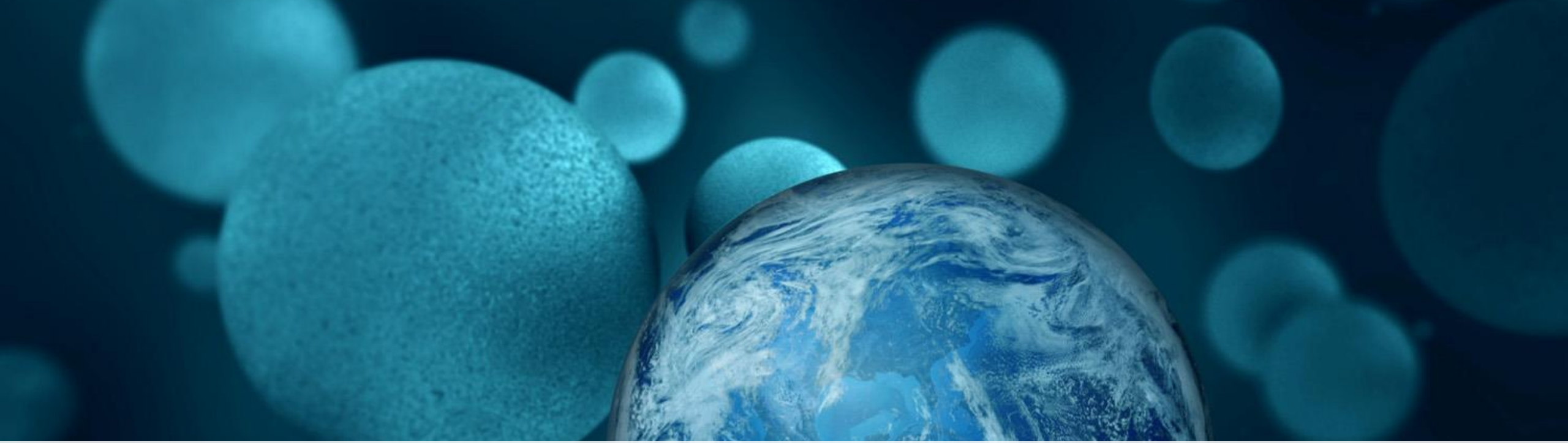

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Scios 2
E-beam/NICol column

Module 3

Scios: E-beam column

- FEG source
- NiCol (column) = Non Immersion Column
- UseCases/SEM Optical modes
- Trinity Detectors
- Automatic E-beam alignments

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E-beam Column

- E-Column:
- Schottky Field Emitter:
- Optimized for high and low beam current mode
- Highest BC=400nA
- Long term probe stability (over 10hrs <0.4%)

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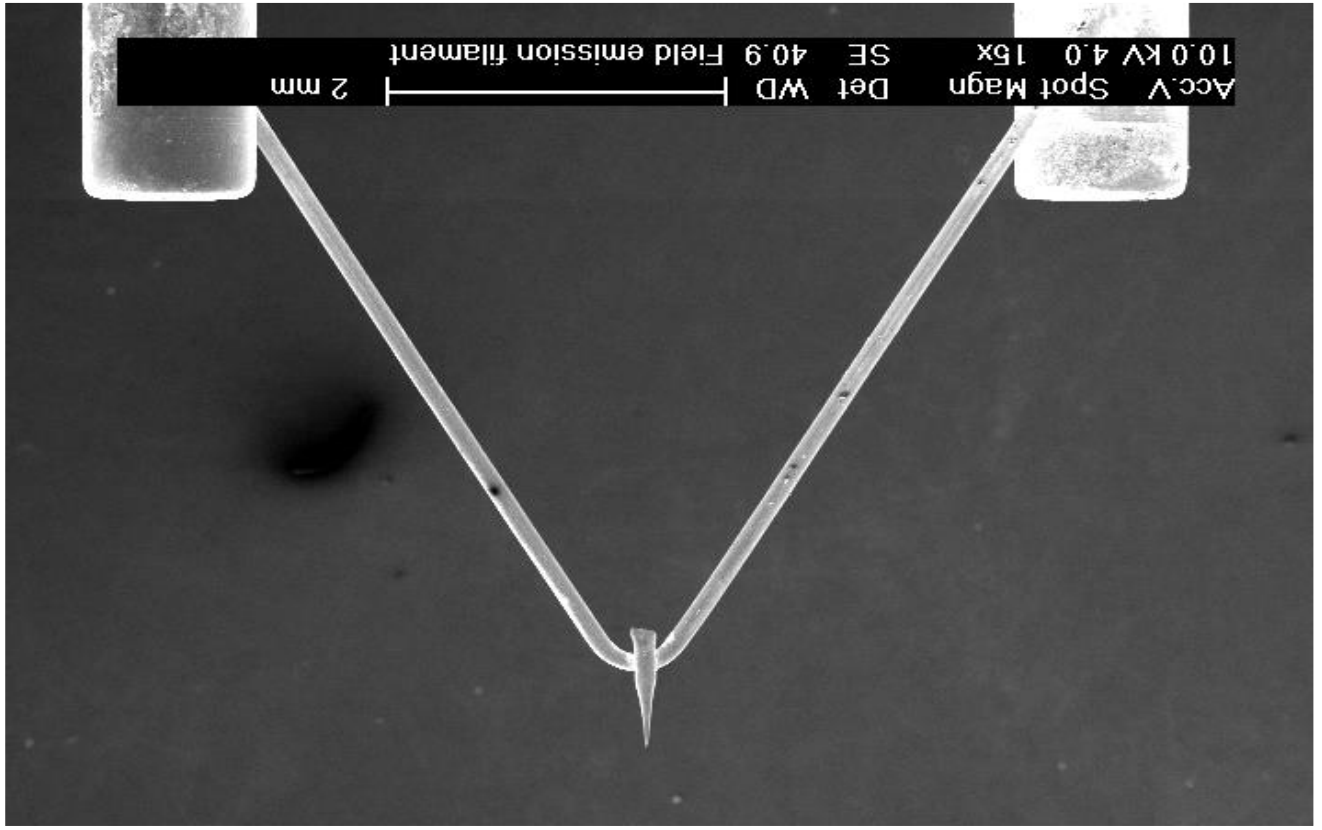
FEG source: Field Emission Filament



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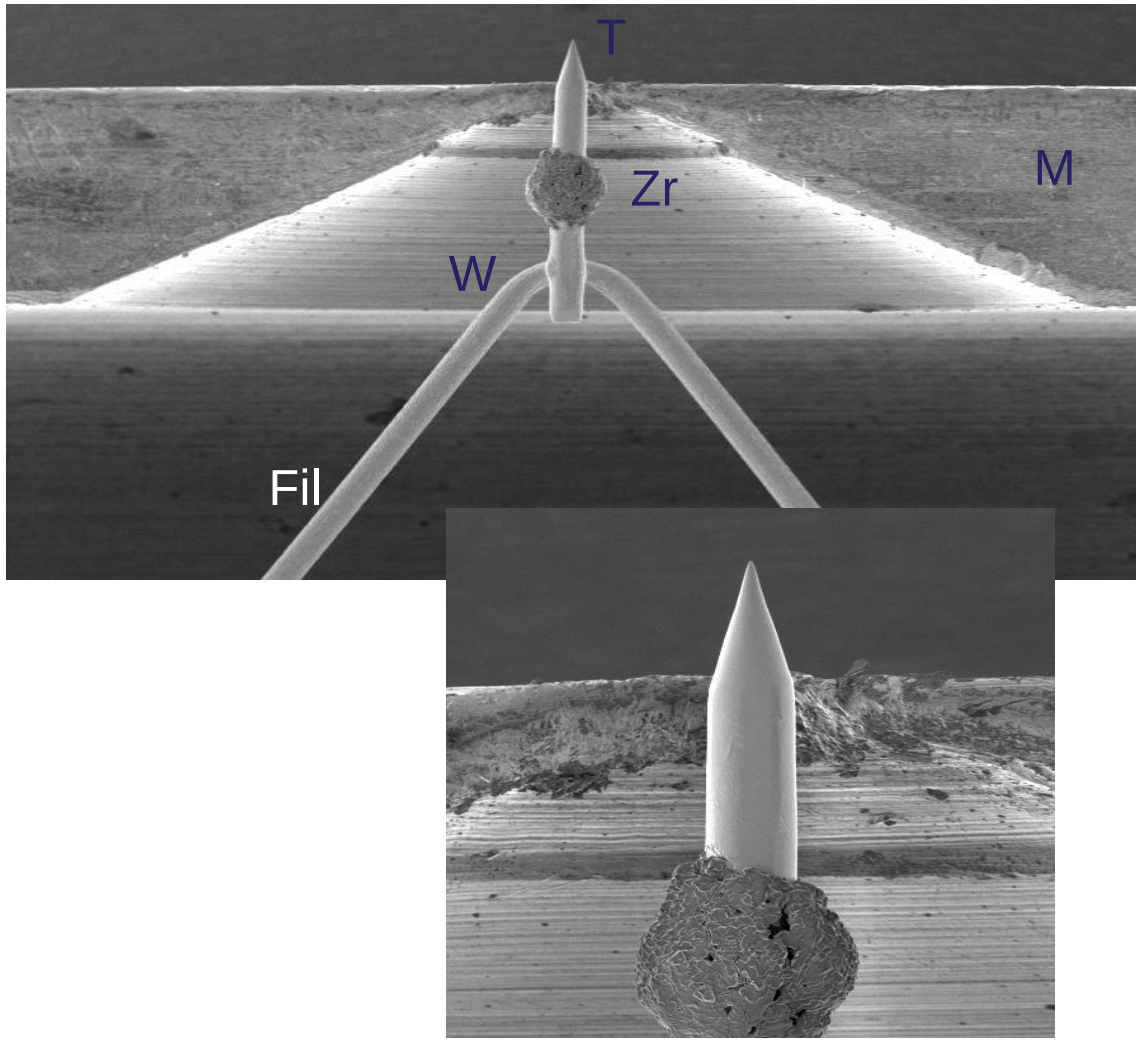
FEG source: Schottky Emitter

