the irises
  - A1 section
  - B1 section
  - B2 section
  - C1 section
- Reference surface
- Catalogue of features related with breakdown activity
  - Random distribution in the regions of high electric field
  - Patches with small craters only
  - Patches with (relatively) large craters in the centre
  - Patches with halos giving higher carbon signal
  - Worm-like very superficial activity
  - Other contaminants
- Extra features apparently not related with breakdown activity
  - Scratches on the flat top of the irises
  - Smaller recrystalised grains in regions deformed by tuning
  - Localised Al contamination in the surfaces of couplers
  - Brazing filler metal drop off the joint coupler/disk (confirms suspicion reported in EDMS 1000659)

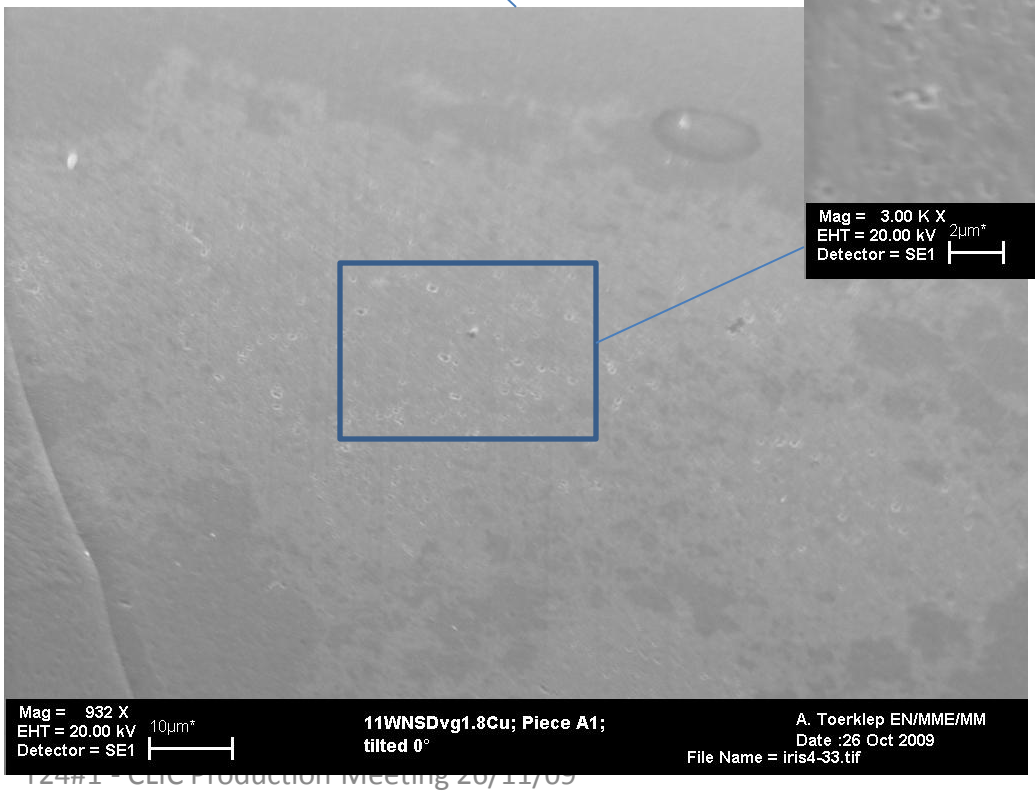
- Breakdown area - Randomly distributed



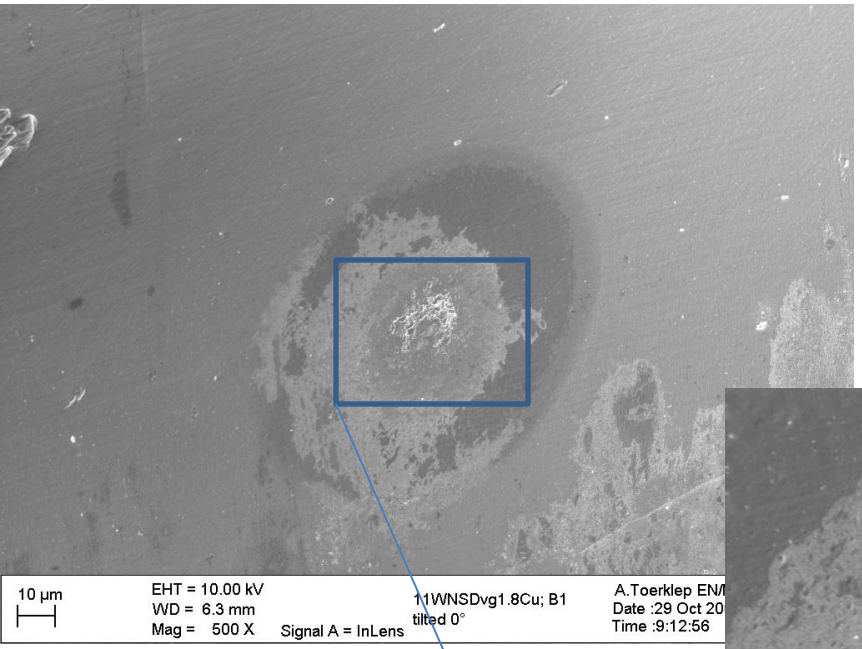
Most common feature are patches with only small craters (~1µm in diameter)

