

XFLASH® 7 DETECTOR WEBINAR

Achieving sub-10 nm EDS spatial resolution on bulk specimen in SEM

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Application Team
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Presenters



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- Application Specialist
- **EDS / EBSD / FlatQUAD / Micro-XRF / WDS**
- Bruker Nano Analytics, Korea

Outline

- Introduction XFlash® 7 for SEM
 - Fast signal processing
 - Data/spectrum quality at high speeds
 - **Esprit LiveMap:** real time chemical imaging
- **Achieving sub-10 nm EDS spatial resolution on bulk specimen in SEM**
 - Spatial resolution in SEM: Influencing factors, beam diameter, kV, optimal pixel size
 - Optimal mapping settings for high resolution measurement. What to consider?
 - Application examples:
 - semiconductor structures (FinFET)
 - Ni-based single crystal superalloy

The Generations of Bruker SDD



LN₂ cooling
Si(Li) detector
Energy resolution : ≈136 eV(Mn-ka)



Peltier cooling
Silicon Drift Detectors (SDD)
Best energy resolution : 121 eV (Mn-ka)

1st generation



XFlash®1000
1997

2nd generation



XFlash®2000
2000

3rd generation



XFlash®3001
2002

4th generation



XFlash®4010
2006

5th generation



XFlash®5010
2008

6th generation



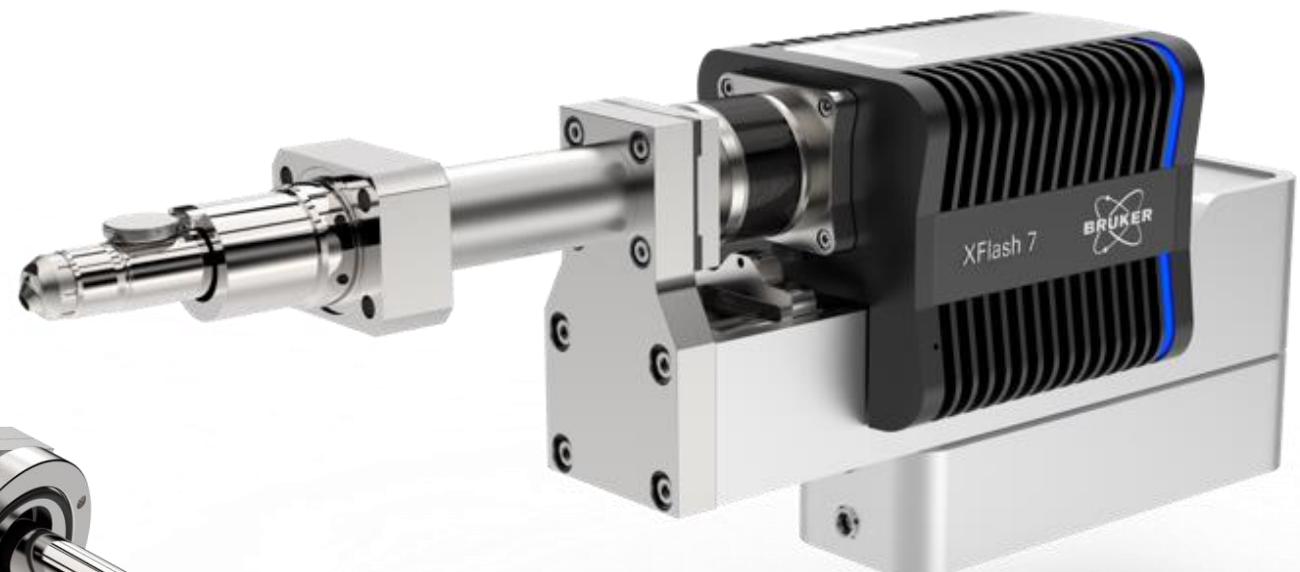
XFlash®6|100

XFlash® 7

Fast. Precise. Reliable.



XFlash® 7 - the detector
for SEM and FIB-SEM



XFlash® 7T - the detector
for TEM and STEM

XFlash® 7 – Be faster!

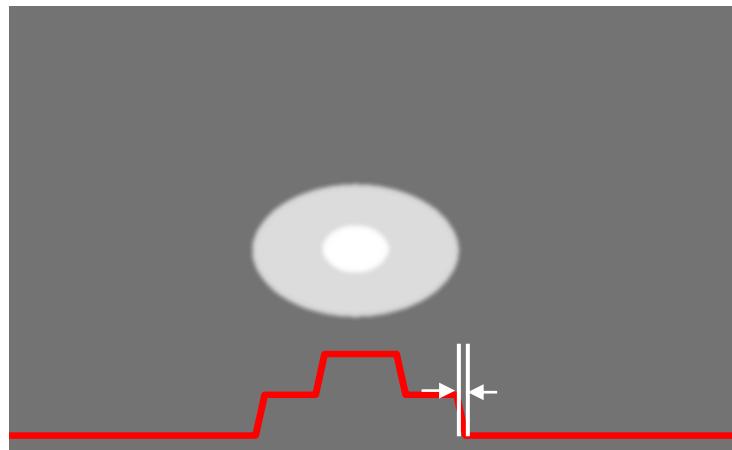
With up to **1,000,000 cps** the XFlash® 7 offers the highest real **analytical throughput** on the market for EDS detectors, meaning:

- Get best results in the shortest time
 - Fast survey maps
 - Fast particle analysis
- No risk of signal loss caused by slow read-out electronics
- Maximize your sample throughput without compromising quality
- **ESPRIT LiveMap** for real-time chemical imaging: use chemical information instead of BSE image signal to navigate on your sample

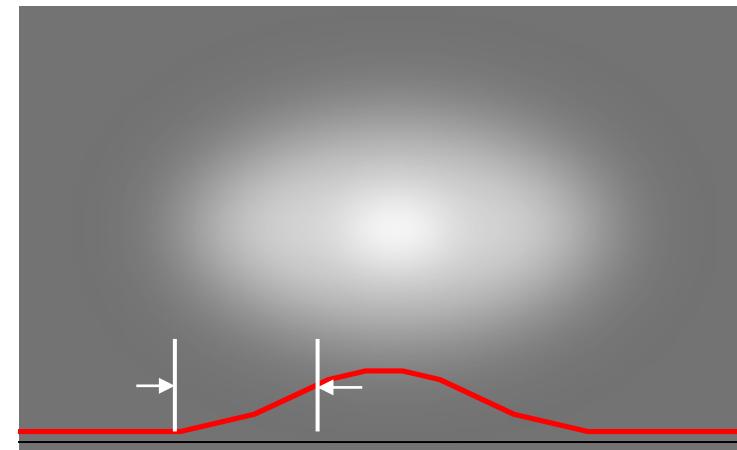


Spatial resolution

- Discern or separate distinct two features -> Spatial resolution
- Separate fine scale features -> High spatial resolution
- Fine scale/High magnification? -> Application

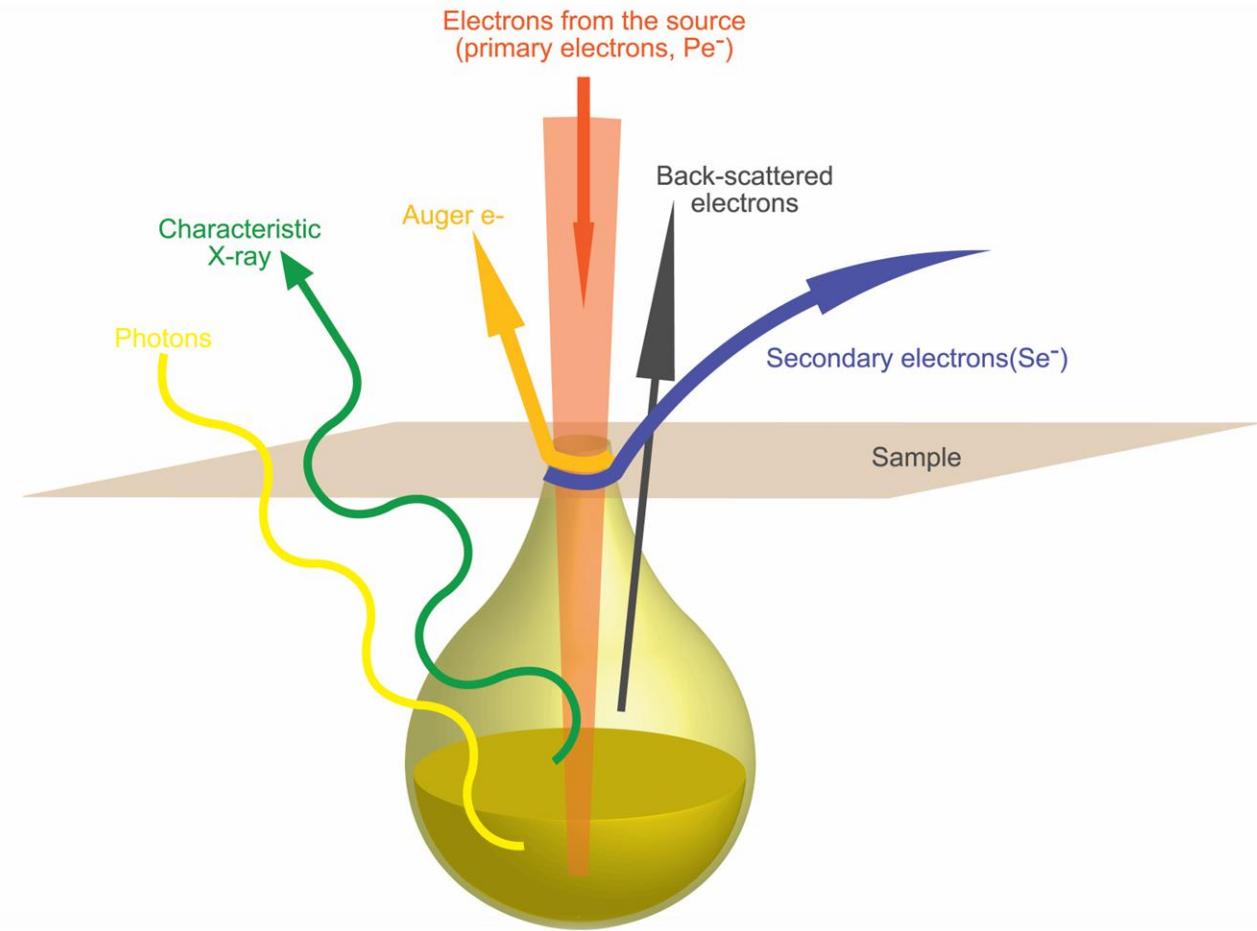
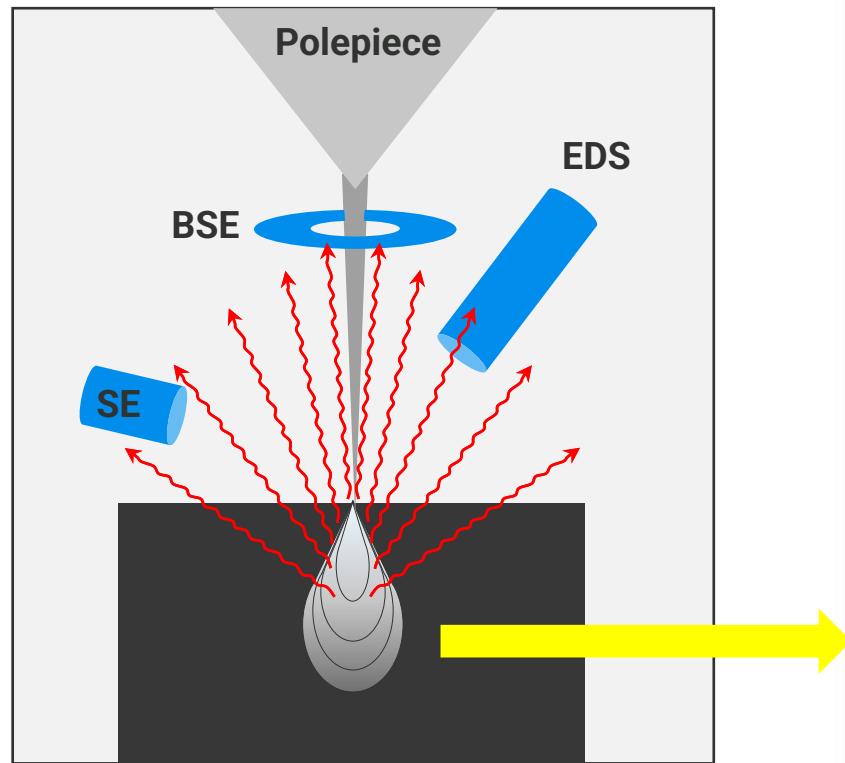


Sharp features – good spatial resolution

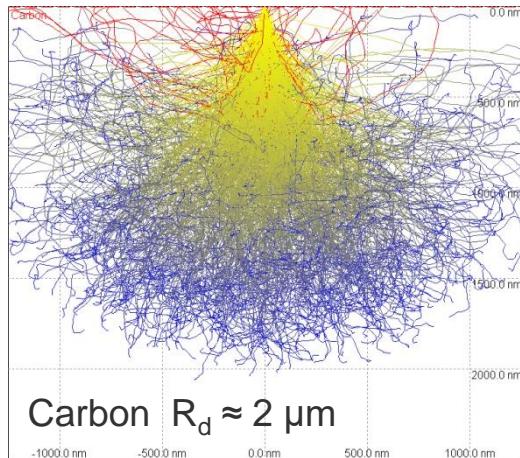


Blurred features – bad spatial resolution

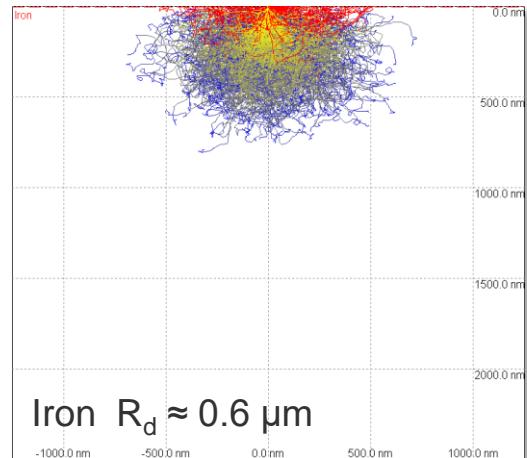
Interaction volume – signal generation



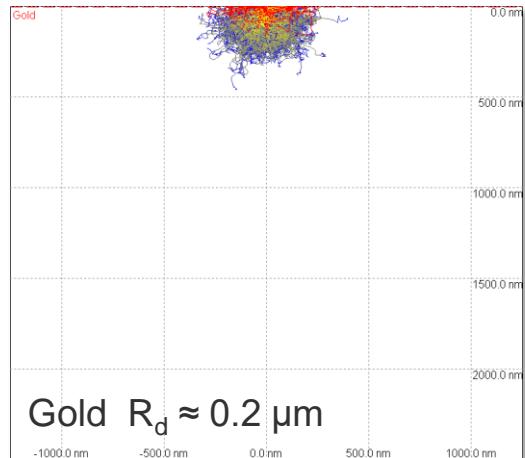
Interaction volume – different materials & kVs