- M = Tip module
- W = Welded tungsten Tip
- Fil = Tungsten wire filament
- T = Sharpened Tip

  (single W crystal)
- Zr = Zirconium (oxide) reservoir



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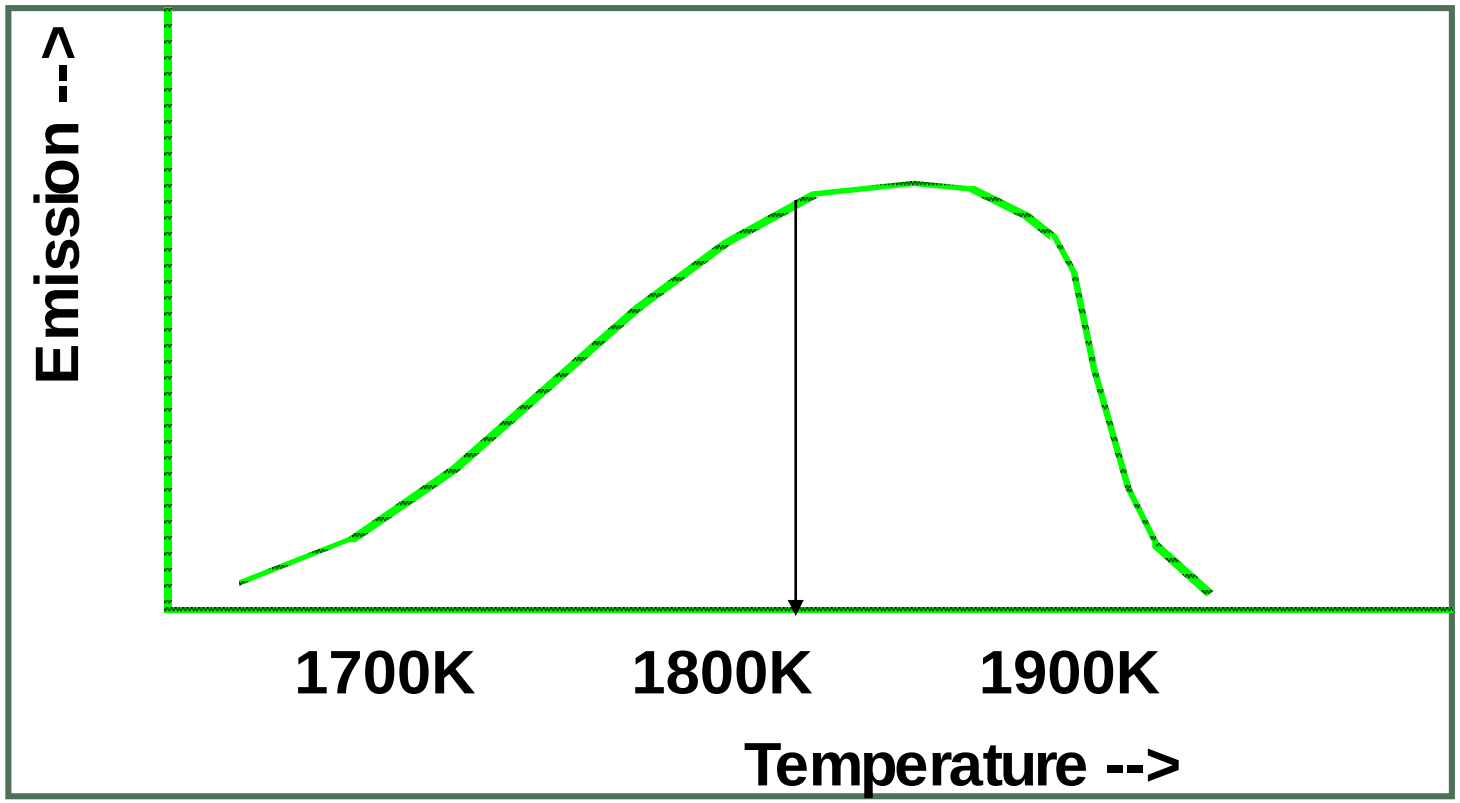
Schottky Emitter: Temperature - Emission



A Schotty Field Emitter has a
Long term probe stability (over 10hrs <0.4%)

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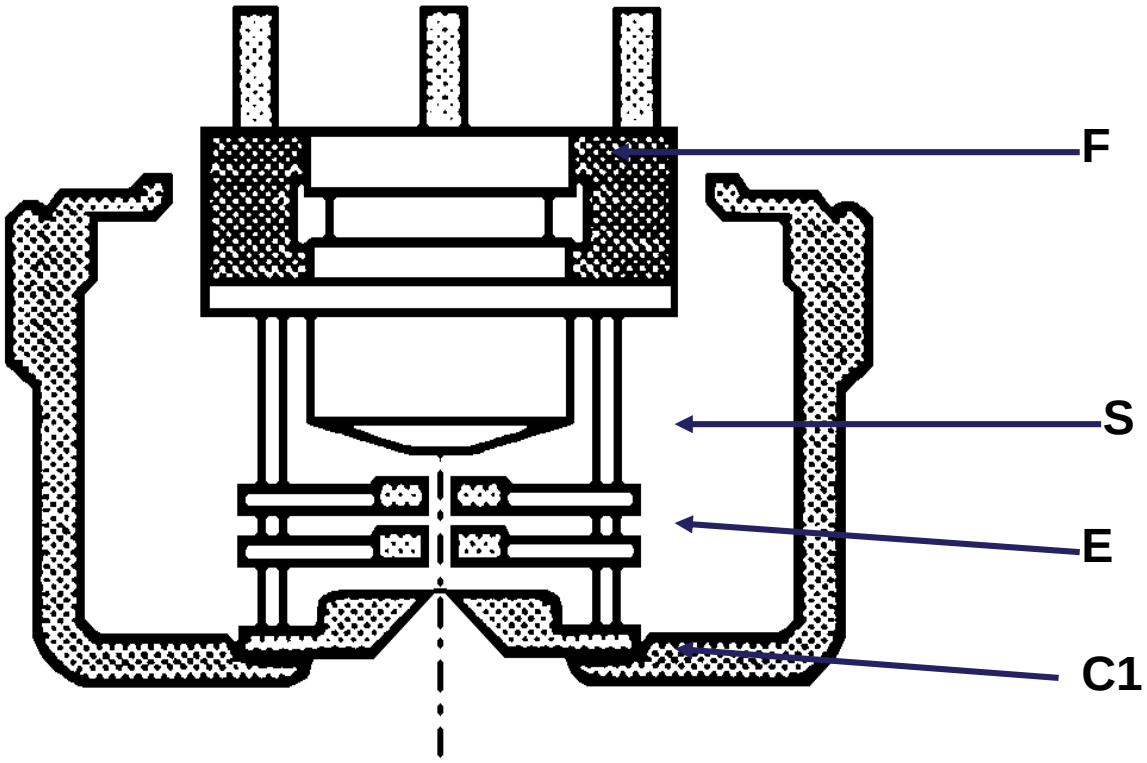
FEG: Schottky Gun Design

- **F**: Filament current input (2.4 Ampere)
- **S**: Suppressor (-500V)

  source position and size
- **E**: Extractor (+5000V) emission
- **C1**: Electrostatic Condenser lens



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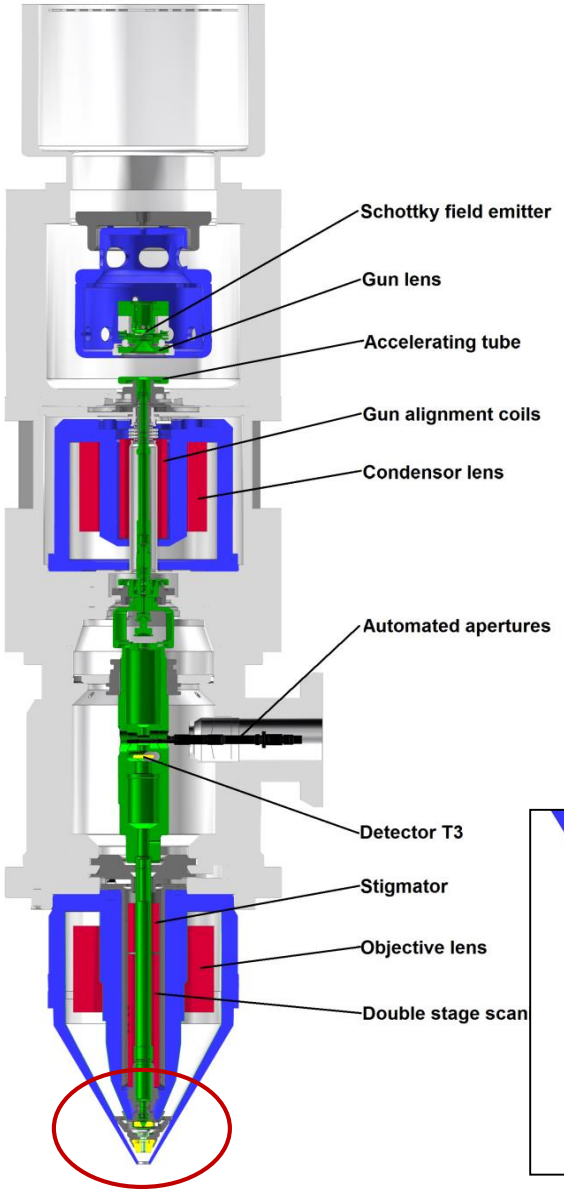
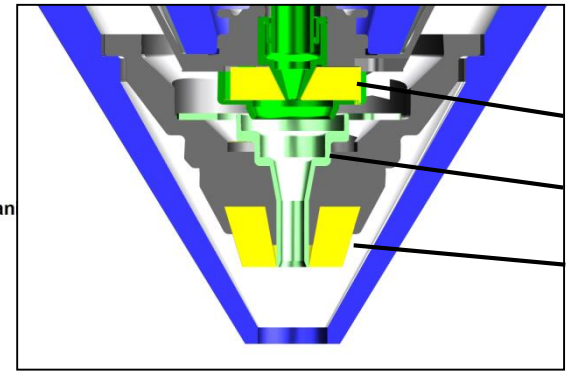
High contrast, fast imaging





