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Comparison between SnPb63/37 - SAC305 solder:

Structure and intermetallics morphologies after thermal stress on PCB – ENIG finishing

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The most important independent electronic laboratory in Europe

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> 6 000 analyzes / year

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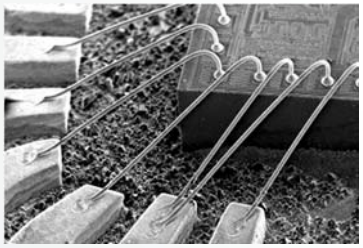

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Energy Storage Devices

Physical Expertise

Electrical Testing

- Construction analysis
- Failure analysis
- Qualifications
- Characterizations

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OBJECTIVES

How to Explain:

- The low occurrence of cracking at PCB/Solder interface on SAC305 solders?

- That IMC with SAC solder are thicker than IMC with SnPb solder, for a same reliability level?

Project Objectives:

- A better understanding of the IMCs observed in section especially during FA

→ link the observations to the structural causes

- Observe and assess the evolution of IMC morphologies according to different parameters (process and / or aging).

- Adadpt new inspection methods for IMC inspection (more representative than the classical cross sectionned view)

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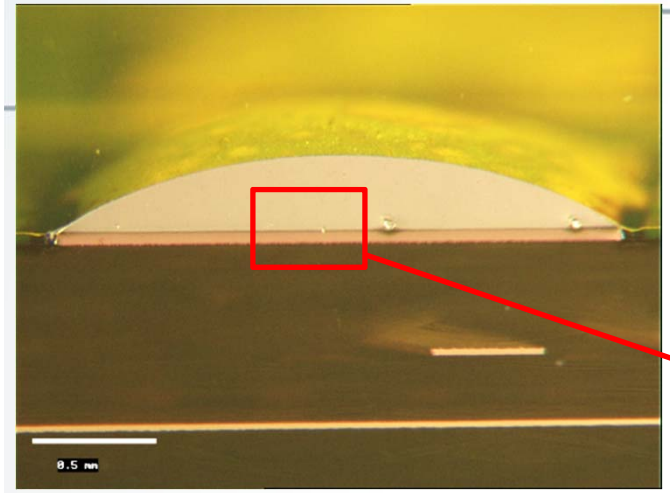
REMINDERS

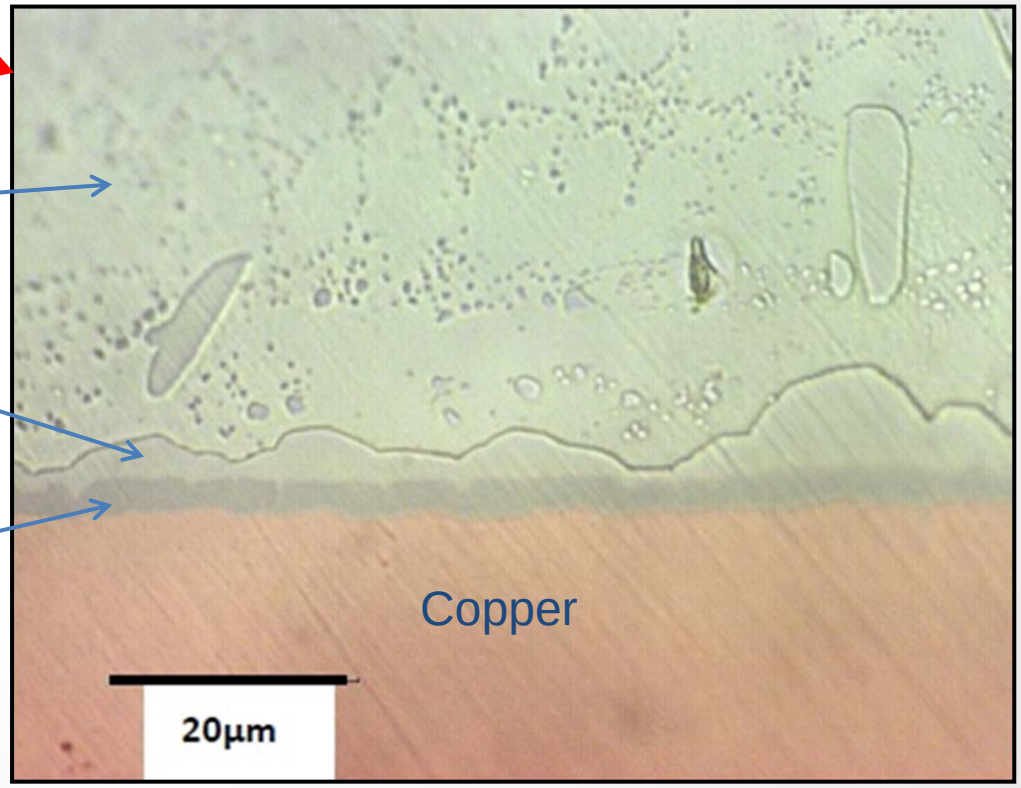


PCB ENIG (Au/NiP/Cu) – View in cross section

Solder
(SAC 305)

Intermetallics
Compounds (IMCs)
Type Sn/Ni

Nickel (ENIG
finishing)



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Taguchi Plan

Aim: Assess the effects and interactions between selected parameters (Process & Ageing) and their levels, on IMC size and morphologies

Solder type	SnPb 63/37*			SAC 305**		
Levels	*#1*	*#2*	*#3*	*#1*	*#2*	*#3*
Bath temperature (°C)	235	255	/	245	265	/
Time on the solder bath (s)	5	10	/	5	10	/
125°C Isothermal ageing time (h)	0	500	1000	0	500	1000

Parameters selected in function of the most common usage in the industry

** SnPb 63/37 (63%wt Sn; 37%wt Pb)*
*** SAC 305 (3%wt Ag; 0,5%wt Cu; Sn Basis)*

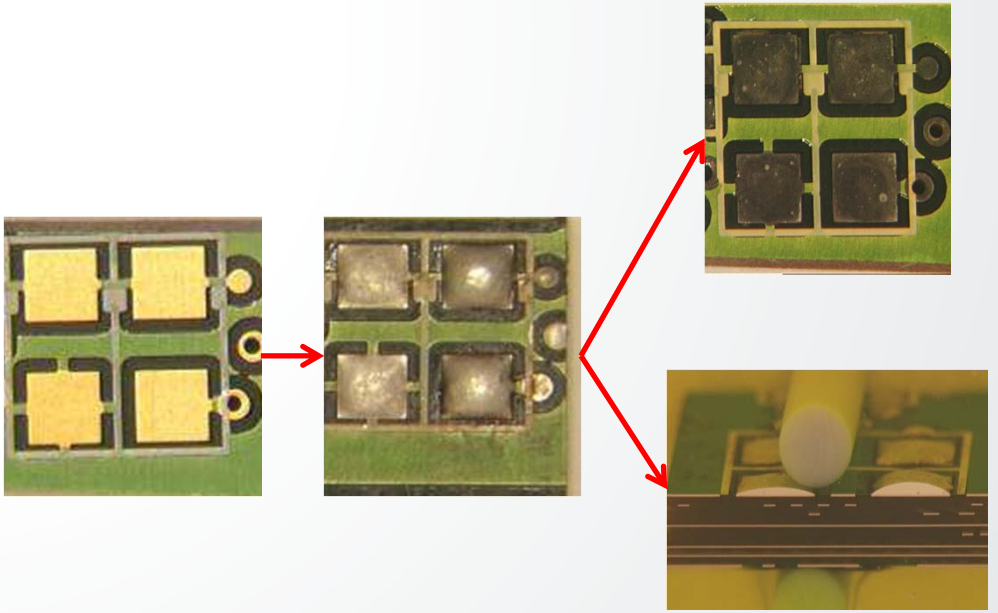
Experimental Procedure

Fixed parameters:

- Sample geometry: SMD Pads with ENIG Finishing (Au: 0,1µm – Ni: 4µm)
- No components assembled
- Soldering by floating method, time & temperature controlled by Menisco device (Métronelec).
- Flux: Type ROL 1

Inspection:

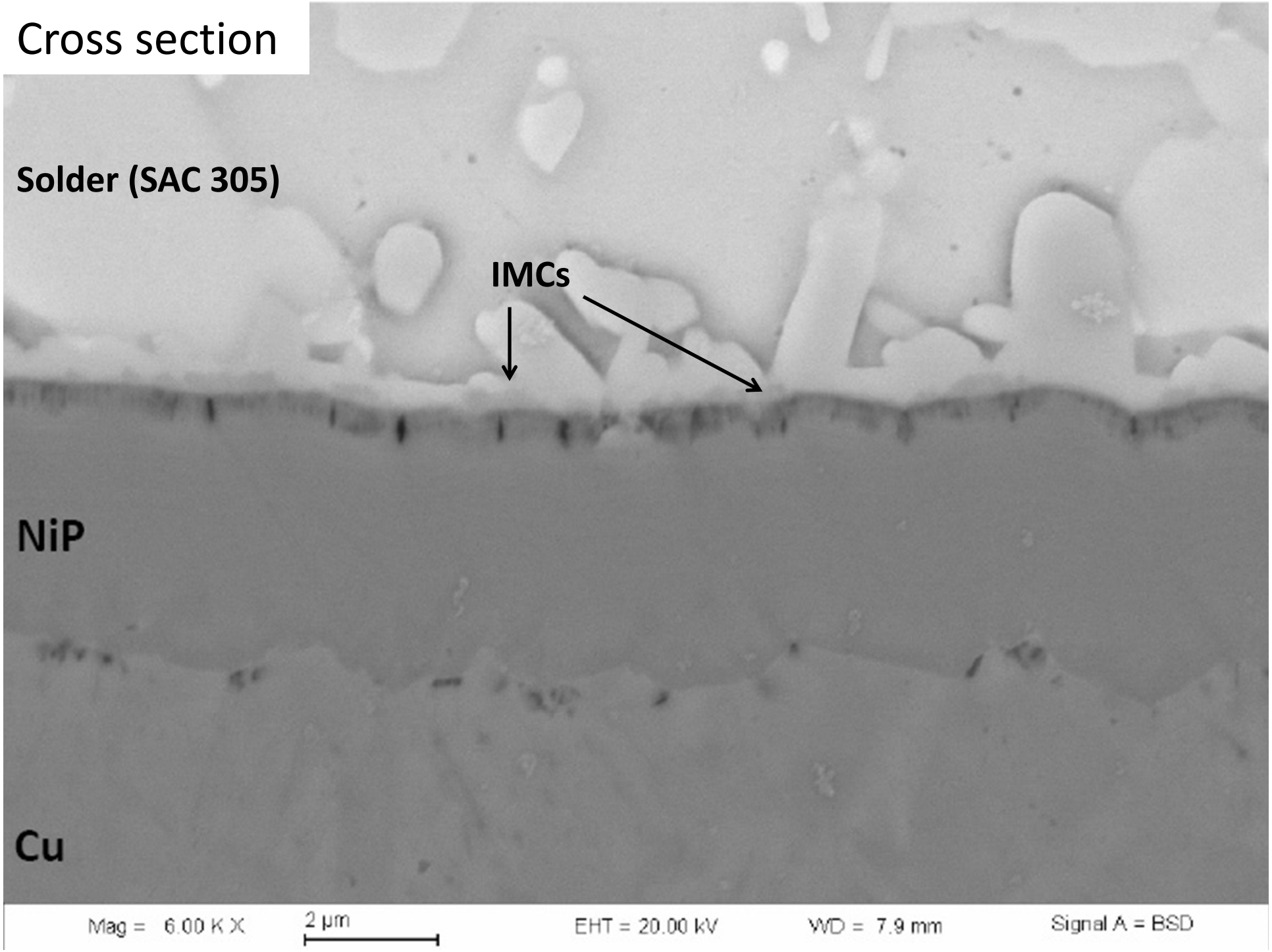
- SEM-EDX inspection
- 3 type of samples for 3 ways of inspection
  - Cross sectioned view
  - Revealed Cross sectioned view
  - Revealed aerial view