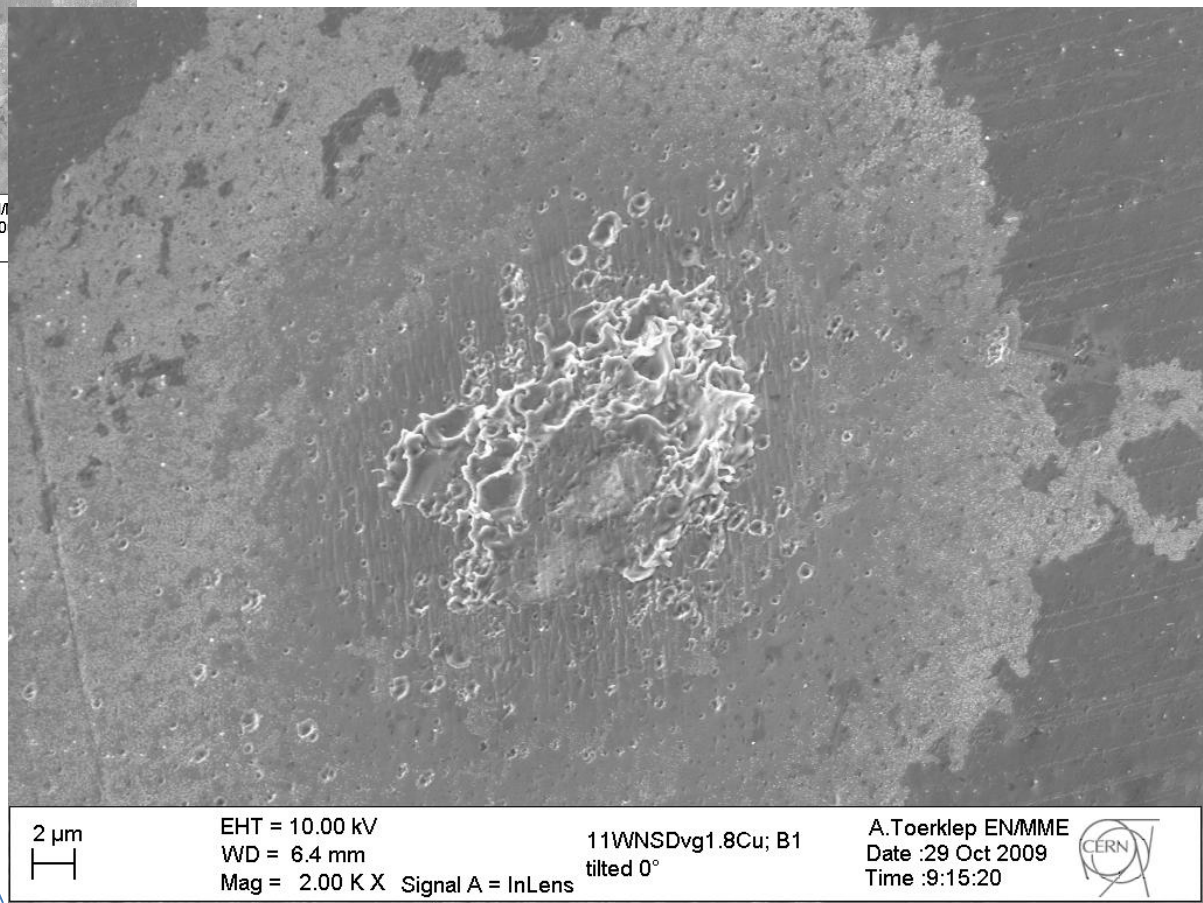






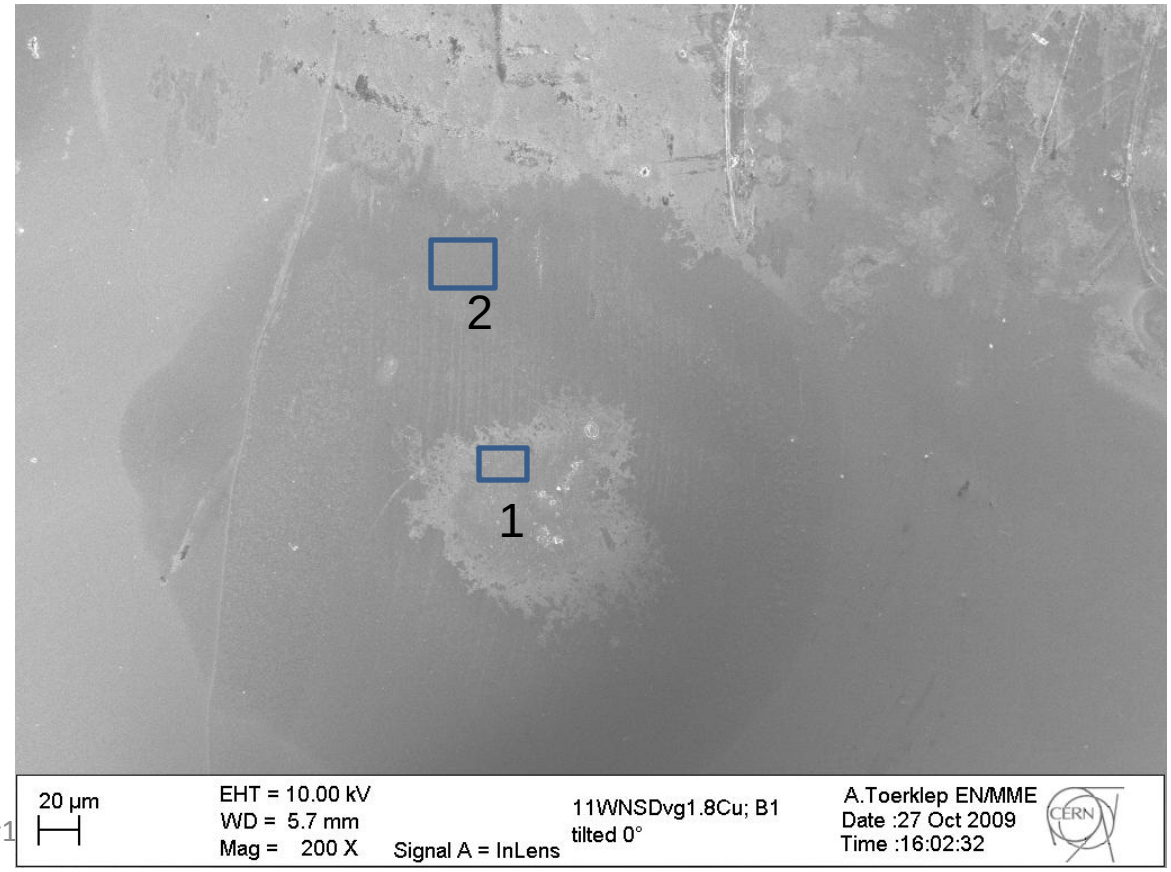
Patches containing bigger craters in the centreare also present but rarer





