Introducing the New Helios 5 UC FIB-SEM:

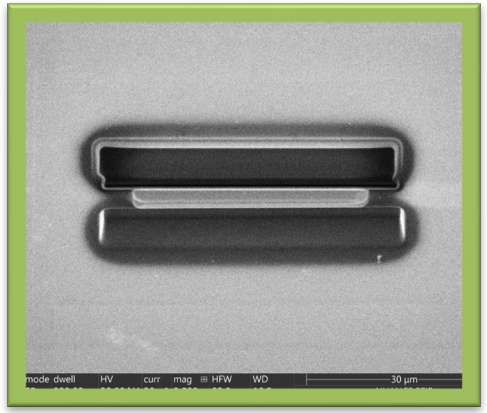
From Elegant Sample Preparation to Detailed 2D or 3D Sample Characterization

2025-08-21

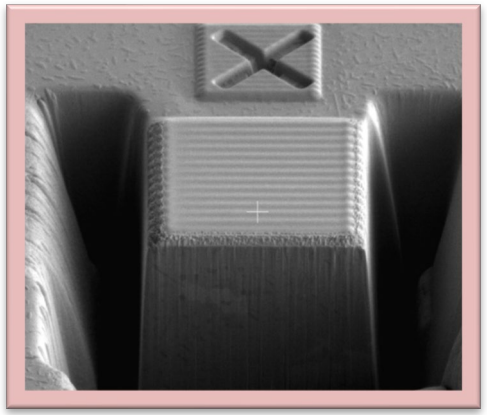
Yu Wen
Postdoctoral Researcher
NU*ANCE* EPIC-FIB&TEM

Ion-solid interaction & applications

Imaging

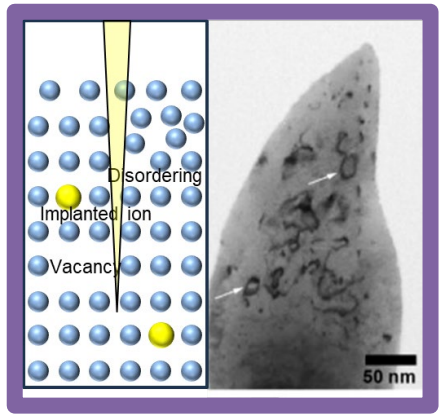


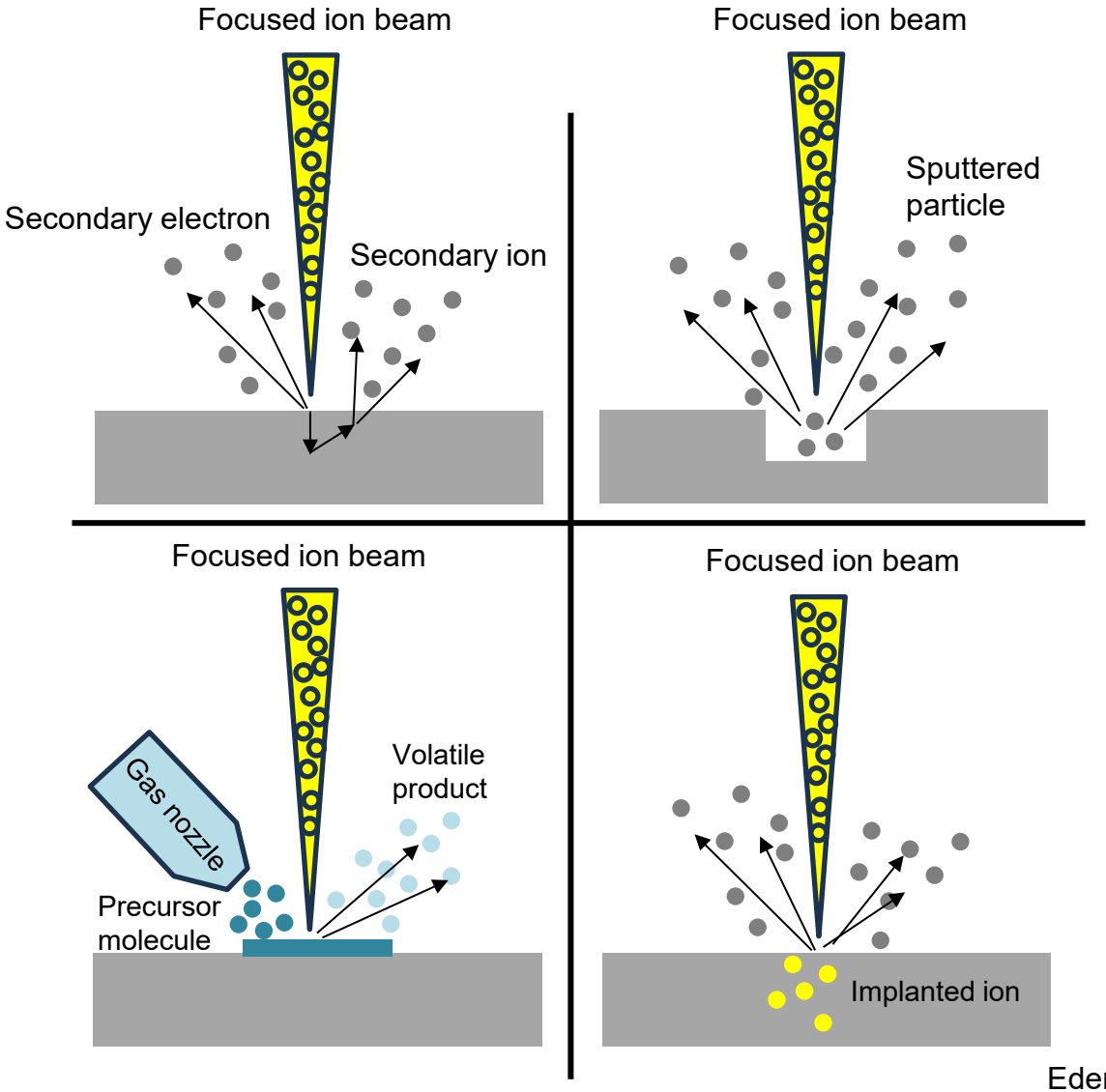
Milling



Deposition

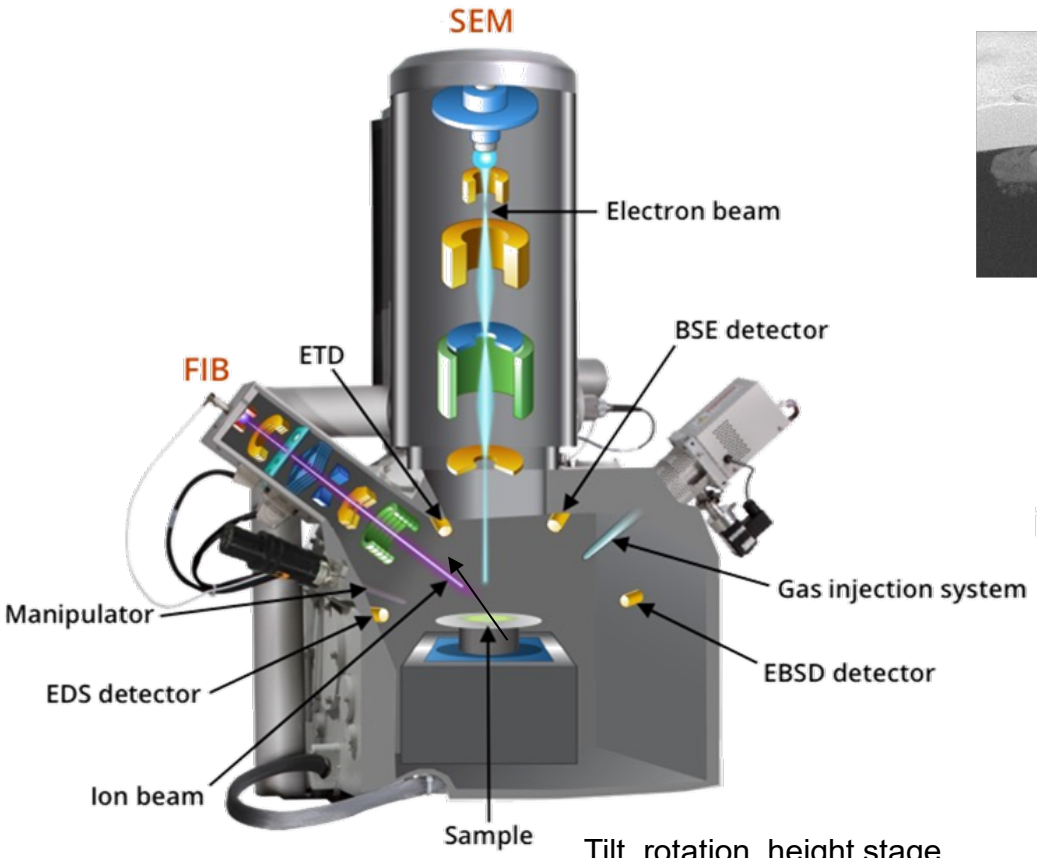
Implantation





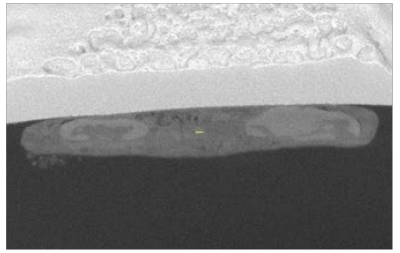
Eder, Katja, et al. *Ultramicroscopy* 228 (2021): 113334.