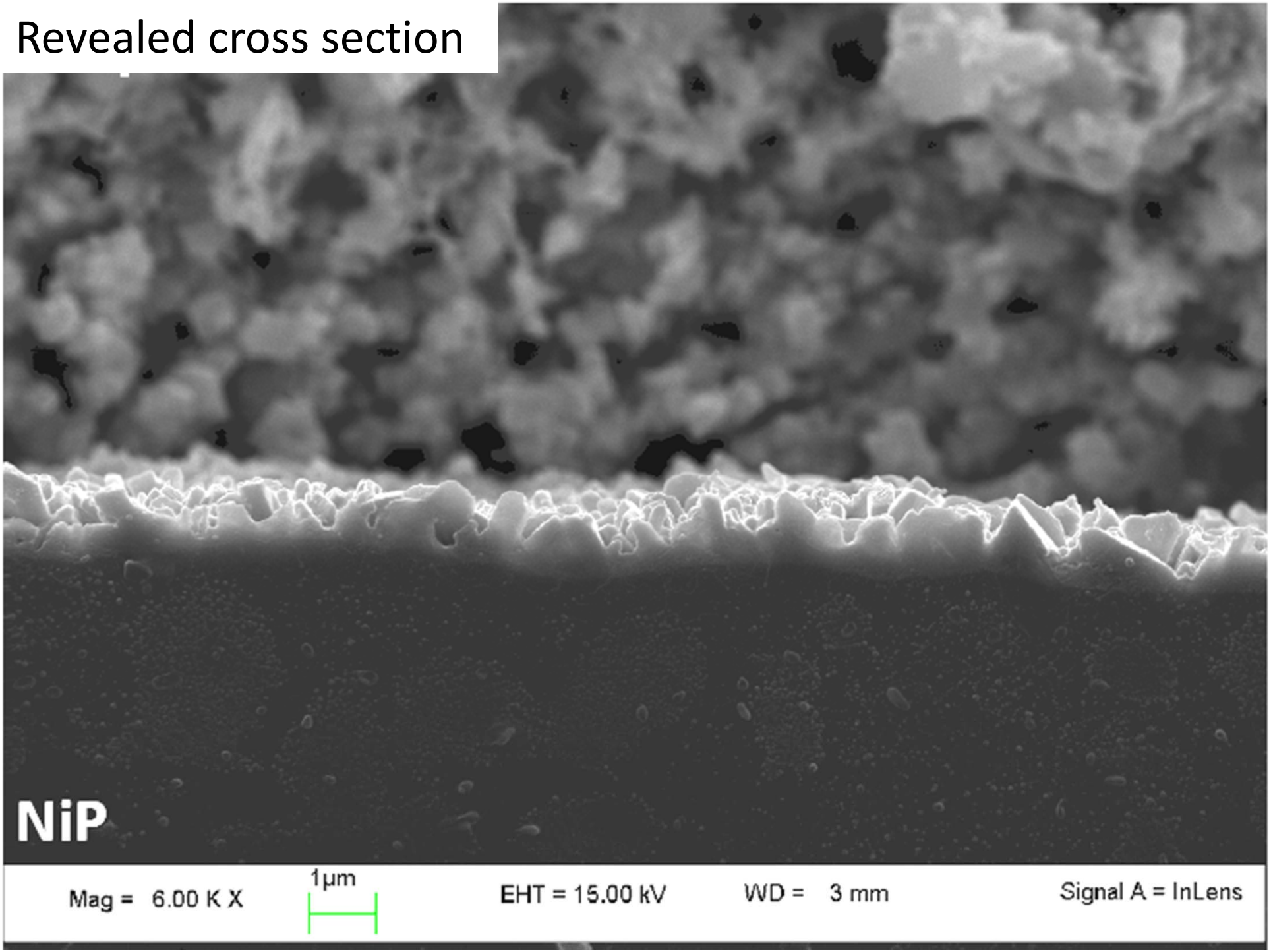
→Size

→Morphology

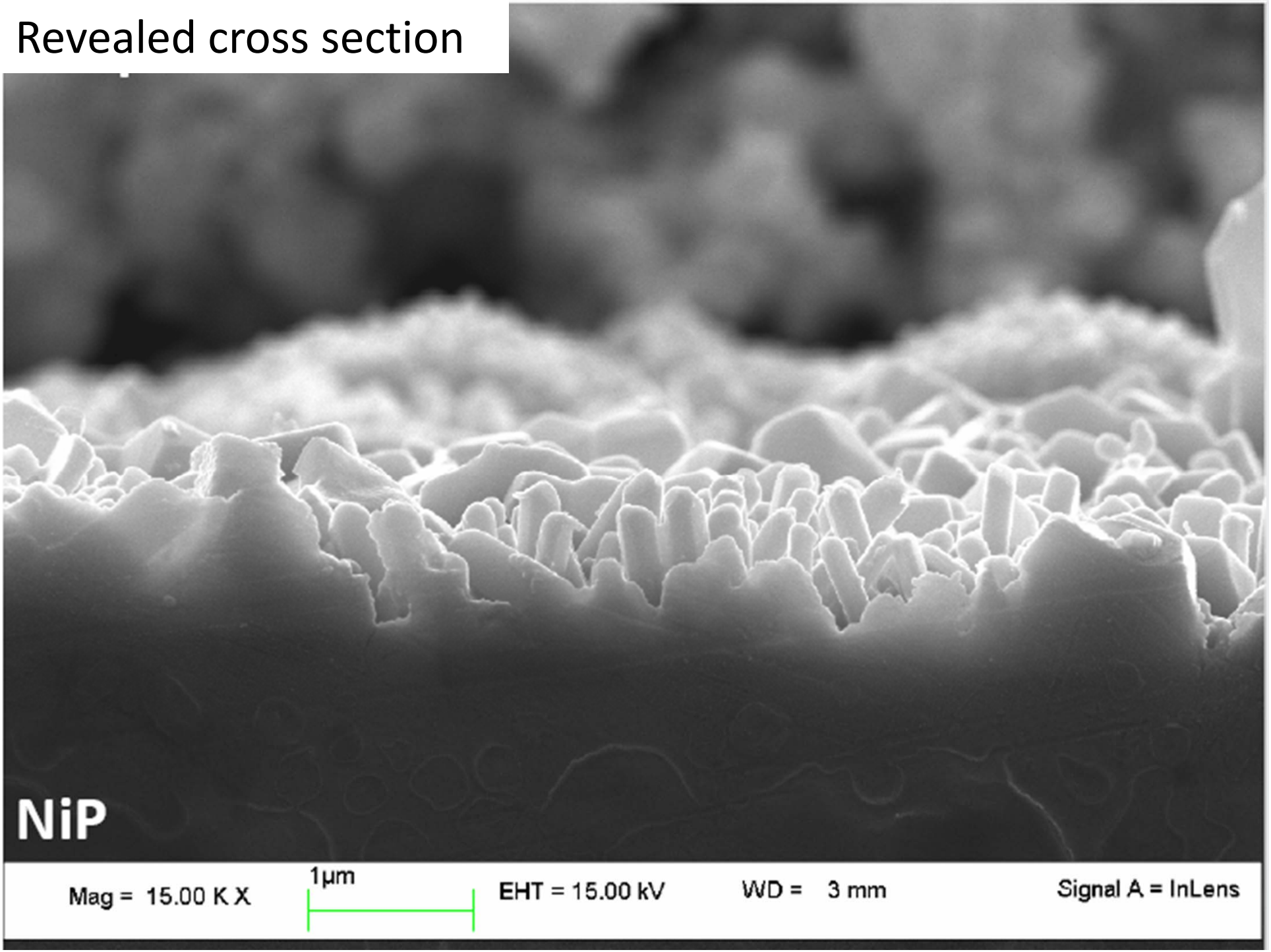
Cross section



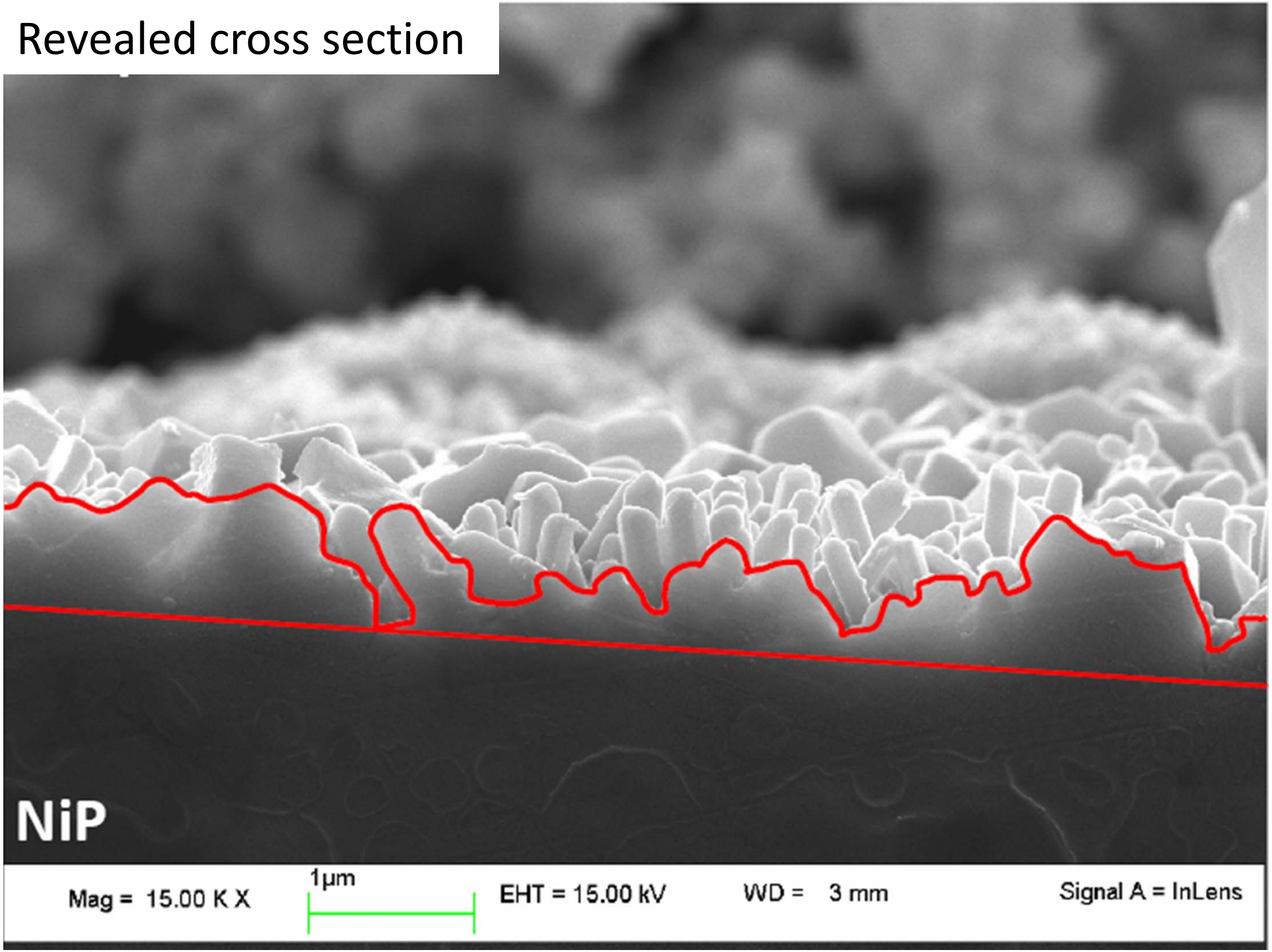
Revealed cross section



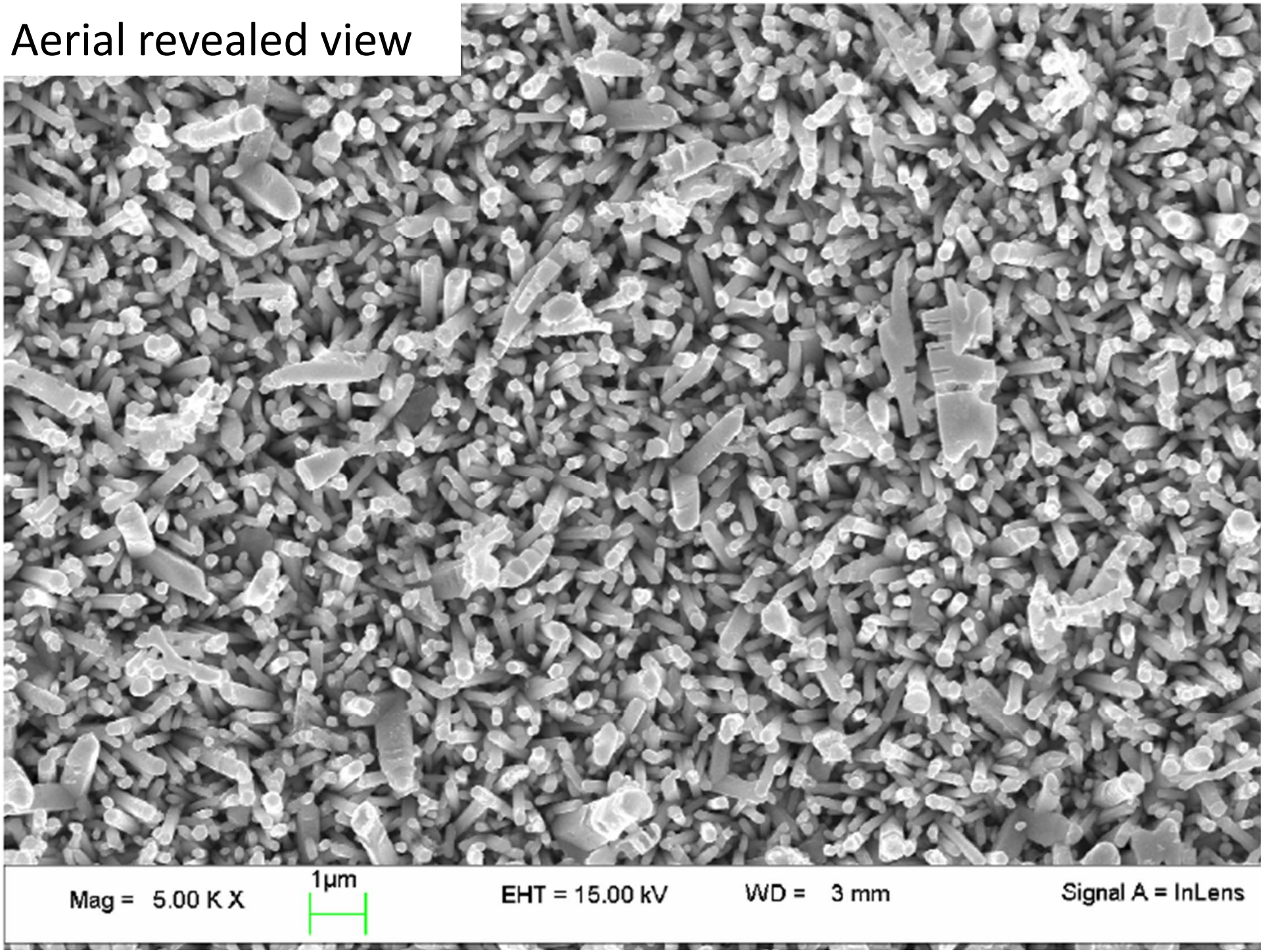
Revealed cross section



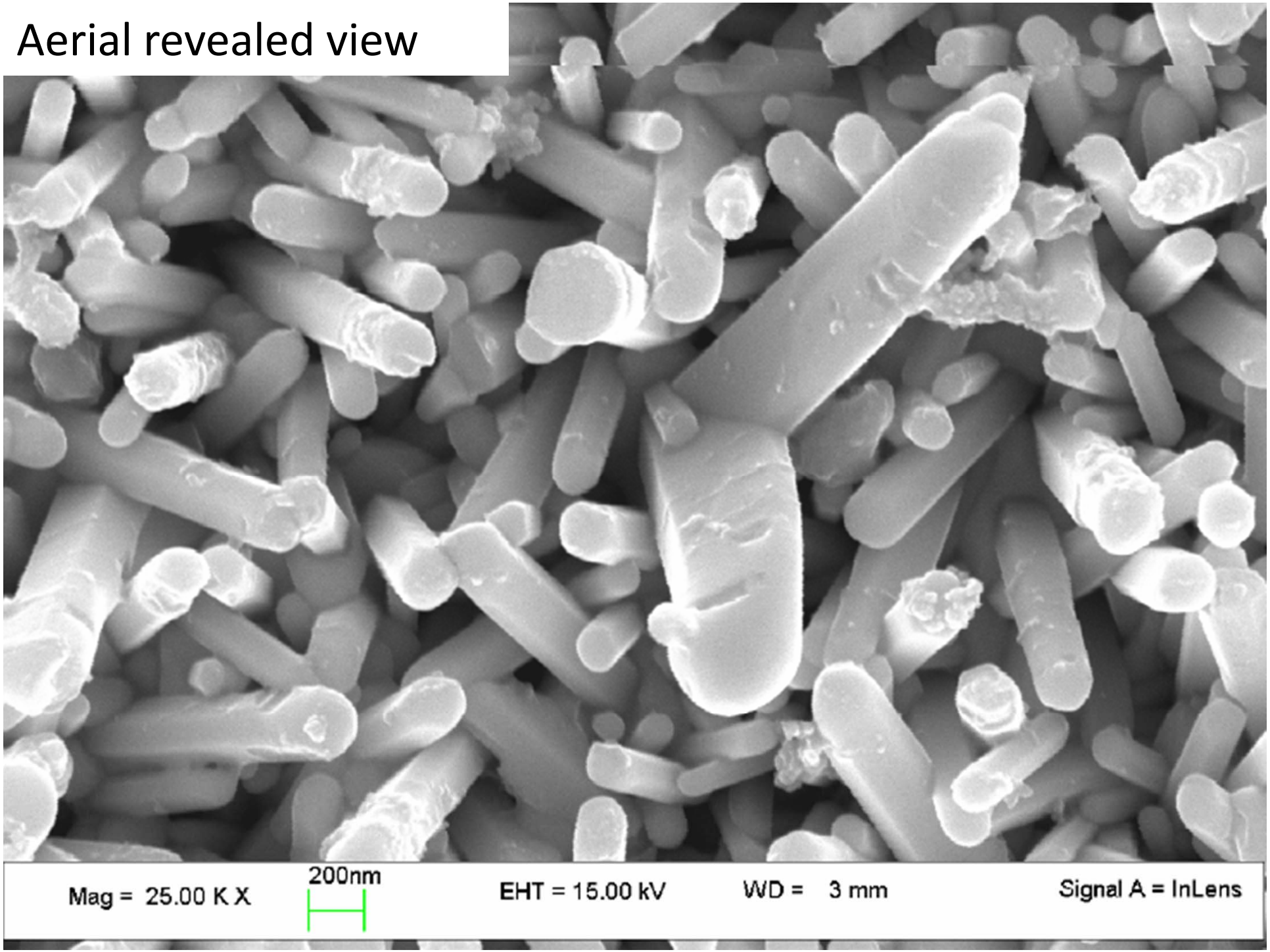
Revealed cross section



Aerial revealed view



Aerial revealed view



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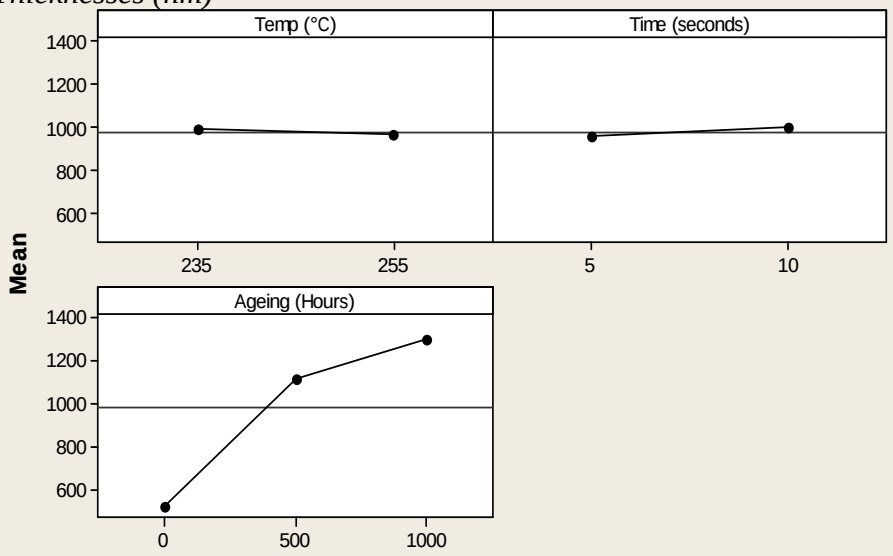
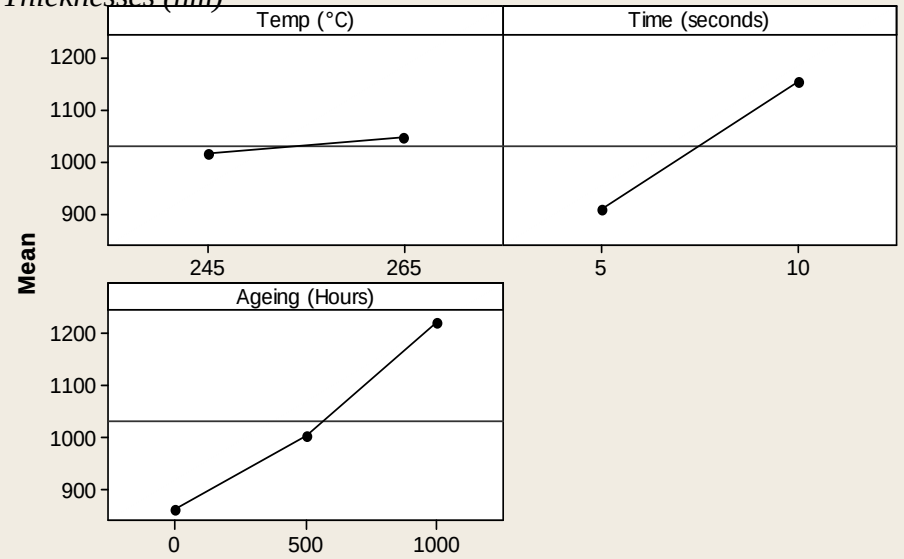
Parameters effects

Effects of the 3 selected parameters

SnPb 63/37 Bath



SAC305 Bath



Each point = Average of de 20 measurements
Standard deviation ~ 100nm

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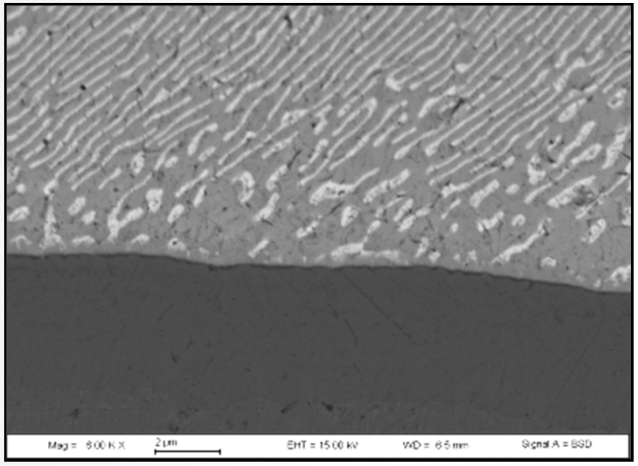
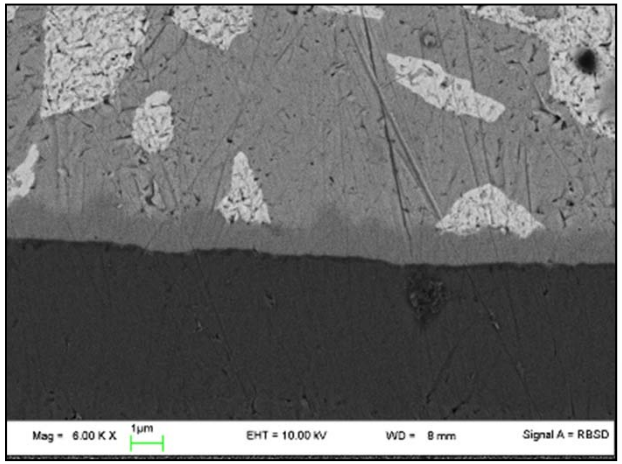
125°C Isothermal Ageing Effect

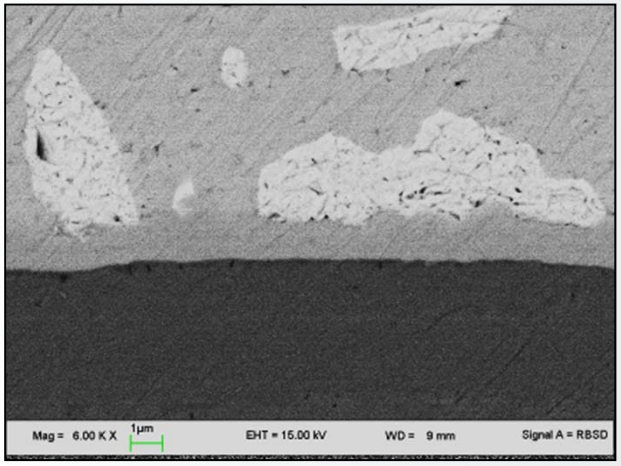