Simultaneous detection of all information with the

In-lens Trinity Detection system and NICol SEM column

- T1: in-lens BSE detector for material and topographic contrast
- T2: upper in-lens detector for excellent edge contrast
- T3: optional in-column detector for extreme surface sensitivity through low energy secondary electron signal collection
- Dual mode final lens for optimum results on all materials – including magnetic samples

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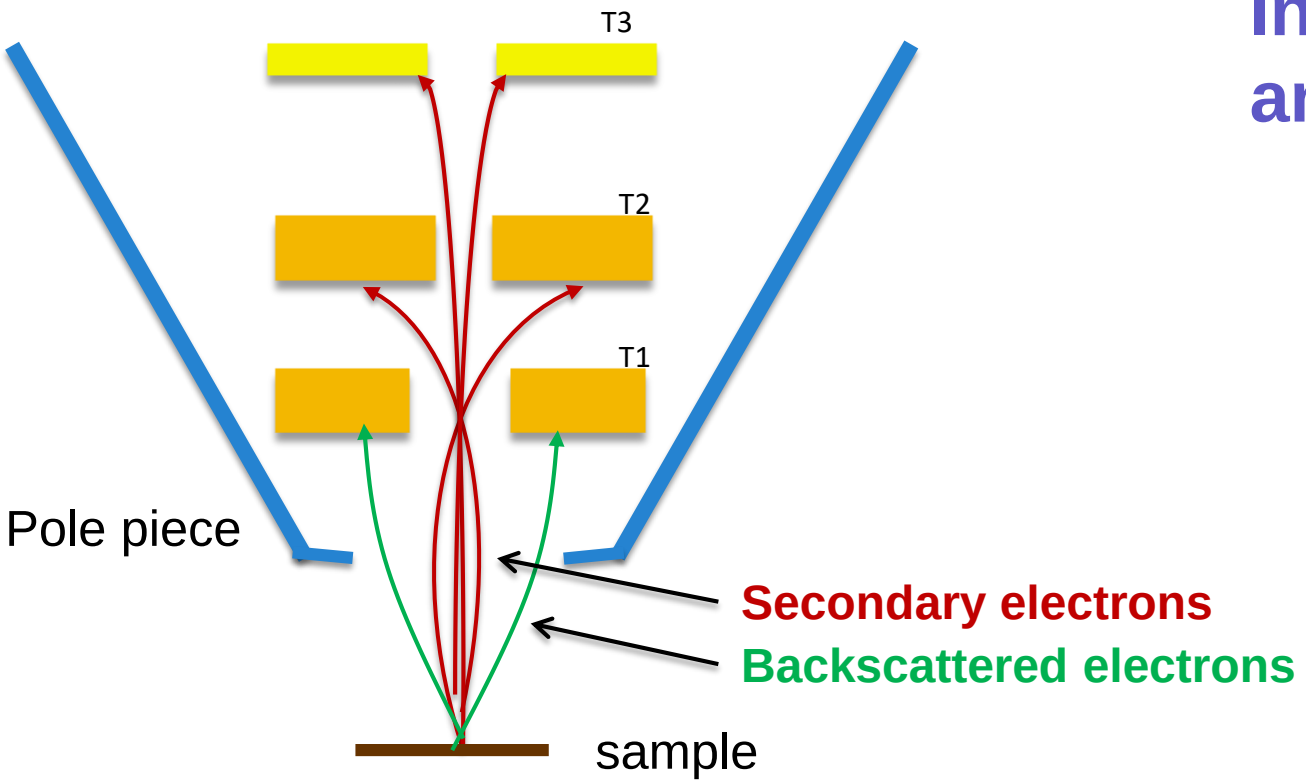
Scios Detection Concept



Simultaneous detection of all information with the

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- T3: optional in-column detector for extreme surface sensitivity through low energy secondary electron signal collection
- Dual mode final lens for optimum results on all materials – including magnetic samples

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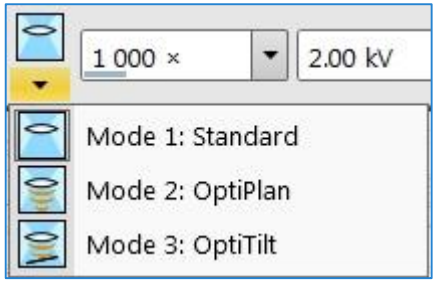
New concept: Column Use Cases

OptiPlan

- High resolution imaging at short WD (≤5mm)



OptiTilt

- High resolution imaging of tilted samples at eucentric WD (≤7mm)

Standard

- Basic operation, navigation, preparation of TEM samples and x-sections, EDX, EBSD

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Scios Use Cases

UseCase	Application	WD	Tilt	Detector	FOV	A-tube	Beam Current range	Stage Bias(SB)
Standard	Navigation, DB mode, analytics	any	any	ETD, T1, T2, ICE, DBS, STEM	max	off	0.8pA -13nA (>13nA _5-30kV)	off
OptiPlan	Best imaging conditions	≤ 5mm	0°	ETD, T1, T2, T3, ICE, DBS, STEM	limited	on	0.8pA -13nA	Optimum = neg SB (default off)
OptiTilt	Cross section Imaging (tilted samples)	≤ 7mm	>5°	ETD, T1, T2, T3, ICE, DBS, STEM	limited	on	0.8pA -13nA	Default +20V

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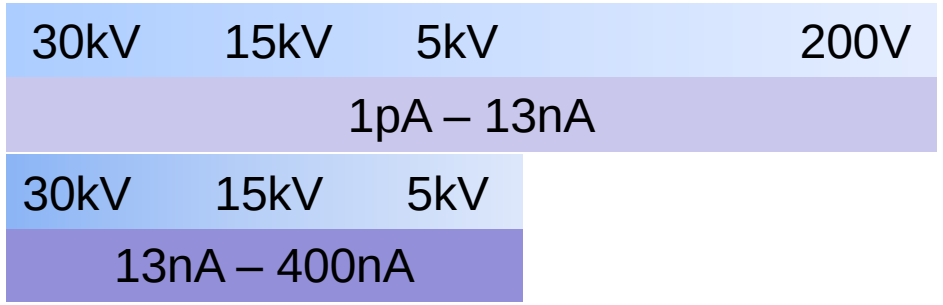
Standard Use Case

- Sample Navigation
- Basic imaging
- FIB work
  - Preparation of TEM samples
  - Preparation of cross sections
  - EDS, EBSD, CL
- A-tube voltage = 0V



UseCase	Application	WD	Tilt	Detector	FOV	A-tube	Stage Bias(SB)
Standard	Navigation, dualbeam mode, analytics	any	any	ETD, T1, T2, ICE, DBS, STEM	max	off	off