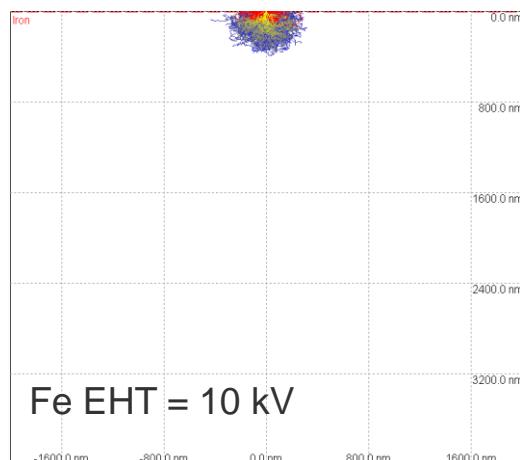
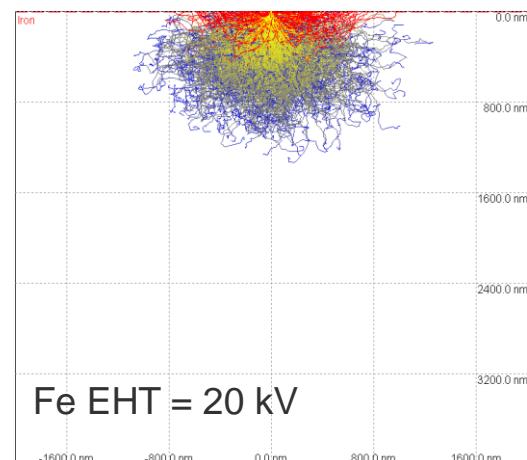
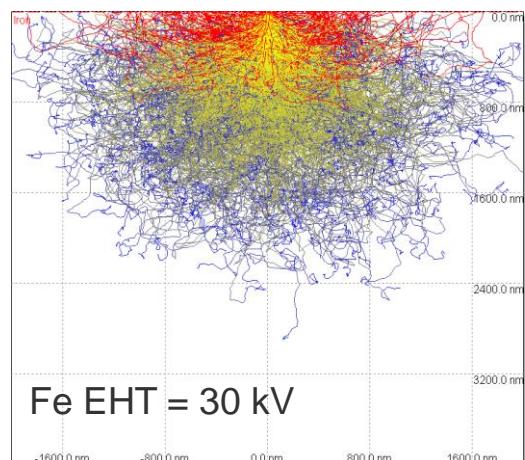
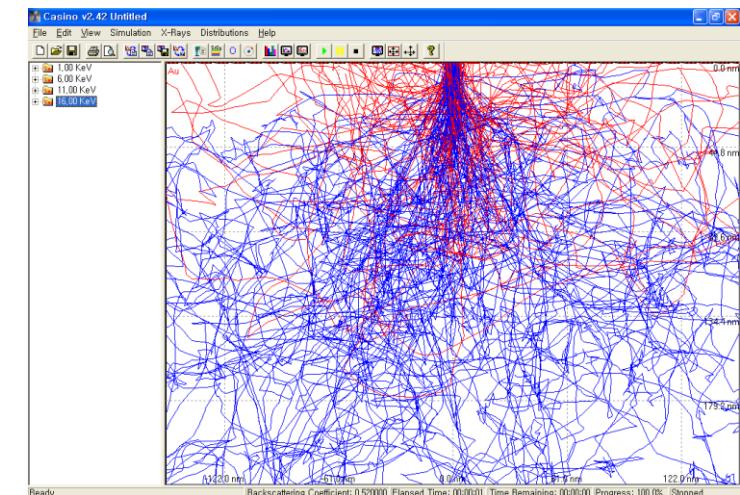
Z=6



Z=26



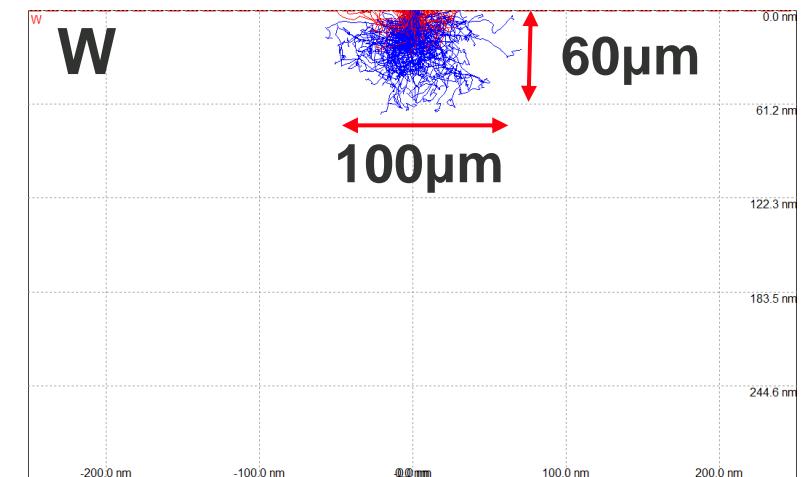
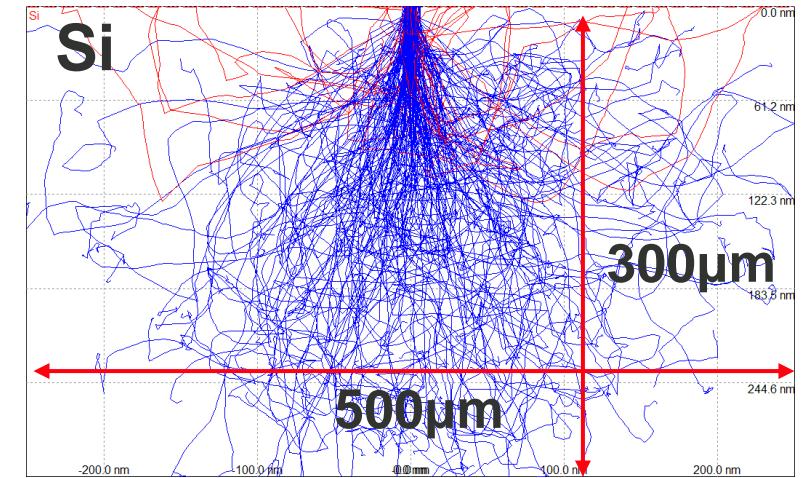
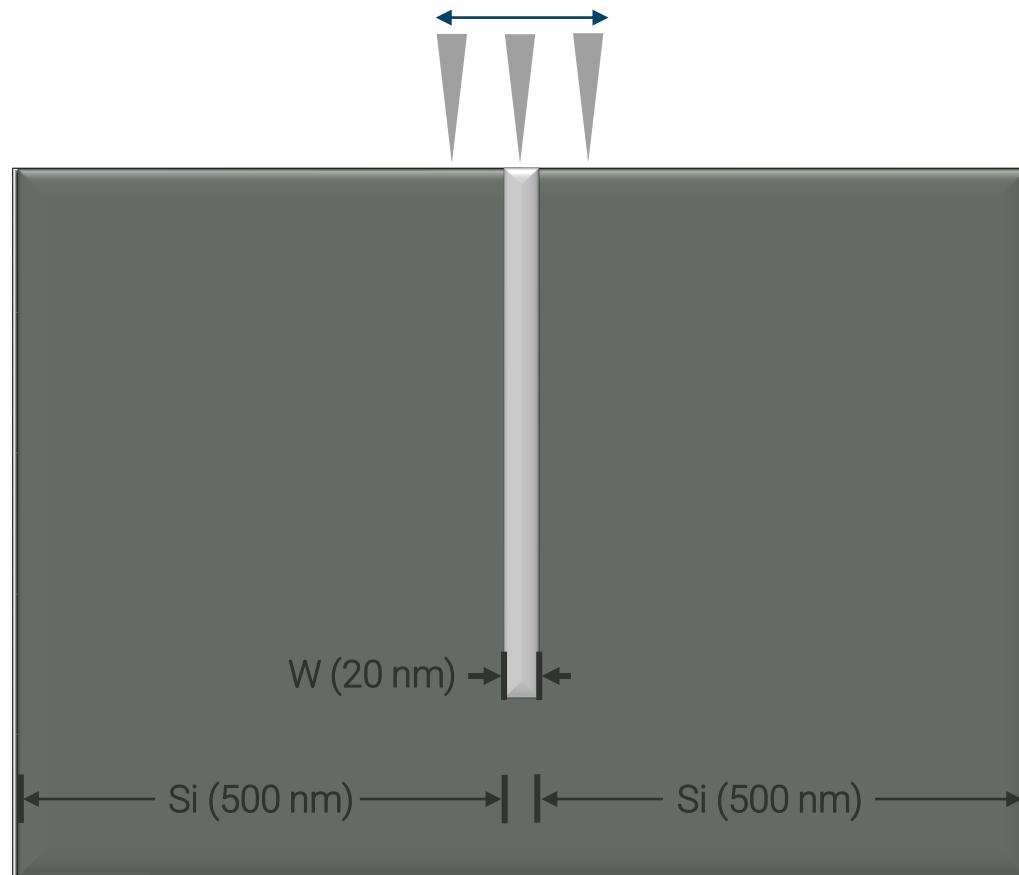
Z=79

 $R_d \approx 0.4 \mu\text{m}$  $R_d \approx 1.3 \mu\text{m}$  $R_d \approx 2.5 \mu\text{m}$ 

- Montecarlo Simulation casino
- <http://www.gel.usherbrooke.ca/casino/>

Interaction volume generation Si – W – Si

- 5 kV beam scanning across a 20 nm tungsten (W) layer in Silicon (Si)



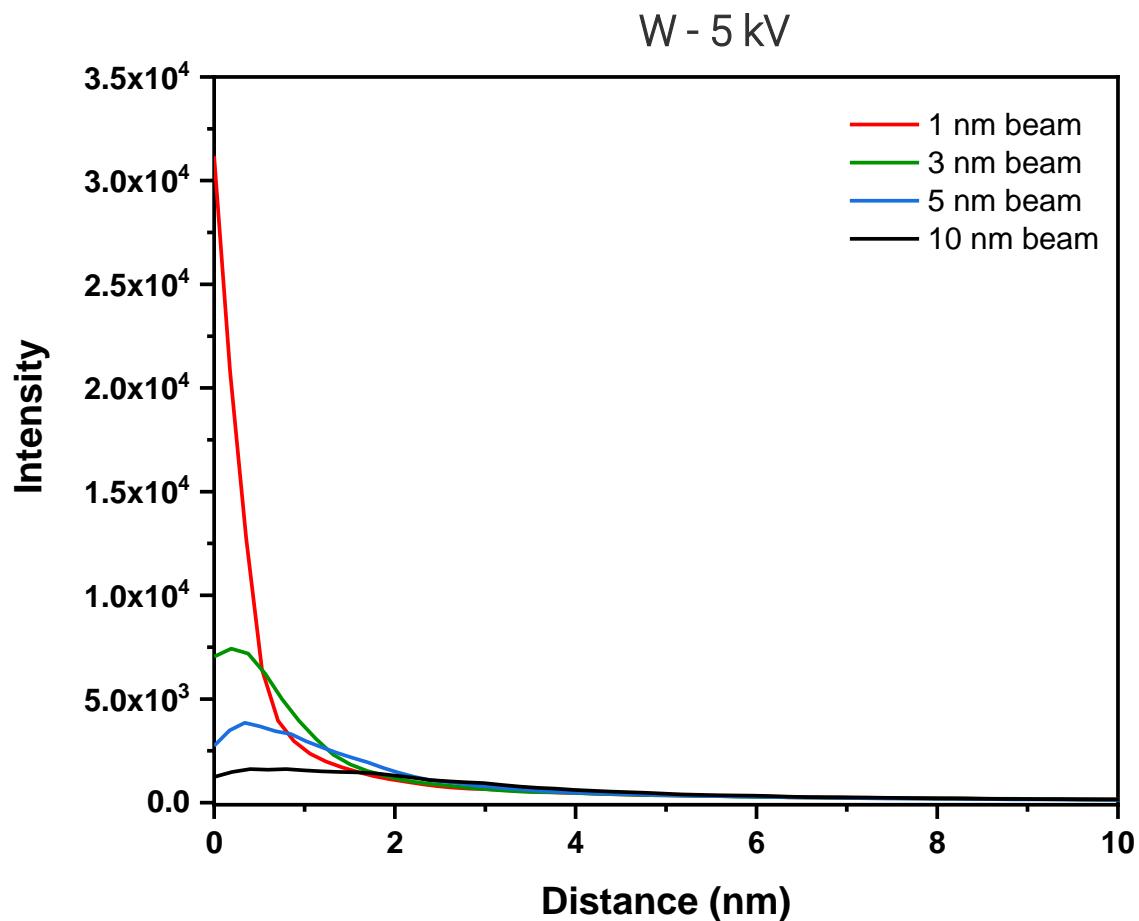
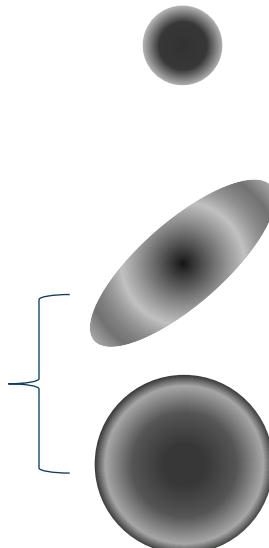
Radial distribution of x-ray intensity vs. Beam diameter

Importance of beam focusing

- Intensity of generated x rays is higher for smaller beam diameter – lower noise around signal

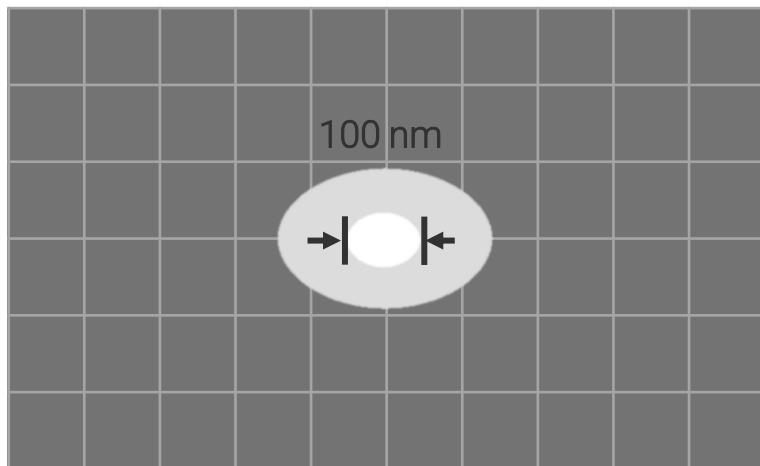
Well focused beam –
Sharp interfaces

Distorted beam –
more noise in map



Pixel size

Image res: 10×6 pixels, pixel size = 100 nm

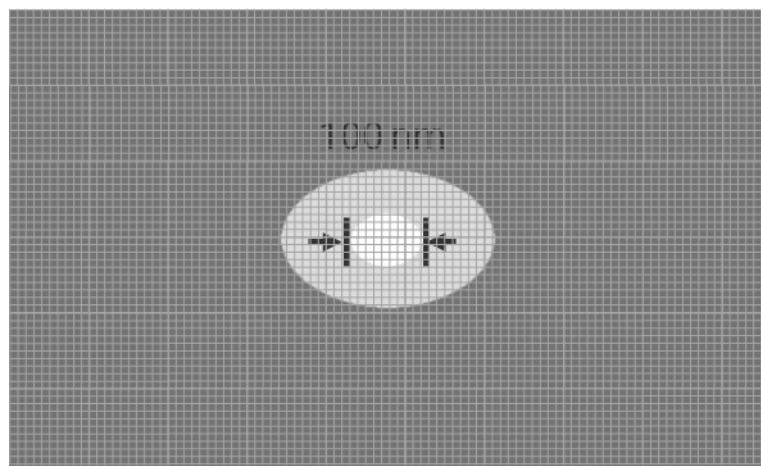


Map = 60 pixels (Under sampling)