FIB-SEM capabilities

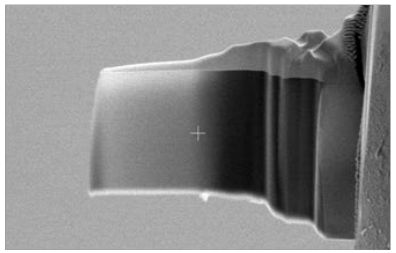


Tilt, rotation, height stage
Cold

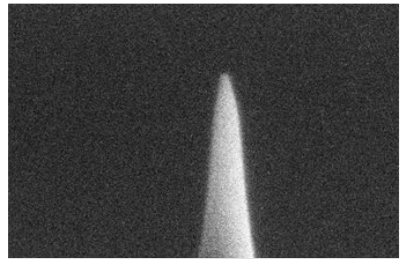
Cross-sectioning



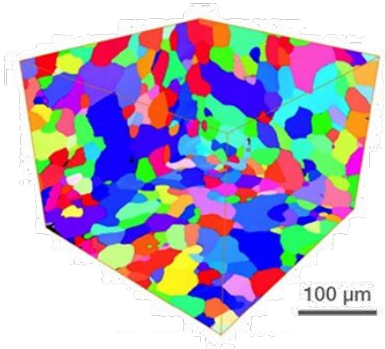
TEM lamellae preparation



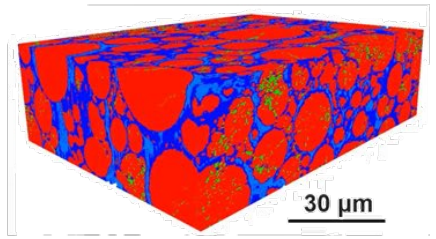
Exotic sample preparation



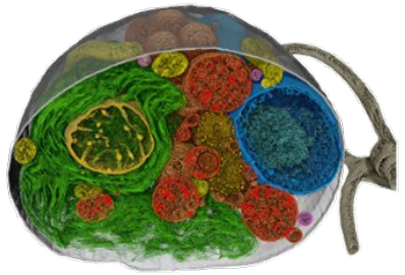
2D/3D EBSD



2D/3D EDS



3D tomography



https://thermofisher.com

https://myscope.training/FIB_Introduction_to_components

EPIC-FIB instruments

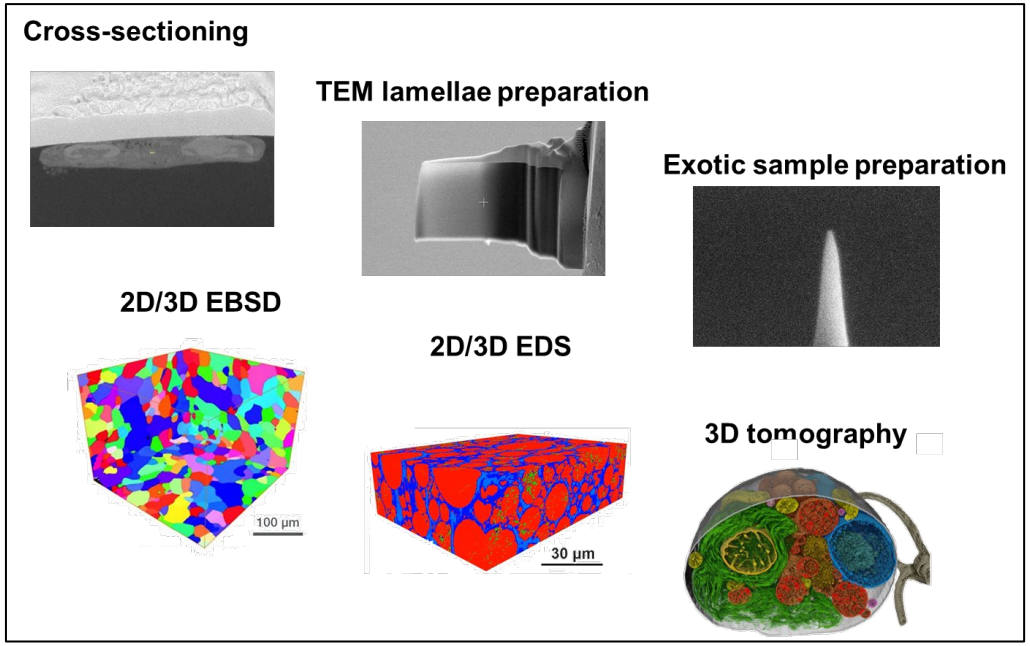
Thermo Scientific™ Hydra Plasma

Plasma source (Xe, O, Ar, N)