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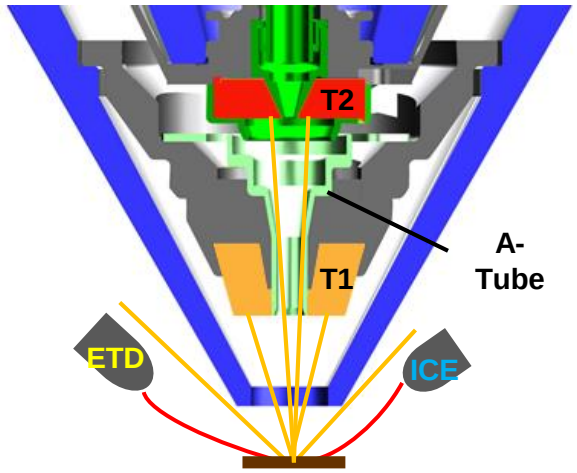
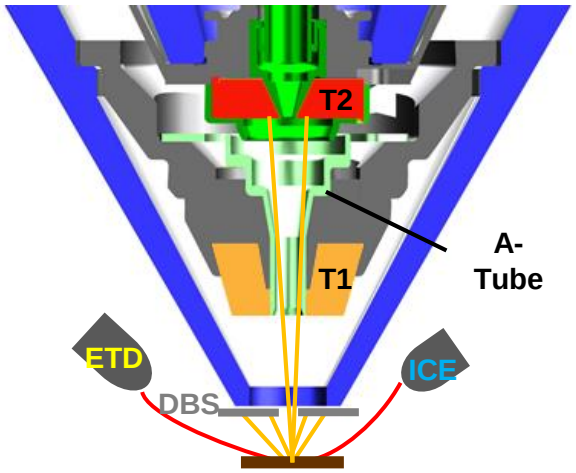
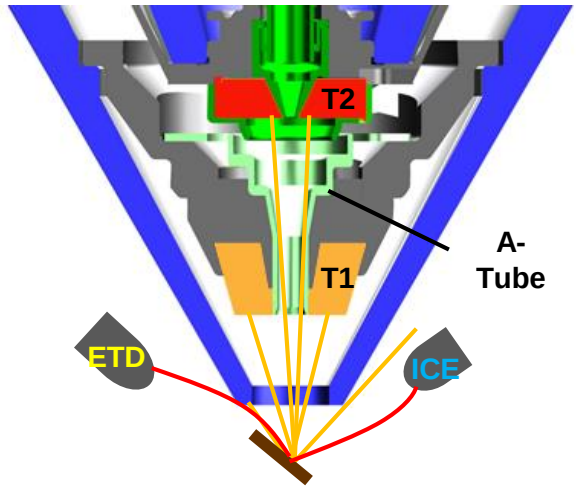
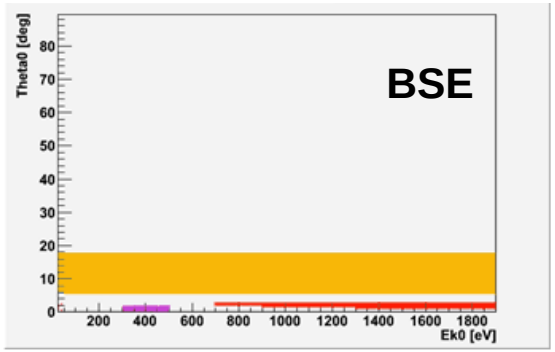
Standard Use Case









Signal detected @ eucentric:

T1: Backscattered electrons ; signal depends on HV and probe current

T2: Backscattered electrons; low signal

T3: No image

ETD: Secondary electrons; topography

ICE: Secondary electrons; topography

NOTE: DBS inserted; blocks BSE's so less signal on T1 (+T2)

Tilted sample; less signal on T1 (+T2) and more signal on ETD and ICE (in tilt axis direction)

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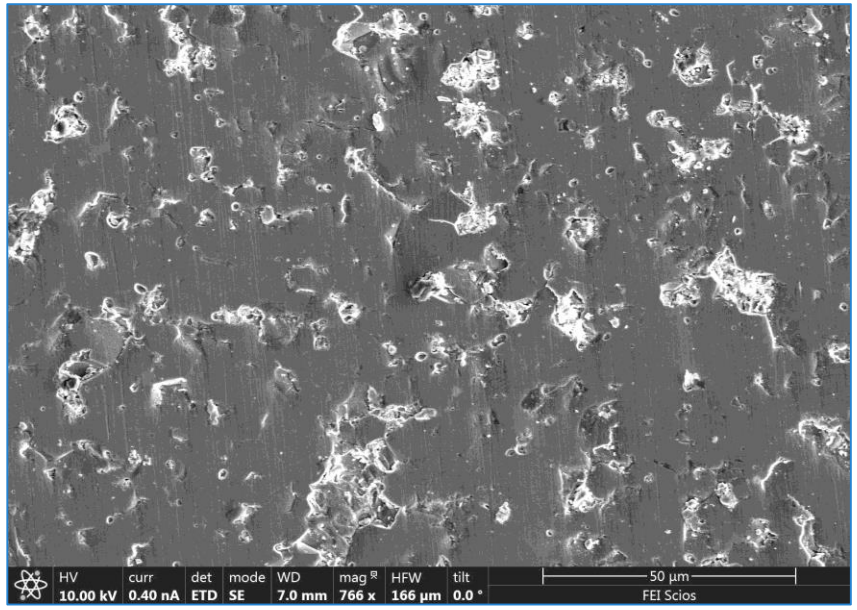
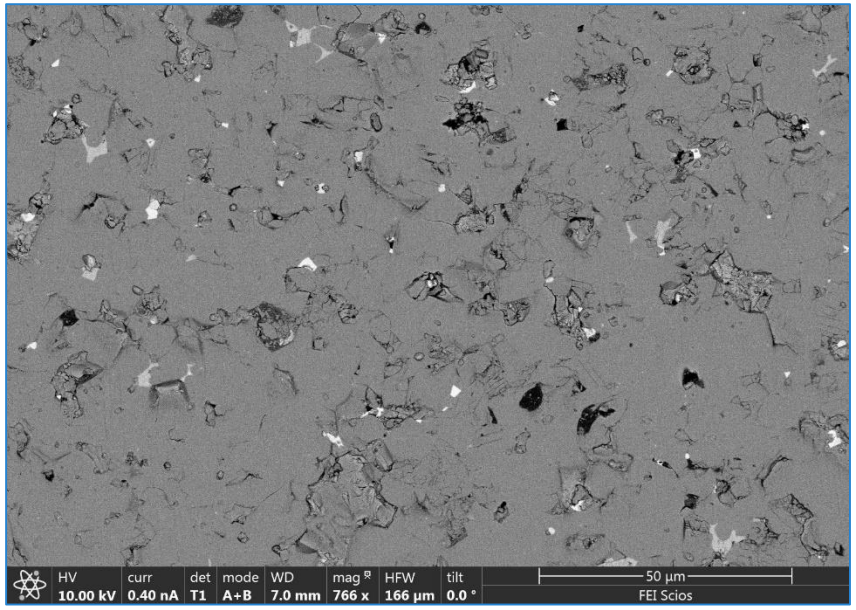
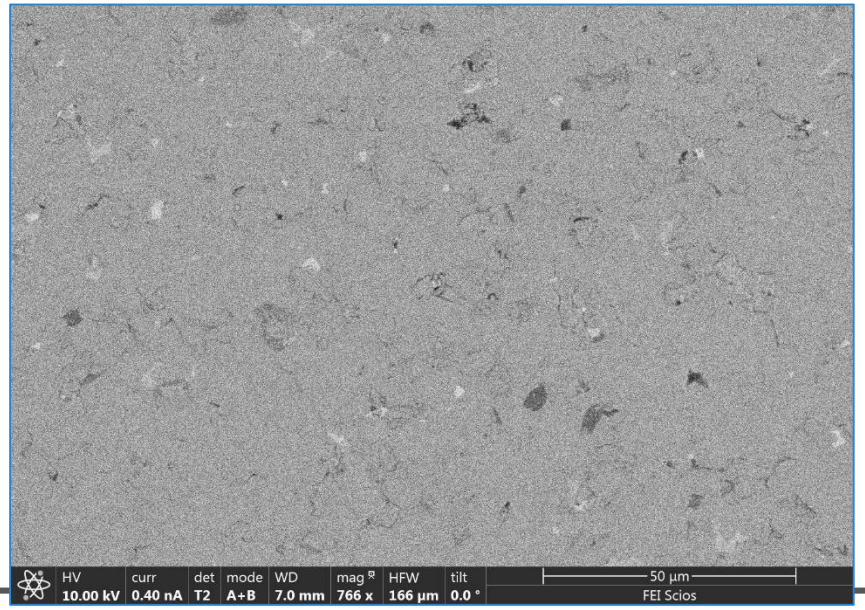
Standard Use Case – Top Down



ETD



T1



T2

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OptiPlan Use Case

- High resolution top down imaging
- Optimized for short WD (2mm)
- A-tube voltage = 8kV
  - accessible HV depend on the WD

UseCase	Application	WD	Tilt	Detector	FOV	A-tube	Stage Bias(SB)
OptiPlan	Best imaging conditions	≤ 5mm	0°	ETD, T1, T2, T3, ICE, DBS, STEM	limited	on	Optimum = neg SB (default off)

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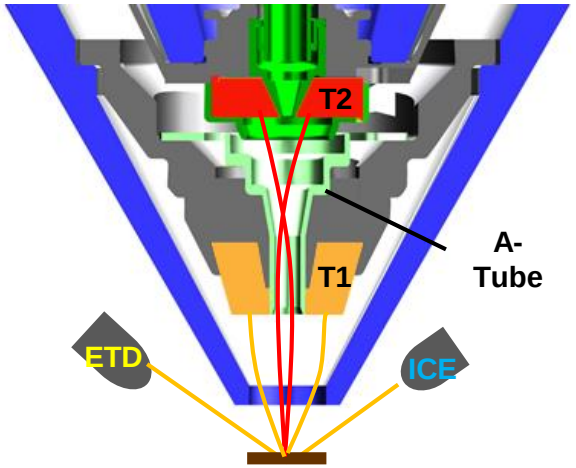
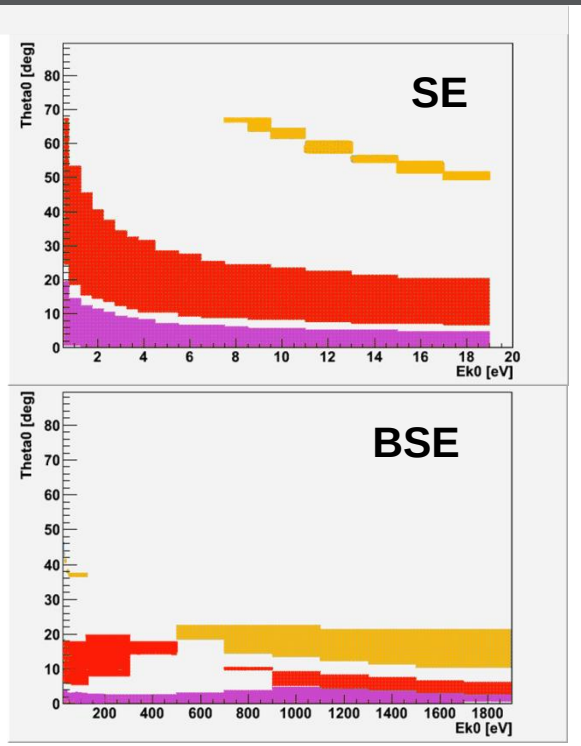
OptiPlan Use Case @ eucentric