Map counts = 200,000

Mean = 3333 counts/pixel

Image res: 200×120 pixels, pixel size = 5 nm

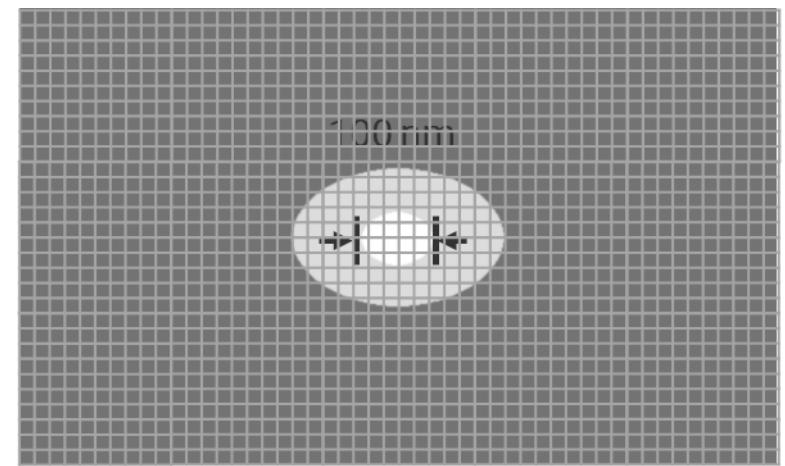


Map = 24000 pixels (Oversampling)

Map counts = 200,000

Mean = 8.33 counts/pixel

Image res: 50×30 pixels, pixel size = 20 nm



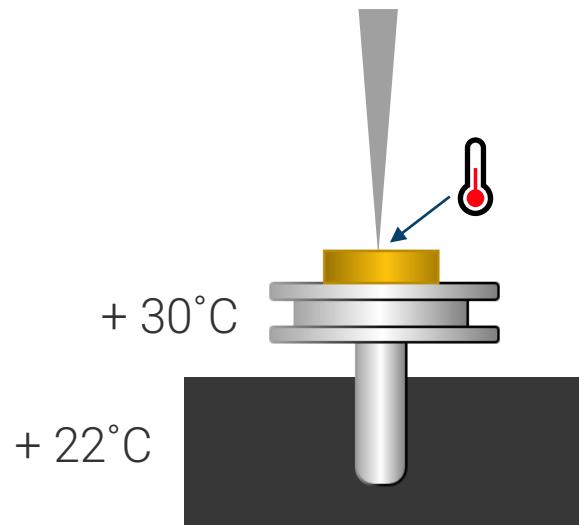
Map = 1500 pixels (reasonable sampling)

Map counts = 200,000

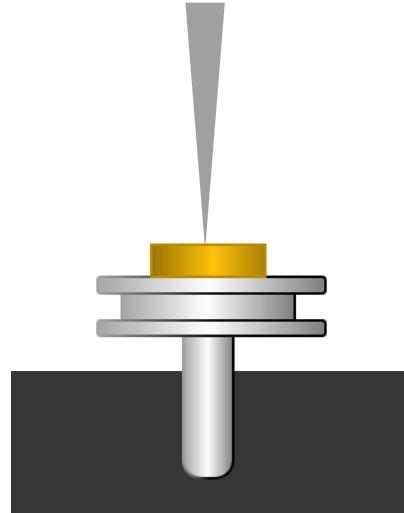
Mean = 200 counts/pixel

Image drift in SEM – Types

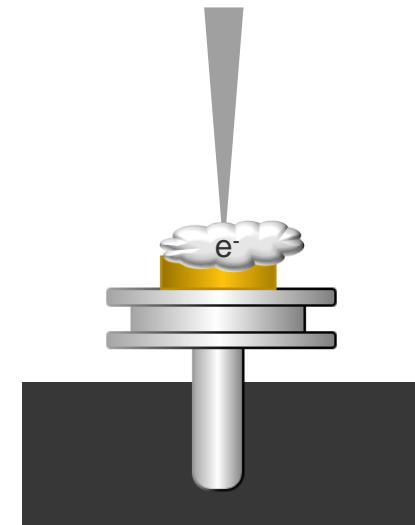
Thermal drift



Mechanical drift



Charge accumulation drift

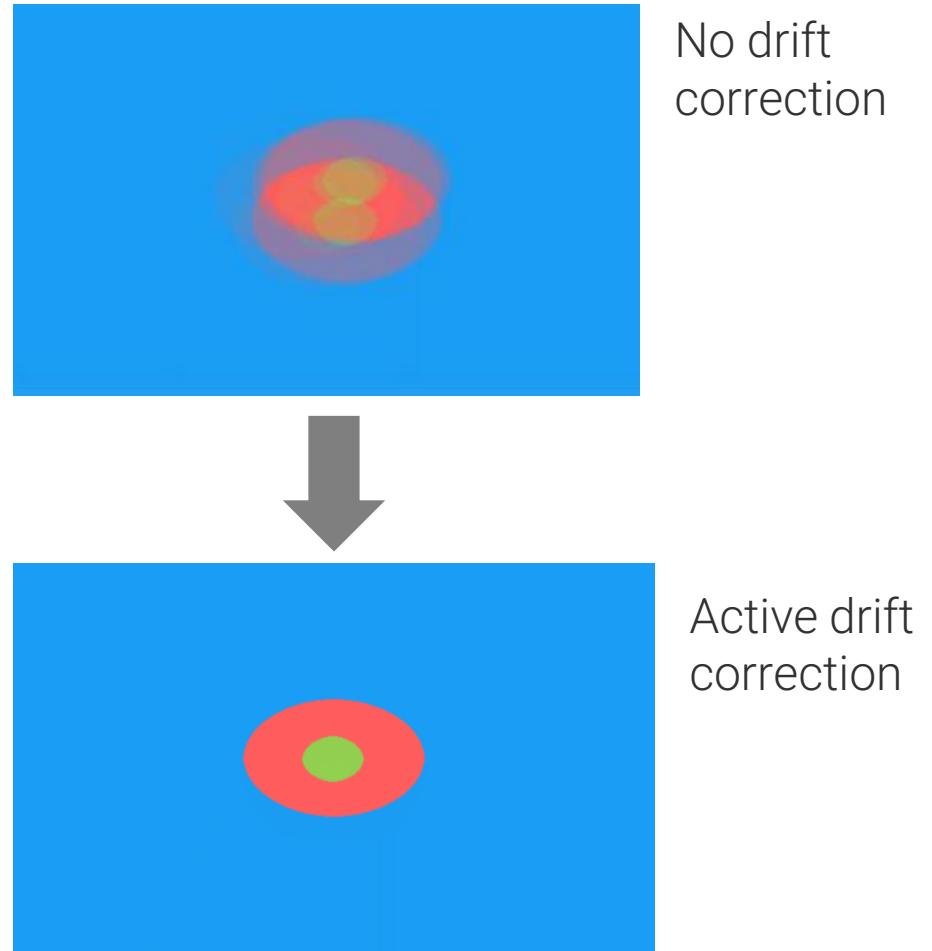


- Beam conditions
- Pixel dwell time

Drift Co. – a must!

Drift compensation and SEM image shift

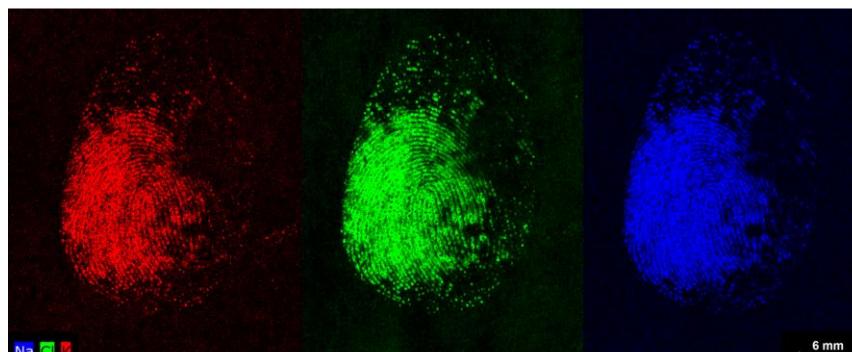
- Image drift is corrected using the SEM image overlay compensation.
- Pixel XY position retained on a feature or interface
- In-lens detector input can also be used (SE contrast is too low)
- Reduced area mapping – better drift correction range



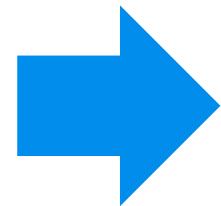
High spatial resolution EDS measurements - Checklist

- Diameter of primary electron beam
- Pixel and map size – avoiding oversampling
- Charging samples – Starting with low kV and low beam current settings
- Drift correction

- **Clean sample, holders and stage**



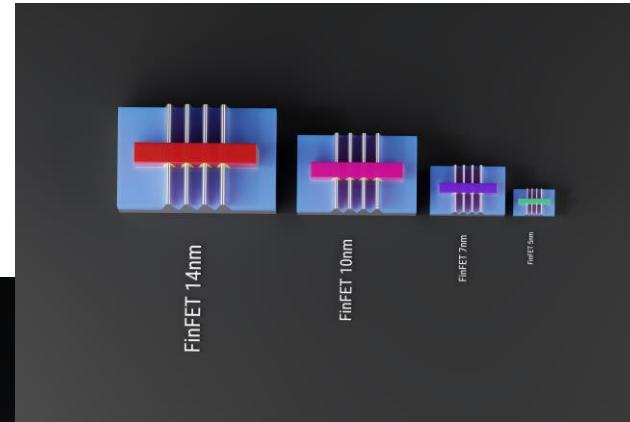
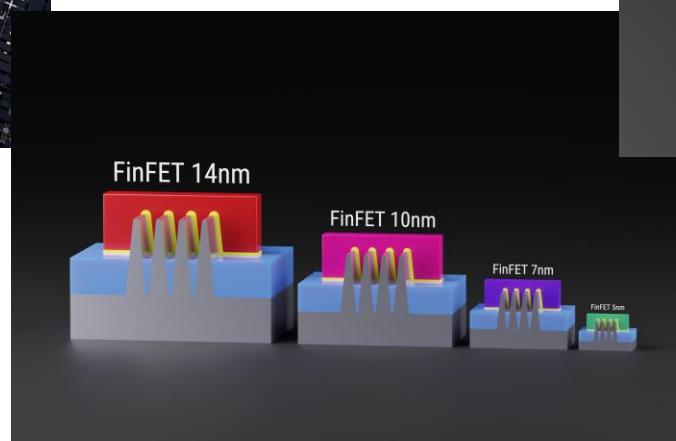
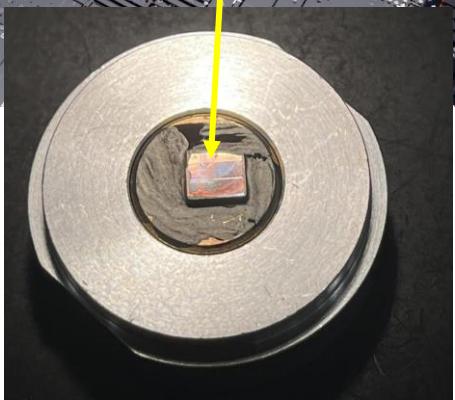
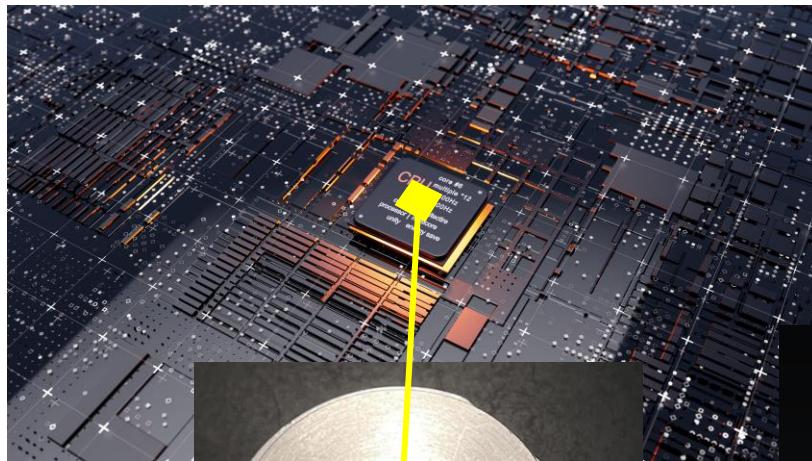
micro-XRF map of a fingerprint



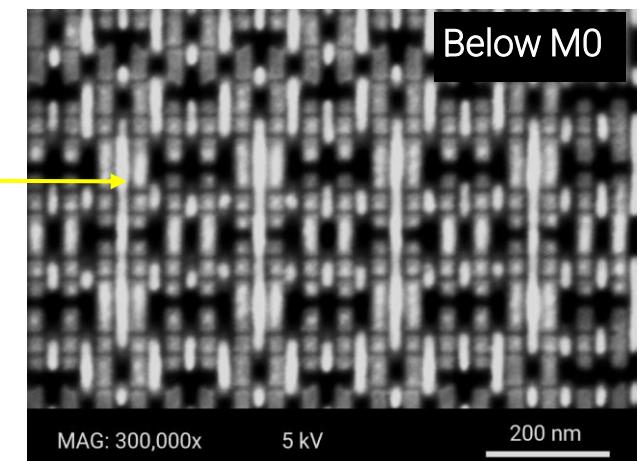
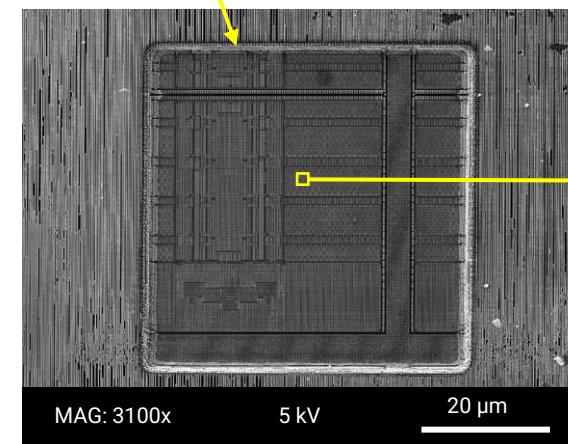
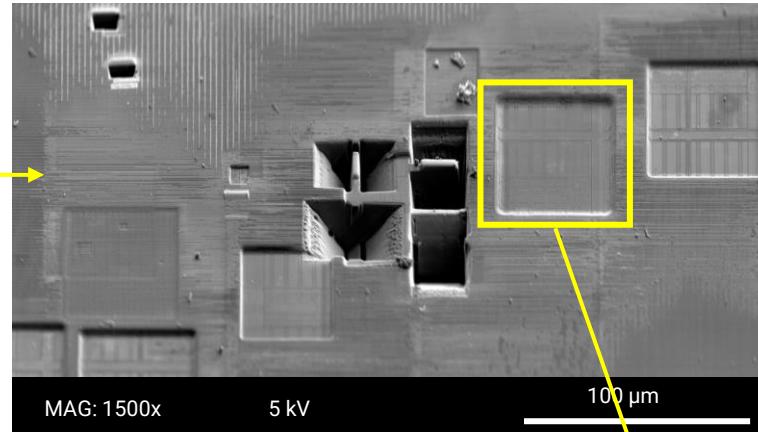
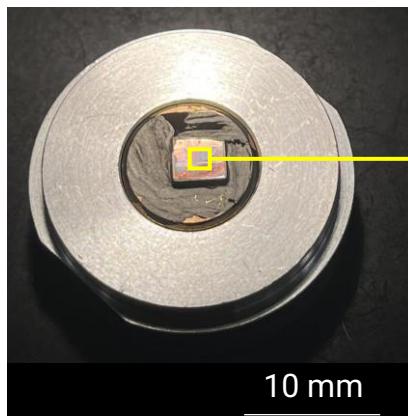
**Minimize beam/carbon
contamination on the samples!!**