Cross sectionned views

0 Hour | **500 Hours** | **1000 Hours**

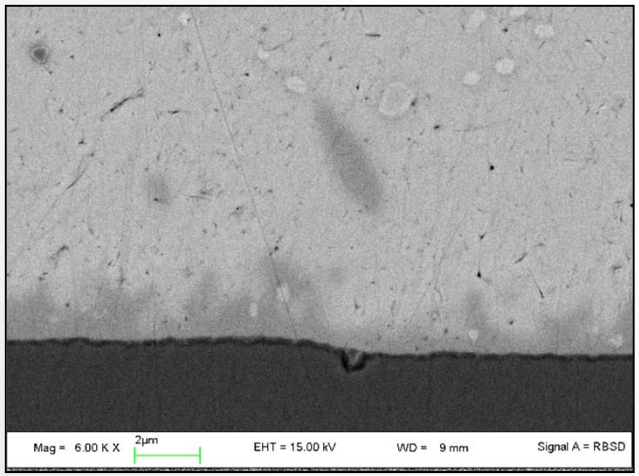
Leaded solder Sn/Pb 63/37

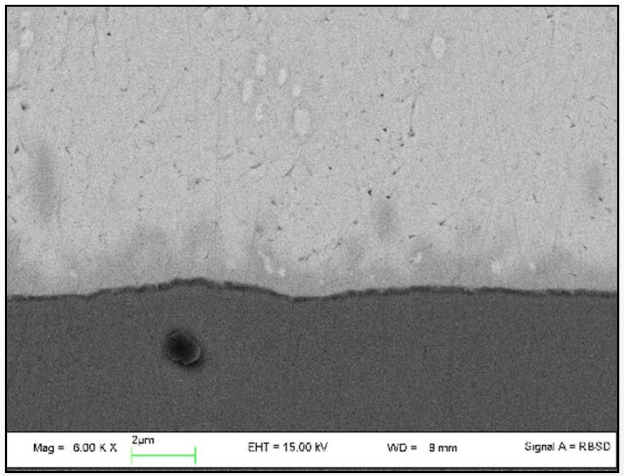


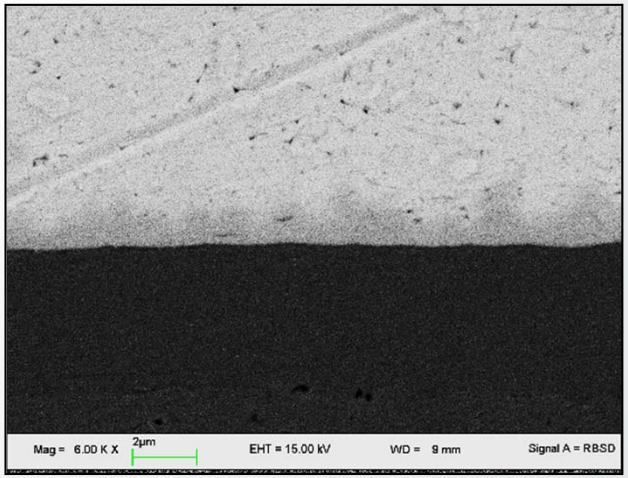




Lead Free: SAC305







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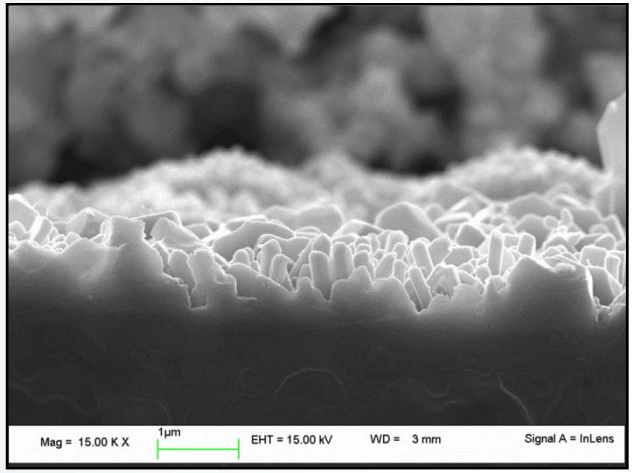
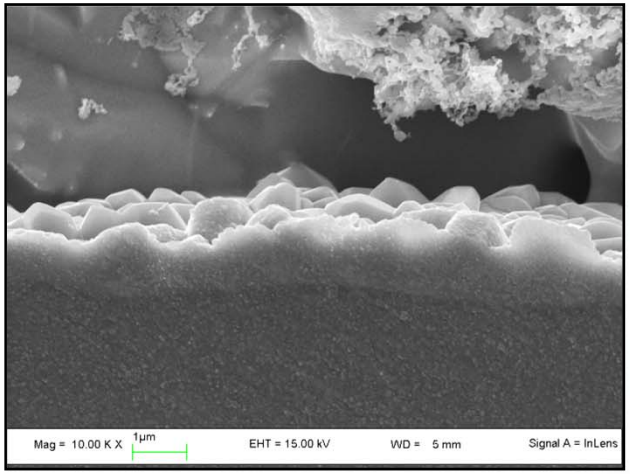
125°C Isothermal Ageing Effect

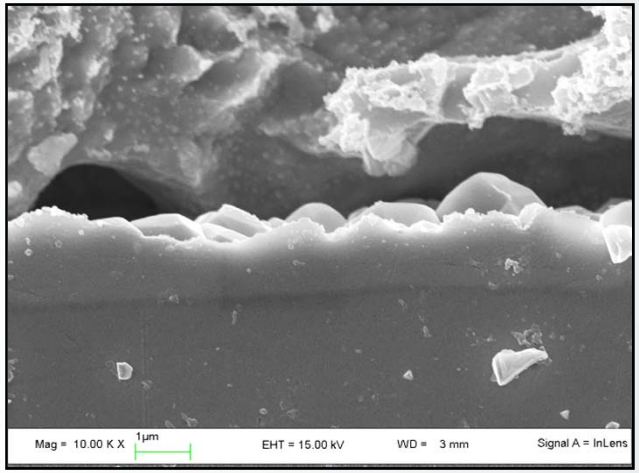
Revealed cross sections

0 Hour | **500 Hours** | **1000 Hours**

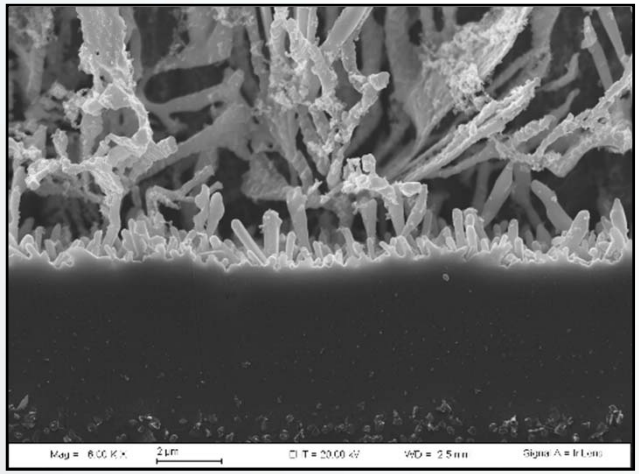
Leaded solder Sn/Pb 63/37

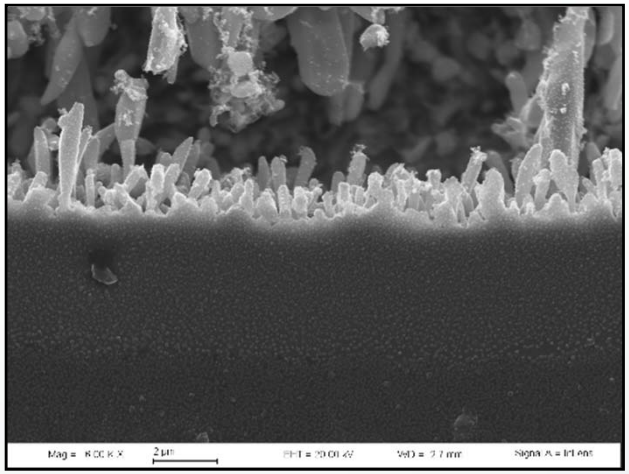


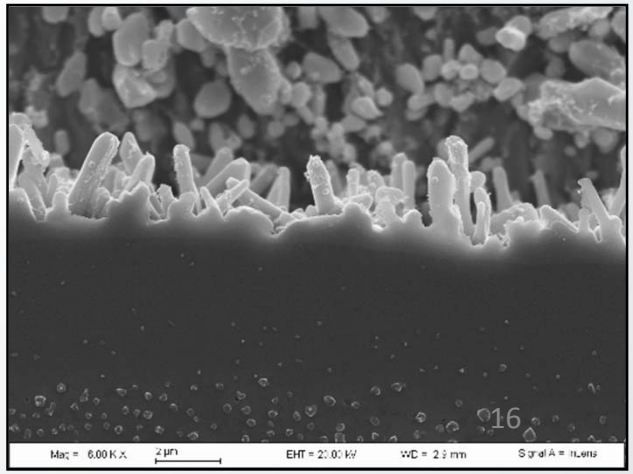




Lead Free: SAC305







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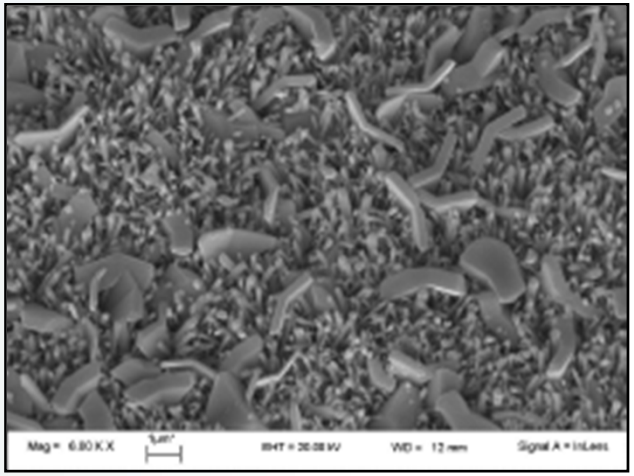
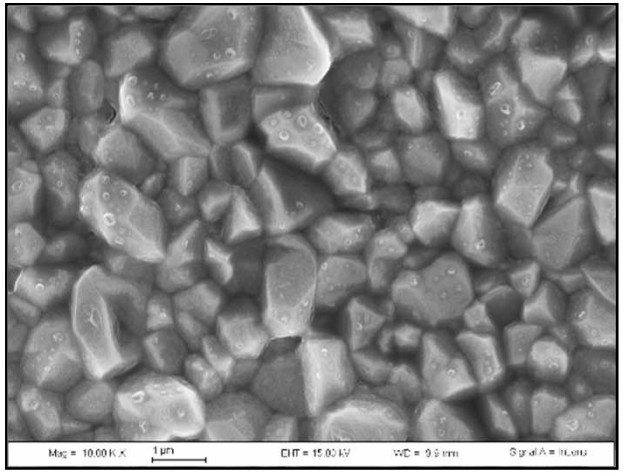
125°C Isothermal Ageing Effect