- Large volume processing
- Cryo-milling/imaging

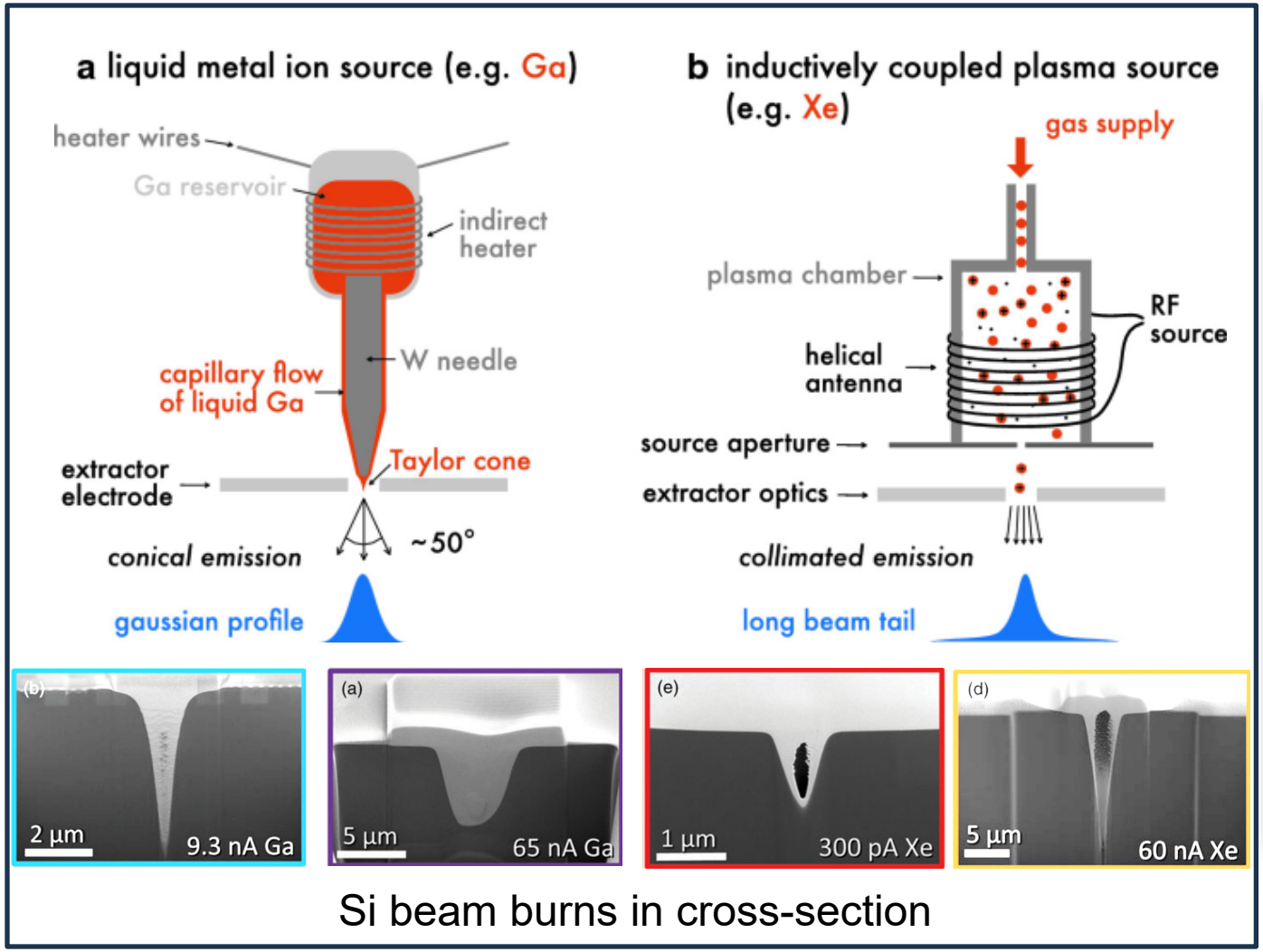
Thermo Scientific™ Helios™ 5 UC

Ga+ source

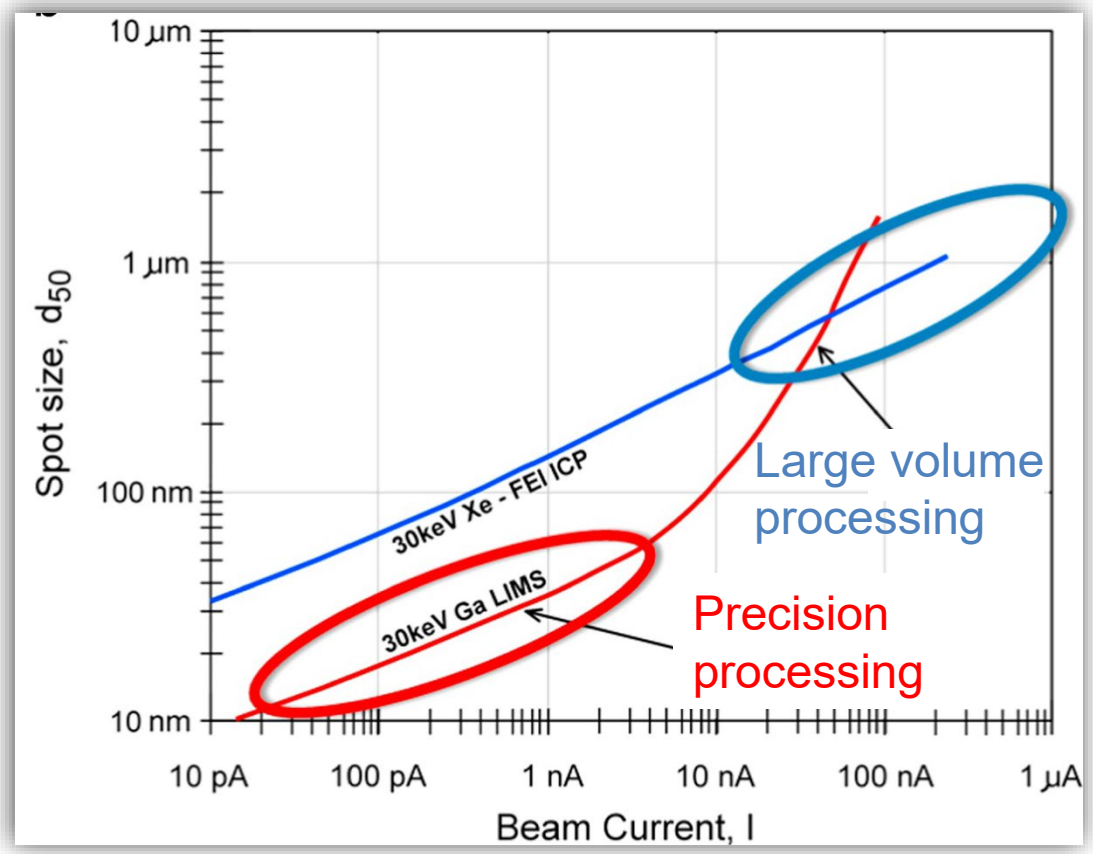


- **Precision milling**
- **Auto-TEM**

Ion beam source: Ga^+ & plasma

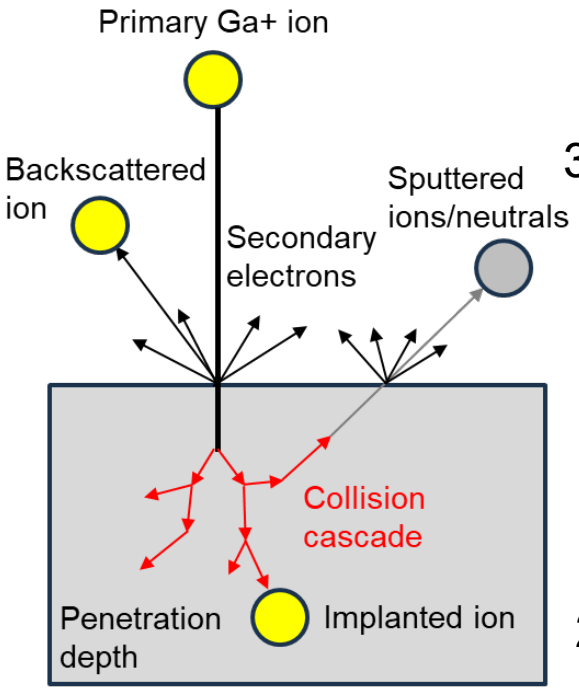


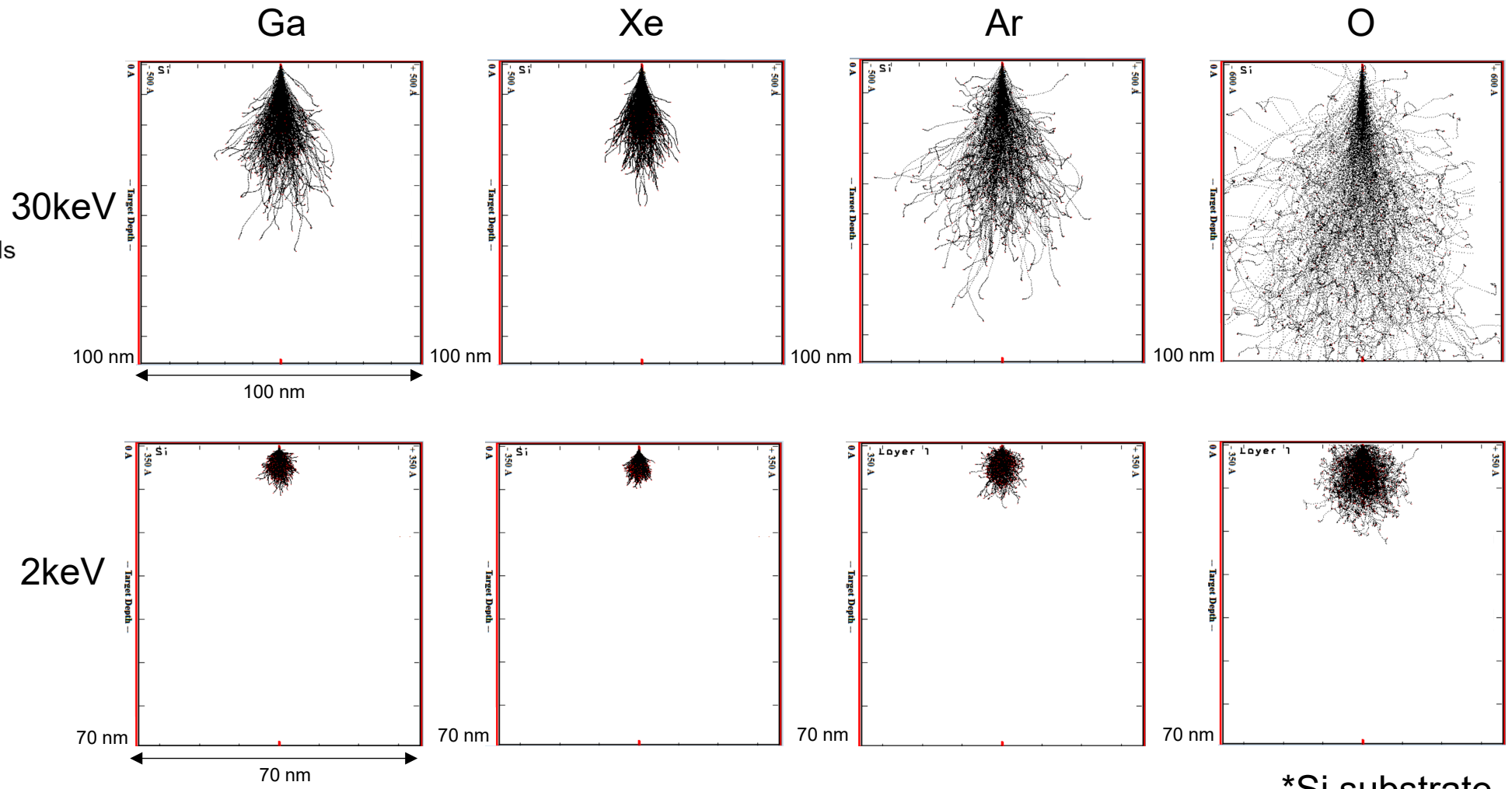
Si beam burns in cross-section



Burnett, T. L., et al. *Ultramicroscopy* 161.119-129 (2016): 253-254.
Vitale, Suzy M., et al. *Microscopy and Microanalysis* 28.3 (2022): 646-658.

Ion implantation: Ga⁺ & plasma





Simulation using Si substrate
SRIM simulation: http://www.srim.org/

*Si substrate

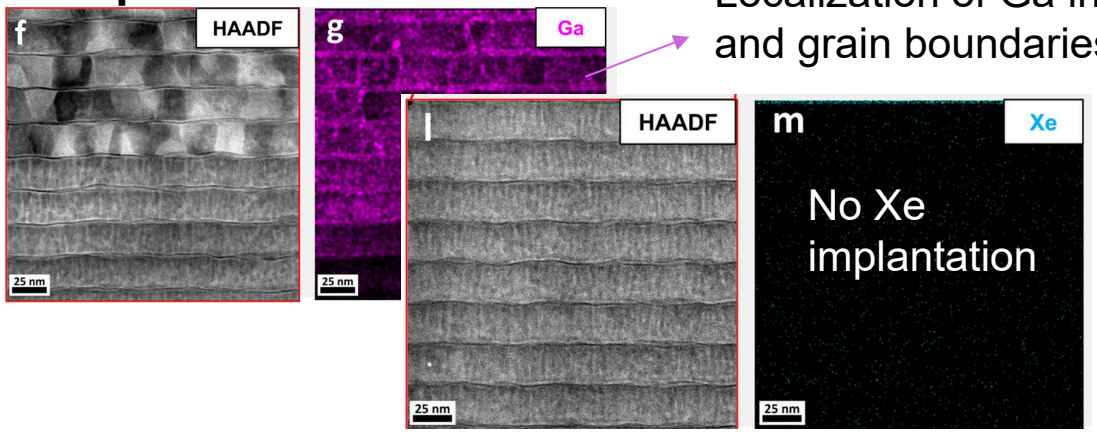
Ion milling behavior: Ga^+ & Xe^+

Sputtering rate

Measured and modelled sputter rates for Ga^+ and Xe^+ ion beams at 30 kV.

Material	Sputter rate measured (μm^3/nC)		Sputter rates calculated from SRIM (μm^3/nC)	
	Ga^+	Xe^+	Ga^+	Xe^+
Diamond	0.09	0.11	0.07	0.09
Si	0.22–0.27	0.35–0.42	0.27	0.37
Al	0.31	0.41	0.37	0.5
Ti	0.31	0.32	0.26	0.28
GaAs	0.86	0.61	1.45	1.61
Cu	0.15–0.55	1.1–1.6	0.69	0.85
Epoxy resin	0.3	0.31	–	–

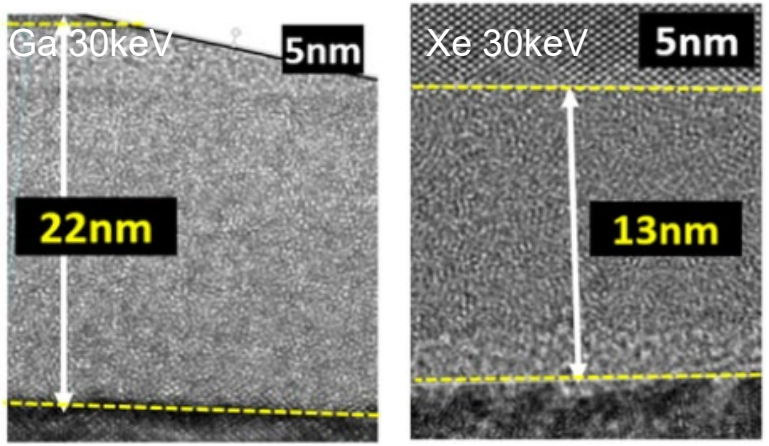
Implantation defects



Localization of Ga in defects and grain boundaries

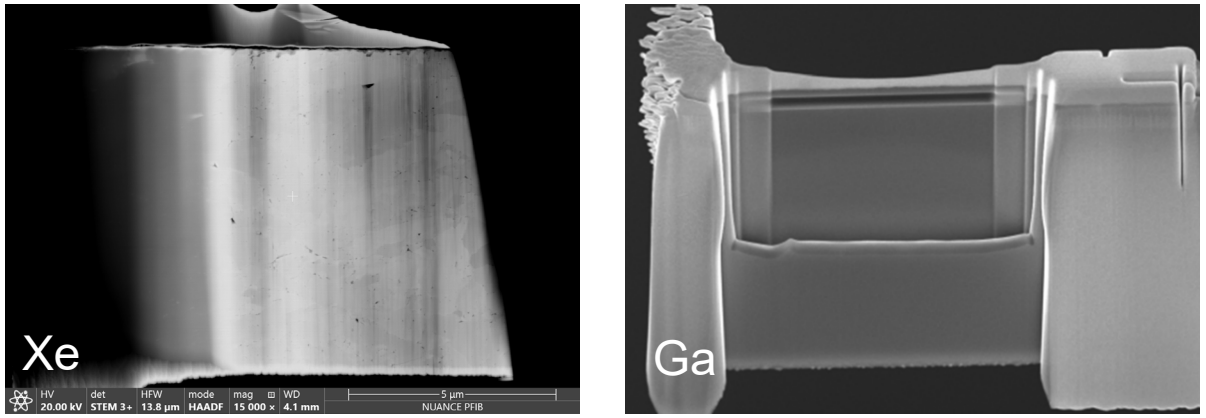
Jansen, Hendrik C., et al. *Scripta Materialia* 260 (2025): 116589.

Damage layer



Burnett, T. L., et al. *Ultramicroscopy* 161.119-129 (2016): 253-254.