T1
T2
T3

T1
T2
T3

Signal detected:

T1: Backscattered electrons ; high angle BSE's, mainly compositional contrast

T2: Secondary electrons; (middle angles + energies), mainly topography

T3: Secondary electrons; (high angles + low energies), mainly surface info

ETD: Backscatters electrons; low angles - topography

ICE: Backscatters electrons; low angles - topography

NOTE: DBS restrictions

Excellent resolution: Character of signal depends on the optical configuration of the column: WD, HV and SB

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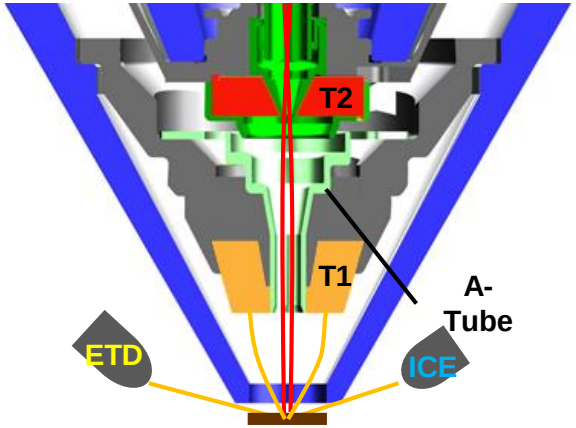
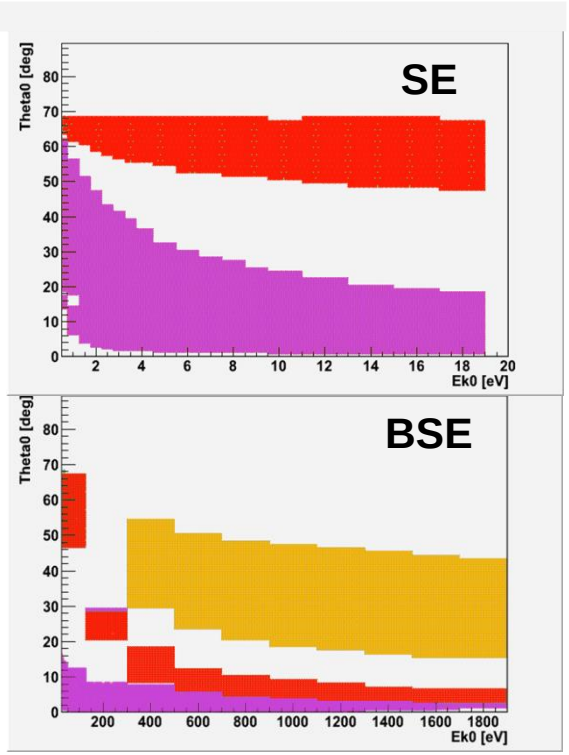
OptiPlan Use Case @ 2mm





T2
T3

T1
T2
T3

Signal detected:

T1: Backscattered electrons ; low angle BSE's, mainly composition (some topo)

T2: Secondary electrons; topography

T3: Secondary electrons; surface sensitive information

ETD: Backscatters electrons; low signal (low angles – topography)

ICE: Backscatters electrons; low signal (low angles – topography)

NOTE: DBS can't be inserted

Excellent resolution: Character of signal depends on the optical configuration of the column: WD, HV and SB

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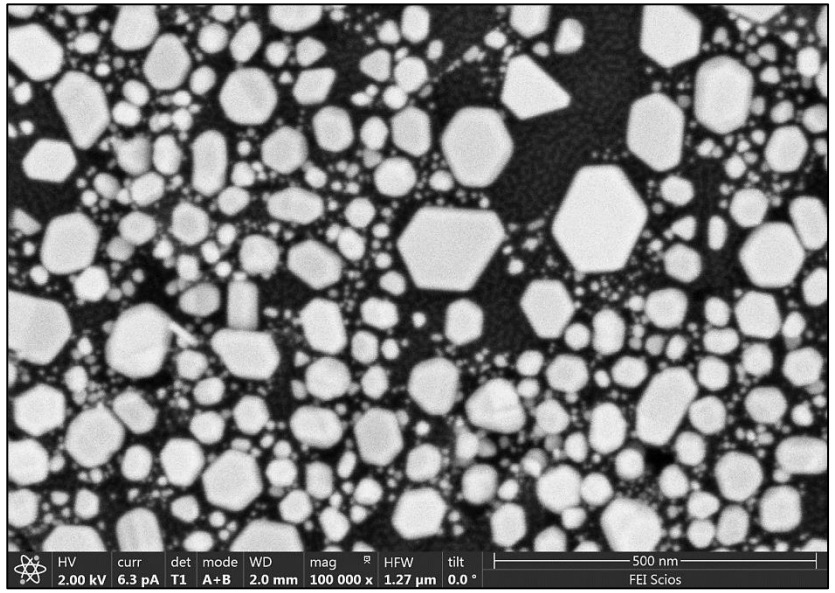
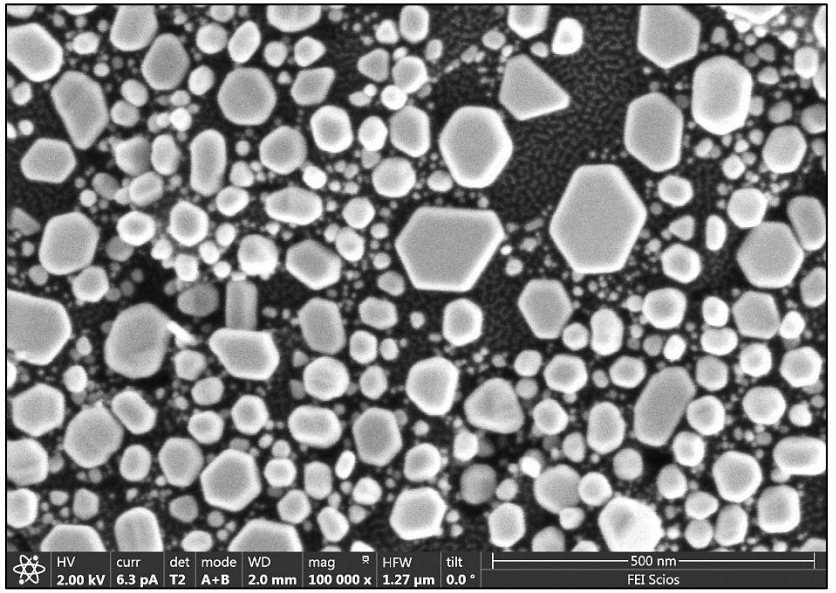
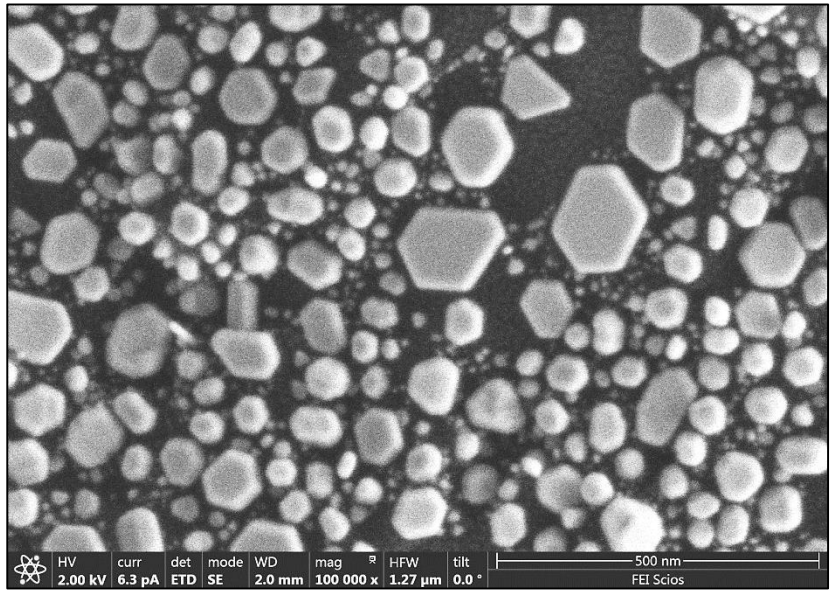
OptiPlan Use Case – WD = 2mm



