

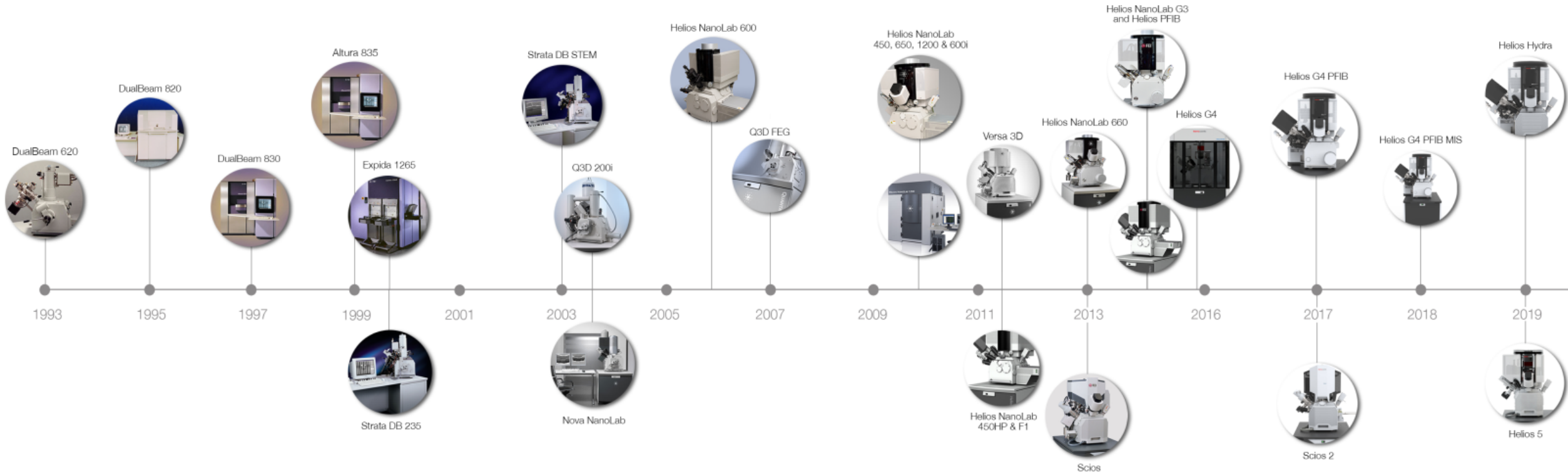
ThermoFisher
SCIENTIFIC

Fully Automated In-Situ Sample Preparation with New Generation Helios 5 DualBeam

David Wall

The world leader in serving science

Electron microscopy innovation at Thermo Fisher...



More than 25 years of DualBeam™ innovations...

Helios 5 Family



Helios 5 CX

Tomahawk HT FIB 100nA
Elstar NG SEM
110 mm DC stage



Helios 5 UC

Tomahawk HT FIB 100nA
Elstar UC+ SEM
150 mm Piezo stage



Helios 5 UX

Phoenix FIB 65 nA
Elstar UC+ SEM
150 mm Piezo stage
ICE detector

Helios 5 UX

Enabling breakthrough innovations with DualBeam™ — faster and easier than ever before



- **Fastest, easiest and the most automated preparation** of highest quality samples for HR S/TEM with AutoTEM 5
- **Access to extreme high-resolution imaging** with the most precise contrast **for users with any experience**
- **Easiest access to highest resolution**, multi-scale and multi-modal subsurface and 3D information
- **Fastest, most accurate, and precise** milling and deposition of complex structures with critical dimensions of less than 10 nm