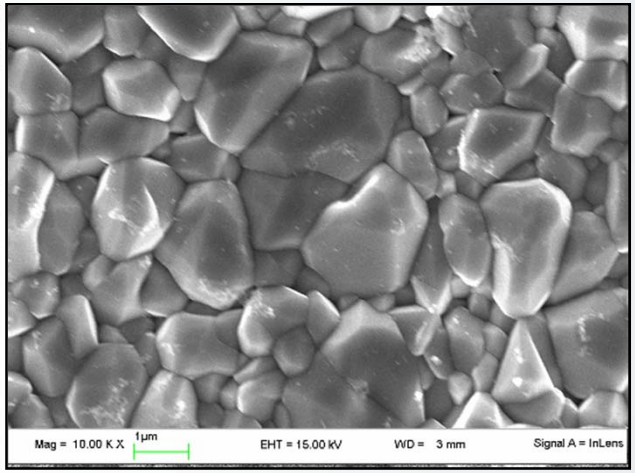
Aerial revealed views

0 Hour | **500 Hours** | **1000 Hours**

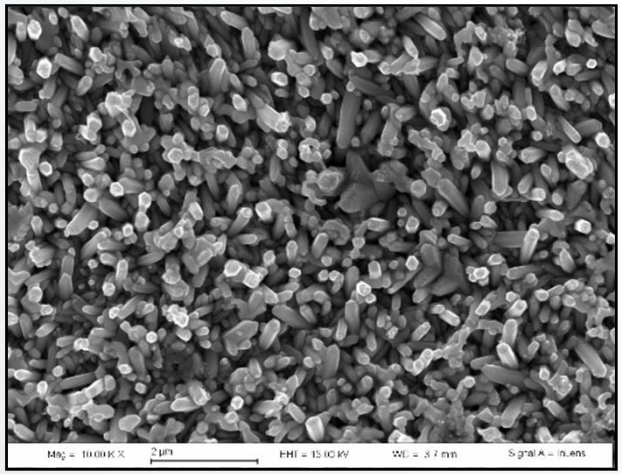
Leaded solder Sn/Pb 63/37

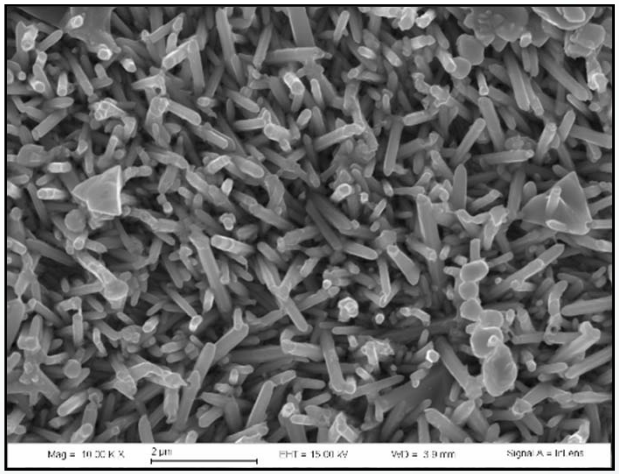


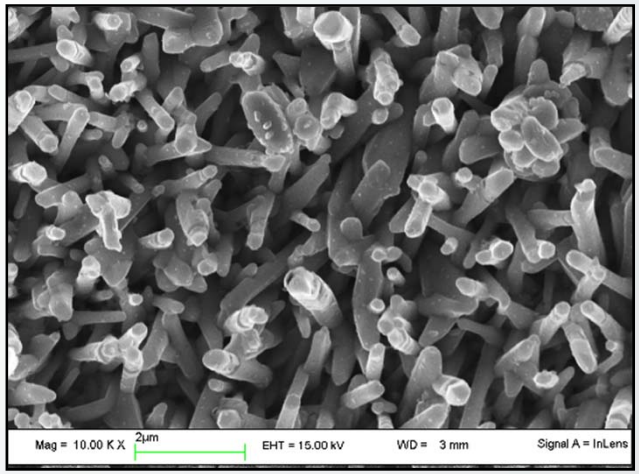




Lead Free: SAC305







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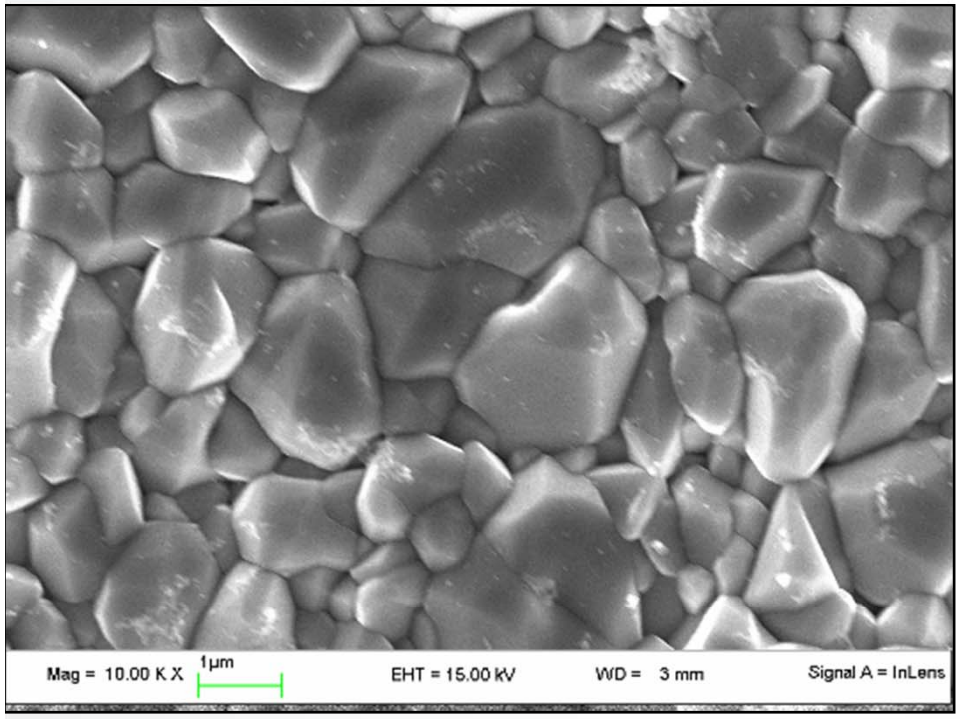
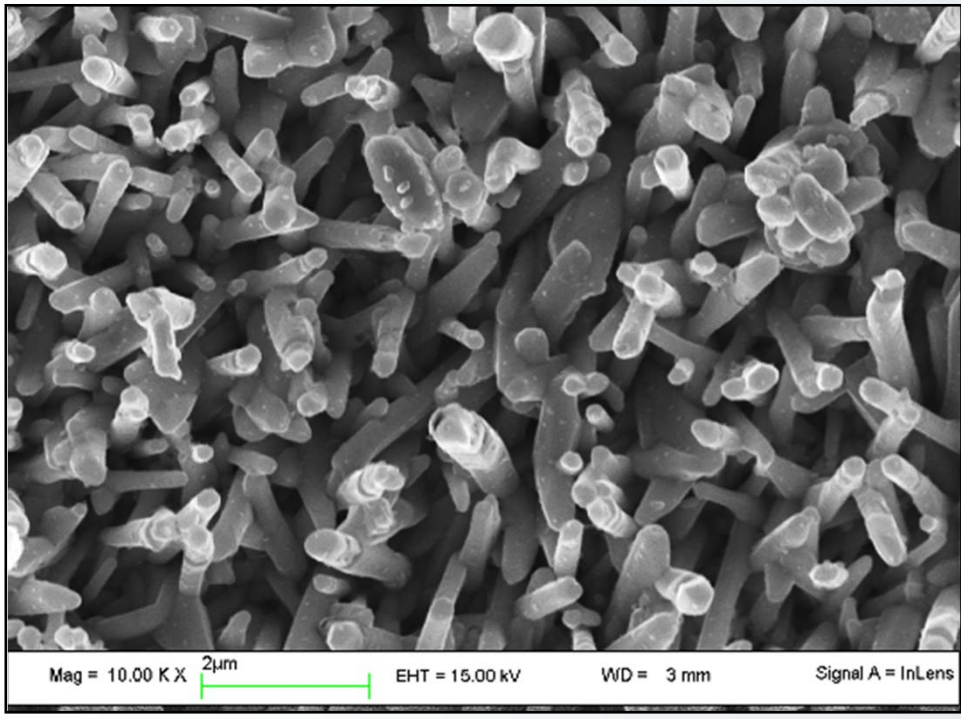
Aerial revealed views @ 1000h

Leaded solder Sn/Pb 63/37



Lead Free: SAC305



Finer structure in SAC, with larger specific surface →better adherence IMC/solder, and then limited the risk of cracking.

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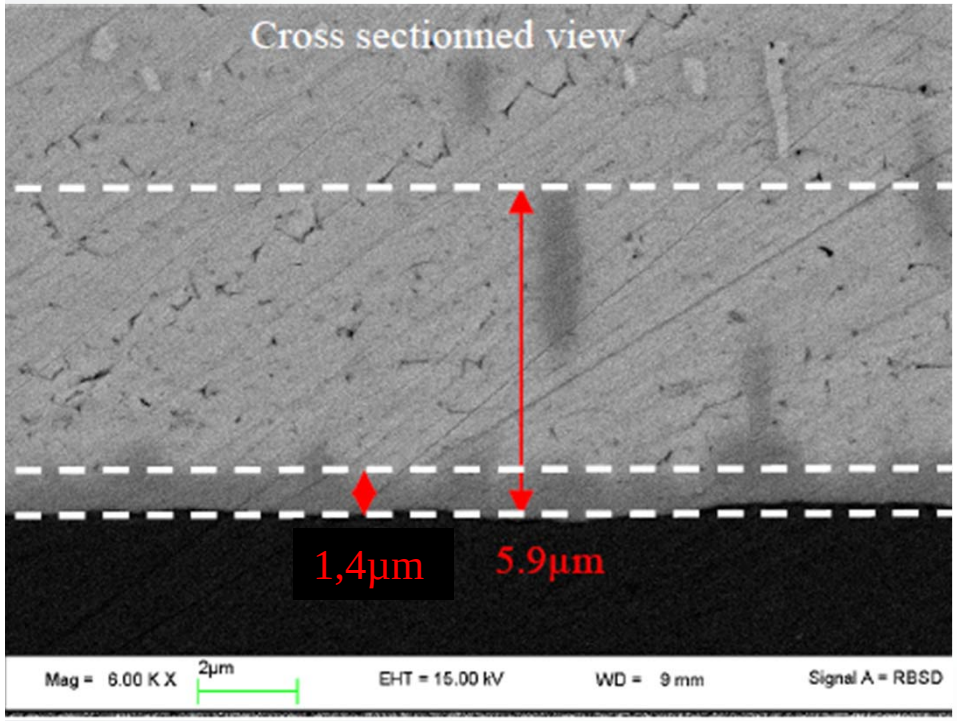
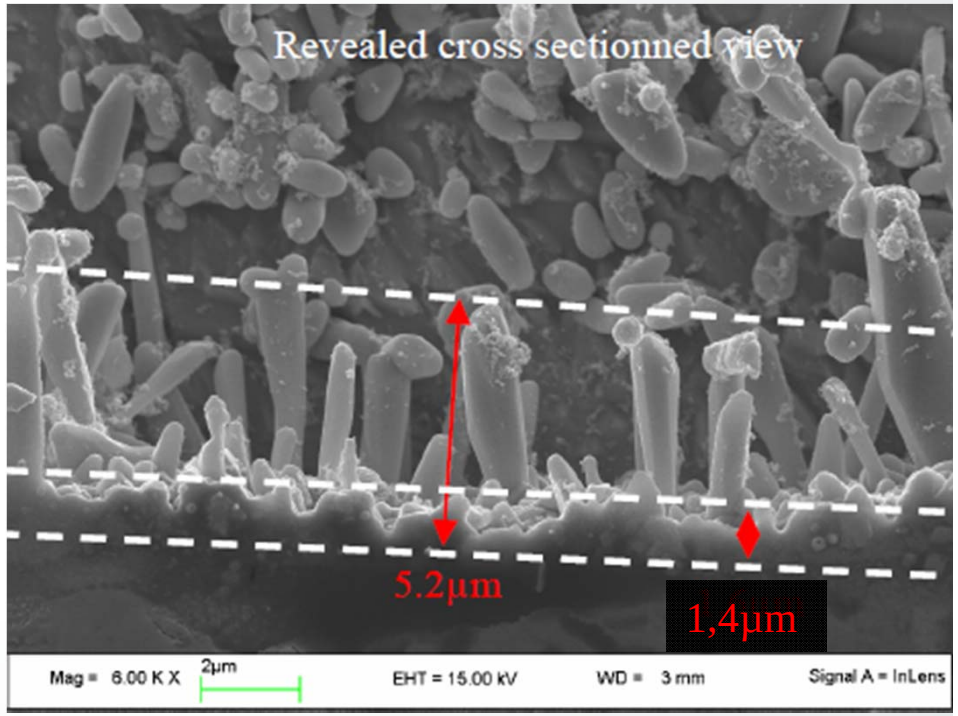
IMC Size measurement on SAC