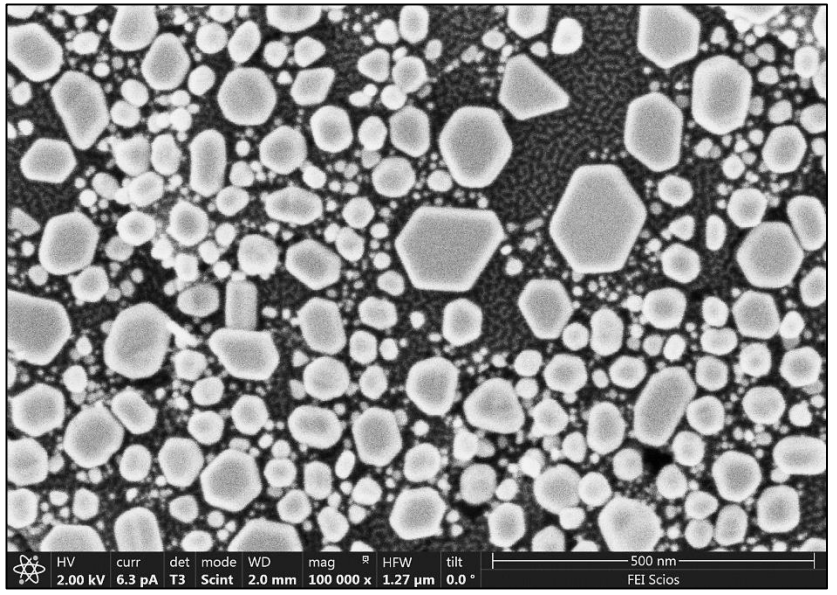
T1



T2



ETD



T3

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OptiTilt Use Case

- High resolution imaging of
  - tilted samples
  - cross-sections
- Optimized for imaging at eucentric WD
- A-tube voltage depends on kV

UseCase	Application	WD	Tilt	Detector	FOV	A-tube	Stage Bias(SB)
OptiTilt	Cross section Imaging (tilted samples)	≤ 7mm	52°	ETD, T1, T2, T3, ICE, DBS, STEM	limited	on	Default +20V

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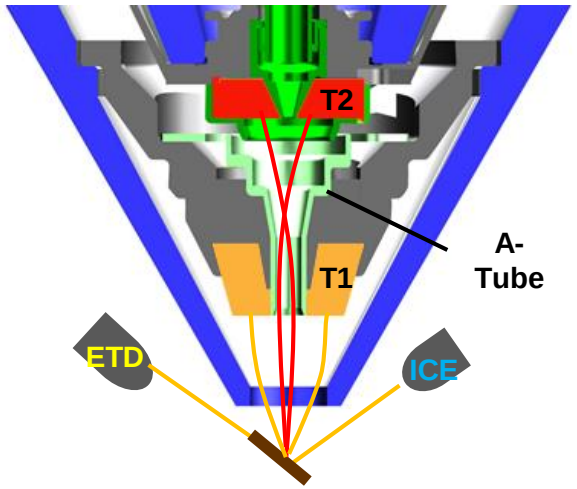
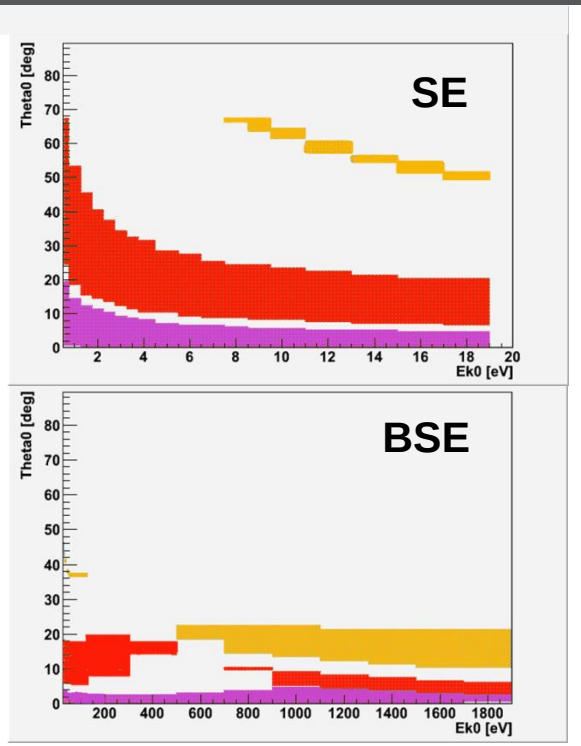
OptiTilt Use Case @ eucentric





T1
T2
T3

T1
T2
T3

Signal detected:

T1: Backscattered electrons ; high angle BSE's, mainly compositional contrast

T2: Secondary electrons; (middle angles + energies), mainly topography

T3: Secondary electrons; (high angles + low energies), mainly surface info

ETD: Backscatters electrons; low angles - topography

ICE: Backscatters electrons; low angles - topography

NOTE: DBS restrictions

Excellent resolution: Character of signal depends on the optical configuration of the column: WD, HV and SB

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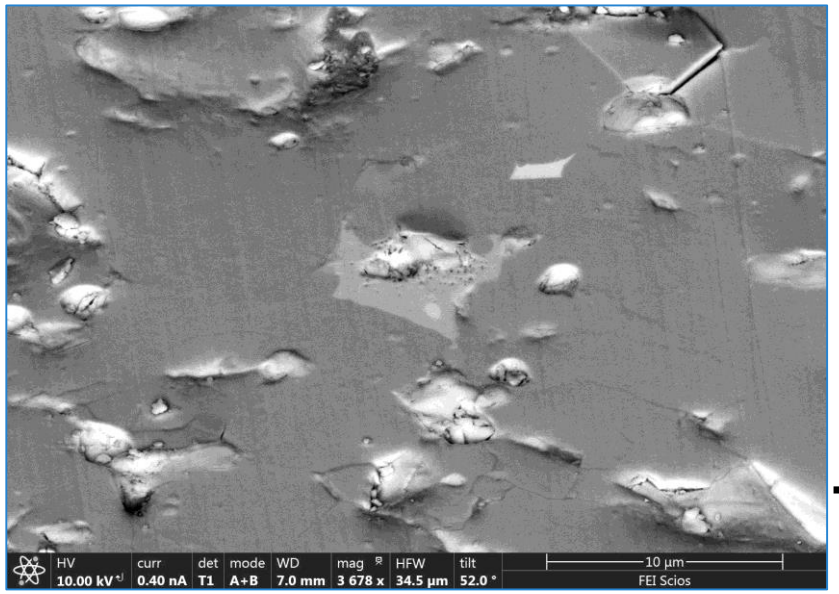
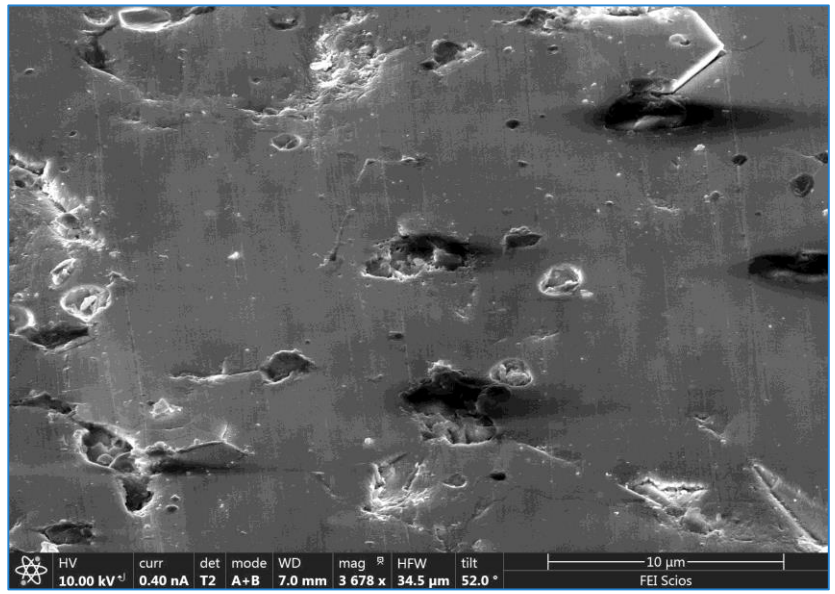
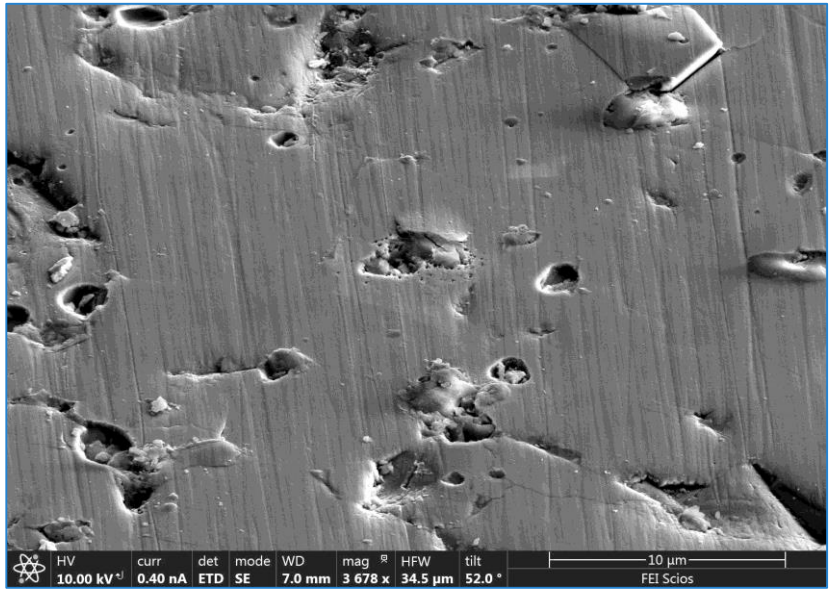
OptiTilt Use Case – Tilted surface