Application examples

1. CPU (FinFET)

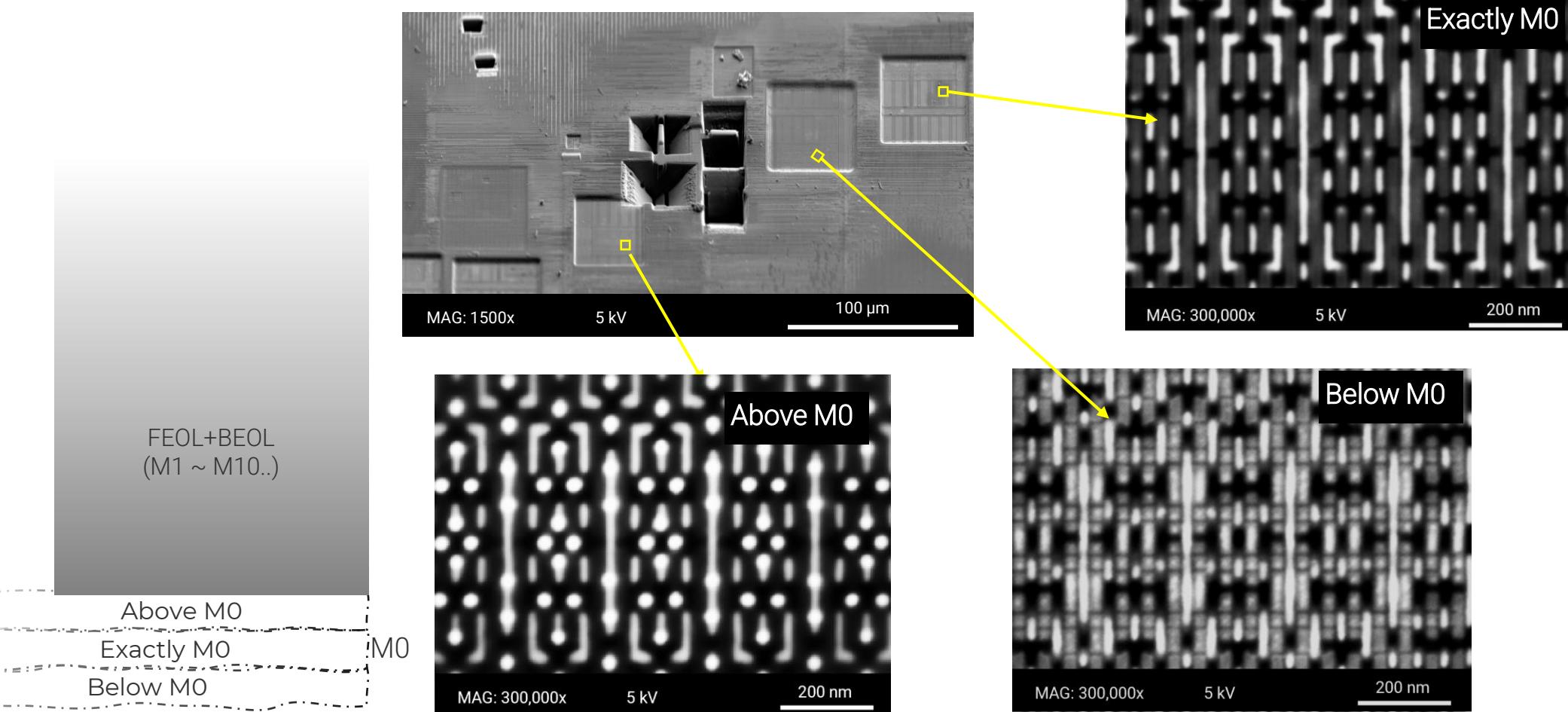


Deprocessed CPU (FinFET) – PFIB delayering



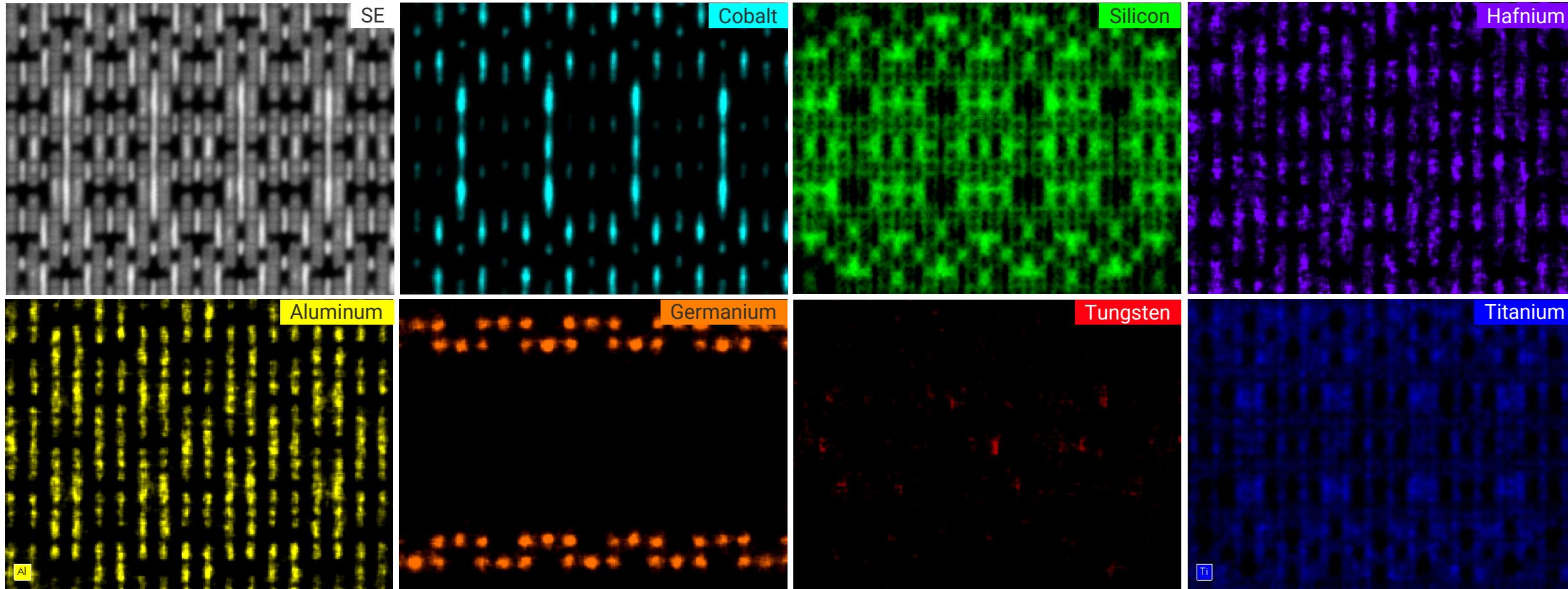
Sample courtesy: Dr. Andrey Denisyuk, TESCAN ORSAY HOLDING, a.s, Brno, CZ