Curtaining effect



Ga⁺ FIB - Helios 5 UC capabilities

XHR Field emission electron

High resolution SEM imaging

Powerful tools

- Piezo stage
- Plasma cleaner
- MultiChem (C, Pt, W)
- Micro manipulator
- Automatic software

Ga ion optics

Precision ion milling
- Cross-Section
- TEM sample preparation
- Exotic sample preparation

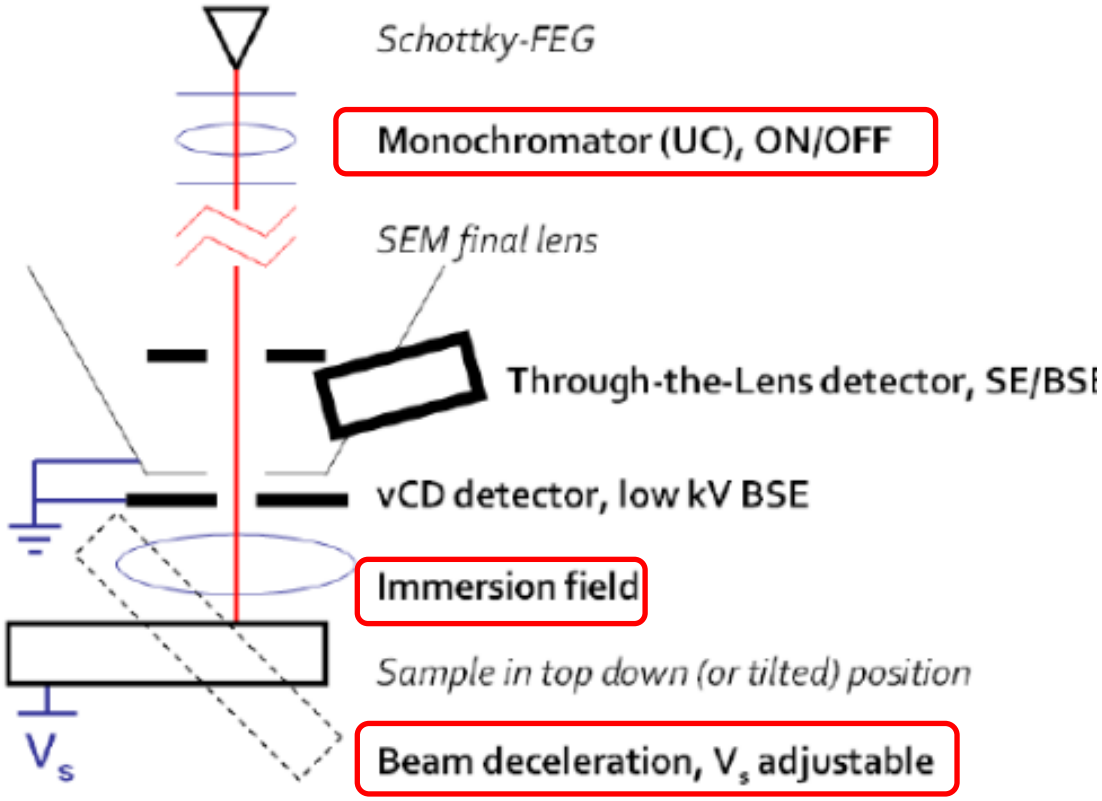
EDS detector

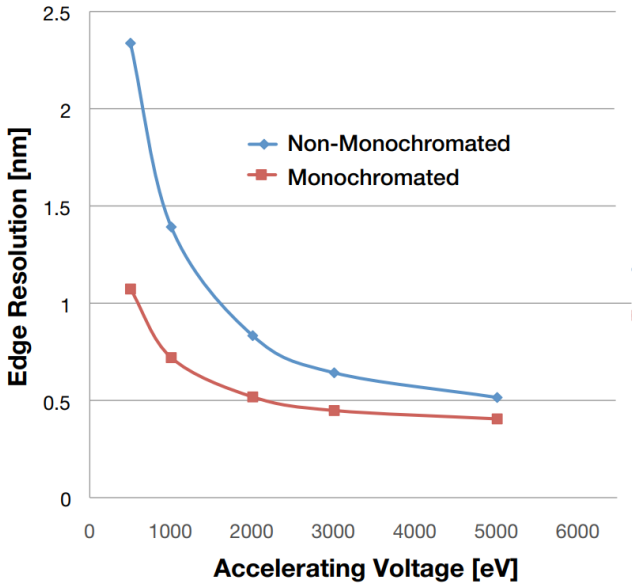
- High performance EDS analysis

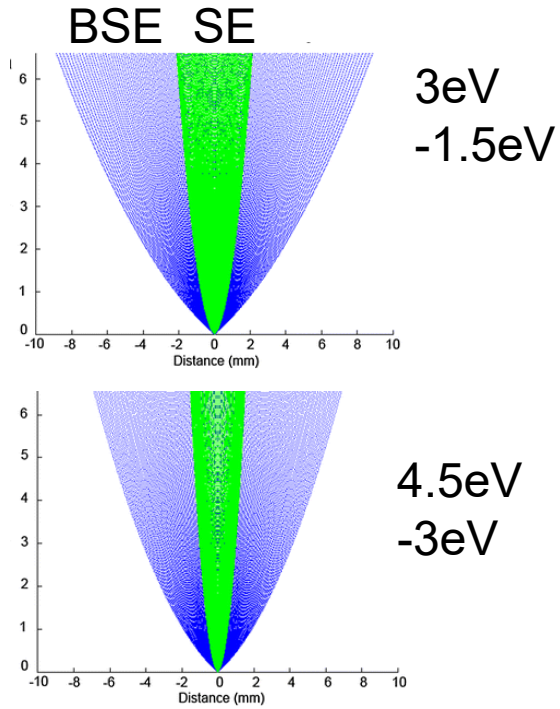
Multi imaging detectors

- SE/BSE/SI detectors
- Retractable BSE detectors
- STEM detector

Extreme high resolution field emission SEM



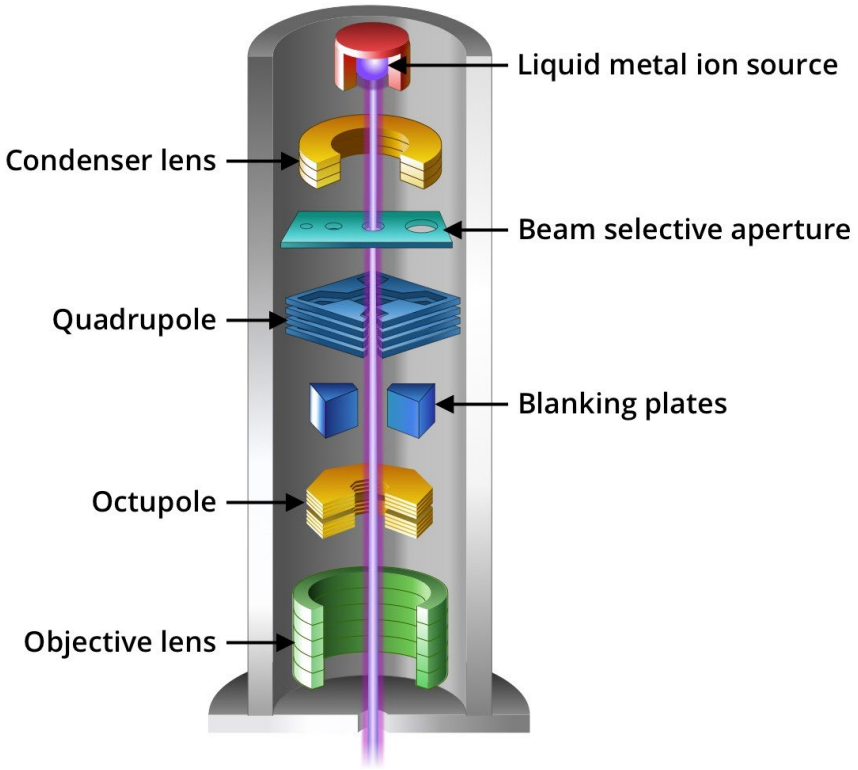




- Beam energy spread < 0.2eV
- Electron beam deceleration down to 20eV
- Sub-nanometer resolution
  (0.6 nm at 30kV STEM / 0.7 nm at 1 kV)

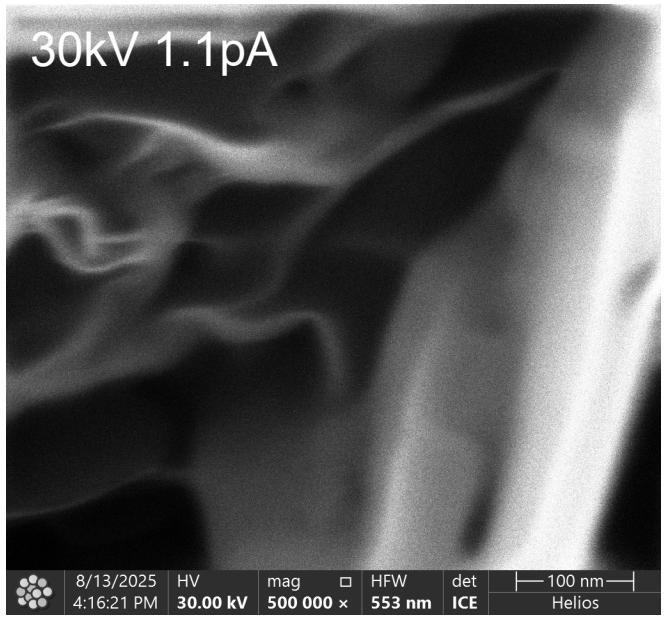
Roussel, Laurent Y., et al. *Scanning Microscopy 2009*. Vol. 7378. SPIE, 2009.
Bouwer, James C., et al. *Advanced Structural and Chemical Imaging* 2.1 (2016): 11.

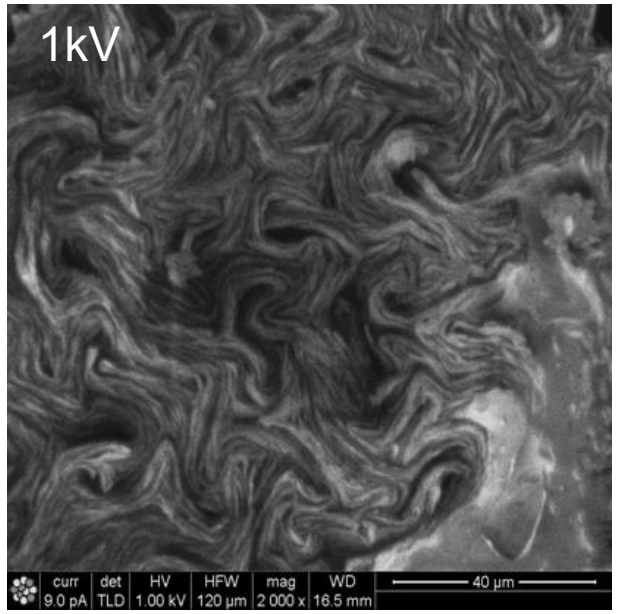
High-resolution (field emission) ion optics