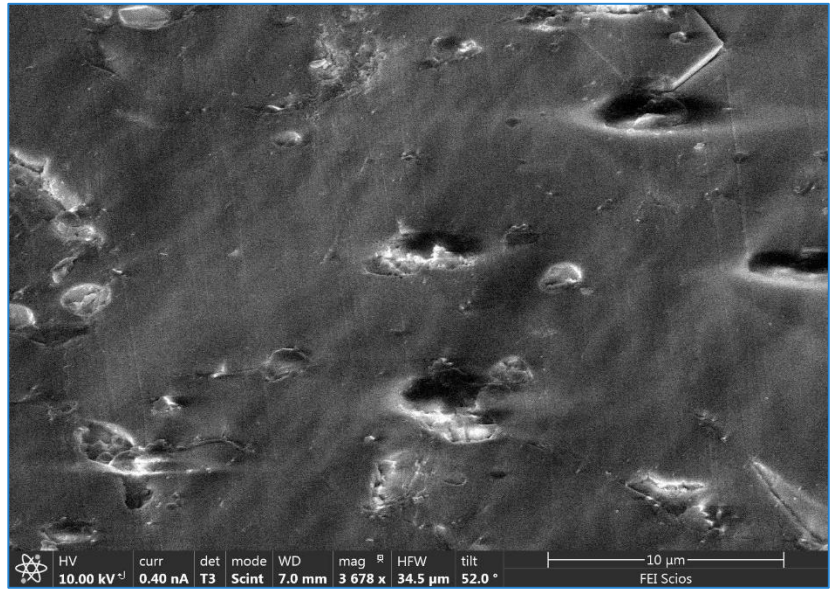
T1



T2



ETD



T3

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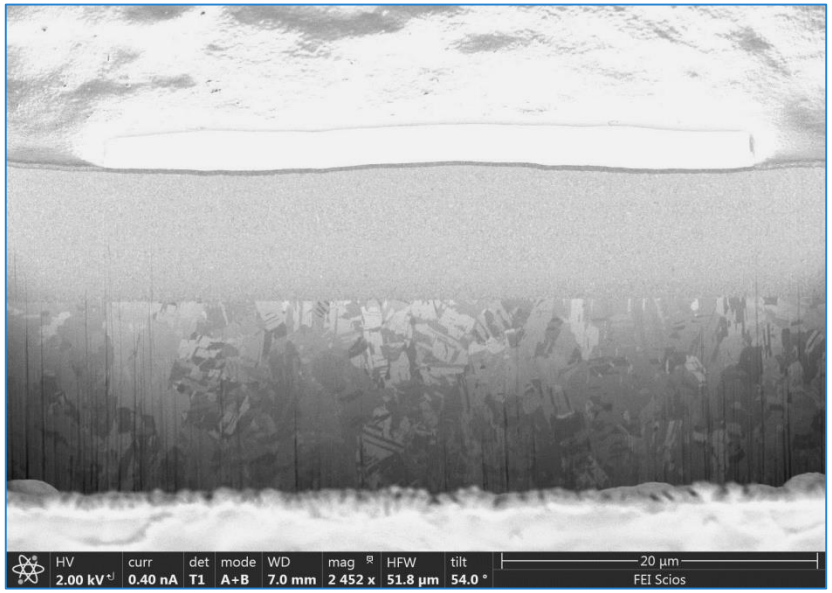
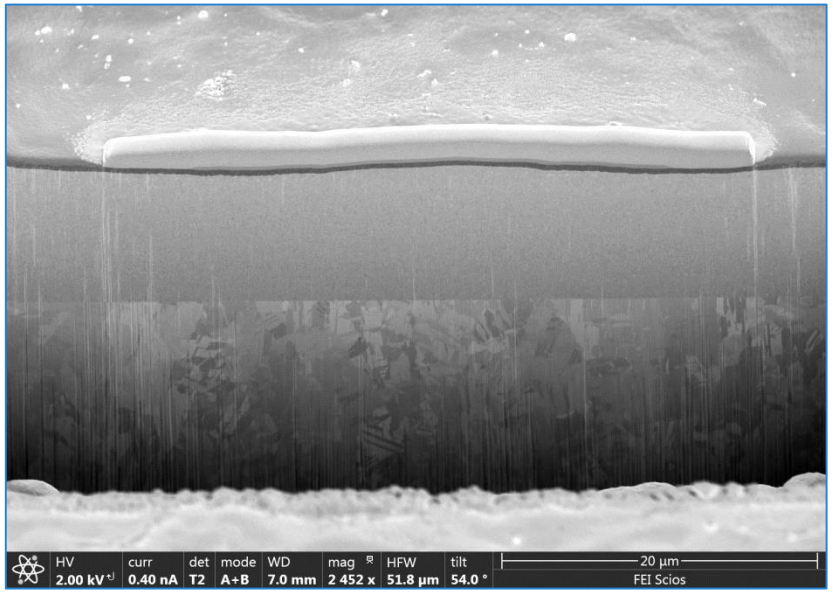
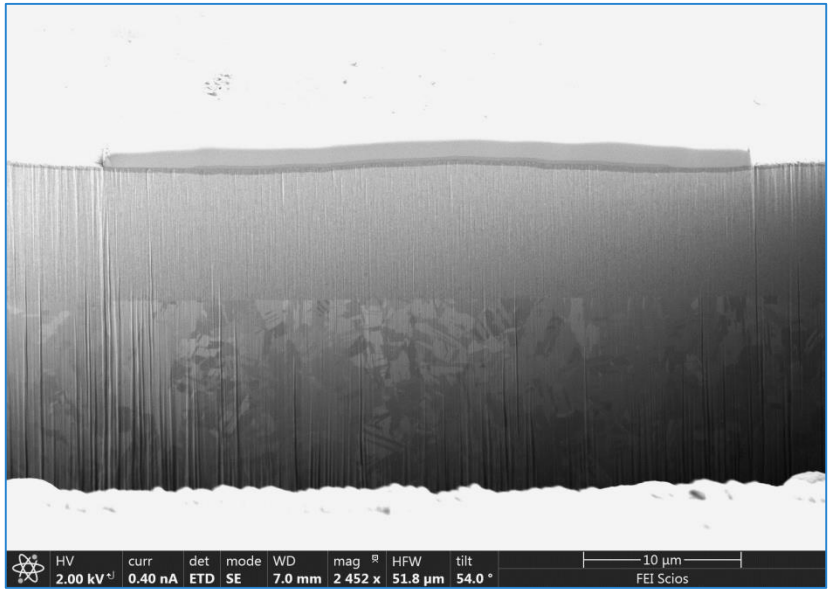
OptiTilt Use Case – Cross Section @ eucentric