Deprocessed CPU (FinFET) – PFIB delayering



Sample courtesy: Dr. Andrey Denisyuk, TESCAN ORSAY HOLDING, a.s, Brno, CZ

5 kV, 300kx MAG, Below M0

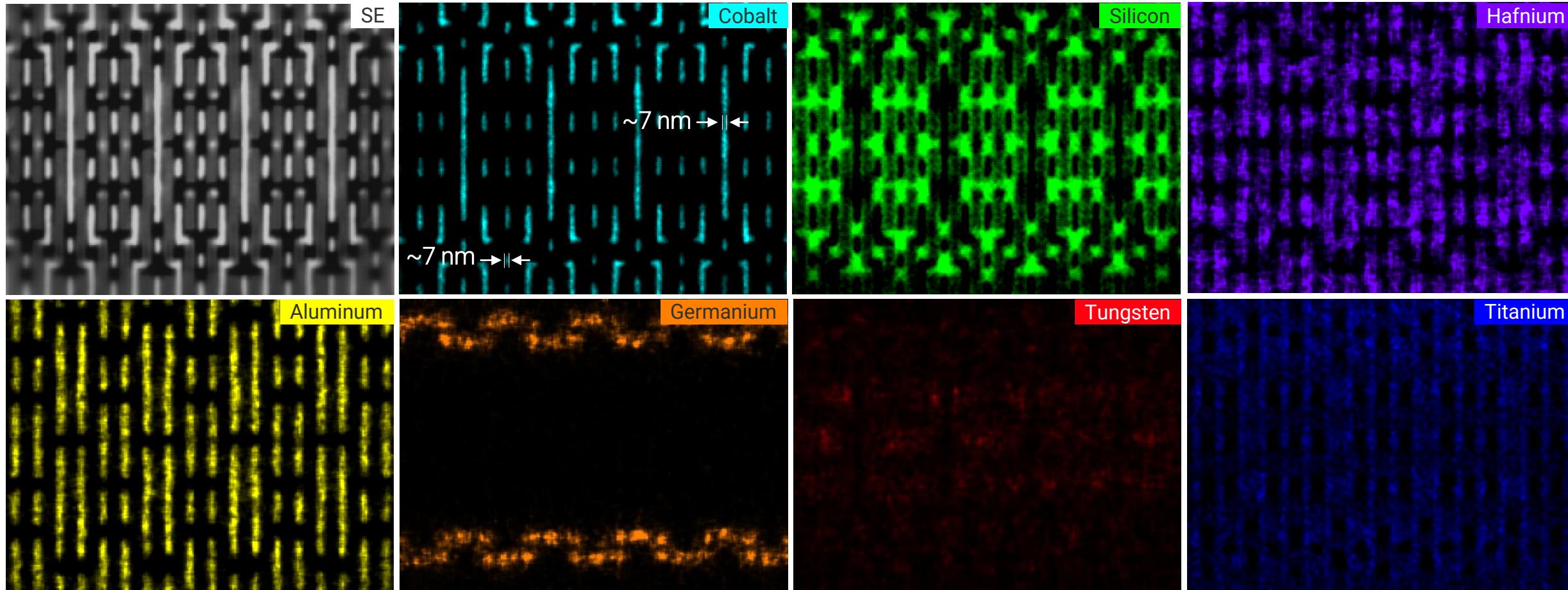


MAG: 300,000x

HV: 5 kV

500 nm

5 kV, 300kx MAG, Exactly M0

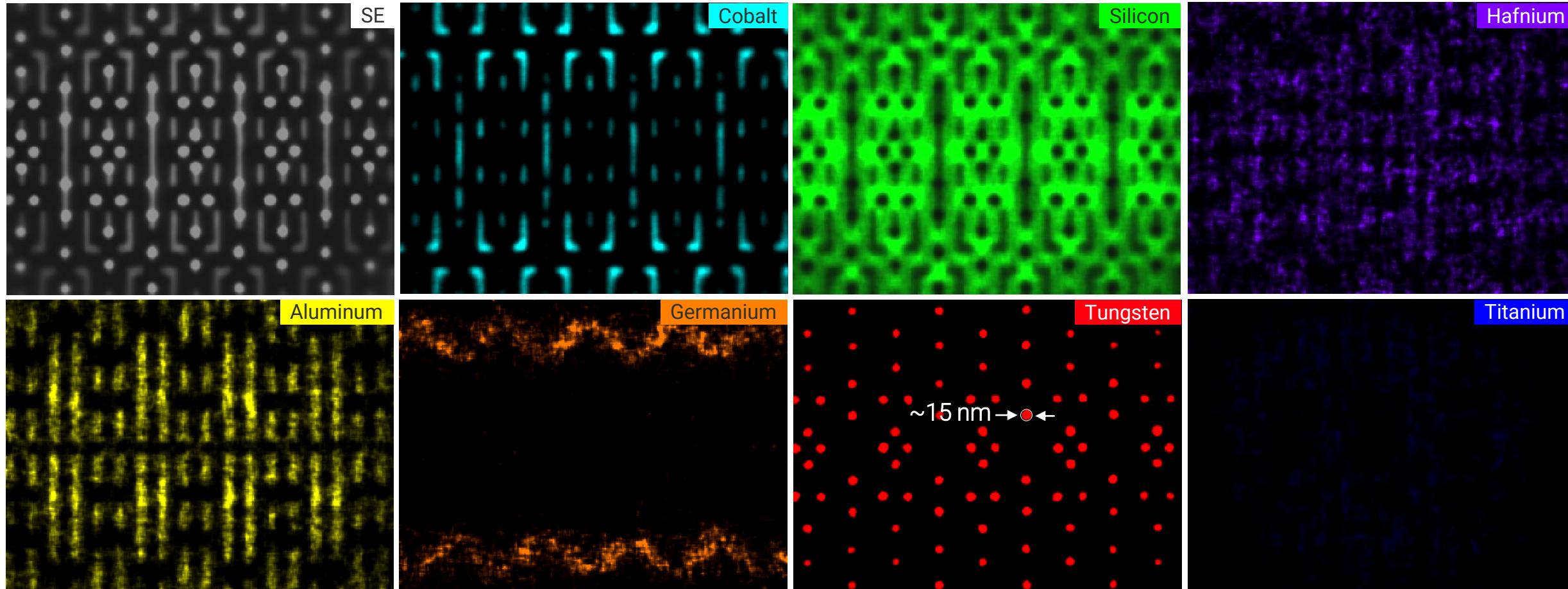


MAG: 300,000x

HV: 5 kV

500 nm

5 kV, 300kx MAG, Above M0

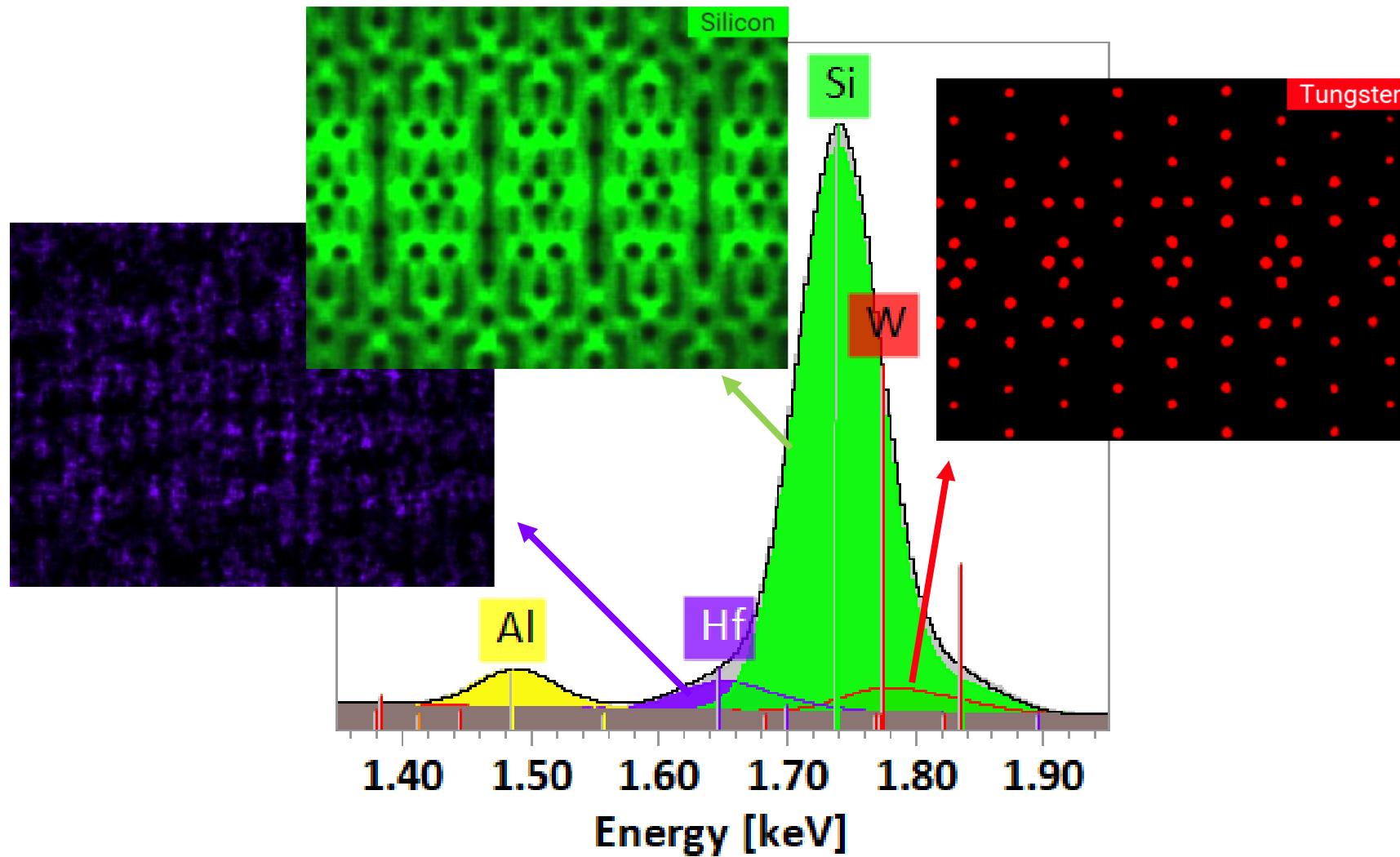


MAG: 300,000x

HV: 5 kV

500 nm

Automatic peak deconvolution – Above M0

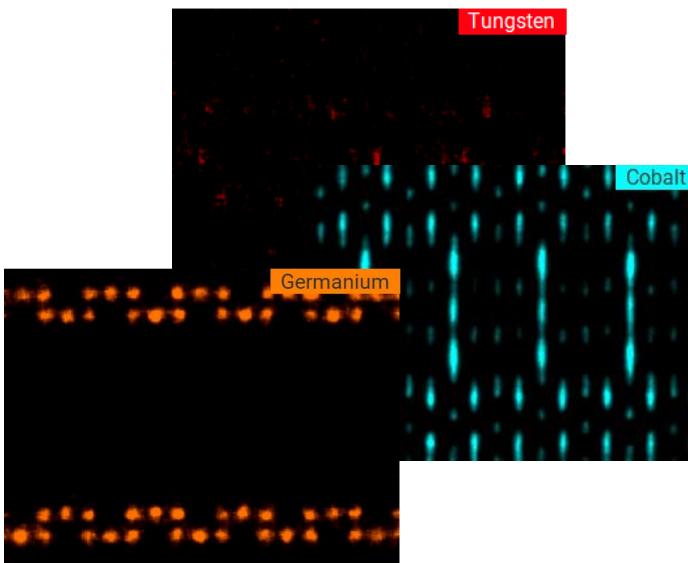


Measurement parameters

Below M0

EDS MEASUREMENT PARAMETERS

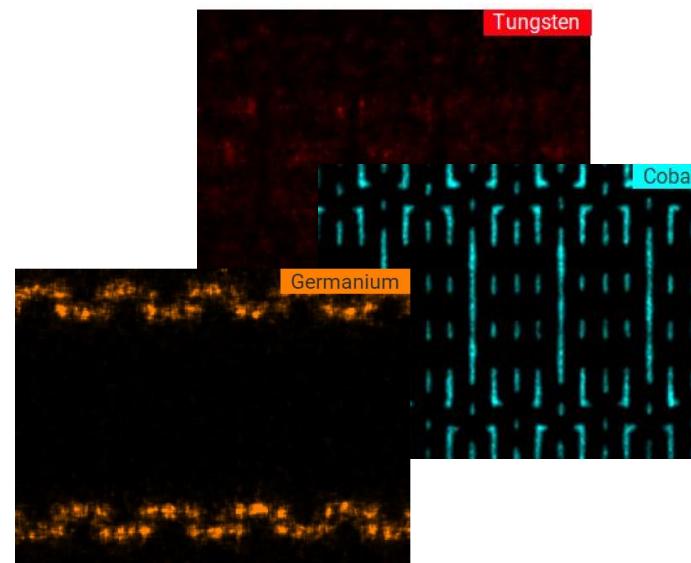
Count rate	15500 cps
Probe current	380 pA
Total counts	4.6E+7 (46M)
Map size	300 x 225 px



Exactly M0

EDS MEASUREMENT PARAMETERS

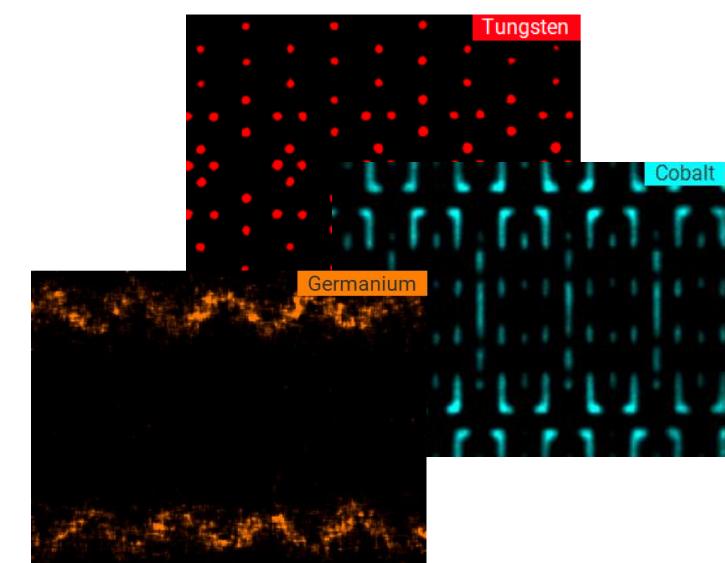
Count rate	15200 cps
Probe current	350 pA
Total counts	4.2E+7 (42M)
Map size	300 x 225 px



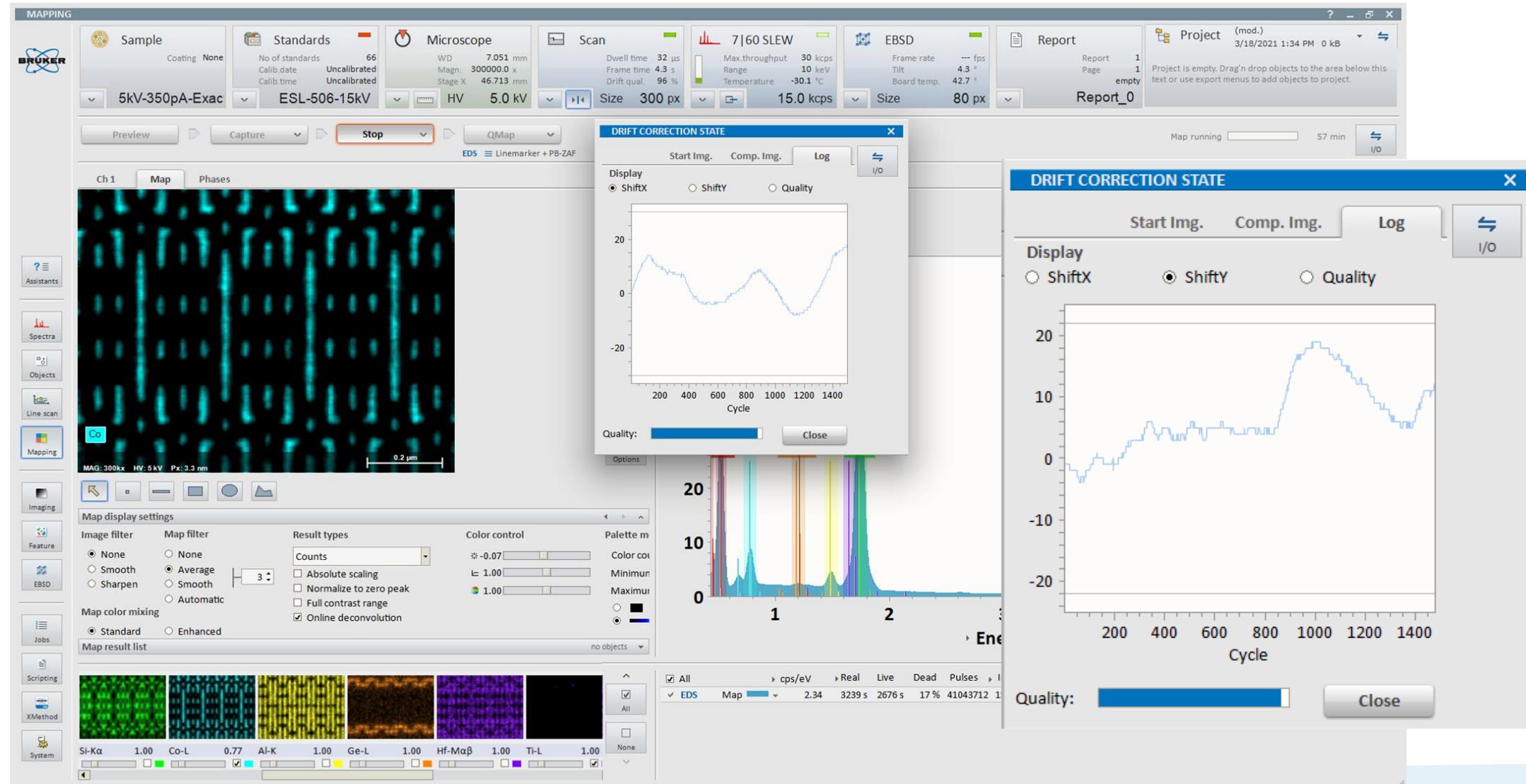
Above M0

EDS MEASUREMENT PARAMETERS

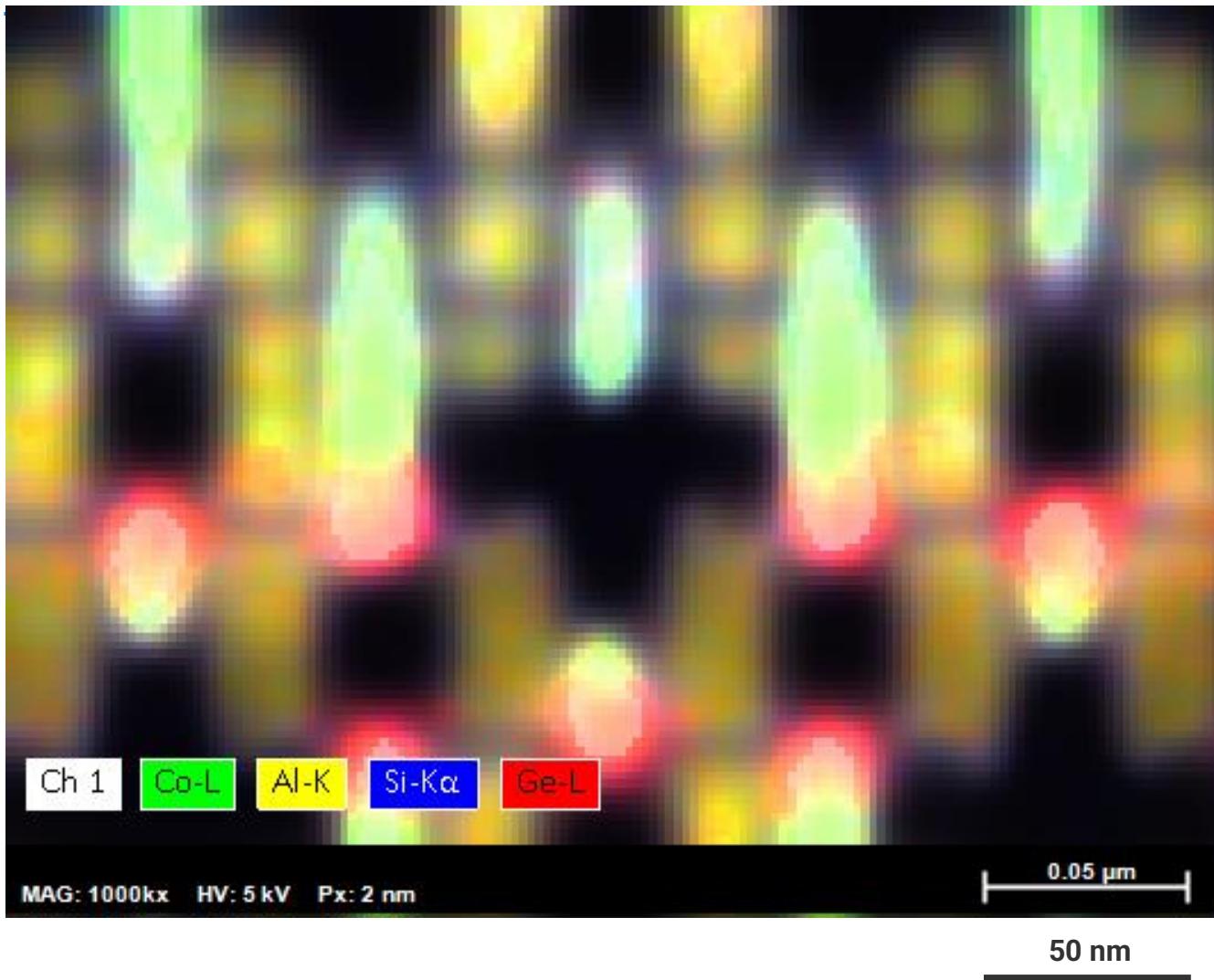
Count rate	15600 cps
Probe current	390 pA
Total counts	4.6E+7 (46M)
Map size	300 x 225 px