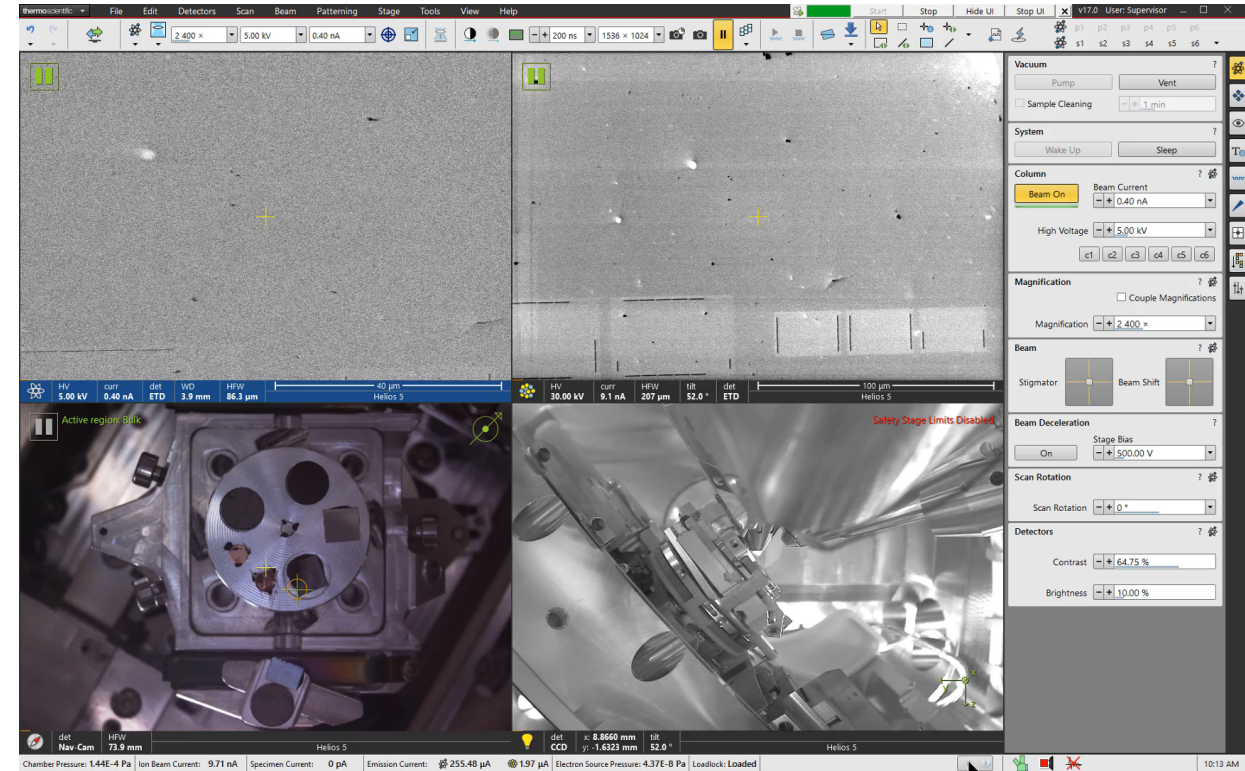
Helios 5 – No user alignments

SEM

Automated, unattended SEM alignments to maintain optimum SEM performance

FIB

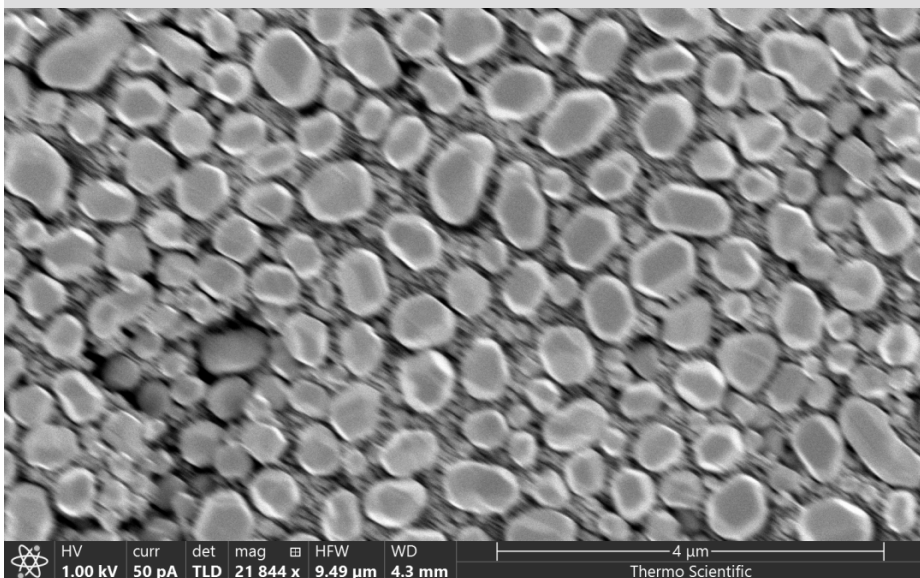
Automated, unattended FIB alignments to allow for best milling performance and automation