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Synthesis

Results	Leaded Sn/Pb 63/37 Bath	Lead free SAC 305 Bath
IMC Thicknesses	Min (T0): 0,46 µm, Max (T1000): 1,47 µm	Min (T0): 0,74 µm Max (T1000): 1,36 µm
Morphology	@T0: 2 phases, fine structures @T500 and T1000: 1 phase, coarse structure	Fine structure whatever the ageing time
Formation/growth conditions	Large effect of isothermal ageing Low influence of process parameters (Time and Temperature)	Large effect of isothermal ageing Influence of soldering time
Comments	Measurement method in 2D representative	Measurement method in 2D not completely representative

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Conclusion & Next Steps

→ Thickness measurements: necessary, but not sufficient on SAC305
→ Different morphologies at T0 and in ageing
→ SAC 305 IMC size more sensitive to Process parameters (solder time)

<u>Next steps:</u> Check the effects of other parameters:

- Reflow, with temperature profil
- Isothermal temperature
- Other ageing ways (rapid temperature change, cycles…)
- Shape factors (components, vias, leads etc…)
- Other solder alloys
- Power supply
- Cross check morphological observations to mechanical properties (pull test…) and to reliability levels to specific sollicitations
- Other finishing Silver, OSP, ENEPIG (Au/Pd/Ni)

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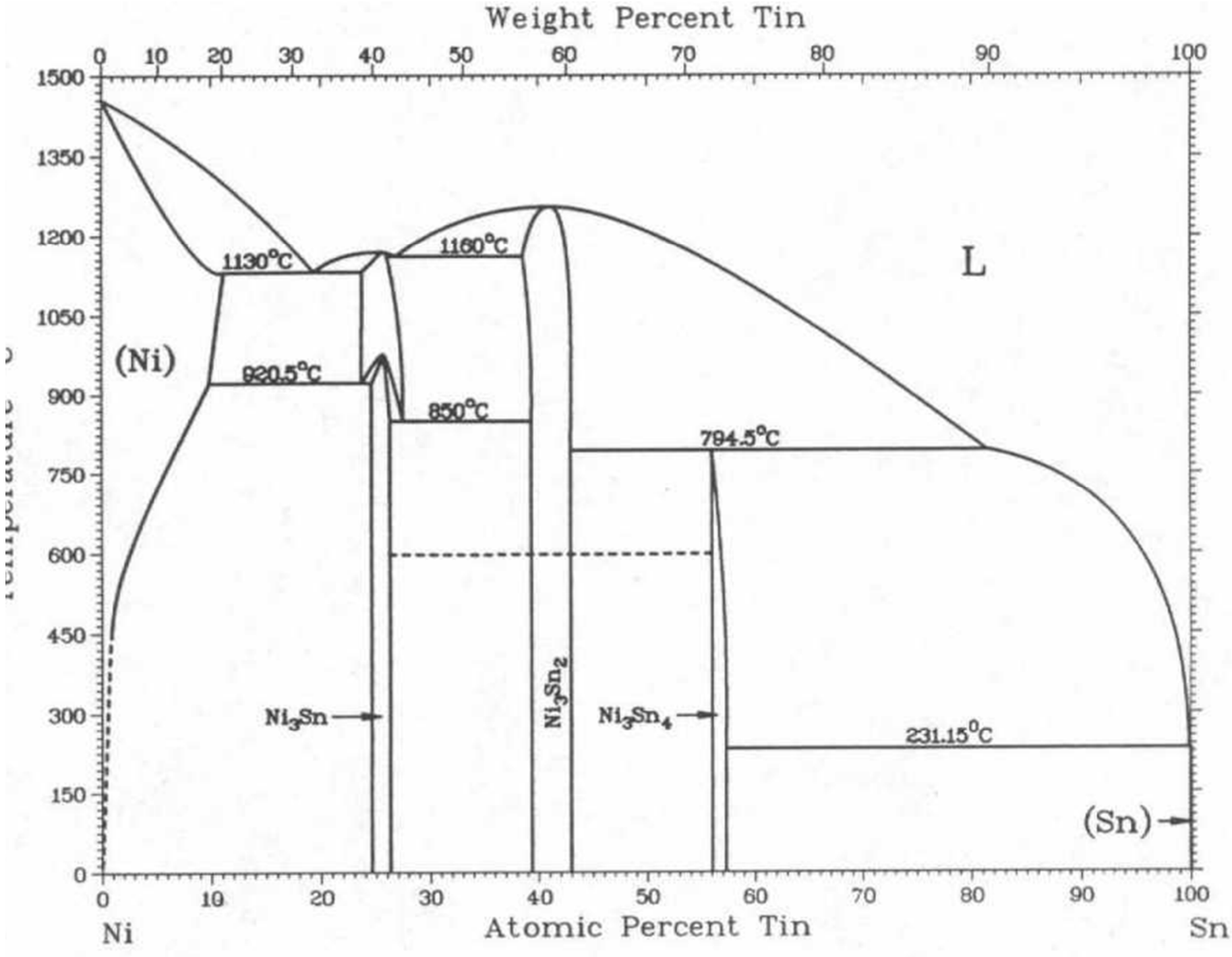
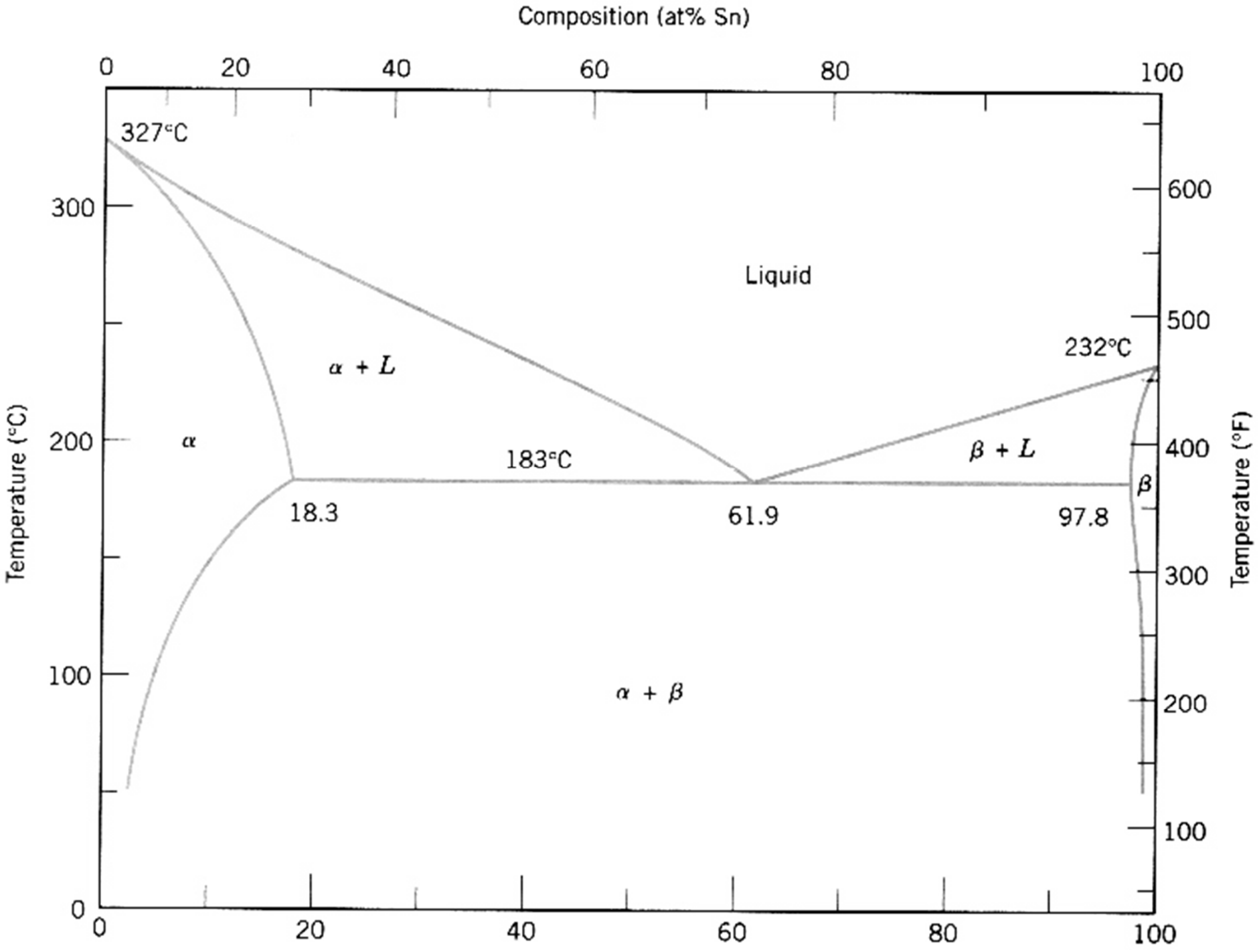
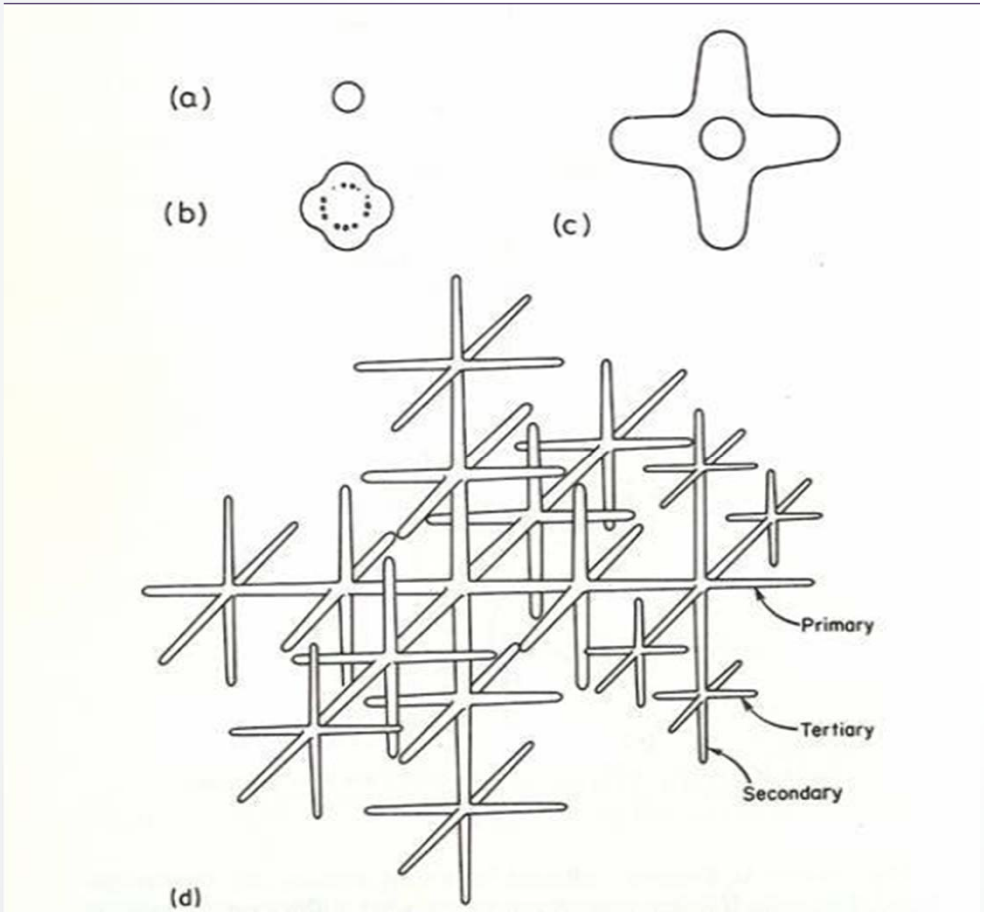
Thanks for your attention

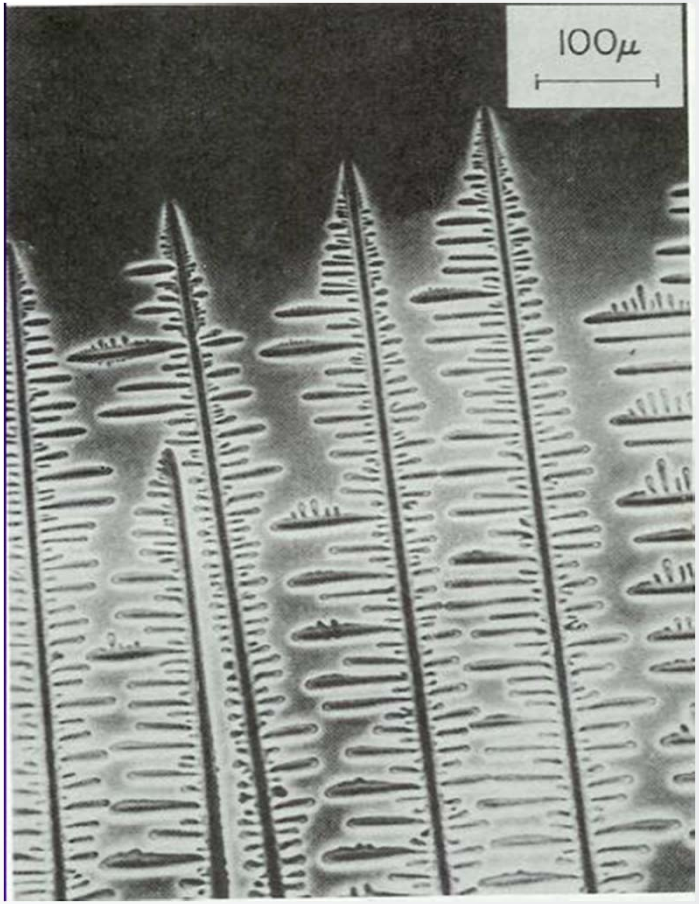
Questions?