Drift correction

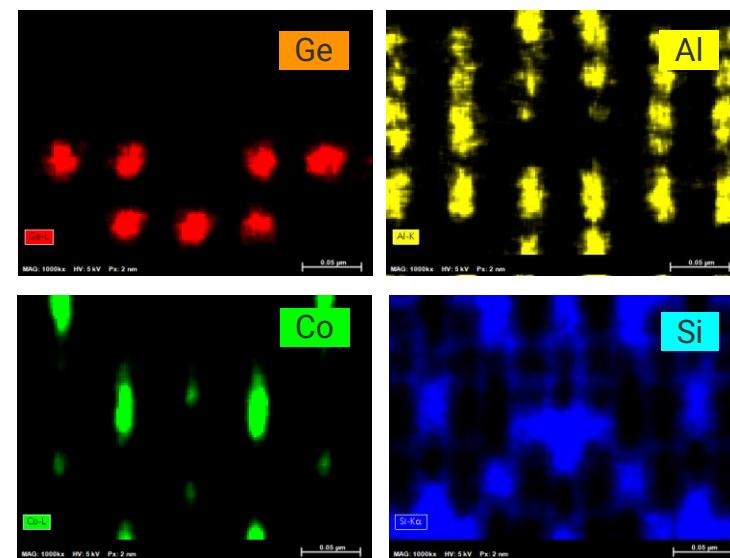


5 kV, 1Mx MAG, Below M0



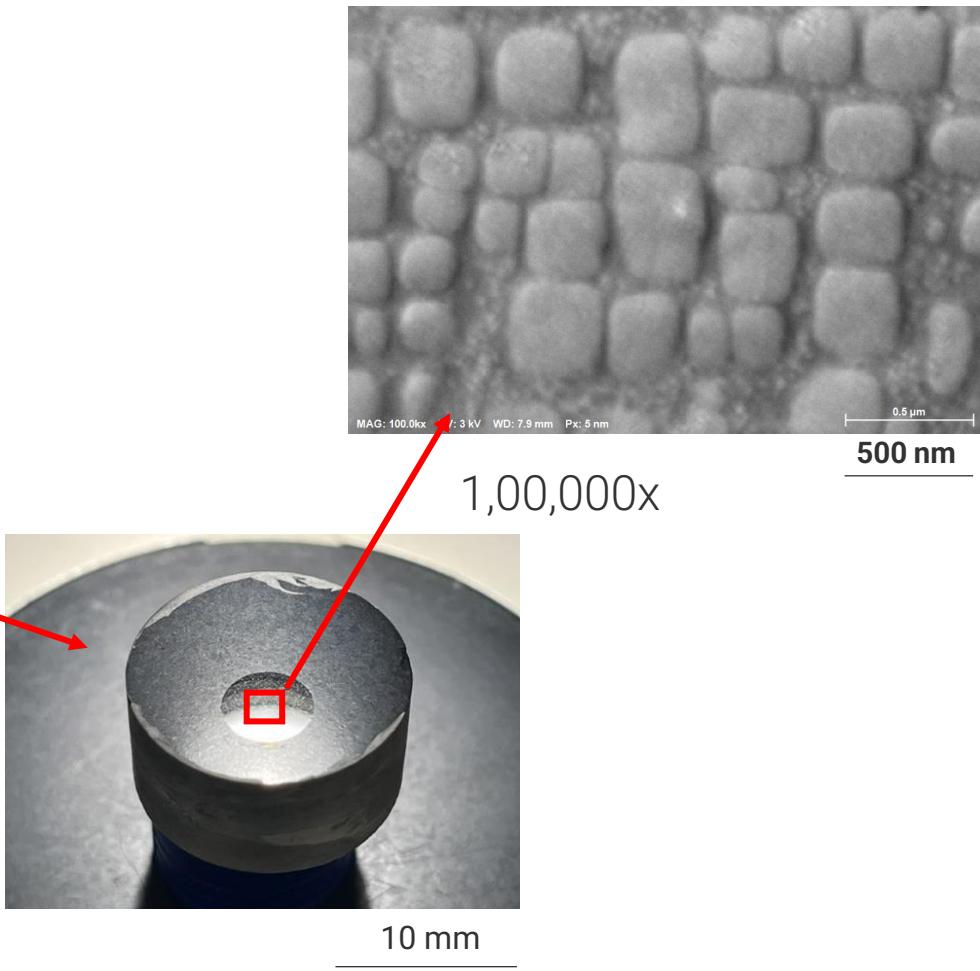
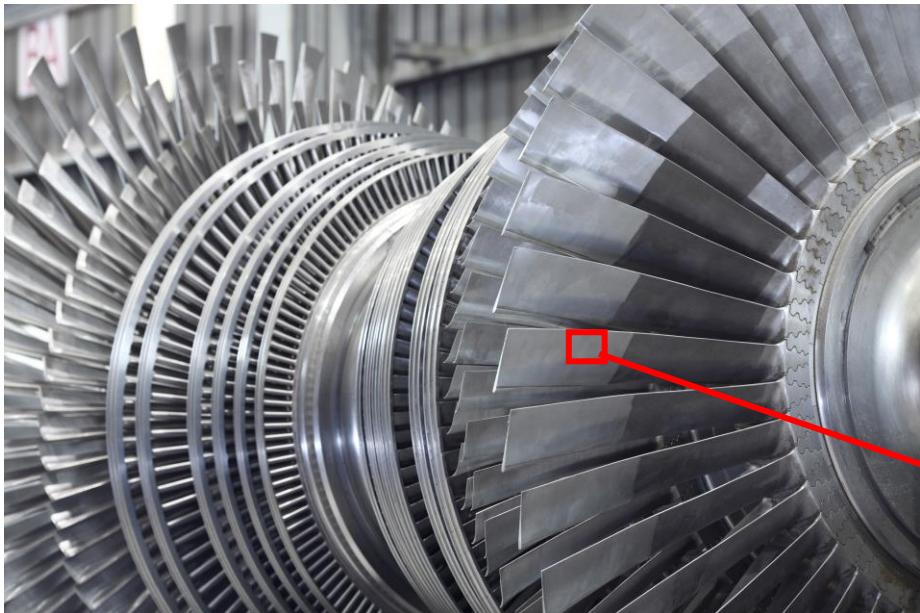
EDS MEASUREMENT PARAMETERS

Measurement time	545 s
Count rate	15,600 cps
Probe current	390 pA
Dead time	18%
Total counts	7E+6 (7M)
H-FOV	300 nm
Map size	200 x 150 px

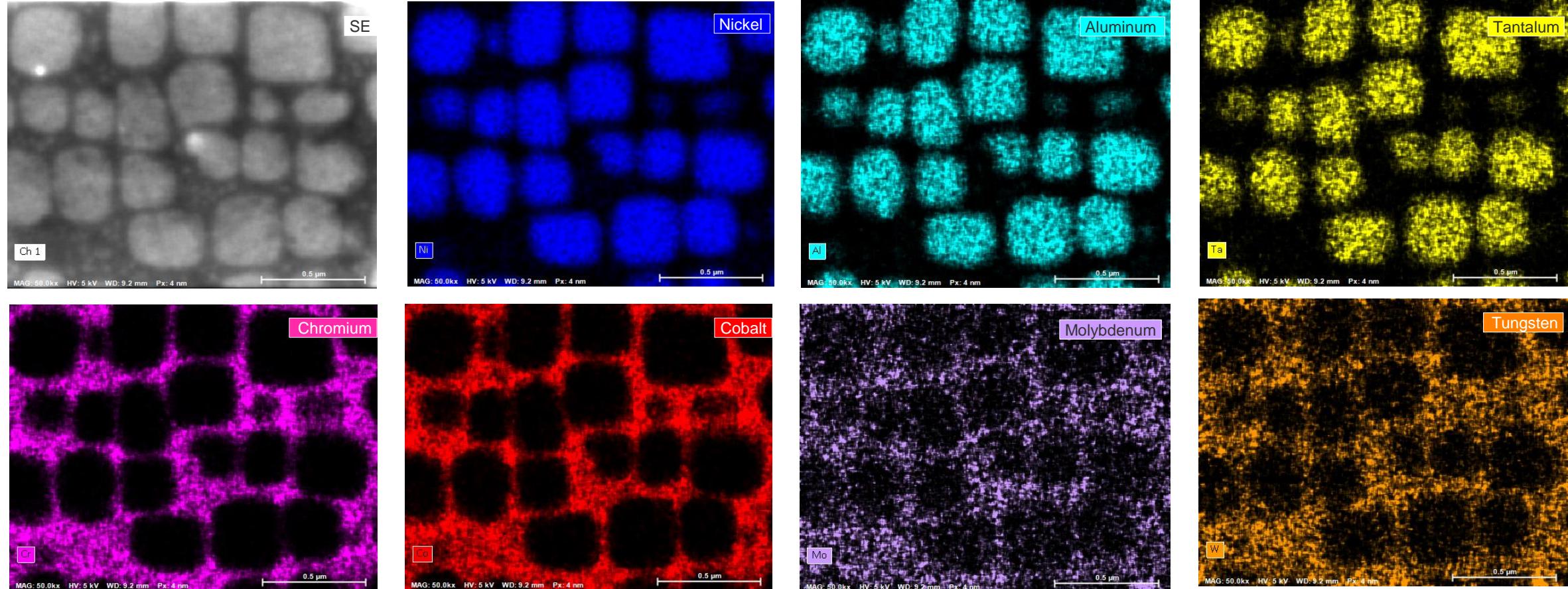
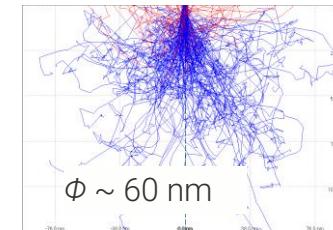


Application examples

2. Ni based single crystal super alloy

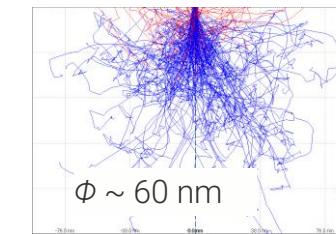
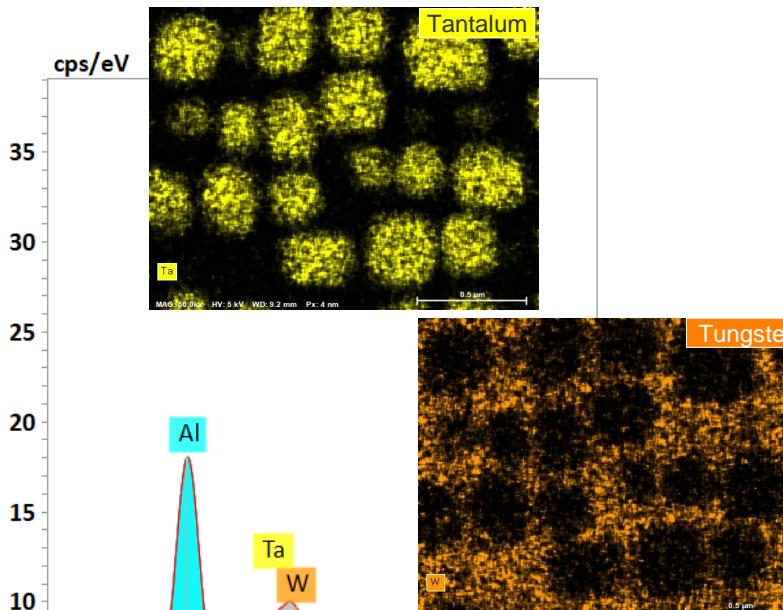
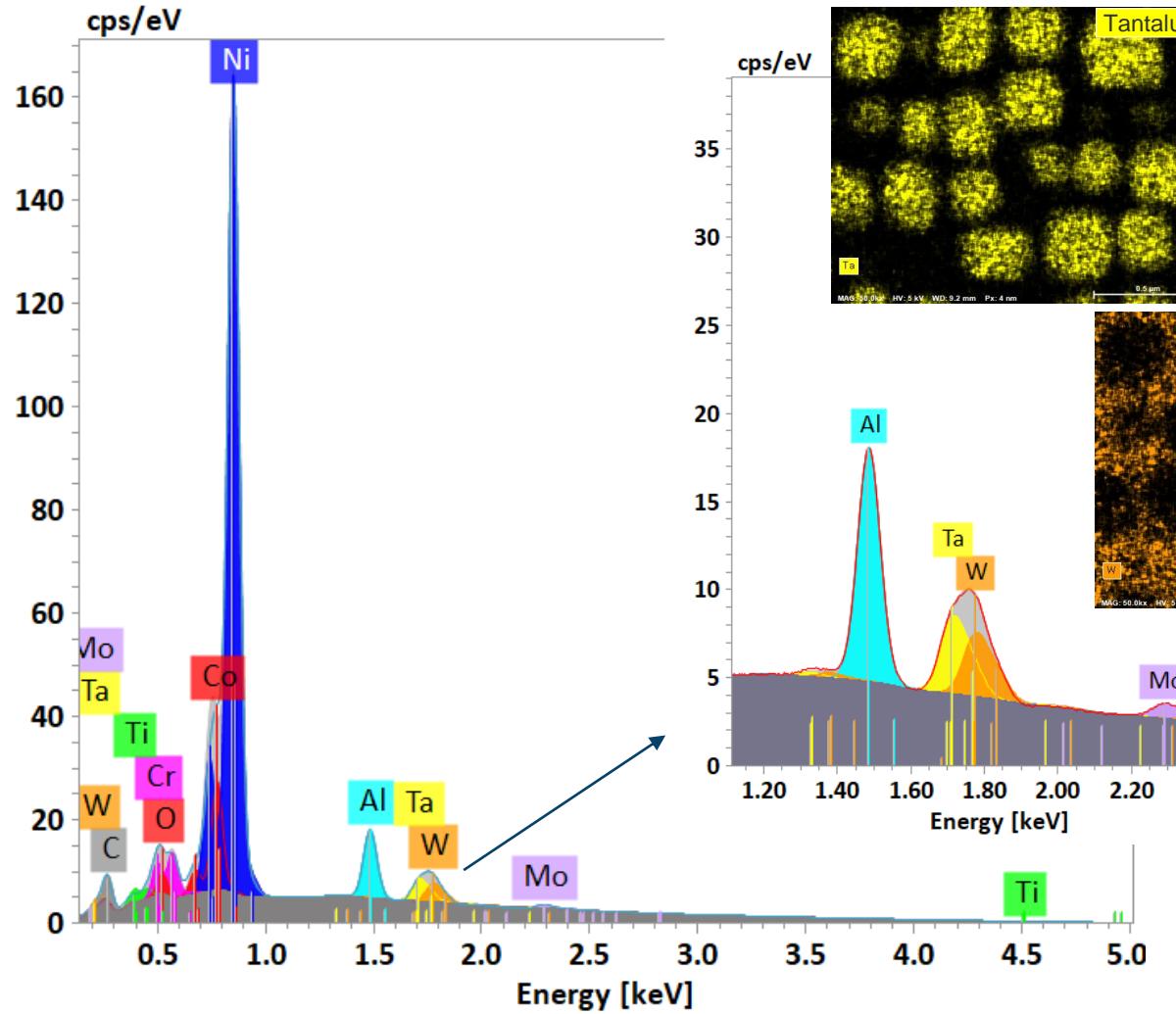