- Differential pumping
- Time of flight correction

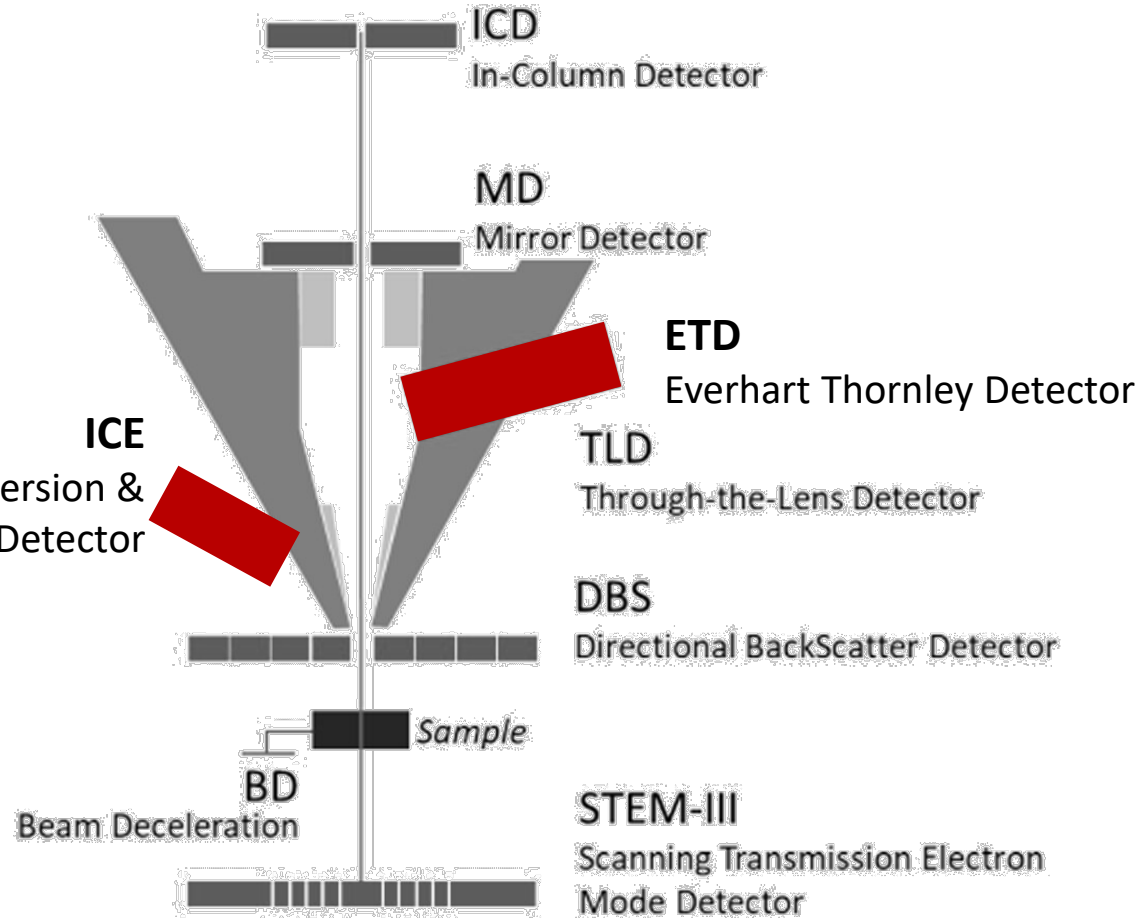
- Ion beam current: 1pA – 100nA
- Accelerating voltage: 500V- 30kV
- 3.6 nm at 30 kV





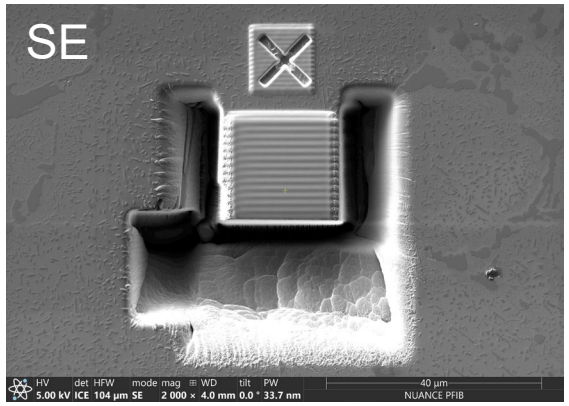
https://myscope.training/FIB_Introduction_to_components

Multi-image detectors

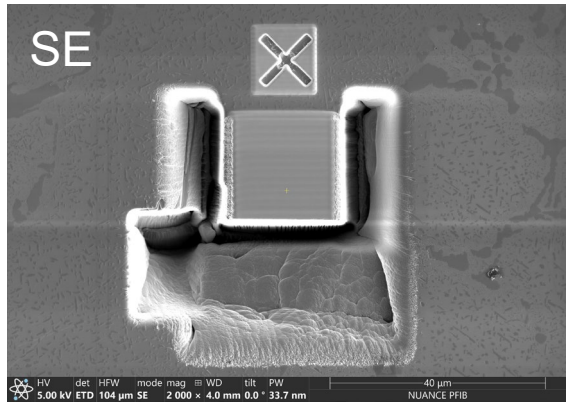


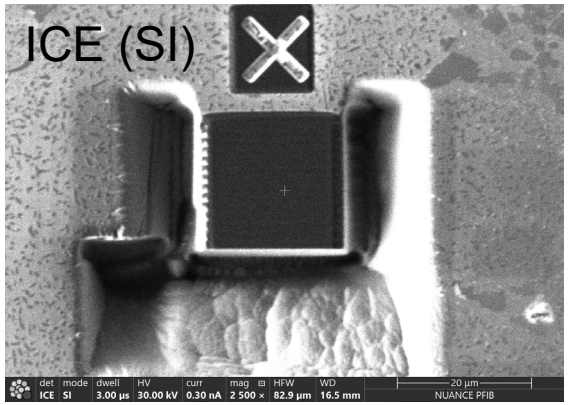
https://thermofisher.com

ETD (SE/BSE)



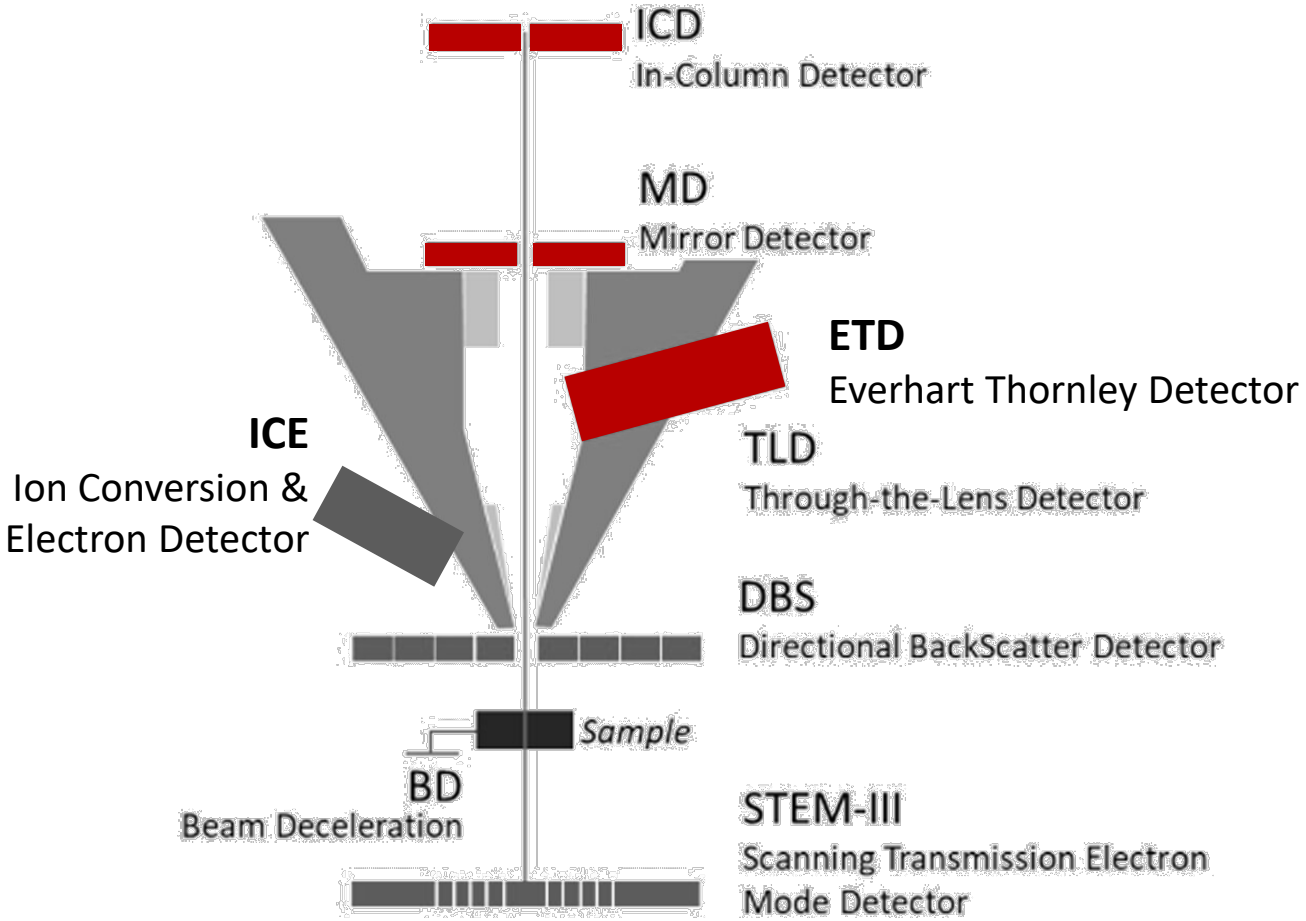
ICE (SE/BSE/SI)





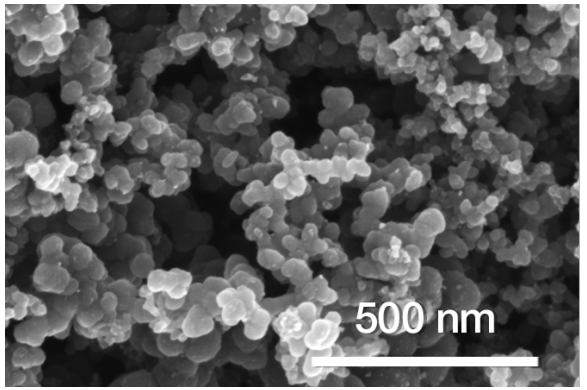
- Most frequently used
- Surface morphology (SE), phase contrast (BSE)
- Semiconductor voltage mapping (ETD)
- TEM lamellae transparency monitor (2-5kV)