In some cases there are dark halos around the areas of activity

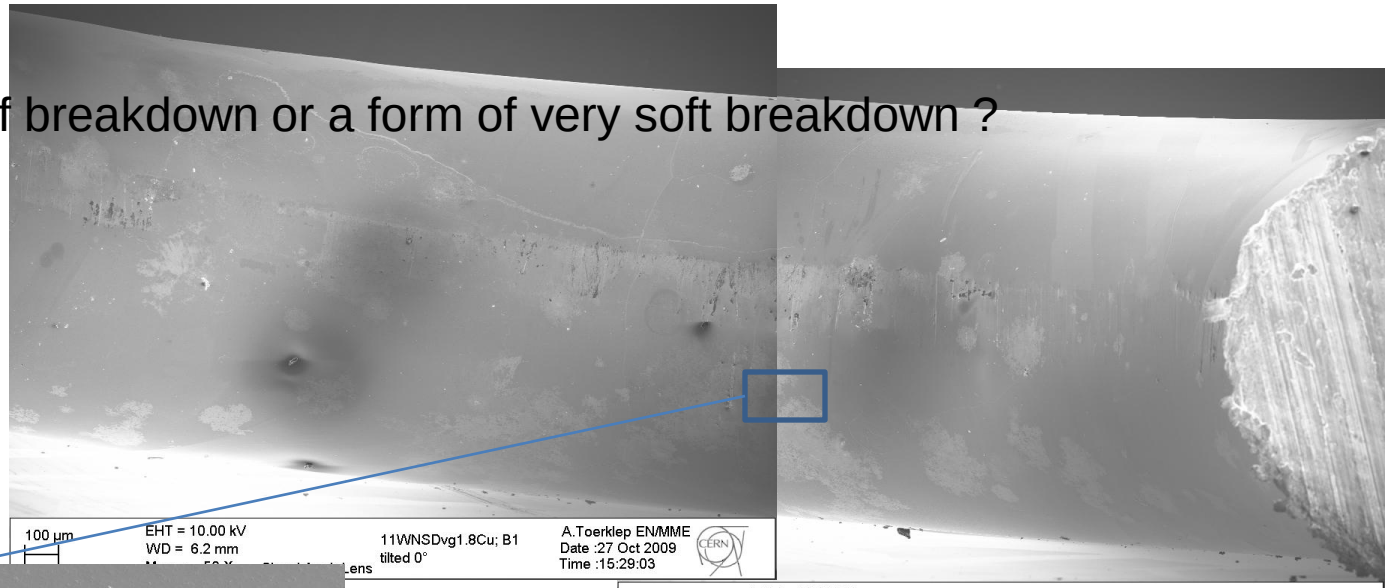
- Both areas show Cu with traces of C and O.
- Dark halos () have slightly higher content of carbon (ex. area 2 vs area 1, 2% vs 1% from semi-quantitative EDS analysis)
- Some carbonaceous contaminant may have been vaporazed during the thermal treatments or by the breakdown activity

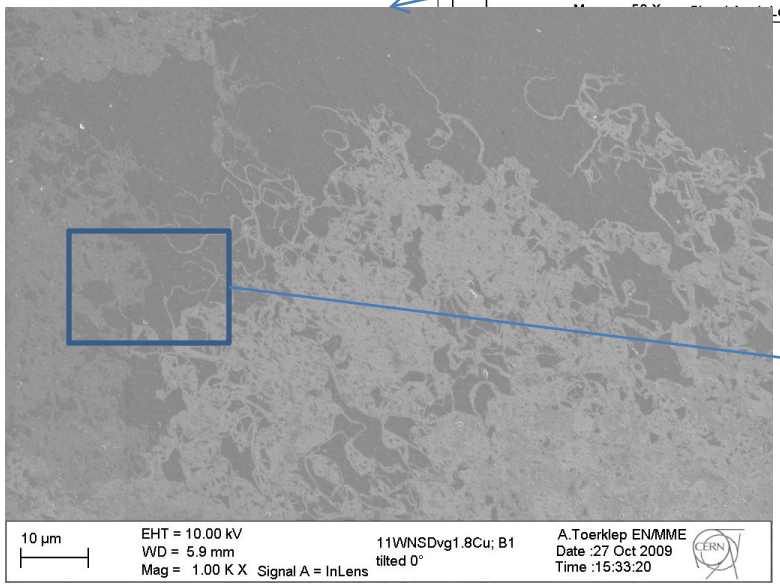


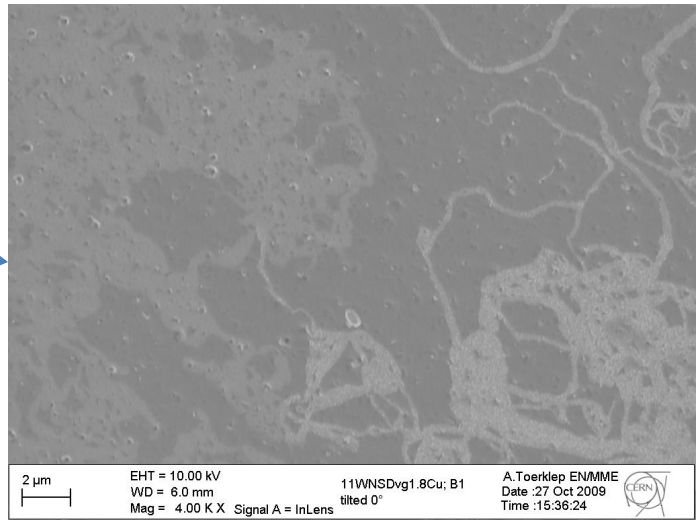
Worm-like features

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 ?







Worm-like features are are:

- Very superficial, as seen from images. The contrast seen may be due reduction of some vey surface oxidation or contamination.
- Due to the RF, it appear in the region of the iris only, not in the other walls of the structure. also because in the middle the are (small) craters.
- More or less noticeable depending on the observation conditions (angle, detector)

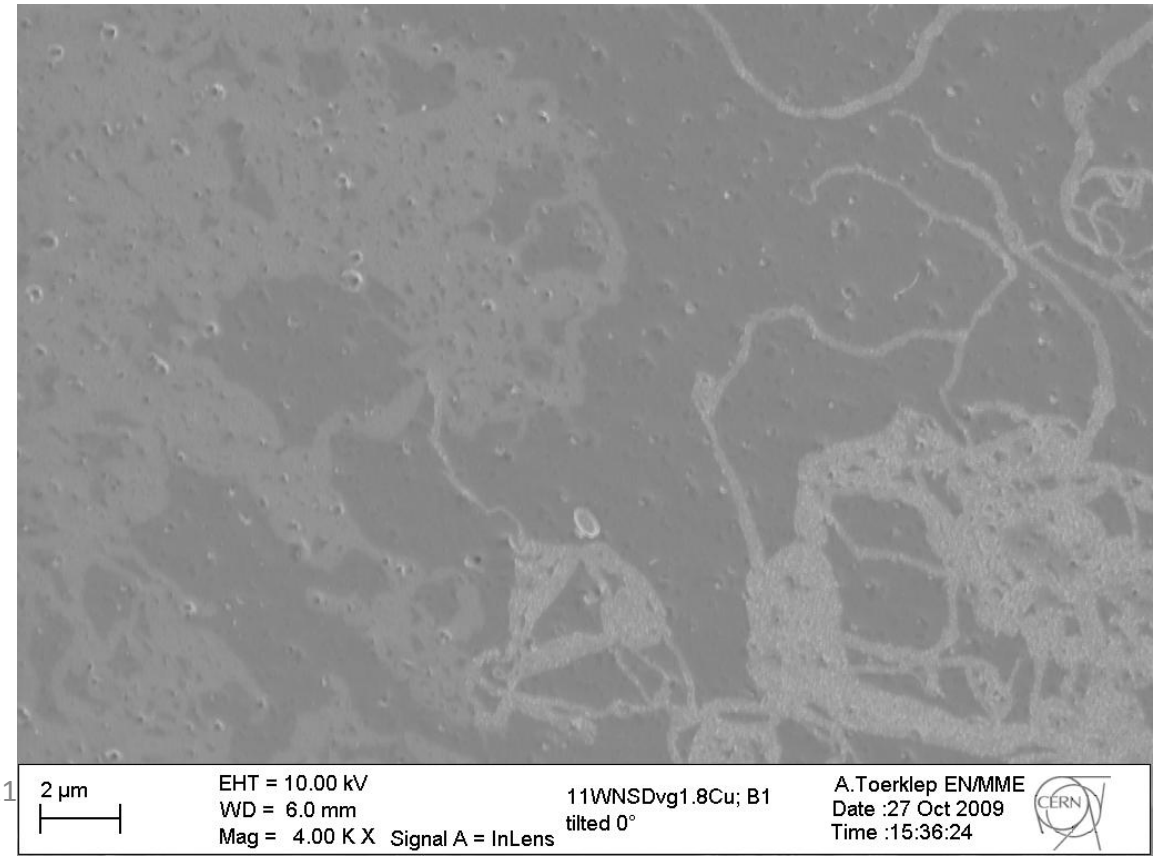
May be we can see it now because a combination of those:

-we look with other eyes (in-lens detector) may be more sensitive

-perhaps the surface is here more prone to reveal slight changes (more oxidized, contaminated?) that in previous cases

-we have here a case very slight or incipient were spaghettis have not been hidden by a more intense damage.

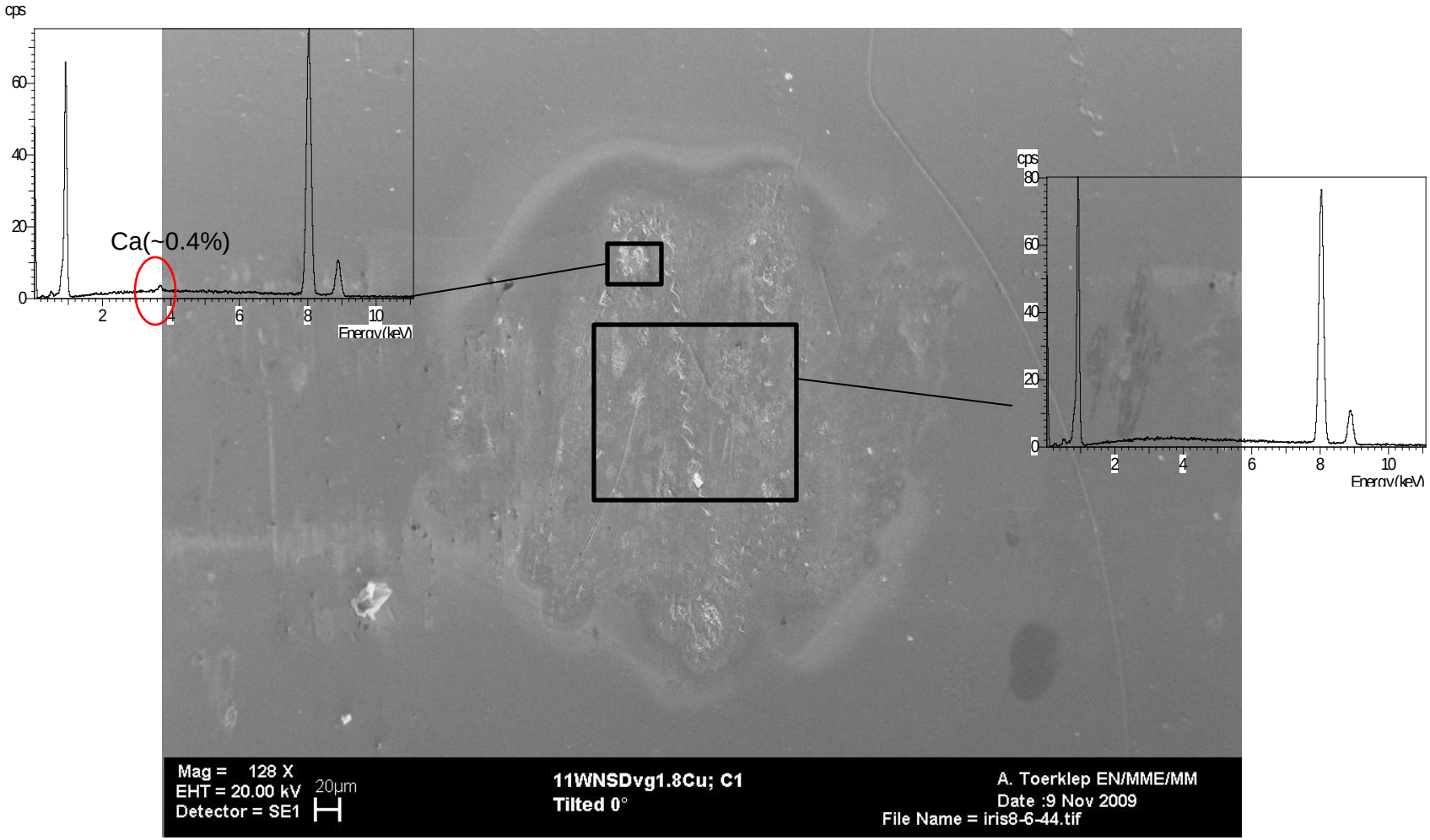
Is it a kind of prelude of breakdown or a form of very soft breakdown ?



Other contaminants.

-EDS analysis in several breakdown areas show that the main traces accompaigning the Cu signal are C and O

-One singular case was found with traces of Ca:

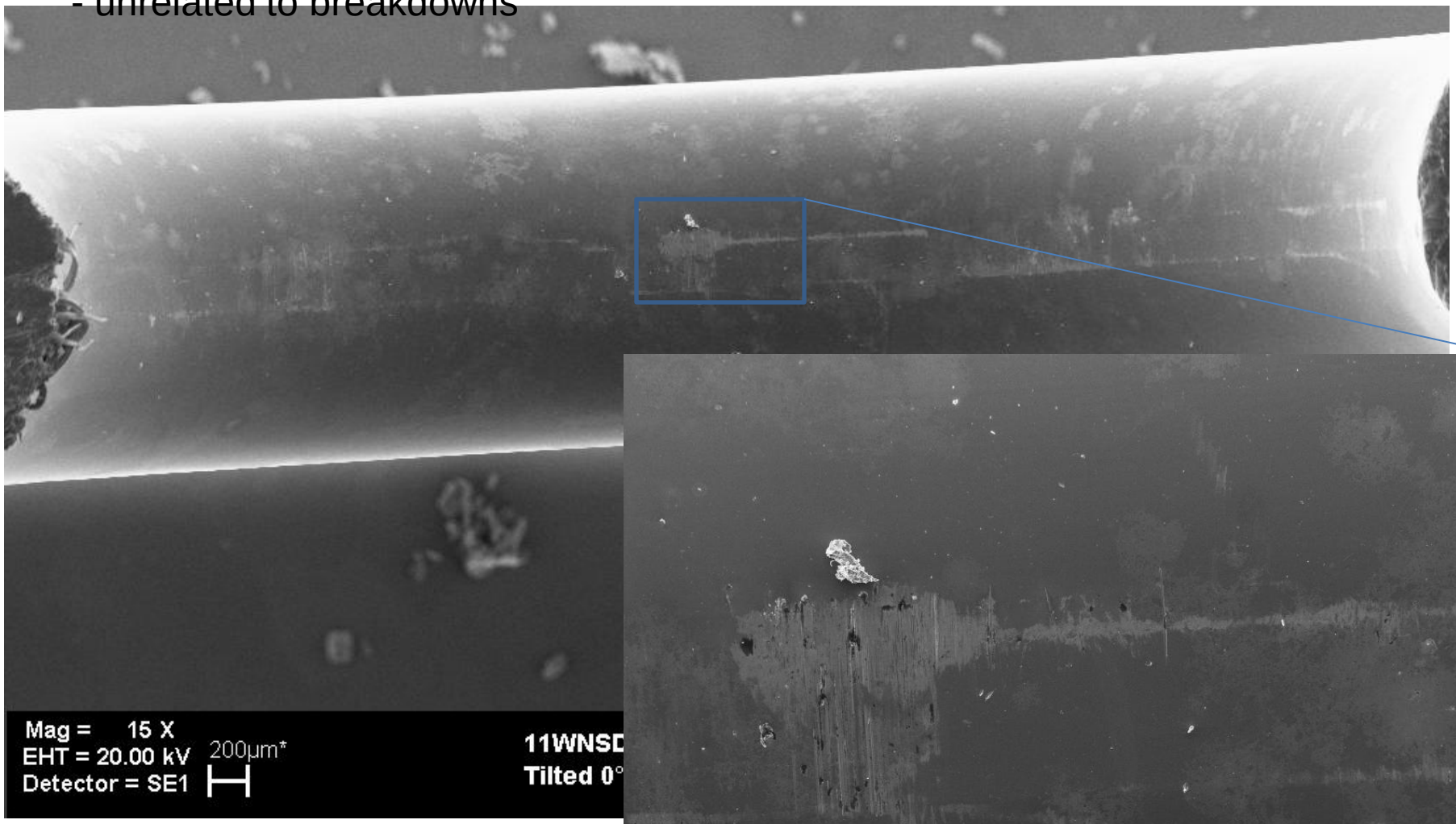


Outline

- Low magnification cartography of the irises
  - A1 section
  - B1 section
  - B2 section
  - C1 section
- Reference surface
- Catalogue of features related with breakdown activity
  - Random distribution in the regions of high electric field
  - Patches with small craters only
  - Patches with (relatively) large craters in the centre
  - Patches with halos giving higher carbon signal
  - Worm-like very superficial activity
  - Other contaminants
- Extra features apparently not related with breakdown activity
  - Scratches on the flat top of the irises
  - Smaller recrystalised grains in regions deformed by tuning
  - Localised Al contamination in the surfaces of couplers
  - Brazing filler metal drop off the joint coupler/disk (confirms suspicion reported in EDMS 1000659)

Scratches

- on hte flat top of every iris
- unrelated to breakdowns

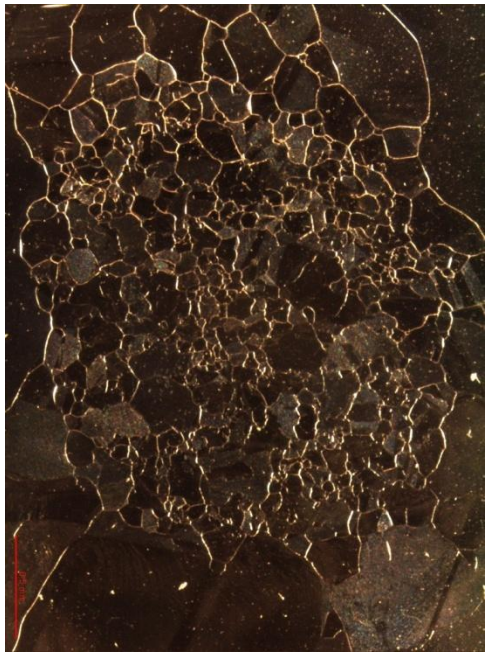


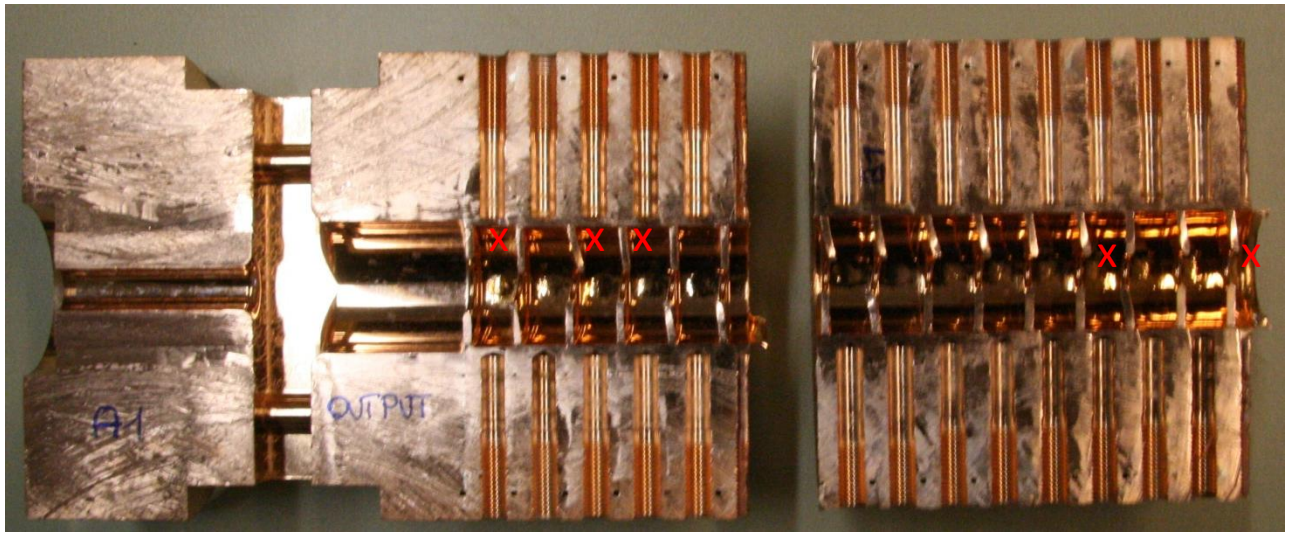
Iris 8-2

Small crystals in regions deformed by tunning

-Explained by the recrystalization during the last heat cycle (removal of oxyde) of regions htat have cumulated plastic deformation during tunning