5 kV measurement at 50,000x magnification



MAG: 50,000 x HV: 5 kV

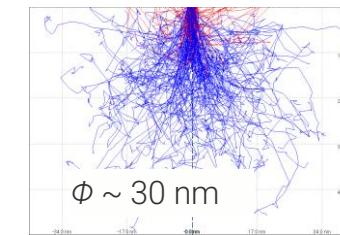
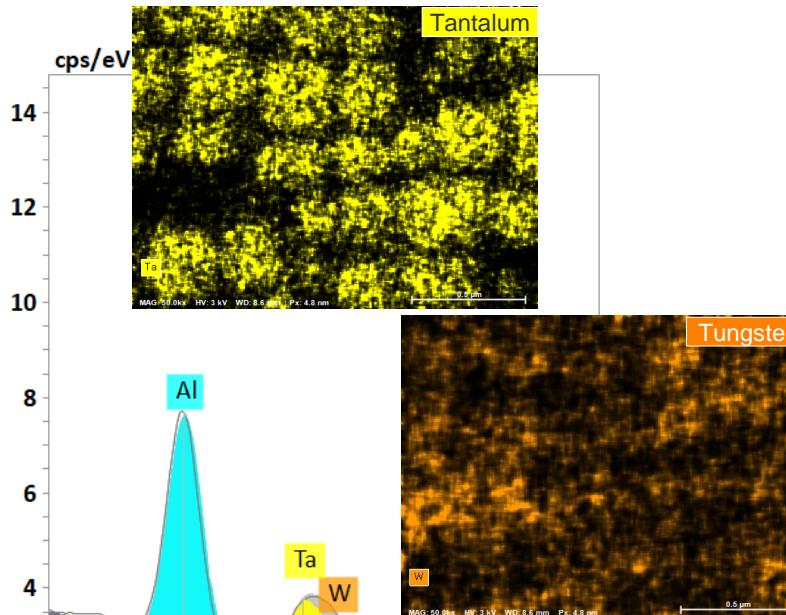
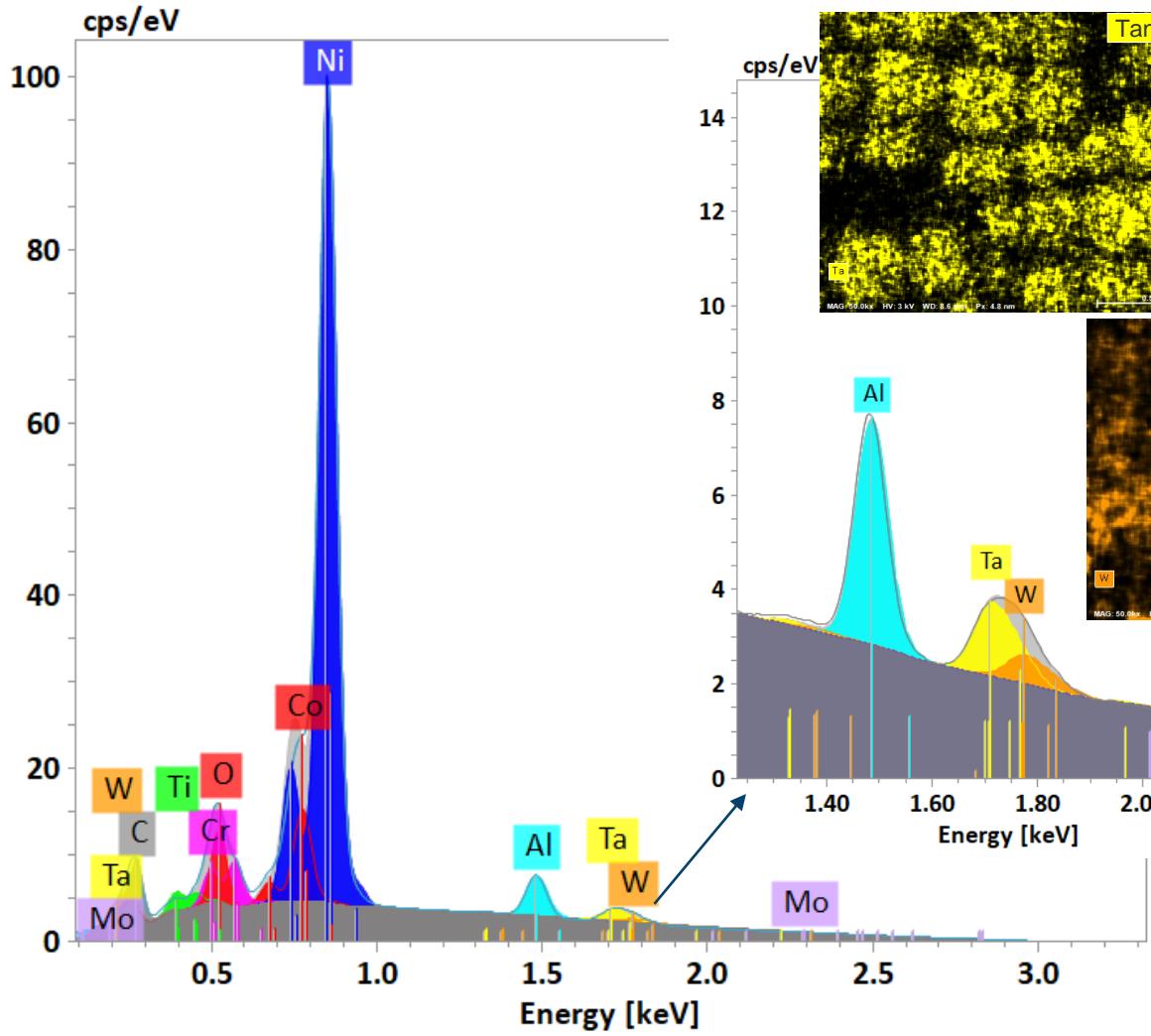
5 kV measurement at 50,000x magnification



EDS MEASUREMENT PARAMETERS

Measurement time	15 min
Count rate	39,000 cps
Dead time	23%
Total counts	3.6E+7 (36M)
Magnification	50,000 x (FOV 2.4 μm)
Map size	600 x 450 px

3 kV measurement at 50,000x magnification

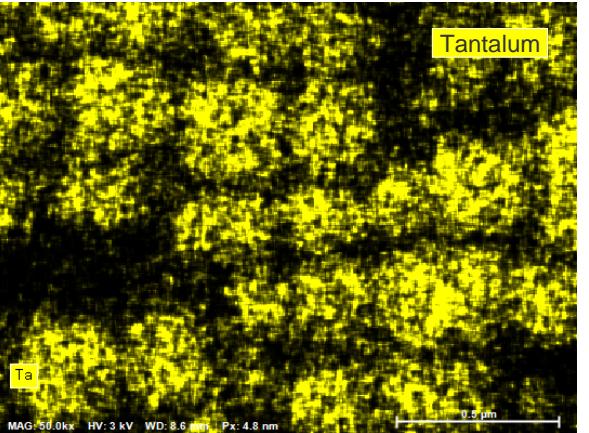
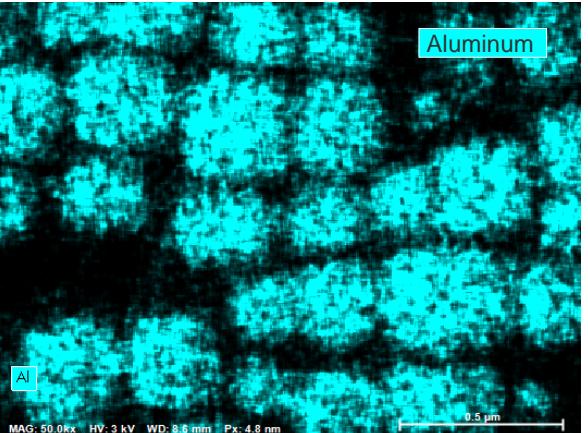
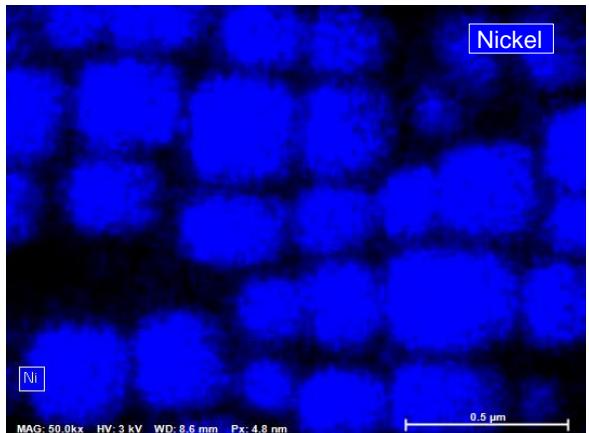
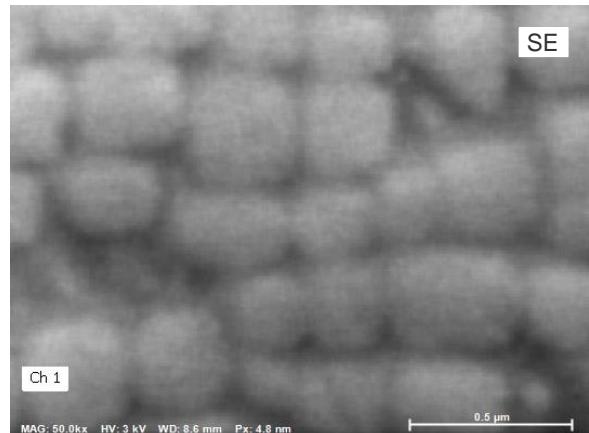


EDS MEASUREMENT PARAMETERS

Measurement time	35 min
Count rate	20,000 cps
Dead time	12%
Total counts	3.4E+7 (34M)
Magnification	50,000 x (FOV 2.4 μm)
Map size	500 x 375 px

3 kV maps: FEG-SEM 1 vs. FEG-SEM 2

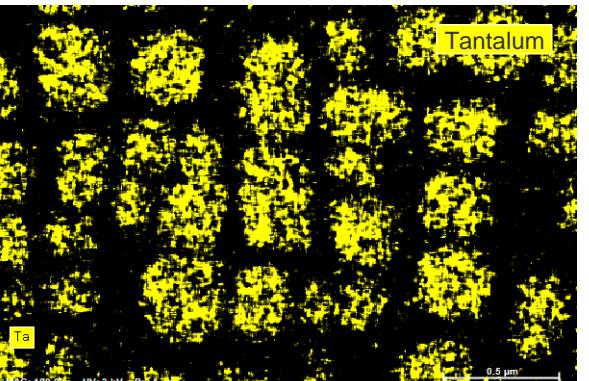
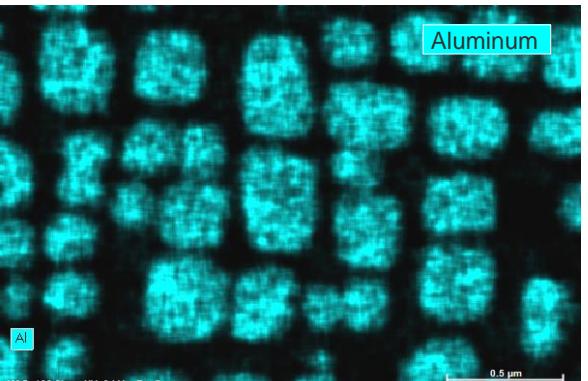
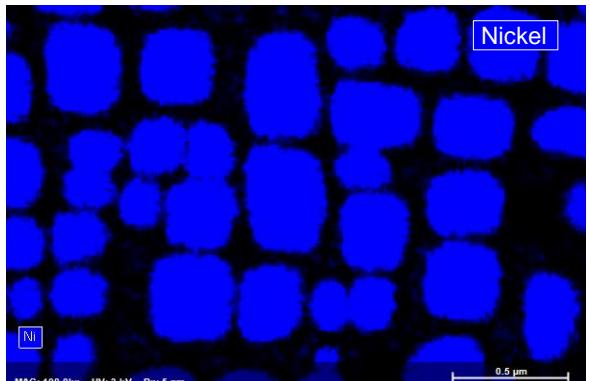
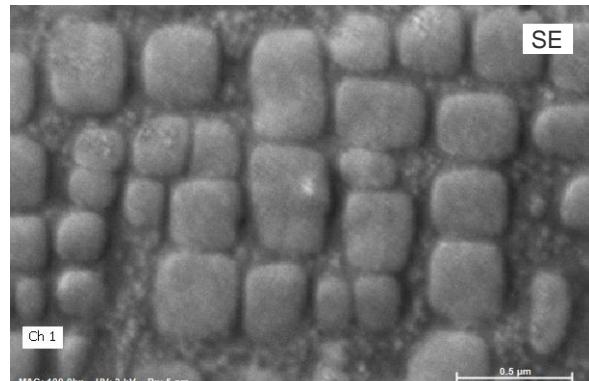
FEG-SEM 1