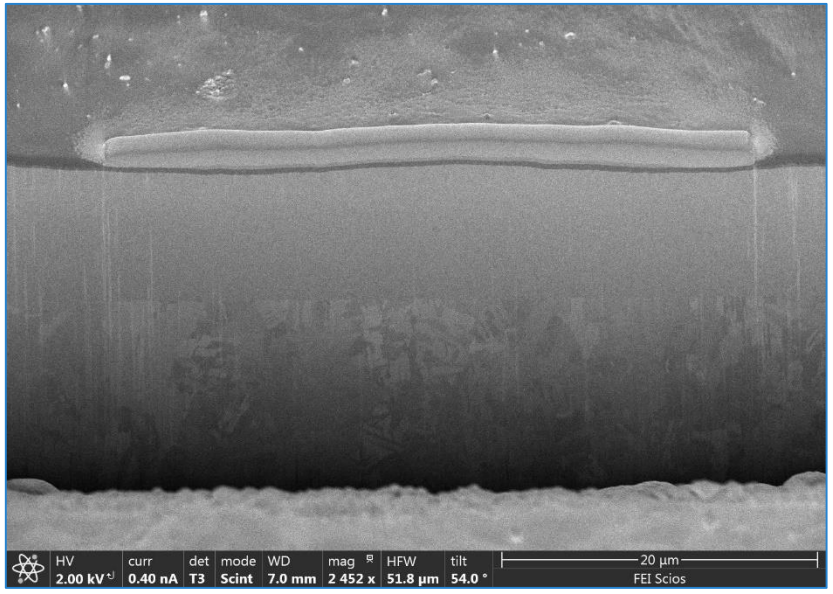
T1



T2



ETD



T3

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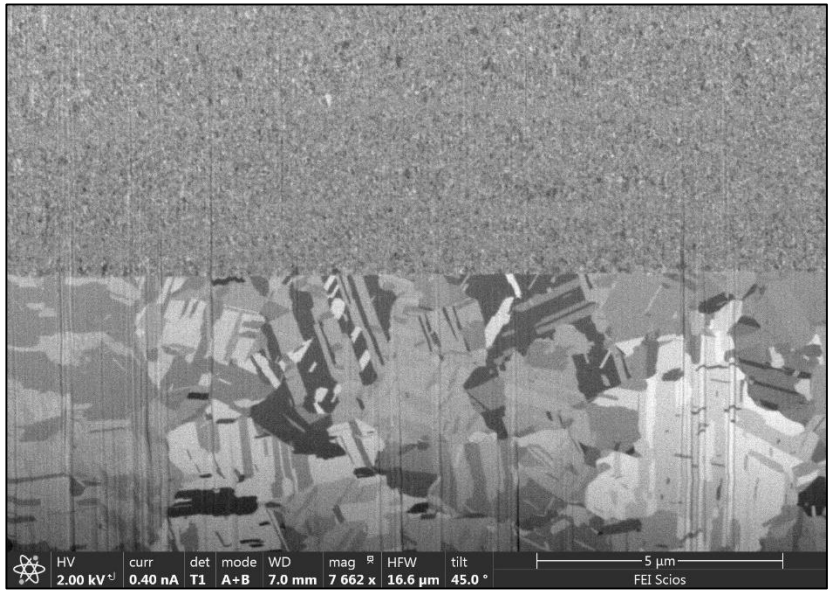
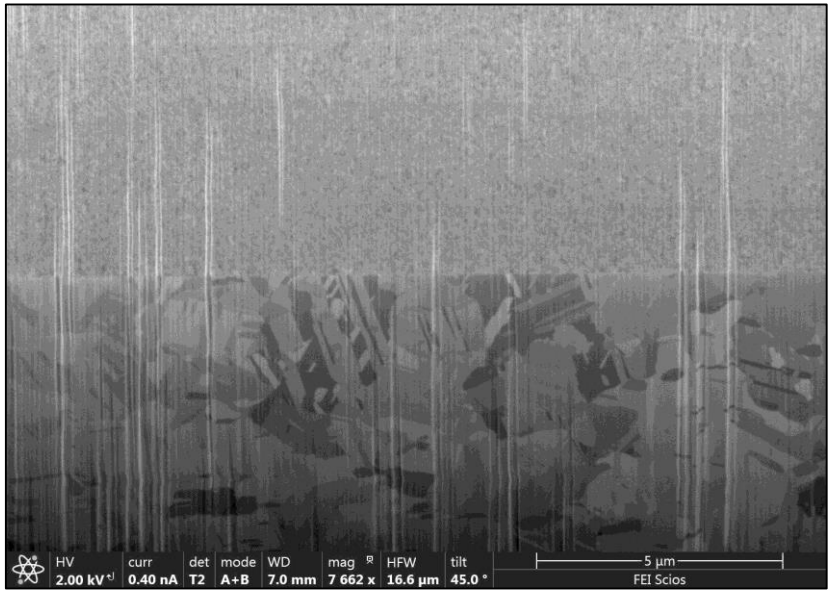
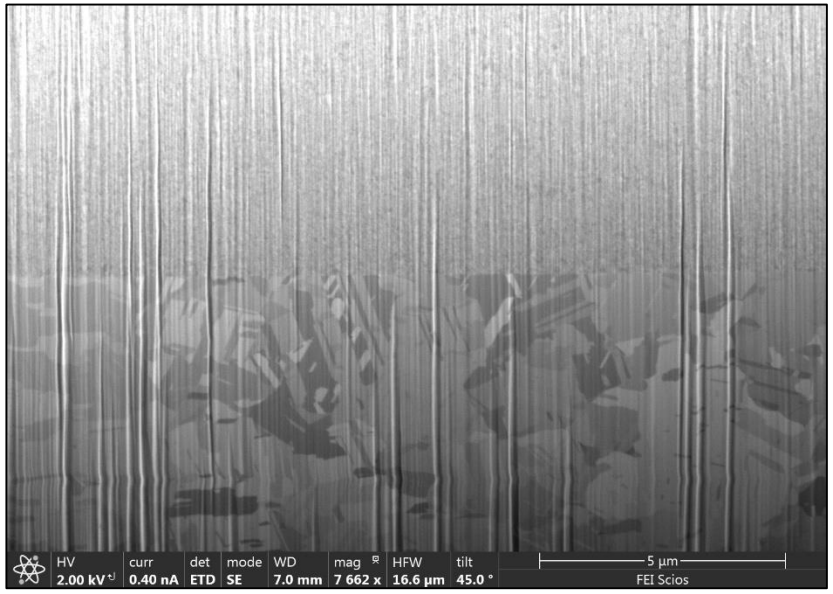
OptiTilt Use Case – Cross Section @ eucentric



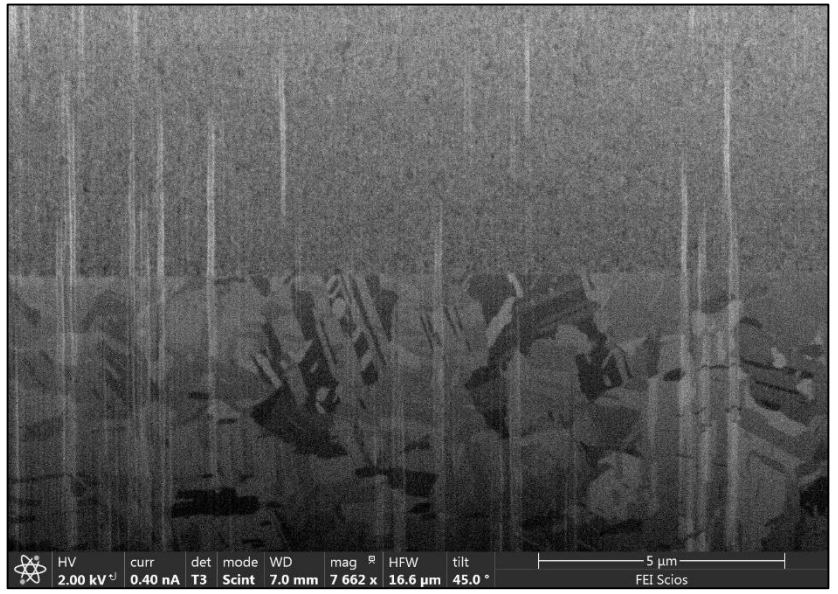
T1



T2



ETD



T3

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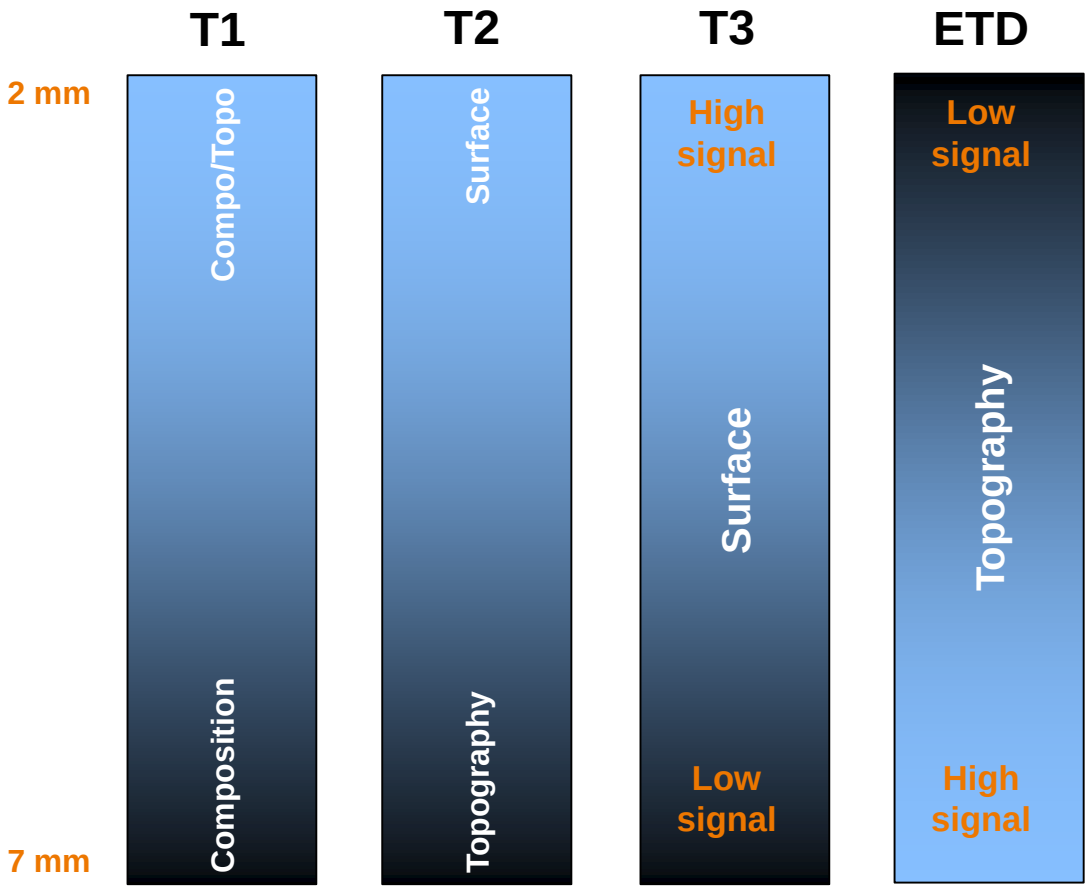
Suggestions for low kV Trinity imaging



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Detector Options

Detector	Availability	Benefits
Trinity • T1 (segmented) In-lens BSE • T2 In lens SE • T3 in Column	Trinity • Standard • Standard • option	Simultaneous imaging of high and low energy SE for extreme surface sensitivity and edge contrast, and segmented BSE for materials contrast and charge free topographic imaging on non-conductive materials
ETD Chamber SE/BSE Detector	standard	High efficiency imaging in all conditions
ICE Chamber SE / SI Detector	option	Optimized for low kV / low current imaging, esp. FIB. Secondary Ion Imaging gives material contrast in FIB images; Extremely surface sensitive info
STEM 3 / STEM3+	option	Simultaneous BF/DF and HAADF imaging for diffraction contrast, material contrast with highest resolution. STEM 3+ gives additional DF segments for better tunable materials contrast in STEM.
DBS – Retractable (below lens) BSE detector	option	Separate material and topographic contrast BSE signal to collect information from every angle. Enables charge filtered imaging on non-conductive material.

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Acceleration Voltages, Spot sizes

Acc. Voltage	Application
1-5keV	True surface info, e-beam deposition, drift suppression
5-15keV	General imaging
15-30keV	STEM imaging, heavy element X-ray mapping
Spot size	
1-7	Low currents, beam sensitive material
1-7	High res imaging (mag > 50kx)
8-12	Standard imaging
>12	Analytical work, EBID, drift suppression

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