Multi-image detectors

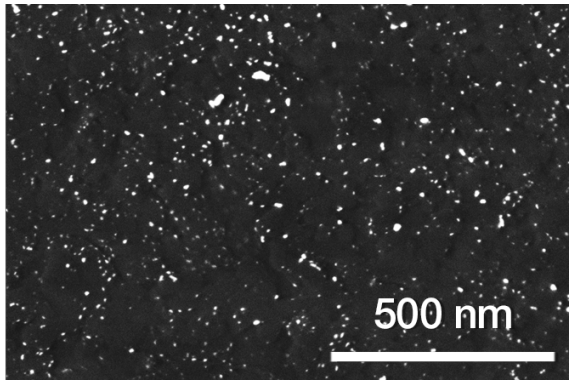


https://thermofisher.com

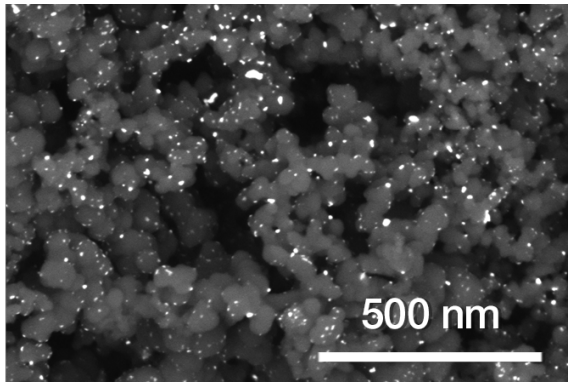
TLD(SE/BSE)



ICD(BSE)

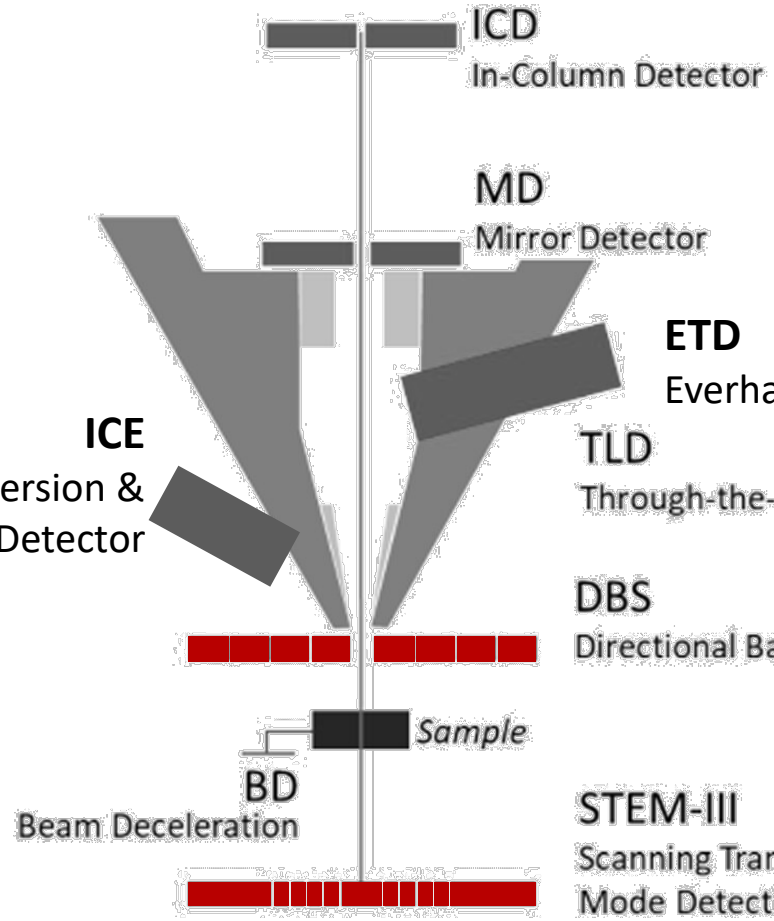


MD



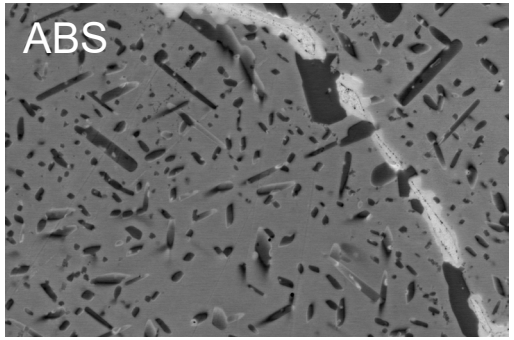
- High resolution low-kV imaging (Immersion mode)
- TLD: morphology
- ICD: Z contrast
- MD: both morphology and Z contrast

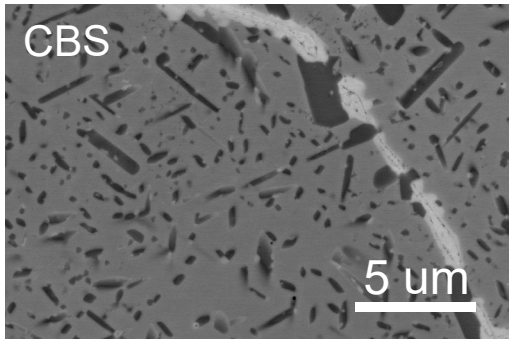
Multi-image detectors



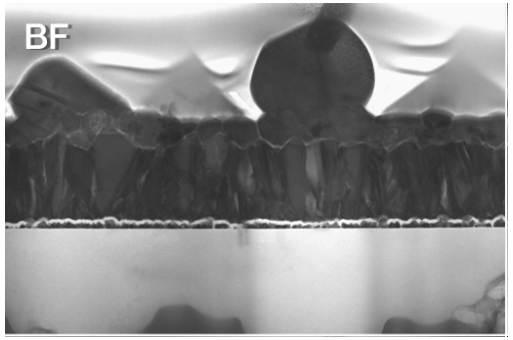
https://thermofisher.com

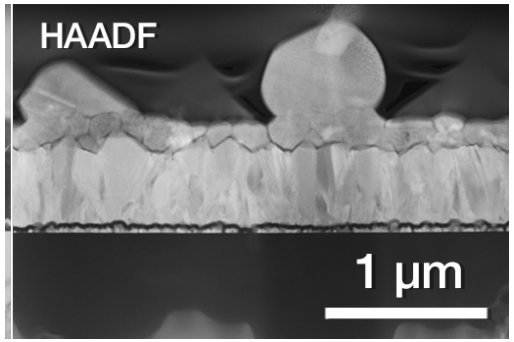
DBS

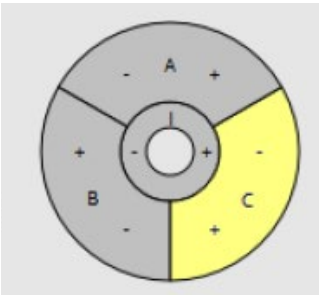


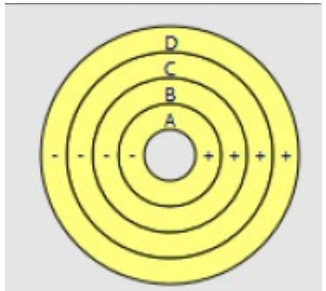


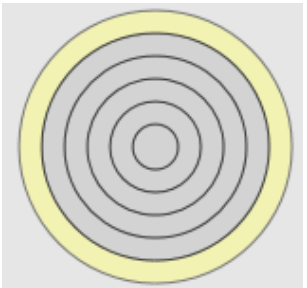
STEM



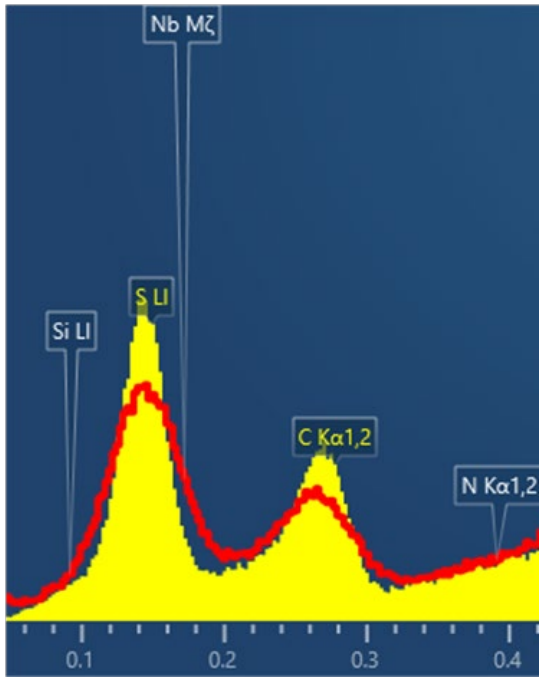


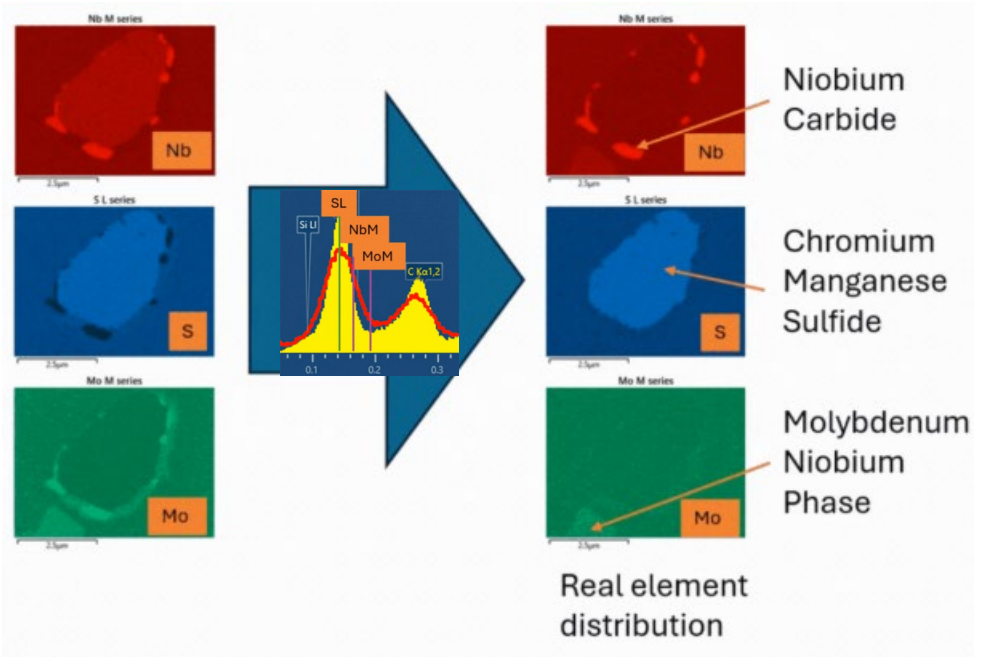






Ultim max infinity EDS analytical detector





- ✓ The highest sensitivity guaranteed
  Sensor sizes: 170 mm²
- ✓ High count rate

- ✓ The best nano-characterization and light element detection (Ckα : 40eV)