- No breakdown activity

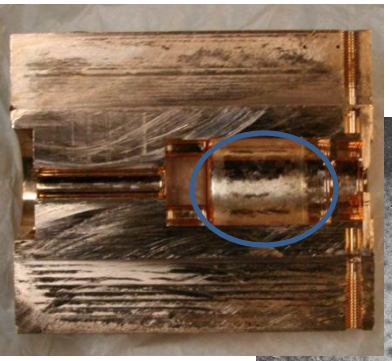


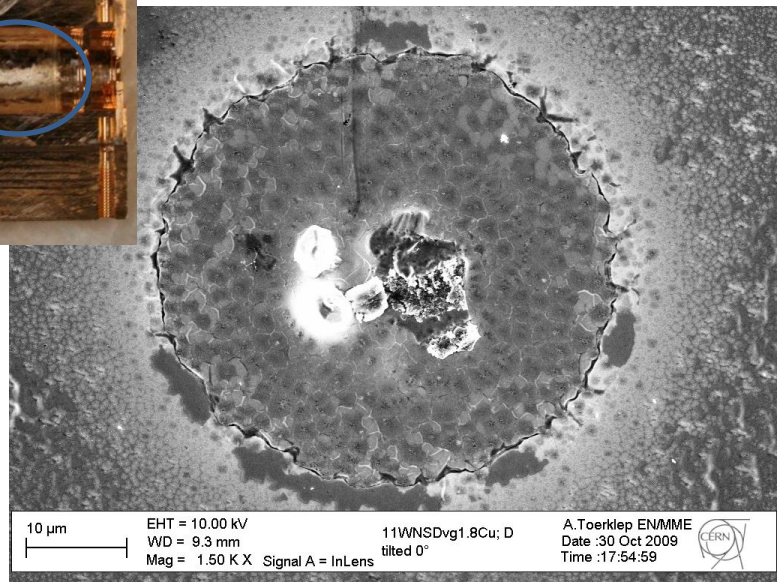


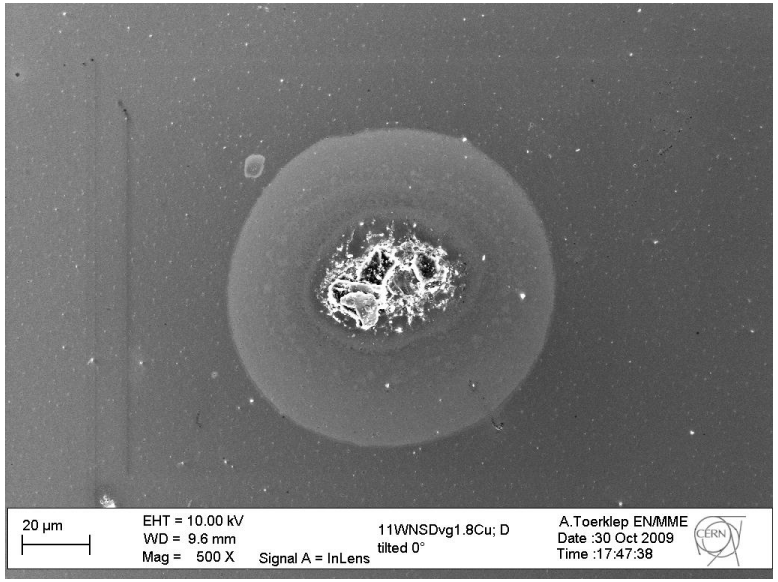
X – small grain size from tuning

Localised Al contamination on the inner surface of couplers

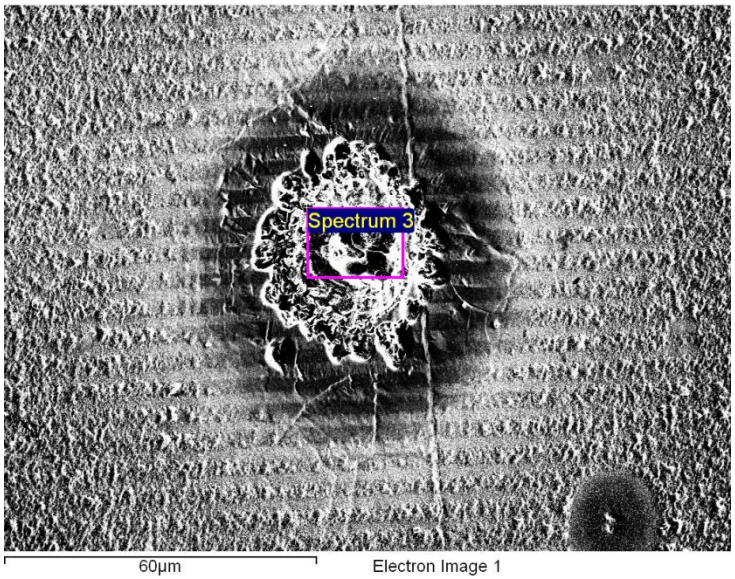
- Most probable cause is the presence of aluminum small particles laying on hte surface that melted and combined with Cu during the brazing cycle
- No evidence of breakdown activity associated to them