Weight Percent Tin
0
10
20
30
40
50
60
70
80
90
100
1500
1350
1200
1050
900
750
600
450
300
150
0
1130°C
1160°C
L
(Ni)
920.5°C
850°C
794.5°C
Ni3Sn
Ni3Sn2
Ni3Sn4
231.15°C
(Sn)
Ni
Atomic Percent Tin
Sn


Composition (at% Sn)
0
20
40
60
80
100
327°C
Liquid
232°C
α + L
α
183°C
β + L
β
18.3
61.9
97.8
α + β
Temperature (°C)
Temperature (°F)
0
100
200
300
100
200
300
400
500
600

Reminders





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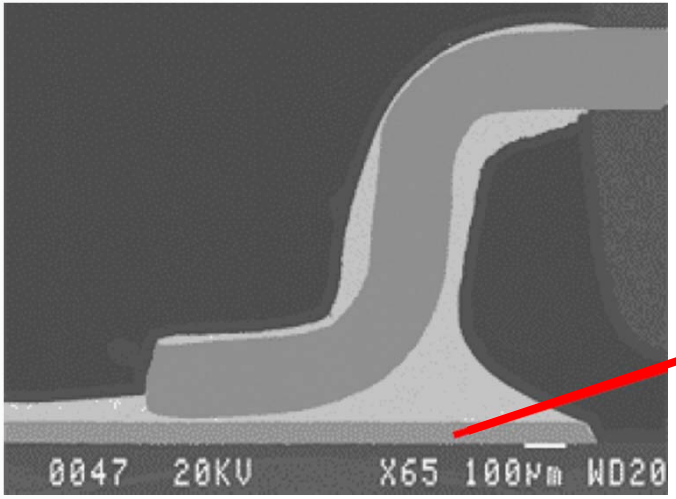
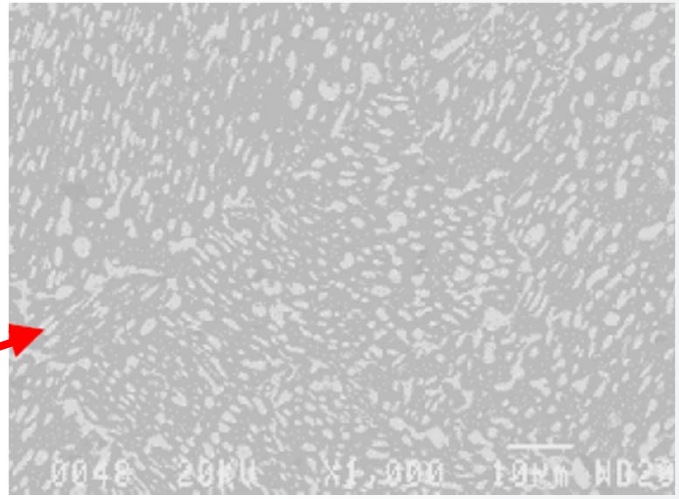
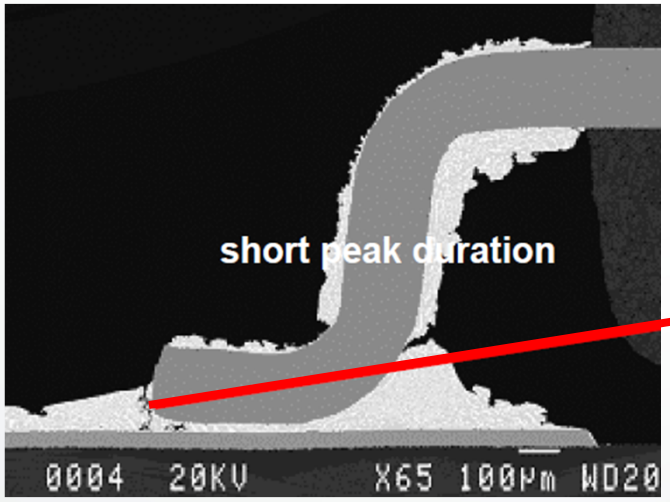
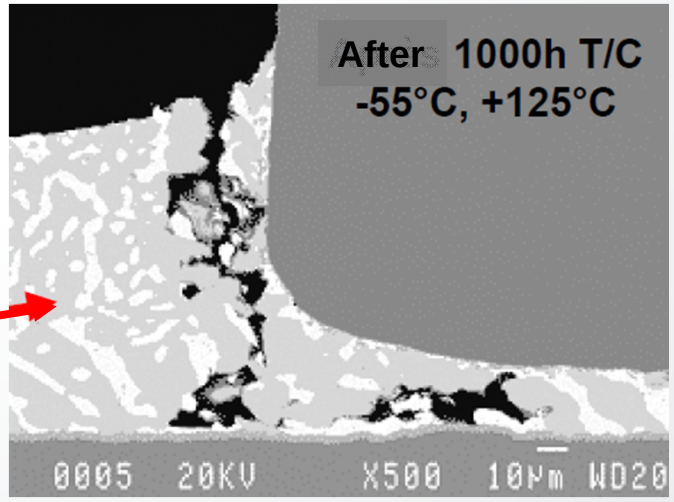
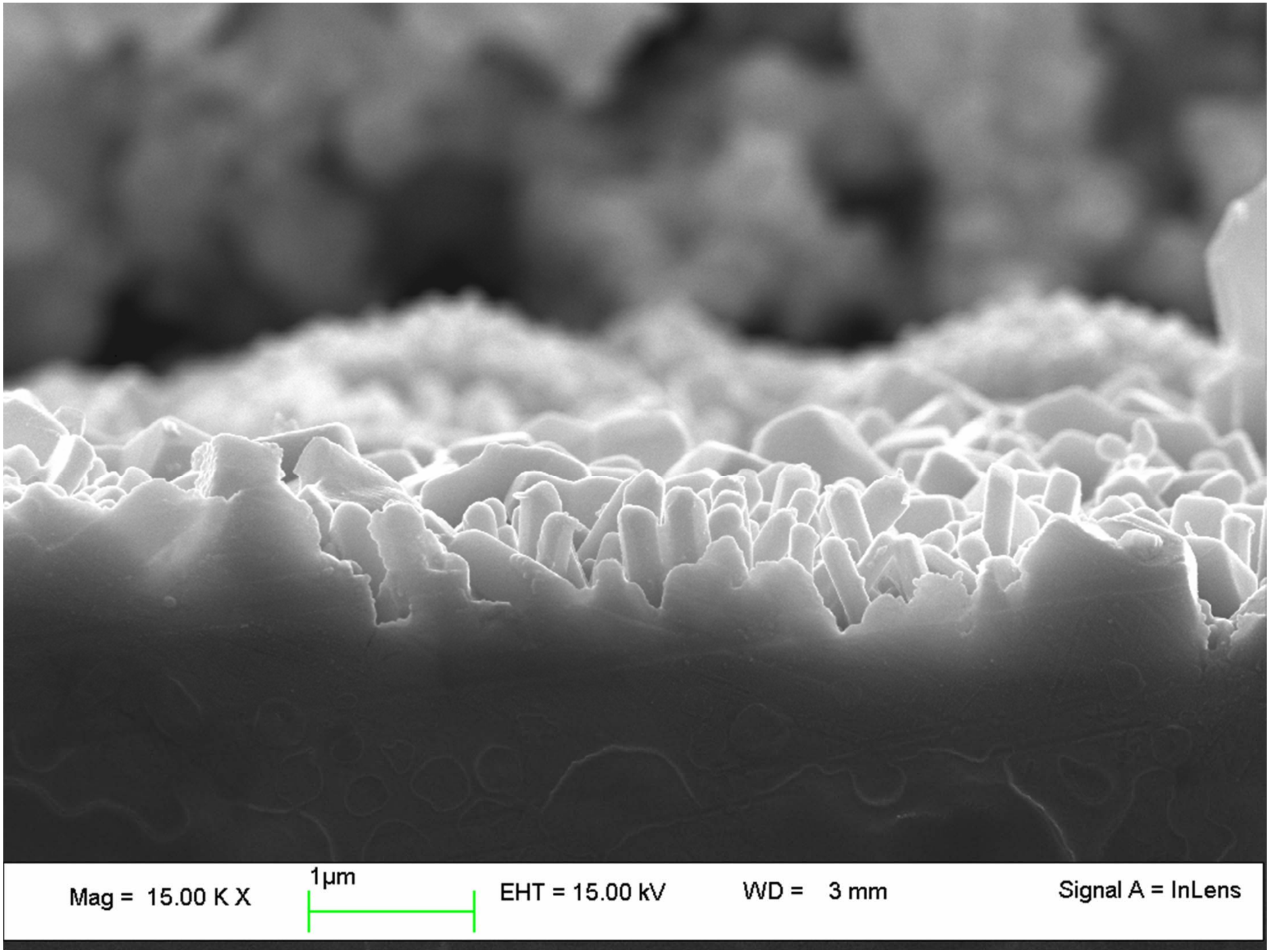
Phase coarsening