- ✓ The most accurate qualitative and quantitative analysis

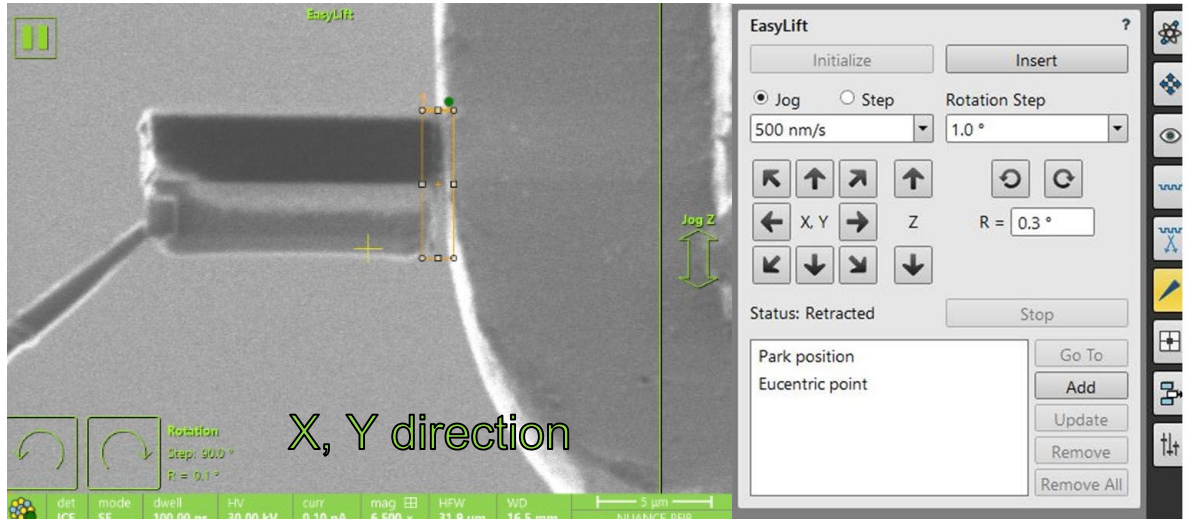
https://nano.oxunst.com/ultim-max-infinity

Accessories

- **MultiChem**

Pt	• bright, fast, granular
W	• bright, amorphous
C	• dark, amorphous

- **EasyLift**

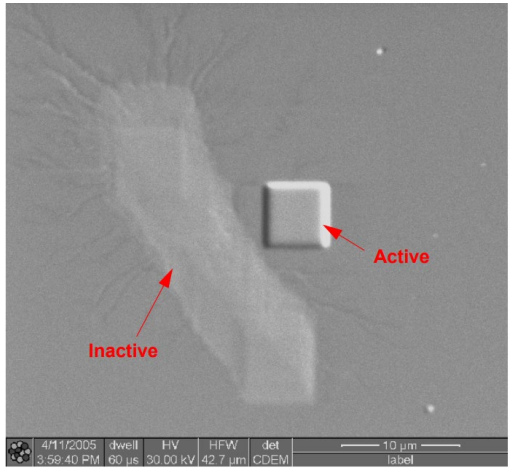


- **Integrated plasma cleaner**

  Ensure a clean specimen surface

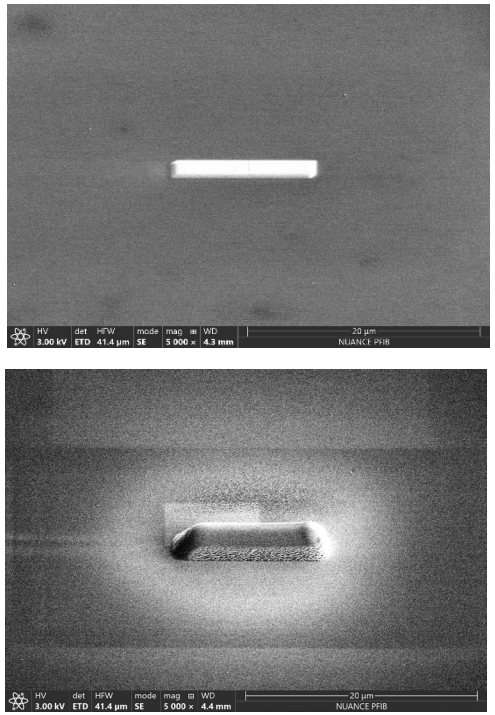
- **Charge neutralizer**

  An electron source and control system to minimize positive ion charge-up
  The electron source produces a broad beam which floods the sample



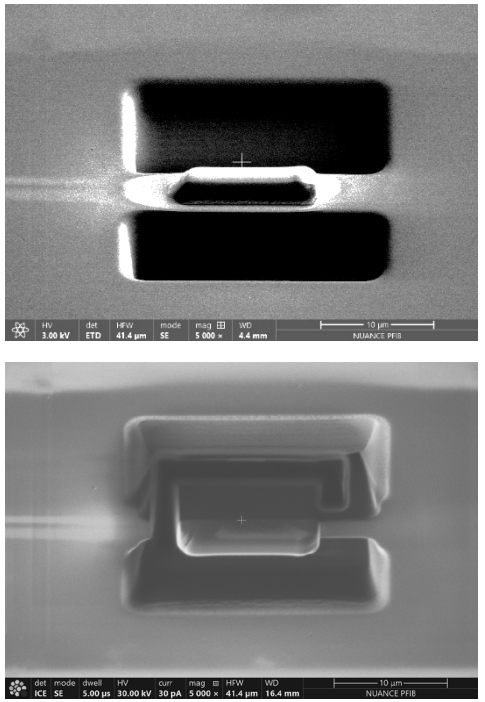
Application – TEM lamellae

Deposition



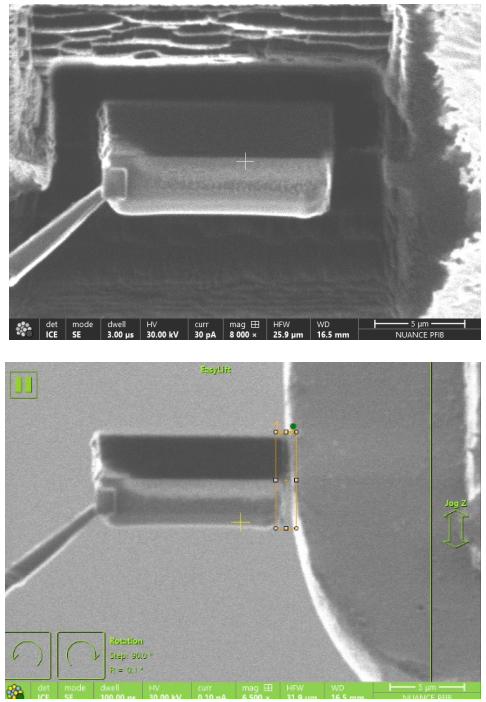
- ✓ 8-12 um in length
- ✓ 100-300nm e-beam layer
- ✓ 1-2um i-beam layer