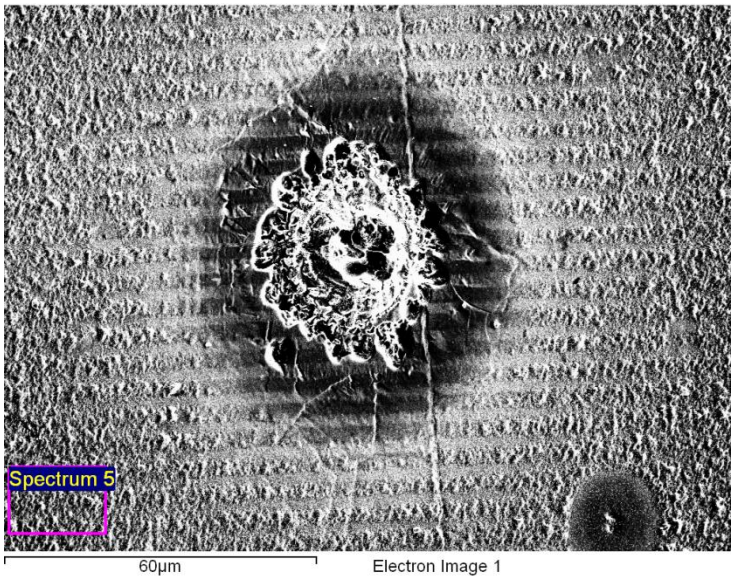


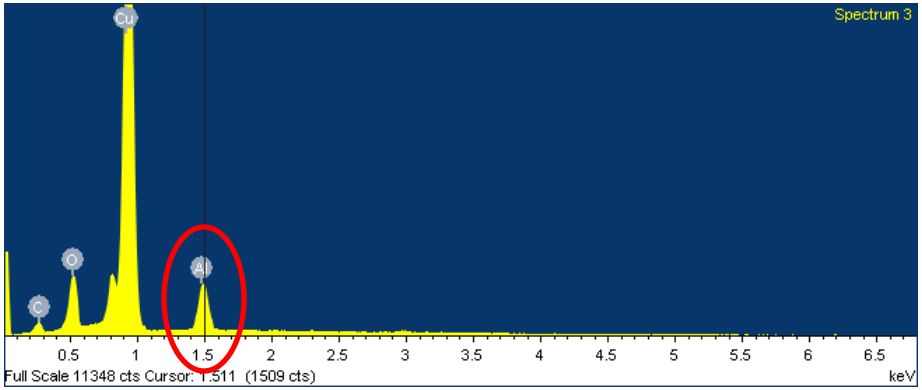


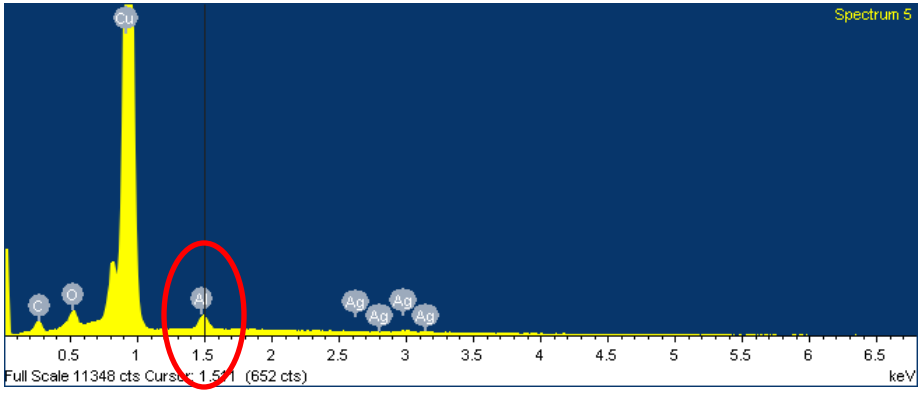


All of the features shows aluminium.