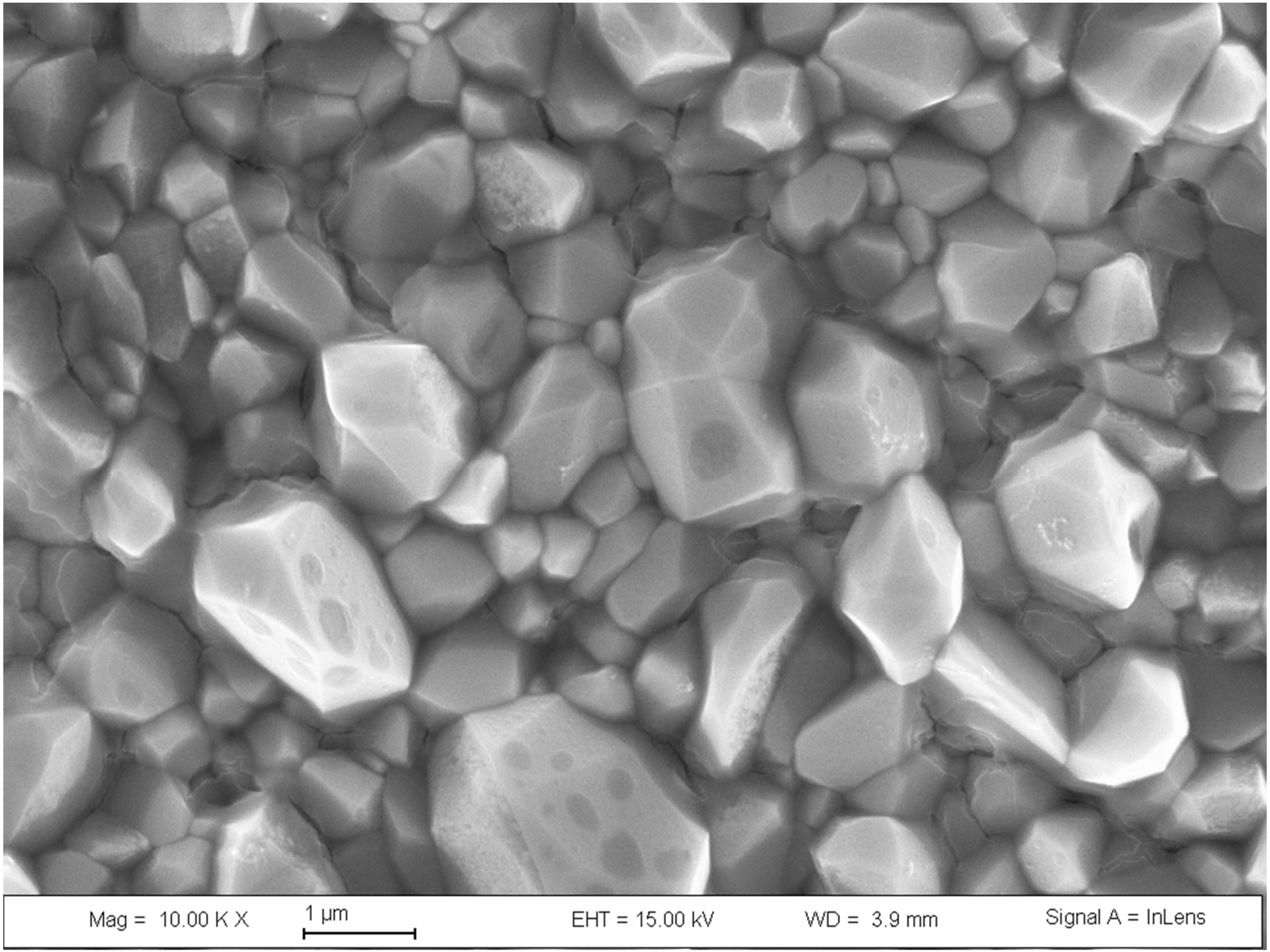


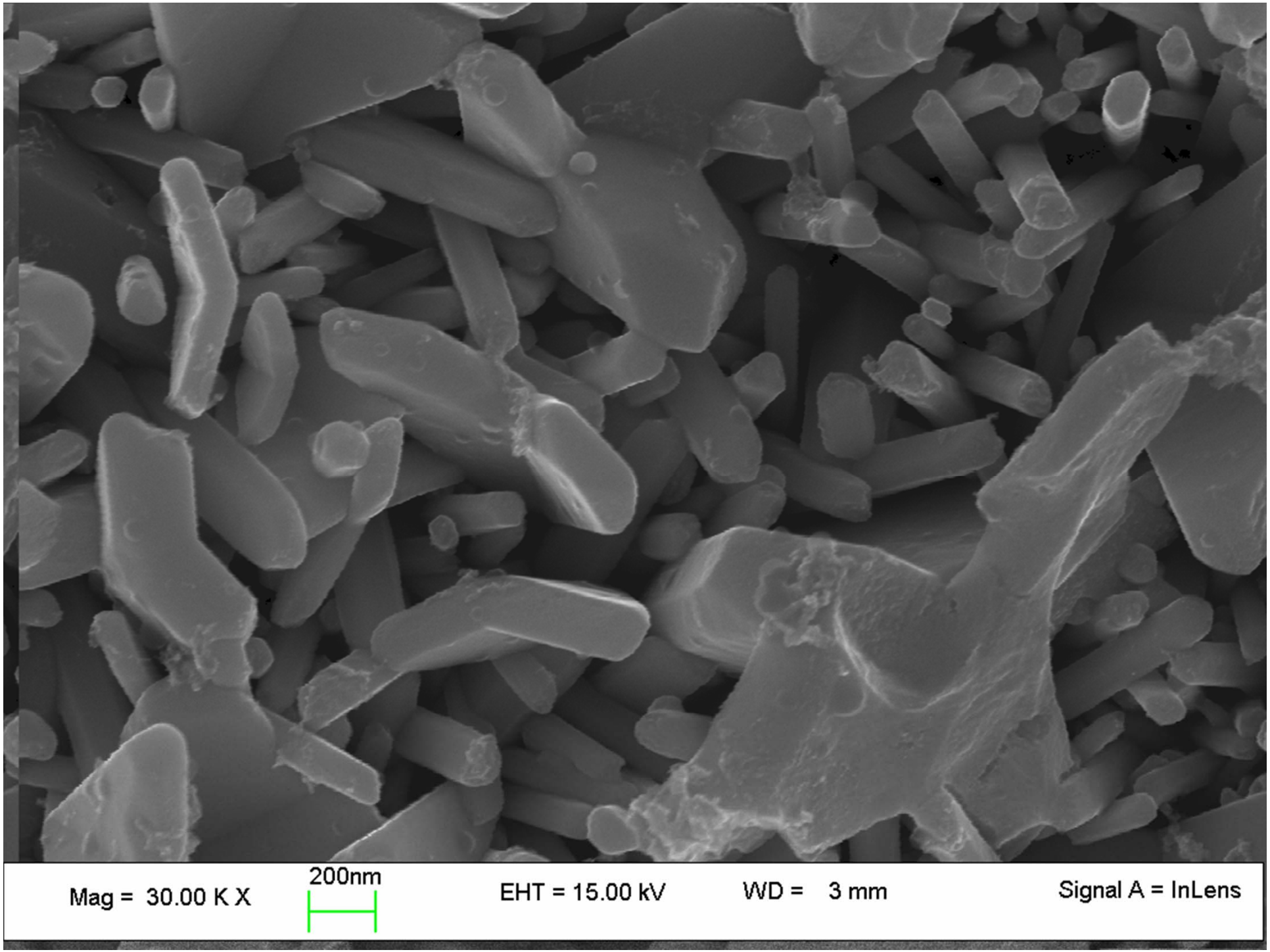


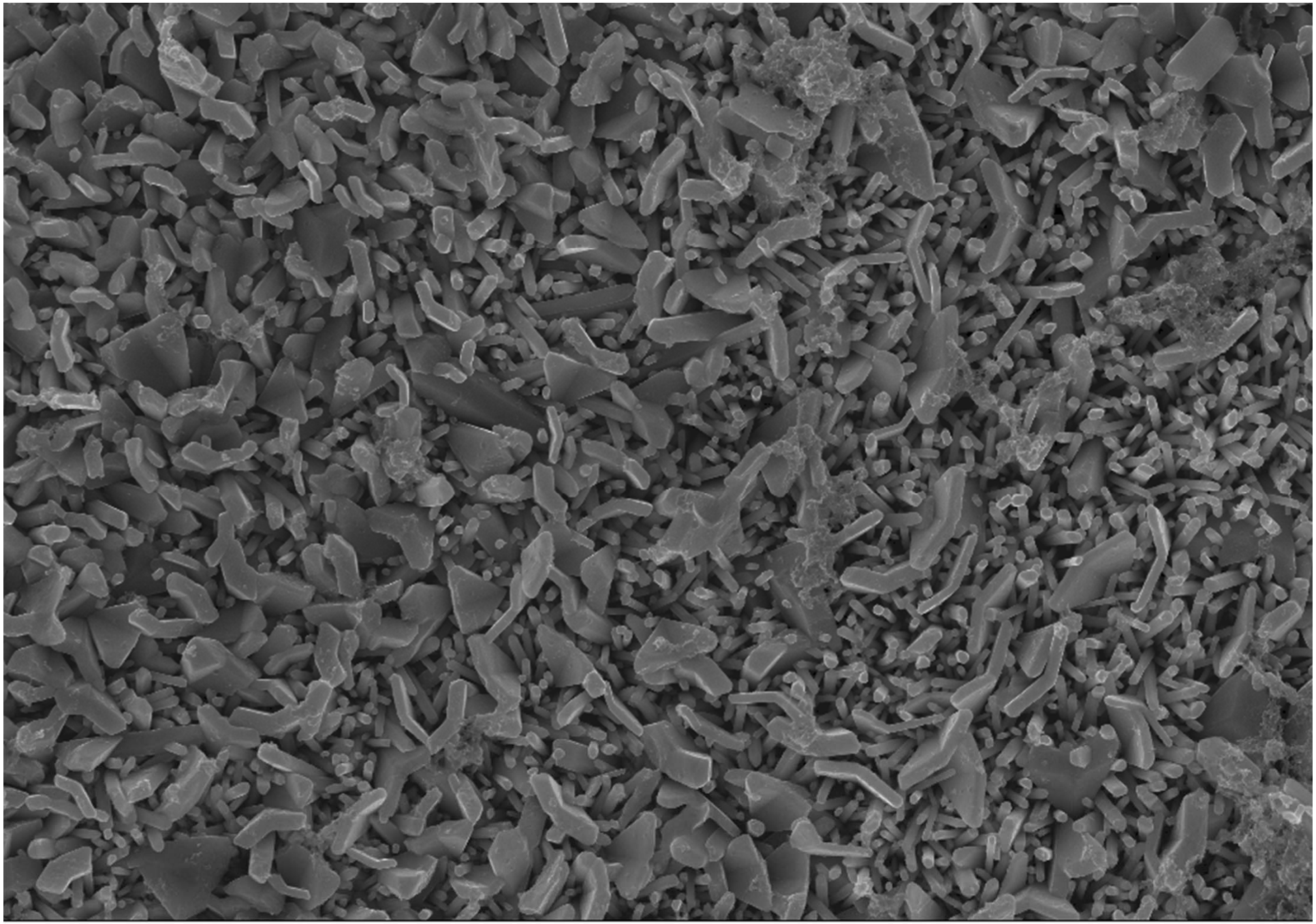


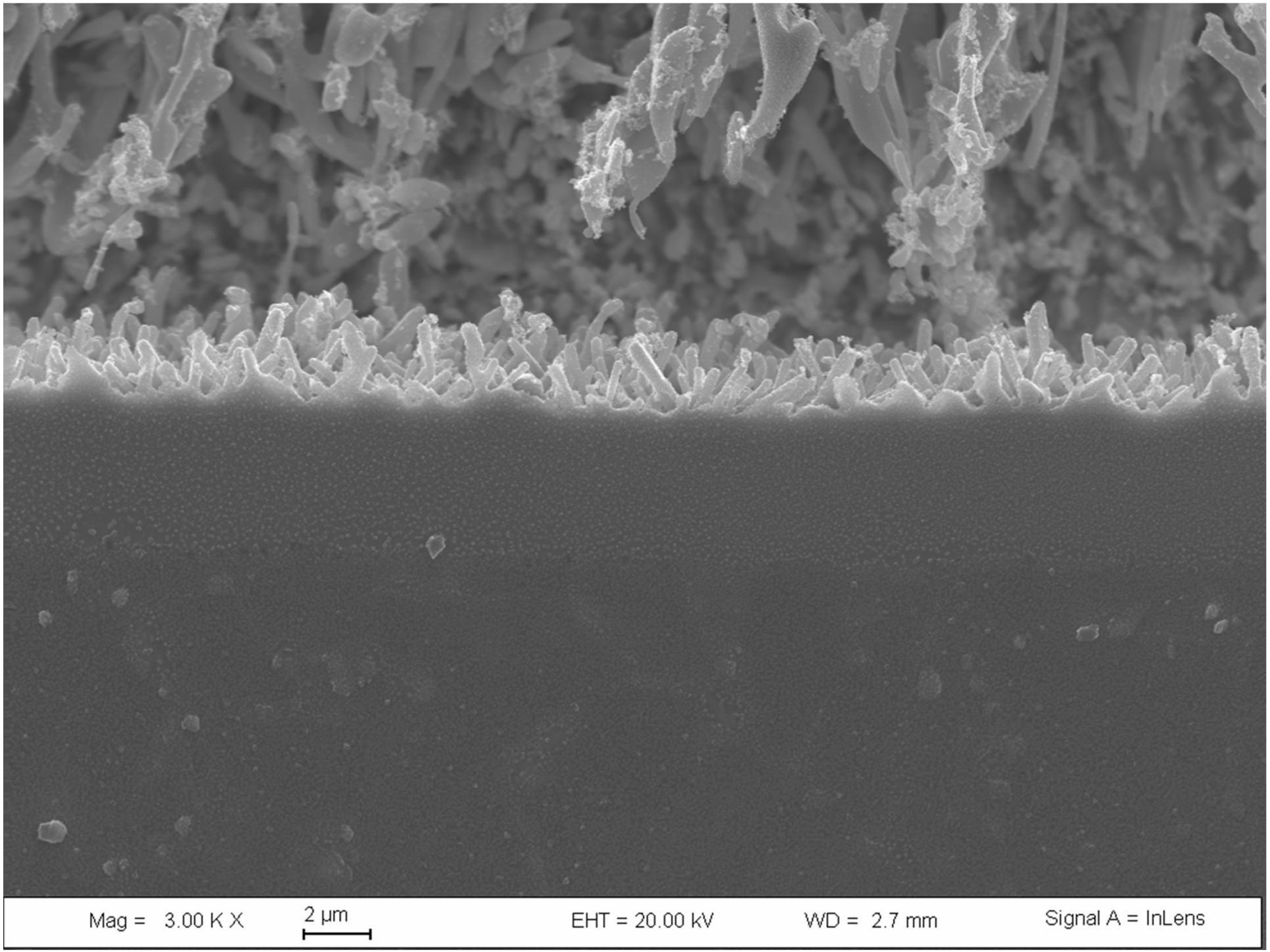


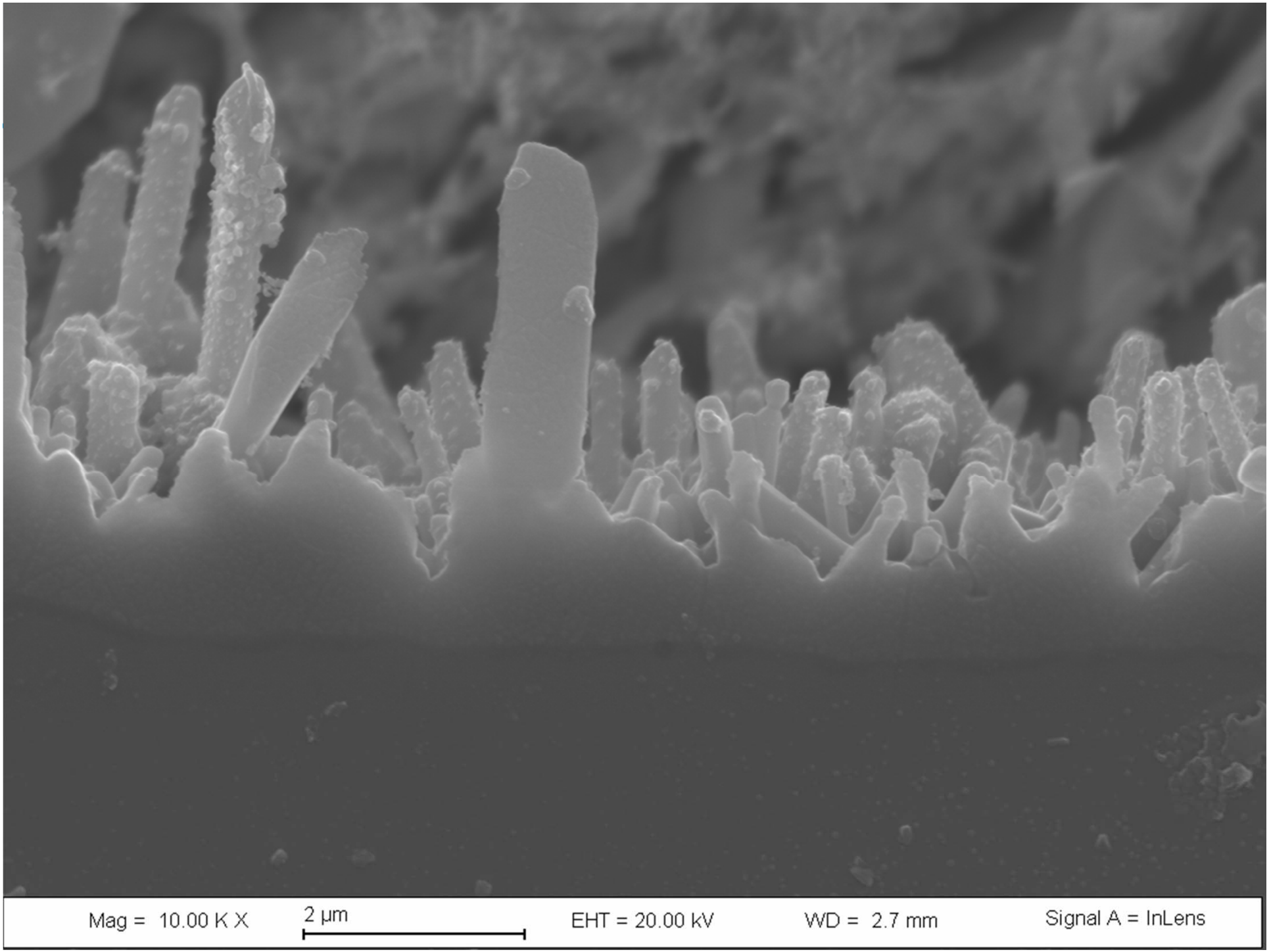

Mag = 15.00 K X
1µm
EHT = 15.00 kV
WD = 3 mm
Signal A = InLens

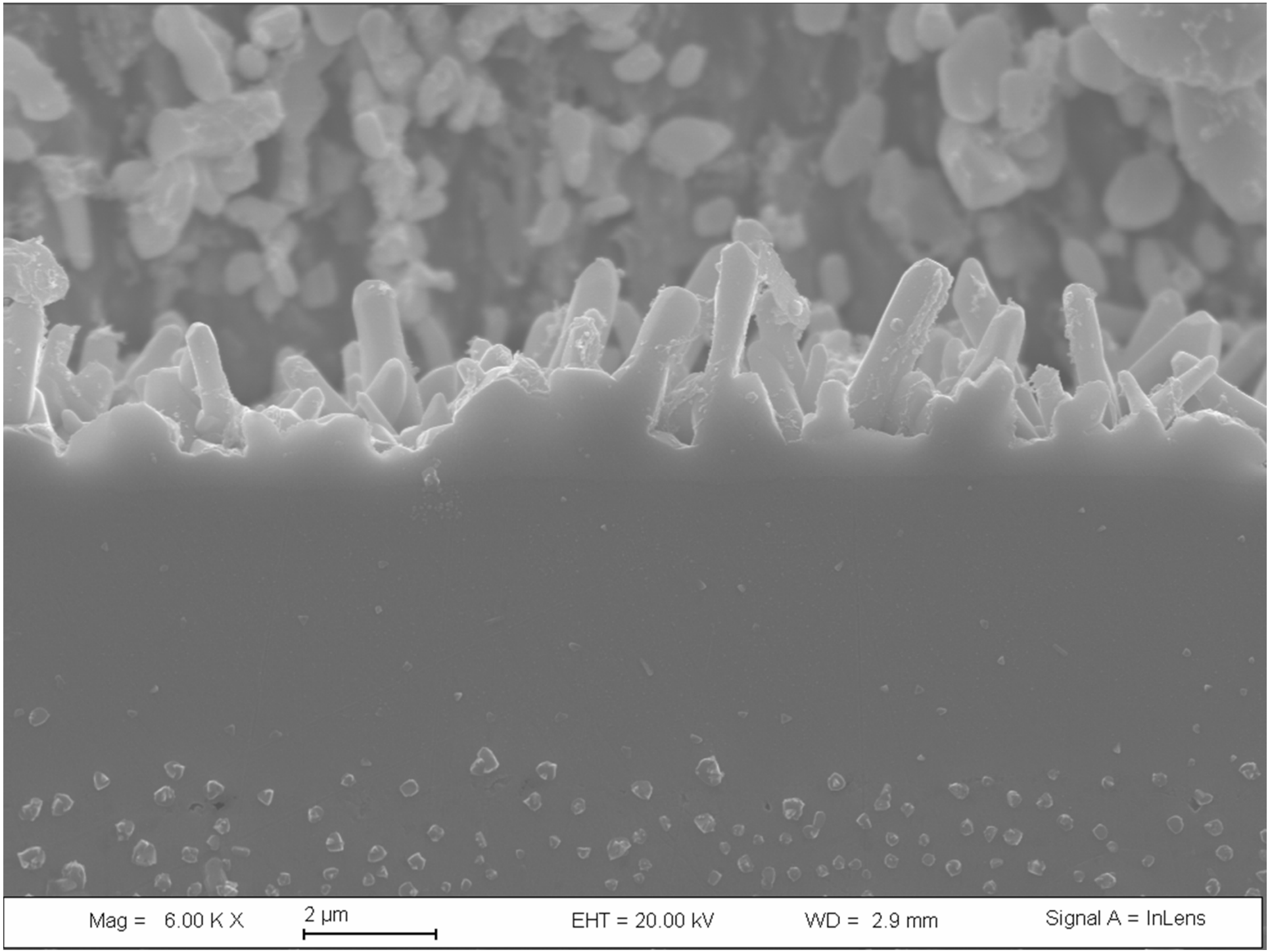

Mag = 10.00 K X
1 µm
EHT = 15.00 kV
WD = 3.9 mm
Signal A = InLens

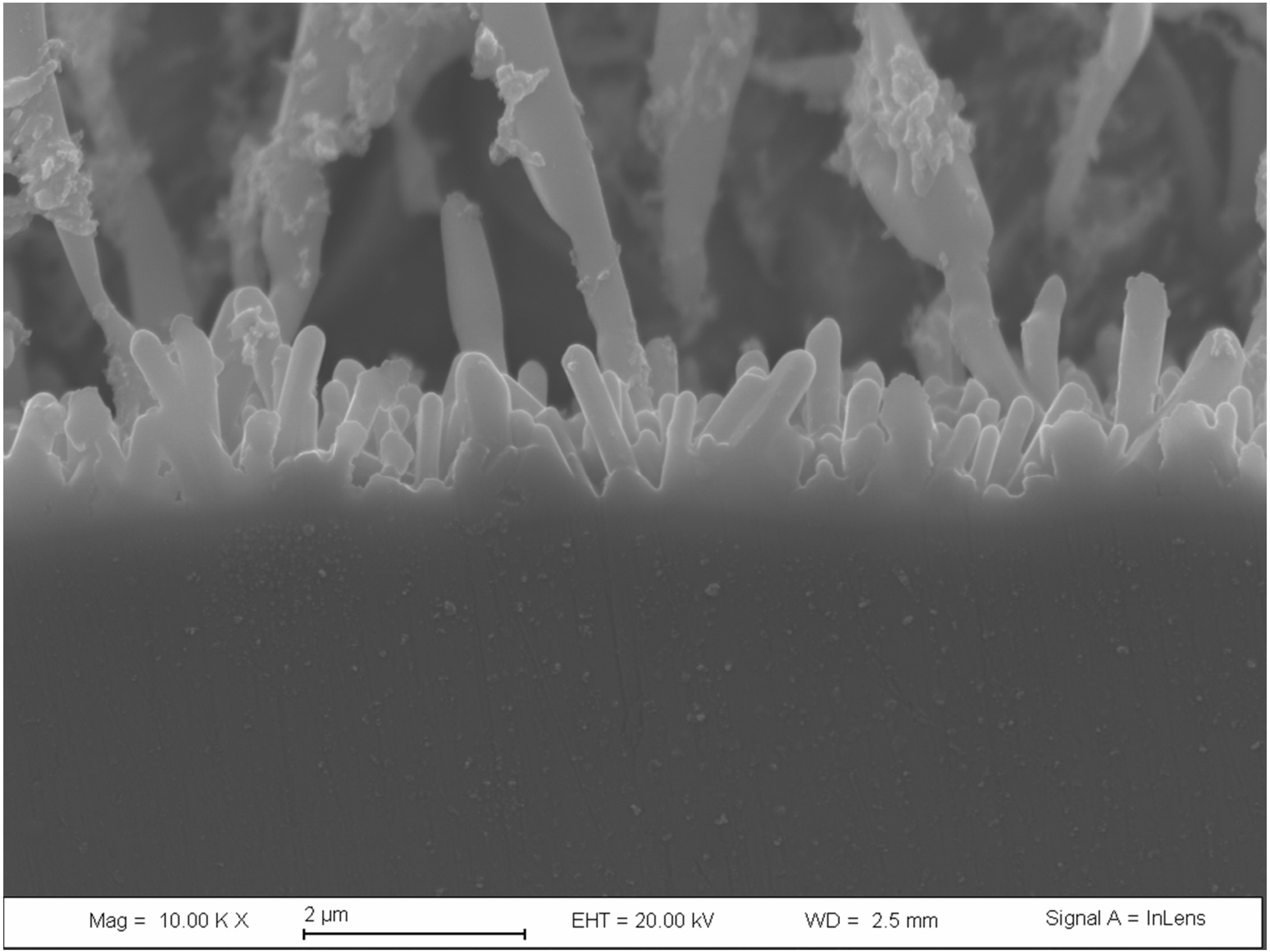

Mag = 30.00 K X
200nm
EHT = 15.00 kV
WD = 3 mm
Signal A = InLens

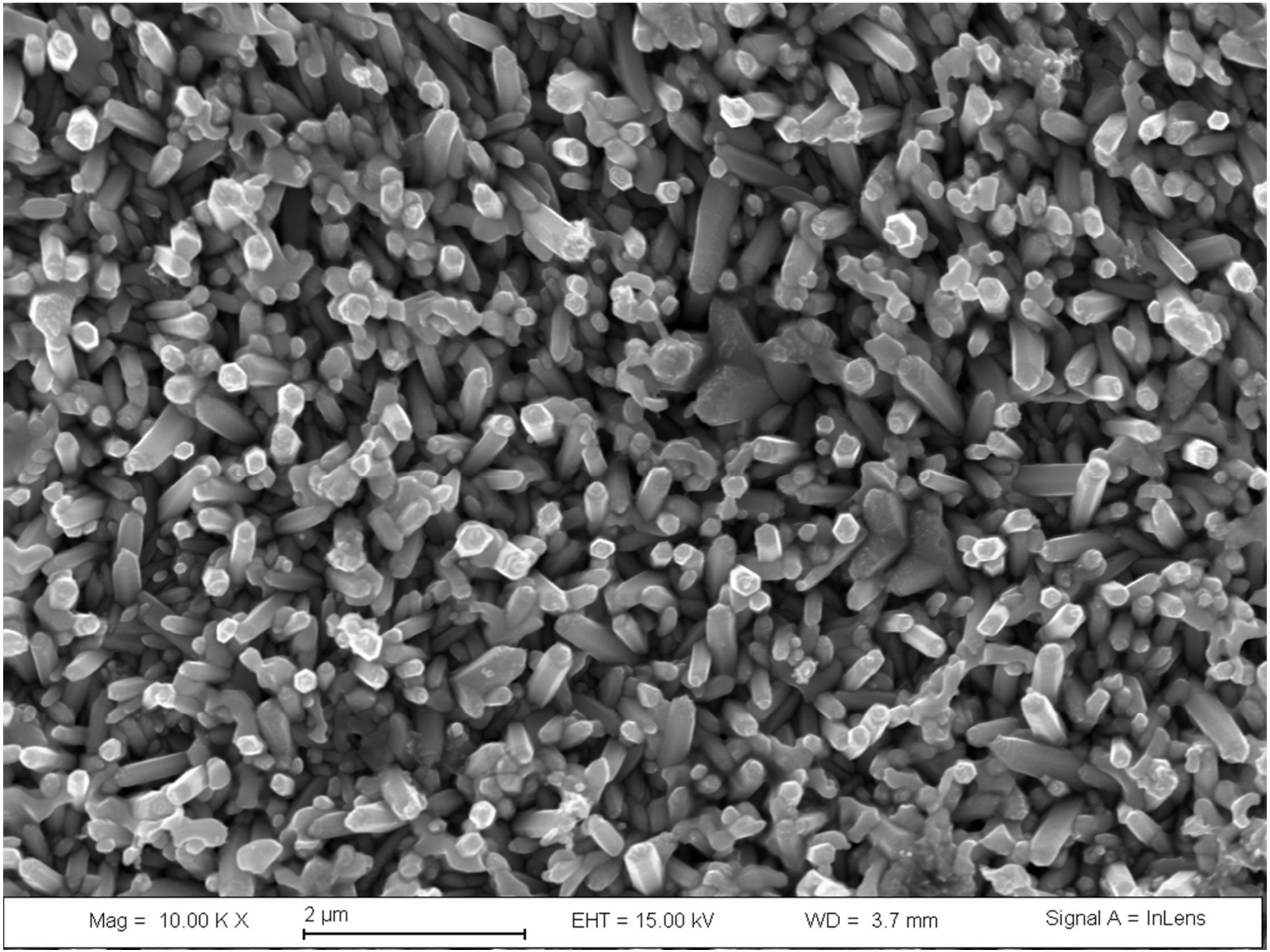

Mag = 6.00 K X
1µm
EHT = 15.00 kV
WD = 3 mm