Trench



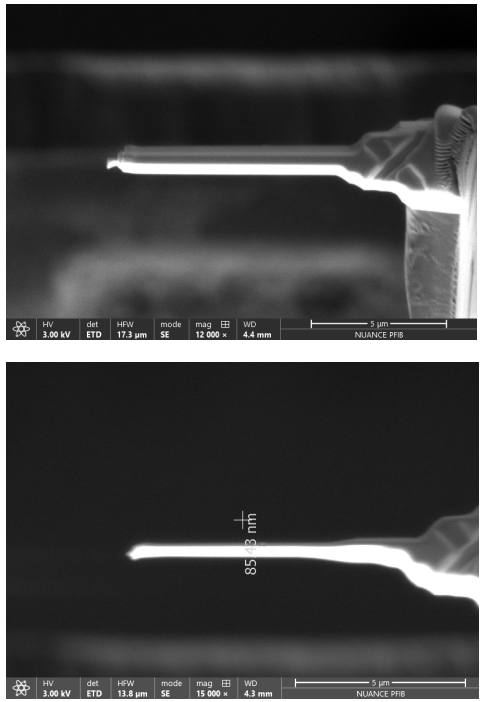
- ✓ 1-1.5 um thickness
- ✓ 6-10um depth

Lift out & attachment



- ✓ ~0.5um welding layer

Thinning & Polishing

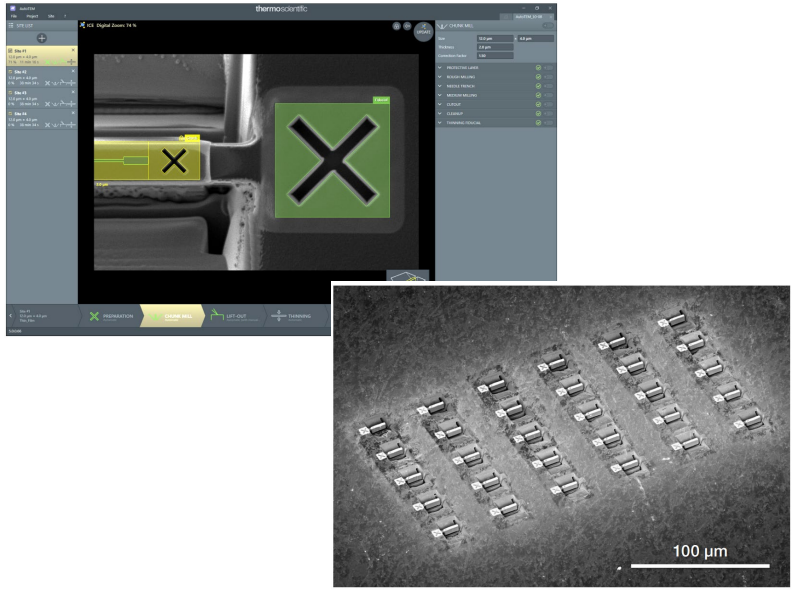


- ✓ 30kV to <100nm
- ✓ Low-kV polishing

Application – Auto TEM lamellae preparation

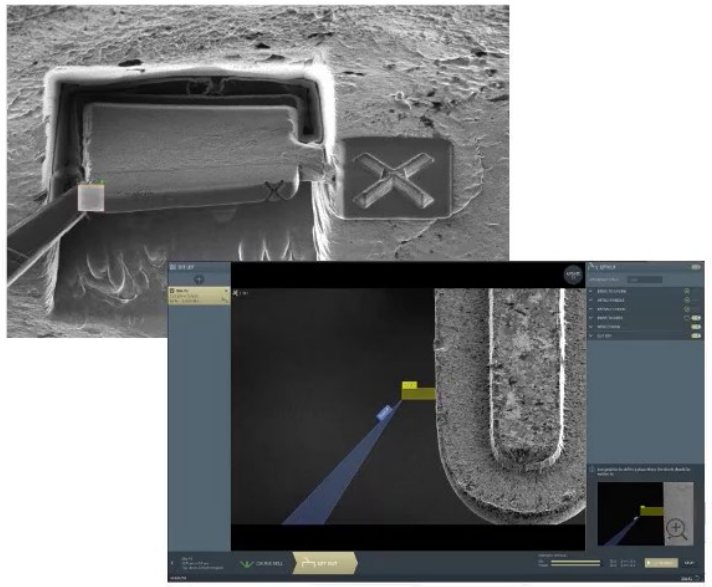
- **AutoTEM 5**

Chunk mill



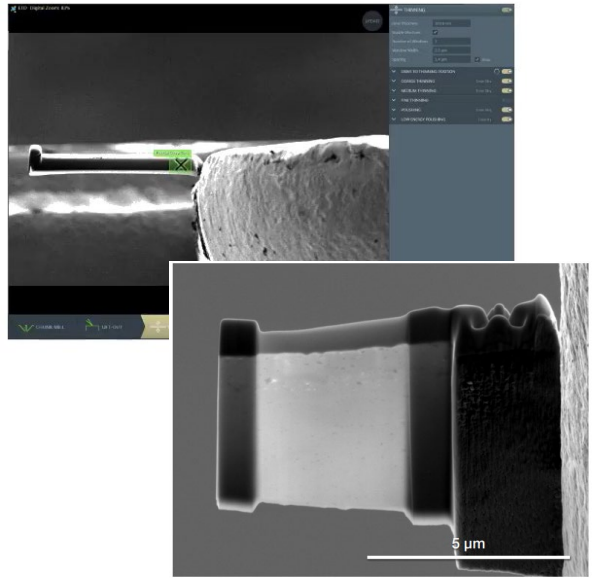
- Fully unattended
- Multisite

Lift-out



- Guided

Thinning



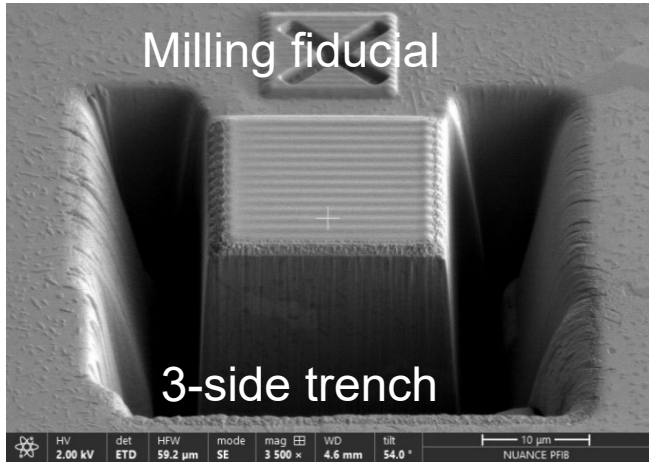
- Automatic

*Know your sample well and optimize parameters first!

Application – 3D characterization

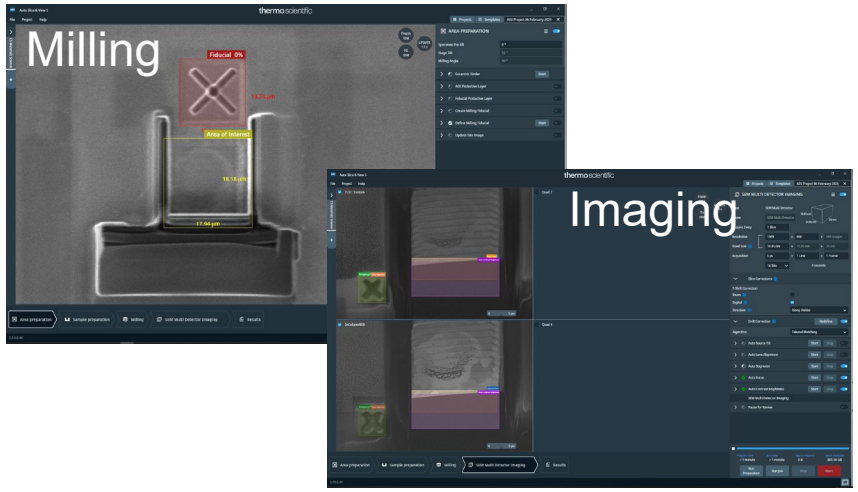
- **Auto Slice & View 5**

Pre-processing



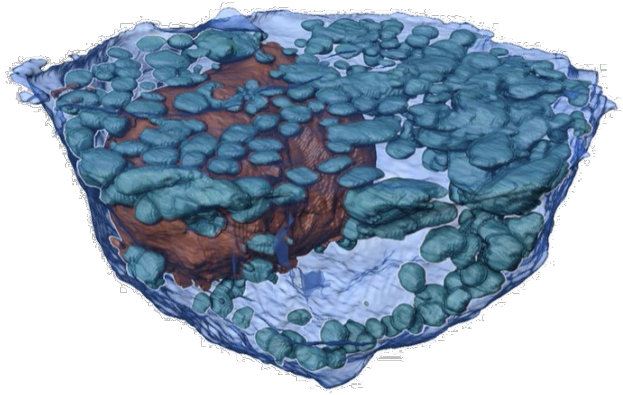
- Block face in bulk
- Chunk liftout
- 0 degree tilt ….

Auto slice & view



- Auto alignment
- Multi-imaging
- EDS

3D reconstruction



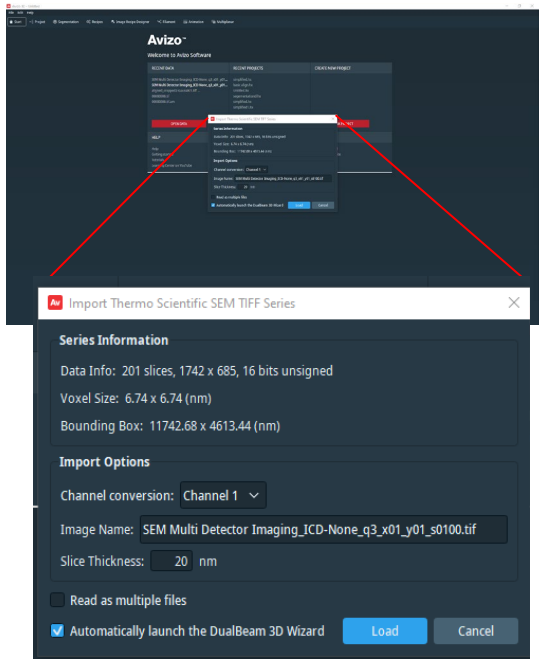
- Avizo (License @NUANCE)
- Dragonfly (Free)
- Microscopy image browser(Free)
- …

* Make larger trench to avoid shadowing

Software highlights

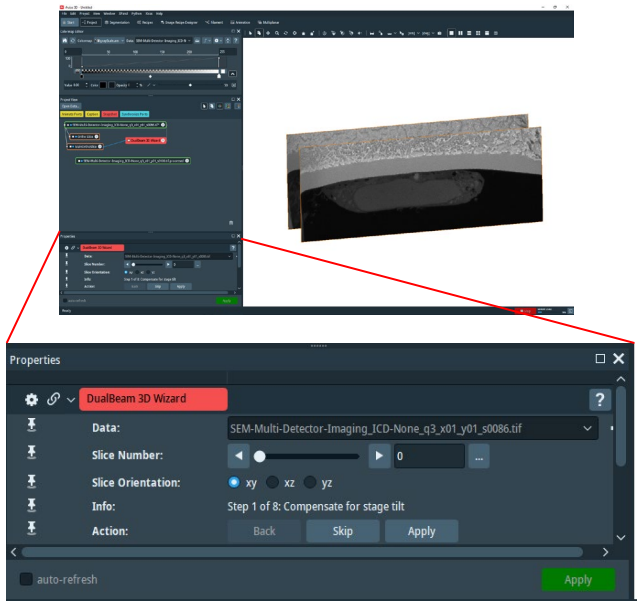
- **Avizo 3D**

Data import



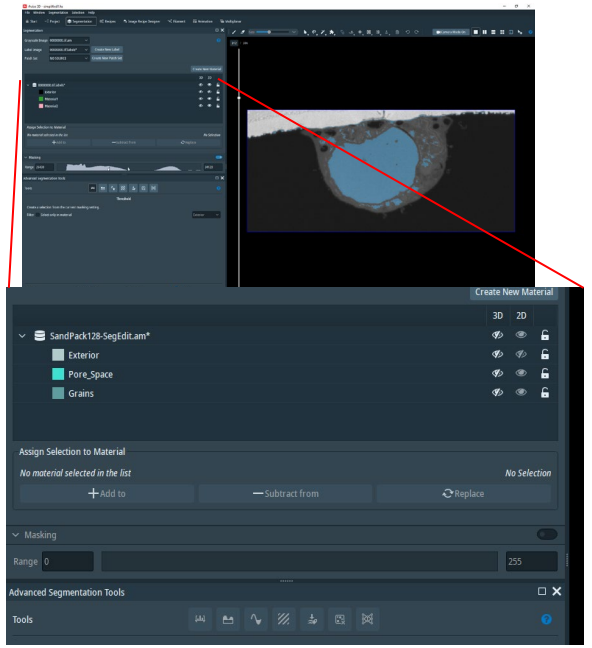
- Stack images (.tiff, .jpg, .png, .bmp…)
- Slice thickness

Image Processing



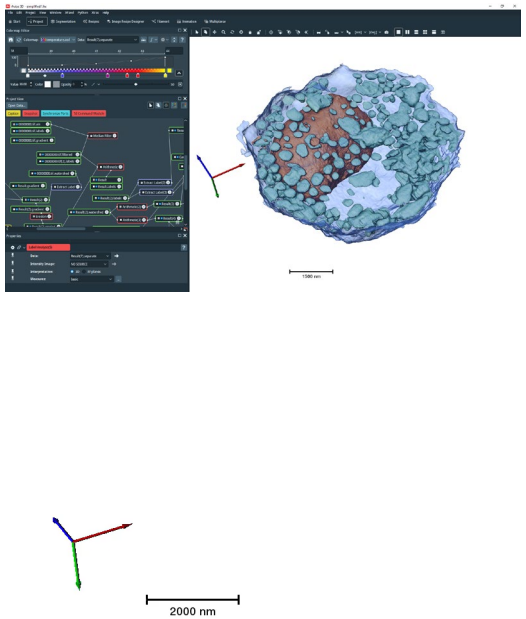
- DualBeam 3D wizard
- Tilt compensation
- Denoising
- …

Segmentation



- Thresholding
- (semi) Manually
- AI-assisted

Image/Movie export



- Slice-through visualization
- Orbital path
- Scientific bar

EPIC-FIB match maker

Hydra Plasma

Large volume

- High current for rapid trench
- Bulk 3D tomography
- 3D EBSD/EDS

Low implantation (Xe+)

- Al alloy (Free Ga+)
- Minimum alloying artifacts

Specific ion source (O+, Ar+, N+)

Helios™ 5 UC

High resolution nanopatterning

- Precision milling / Low-kV polishing
- TEM lamellae / APT sample
- Delicate nanostructure

Piezo stage

- Auto TEM workflow
- Small volume tomography

Fast and accurate EDS

AVAILABLE SOON (SEPTEMBER)

Contact information

Facility reservation

Paul Smeets
NU*ANCE* FIB/TEM Facility Manager

Email: paul.smeets@northwestern.edu

Yu Wen
NU*ANCE* Postdoc

Email: yu.wen@northwestern.edu

Workshop & Demo in October !!!

THANK YOU