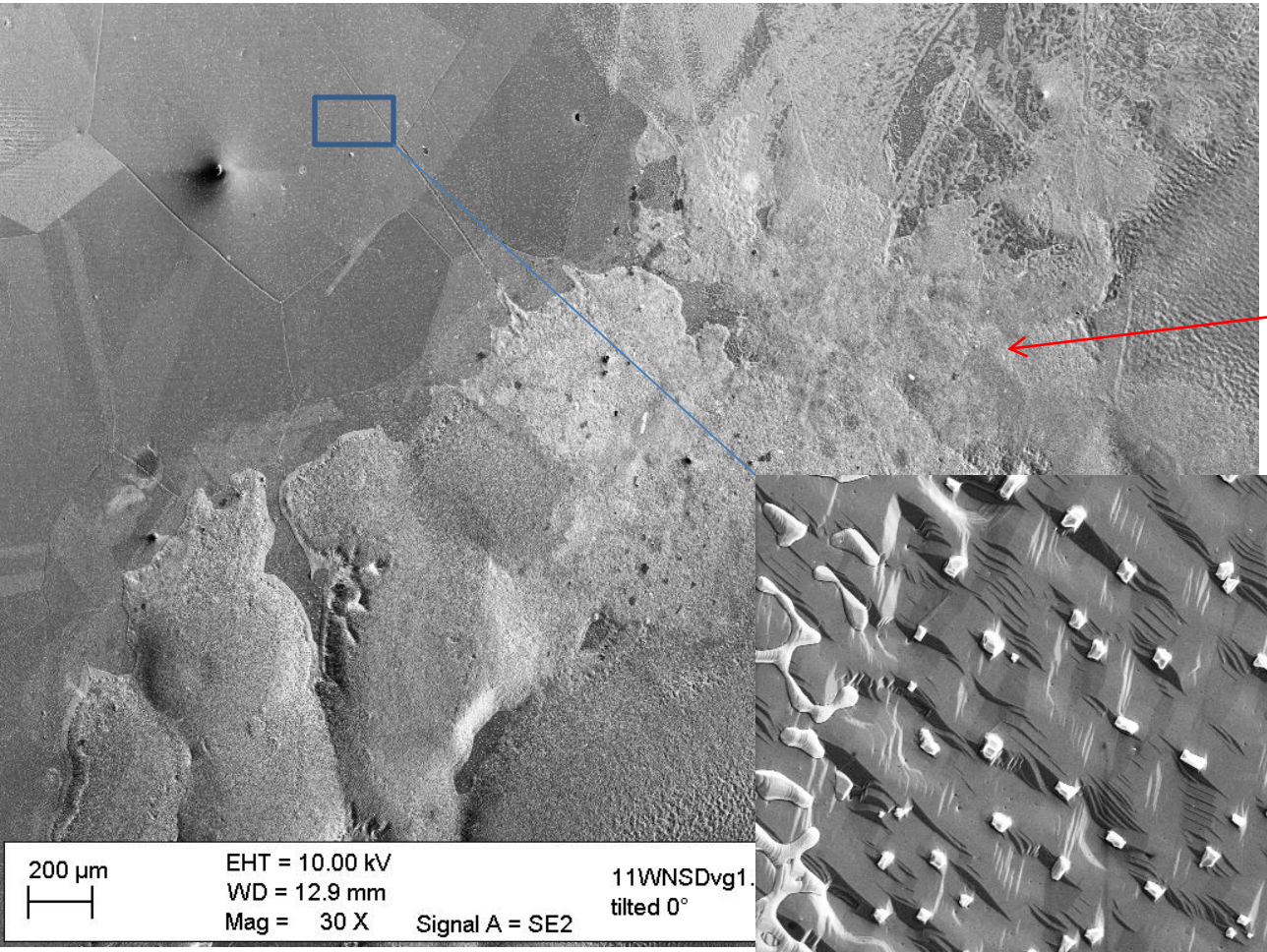




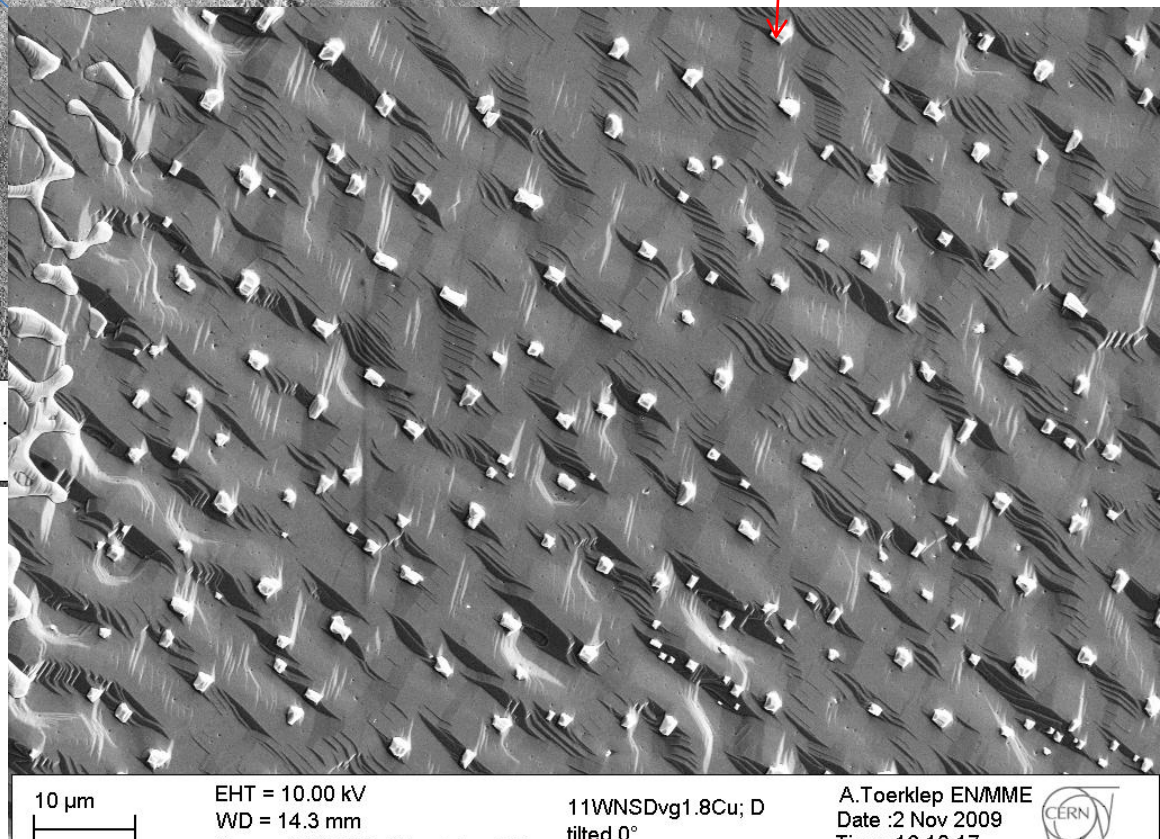


Brazing – input coupler

- No activity related to brazing material.

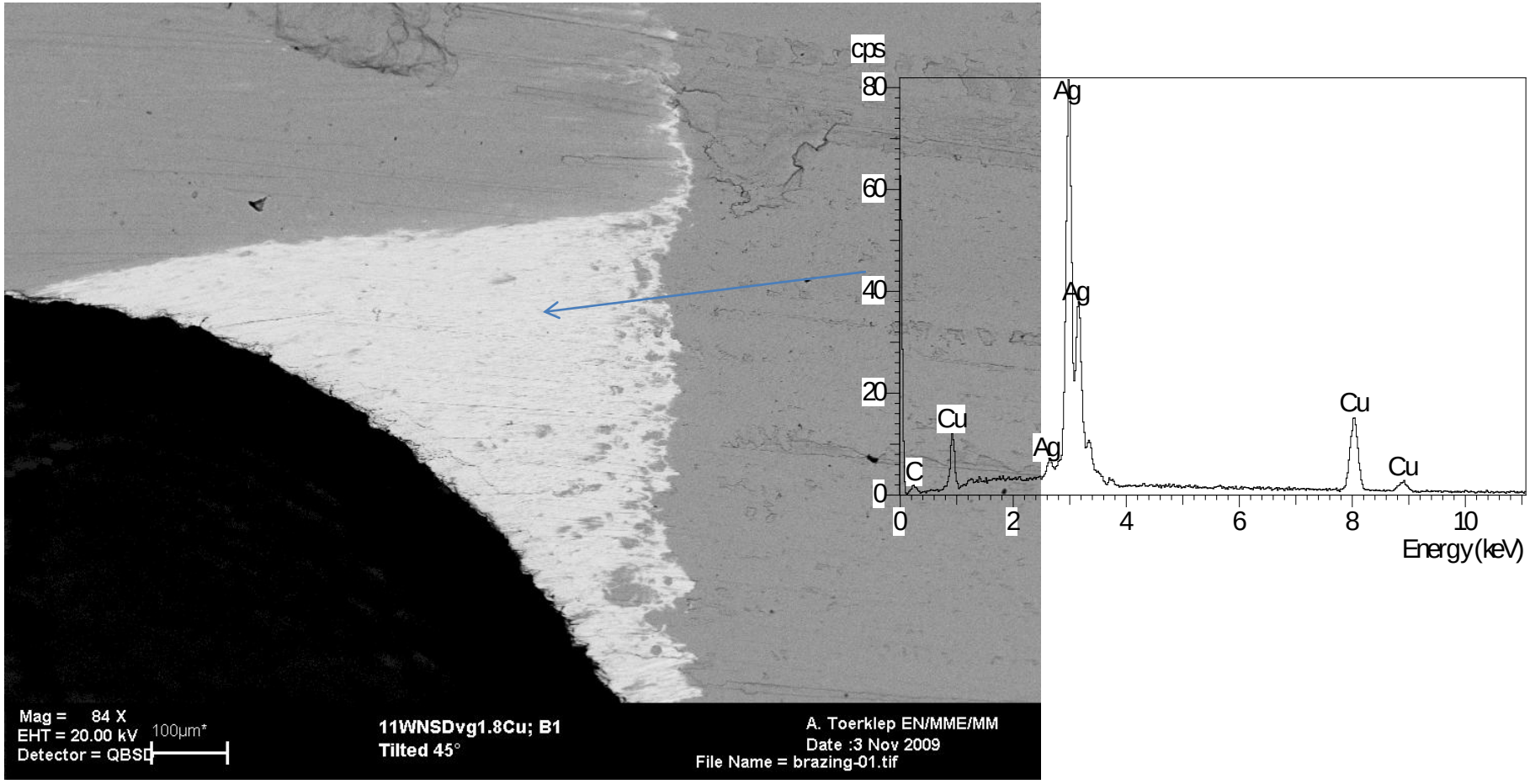


Brazing material



Brazing – Output coupler.

- No traces of Palladium. (semi-quantitative results)
- Could be Ag-Cu eutectic instead of SCP1
- Cutting of sample would be needed for confirmation.



Summary

- Breakdown regions are randomly distributed on the iris tip.
- Scratches visible on all irises. Not related to breakdown activity.
- Inlens vs SE2 detector – Wormlike features more easily visible with Inlens detector.
- Standard surface show faceting due to vacuum brazing.
- Circular features in couplers – composition Cu, **Al**, C and O.
- Brazing material only found in couplers – Brazing material from coupler to disc.
- Small grainsize in the cavity, close to tuning holes. Due to recrystalisation in heat treatment after tuning.
- EDS analysis in different breakdown areas consist mainly of Cu with traces of C and O.
- Dark halos around breakdown areas has slighty higher content of carbon.