Signal A = InLens

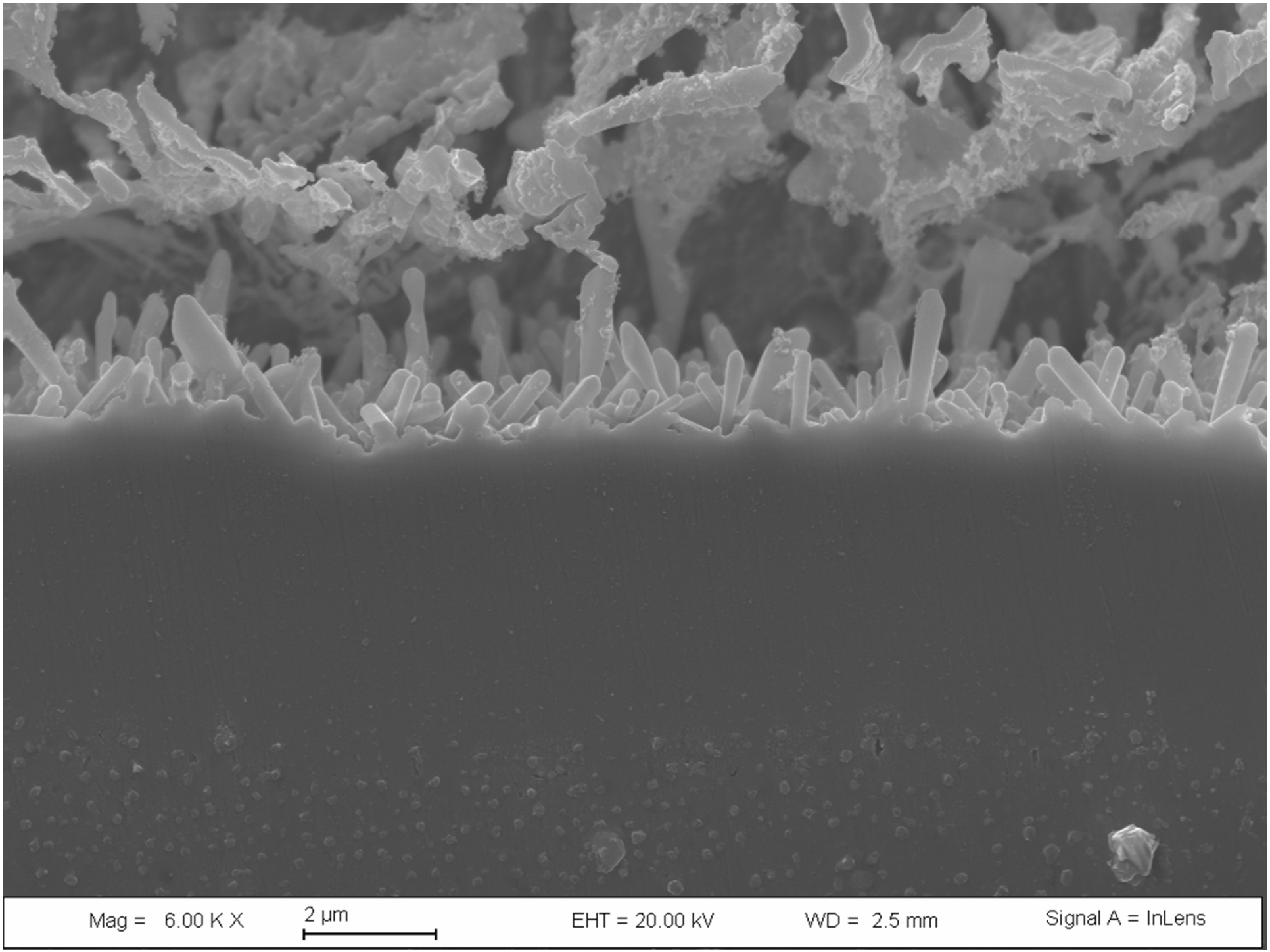

Mag = 3.00 K X
2 µm
EHT = 20.00 kV
WD = 2.7 mm
Signal A = InLens

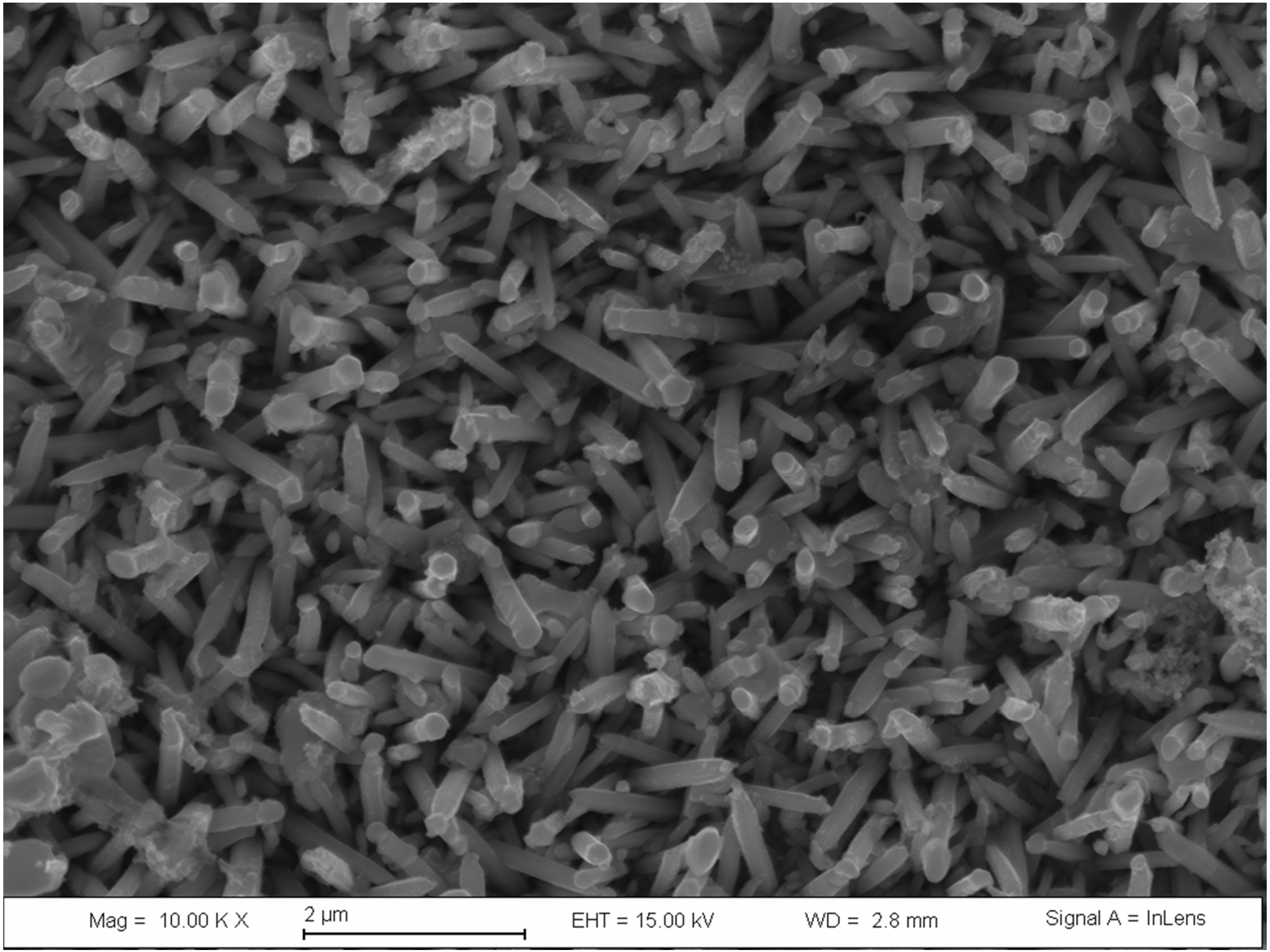

Mag = 10.00 K X
2 µm
EHT = 20.00 kV
WD = 2.7 mm
Signal A = InLens


Mag = 6.00 K X
2 µm
EHT = 20.00 kV
WD = 2.9 mm
Signal A = InLens


Mag = 10.00 K X
2 µm
EHT = 20.00 kV
WD = 2.5 mm
Signal A = InLens


Mag = 10.00 K X
2 µm
EHT = 15.00 kV
WD = 3.7 mm
Signal A = InLens


Mag = 6.00 K X
2 µm
EHT = 20.00 kV
WD = 2.5 mm
Signal A = InLens


Mag = 10.00 K X
2 µm
EHT = 15.00 kV
WD = 2.8 mm
Signal A = InLens