MAG: 50,000 x HV: 3 kV

500 nm

FEG-SEM 2

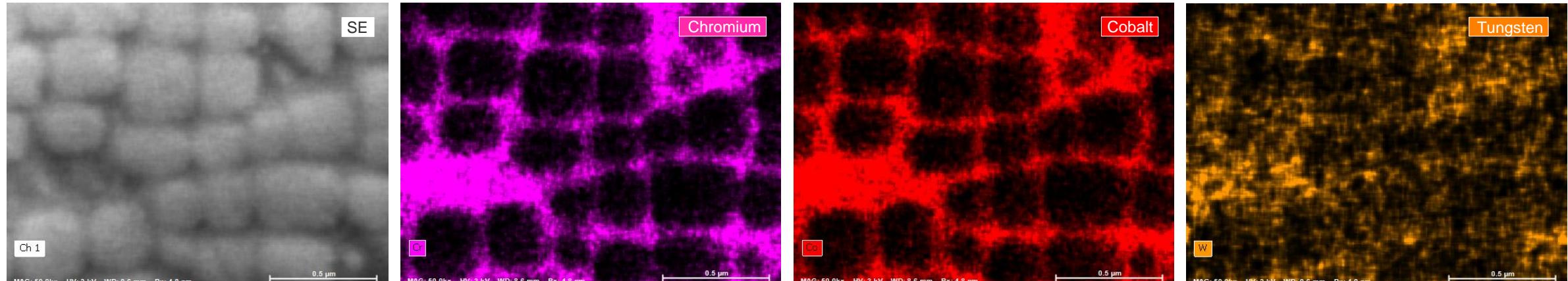


MAG: 100,000 x HV: 3 kV

500 nm

3 kV measurement at 50,000x magnification

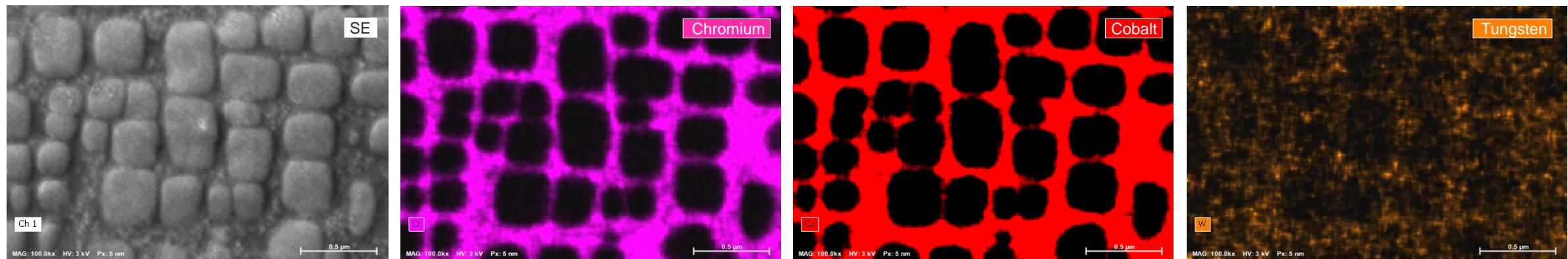
FEG-SEM 1



MAG: 50,000 x HV: 3 kV

500 nm

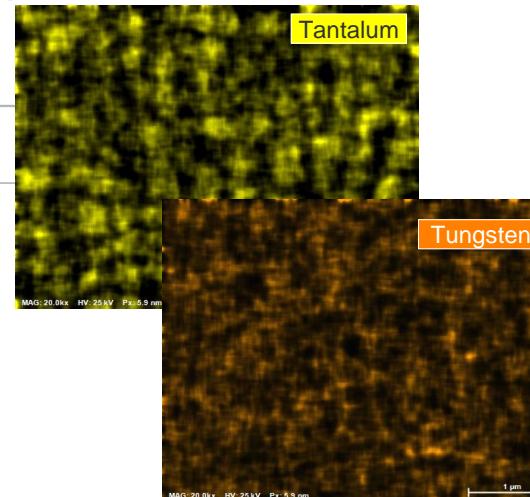
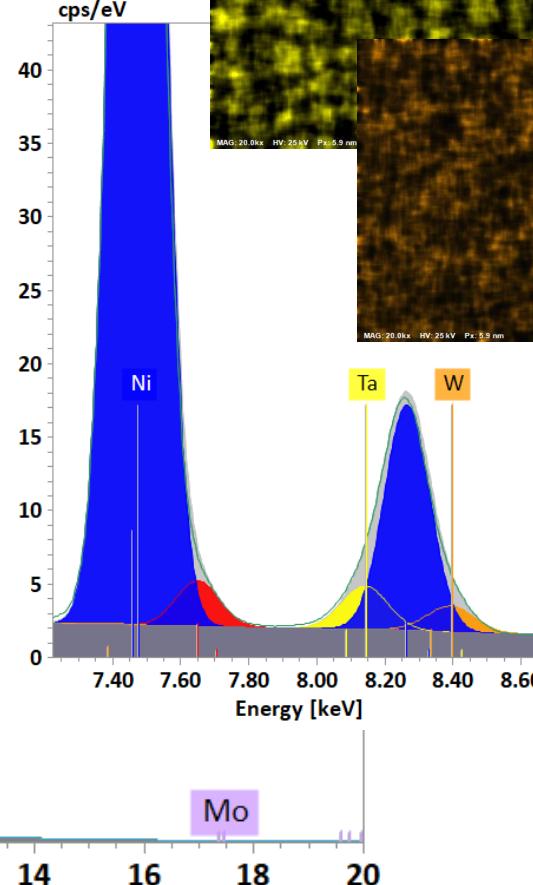
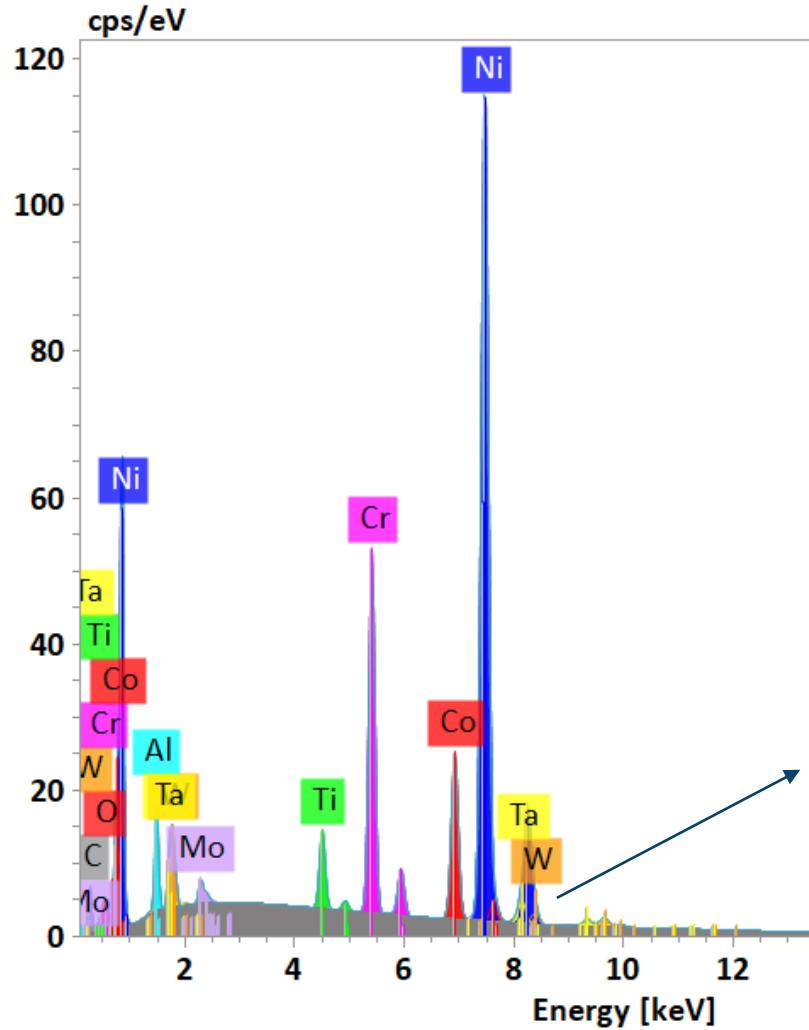
FEG-SEM 2



MAG: 100,000 x HV: 3 kV

500 nm

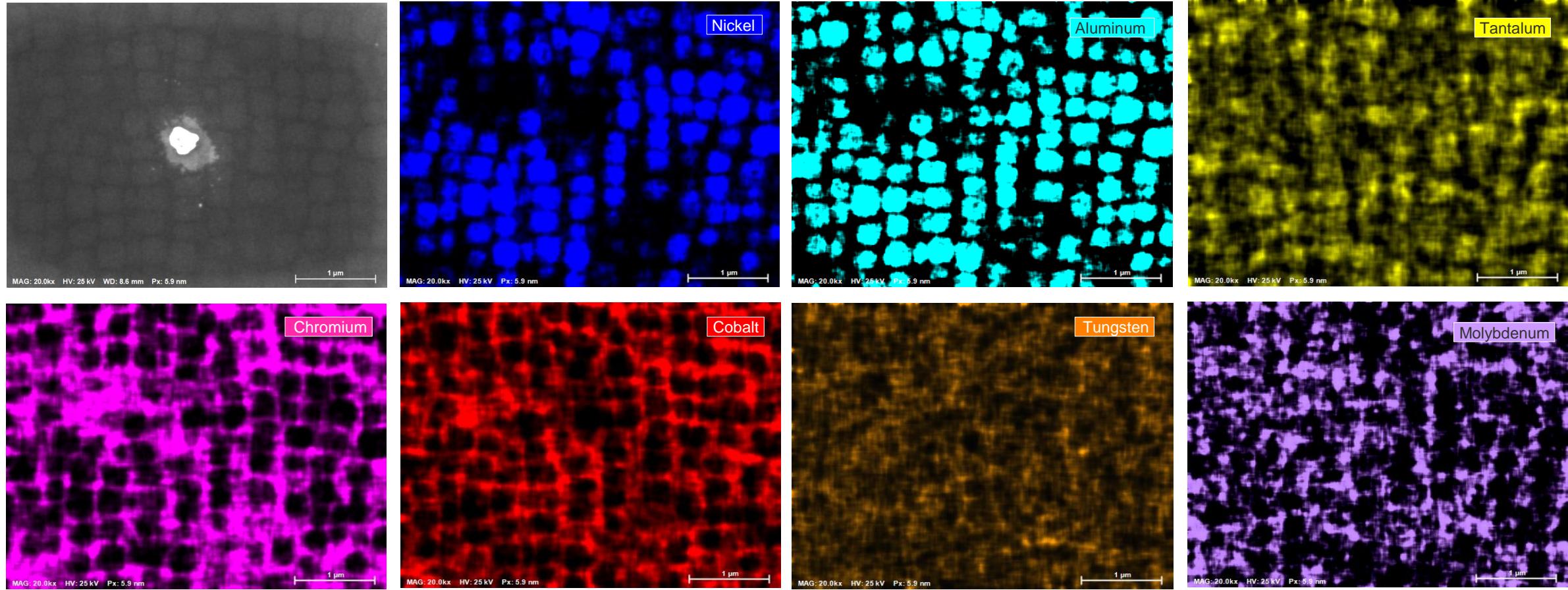
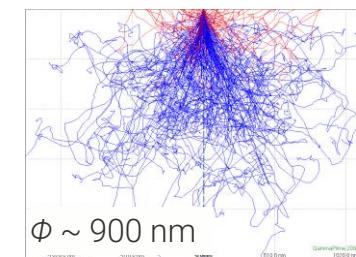
25 kV measurement at 20,000x magnification



EDS MEASUREMENT PARAMETERS

Measurement time	30 min
Count rate	119,000 cps
Dead time	32%
Total counts	1.46E+8 (146M)
Magnification	20,000 x
Map size	1000 x 750 px

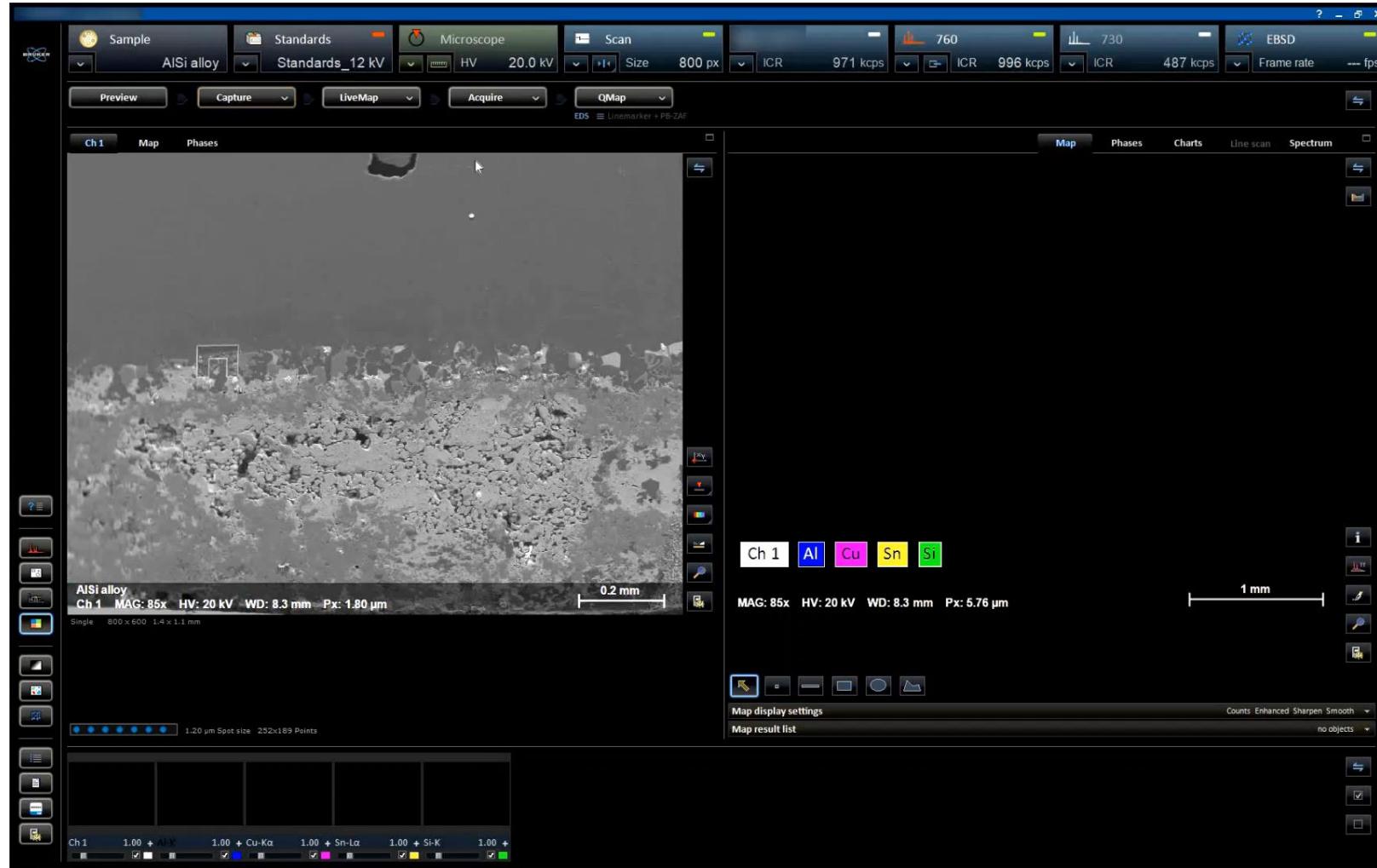
25 kV measurement at 20,000x magnification



MAG: 20,000 x HV: 25 kV

1 μm

Example 7: Live chemical mapping of Sn–Cu solder region in Al-Si alloy



- LiveMaps at 1000 kcps OCR
- Automated hybrid elemental selection – manual + AutoID
- Spectrum extraction with mapping objects
- Trace element identification (single pixel enrichment) during live chemical mapping
- User defined resolution for ESPRIT LiveMap and easy adaptability/switch to conventional mapping from live chemical mapping

Detector used?



EDS/SEM SYSTEM CONFIGURATION

Detector type Bruker 7th Gen XFlash

Resolution 126 eV @Mn Ka

Window SLEW AP3.3



Thank you!

Q&A

Questions?

Please type in the questions
in the **Q&A box** and press ***Send***.