Media showing automated FIB alignments

Helios 5 – Flash: Automated image tuning

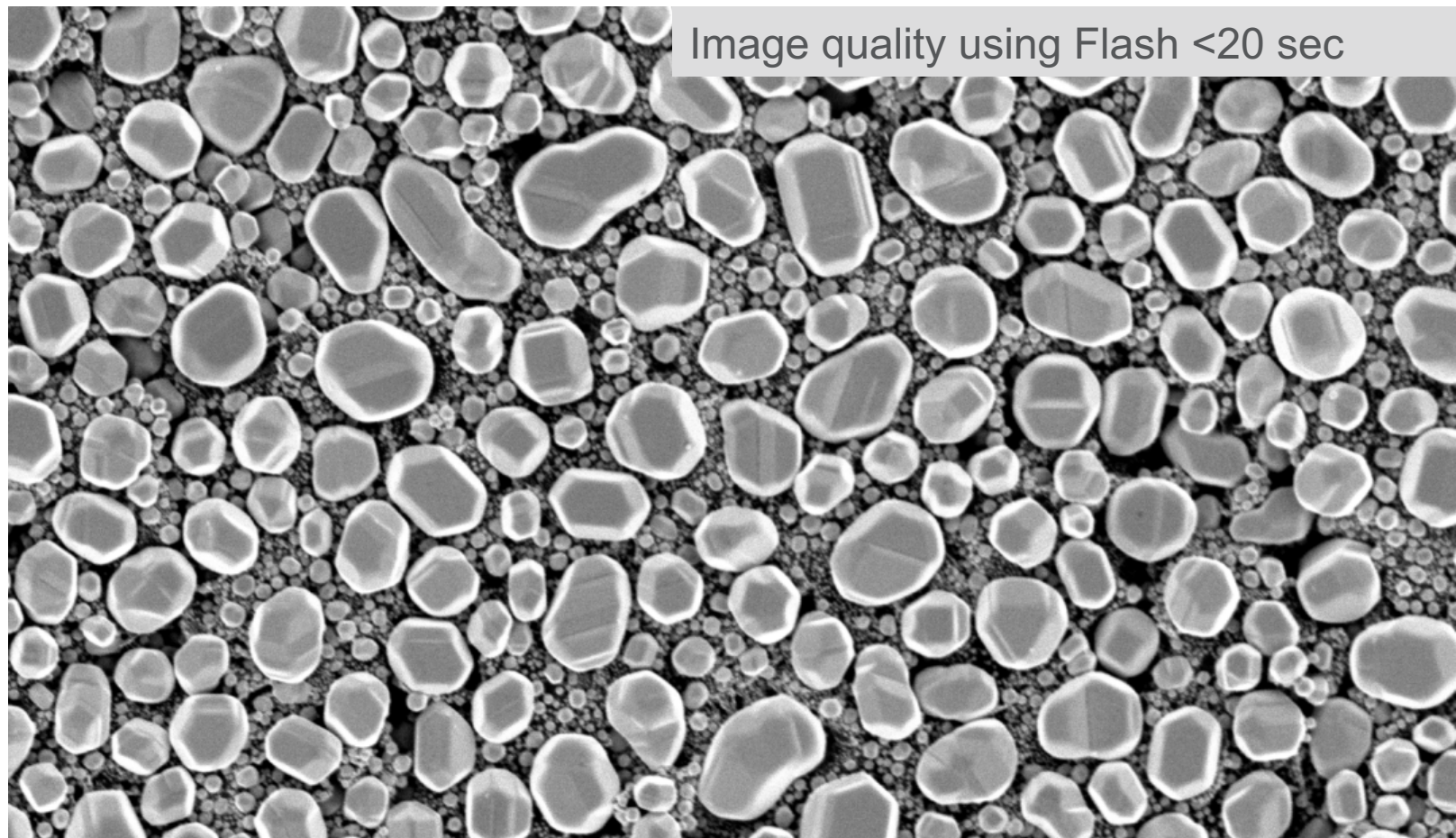
Image with beam on and rough focus



Flash is an auto-tuning tool embedded in xT user interface that tunes stigmation and lens alignment during focus.

Manually, a normal user can take up to 120 seconds to optimize image similar to the Flash tuning

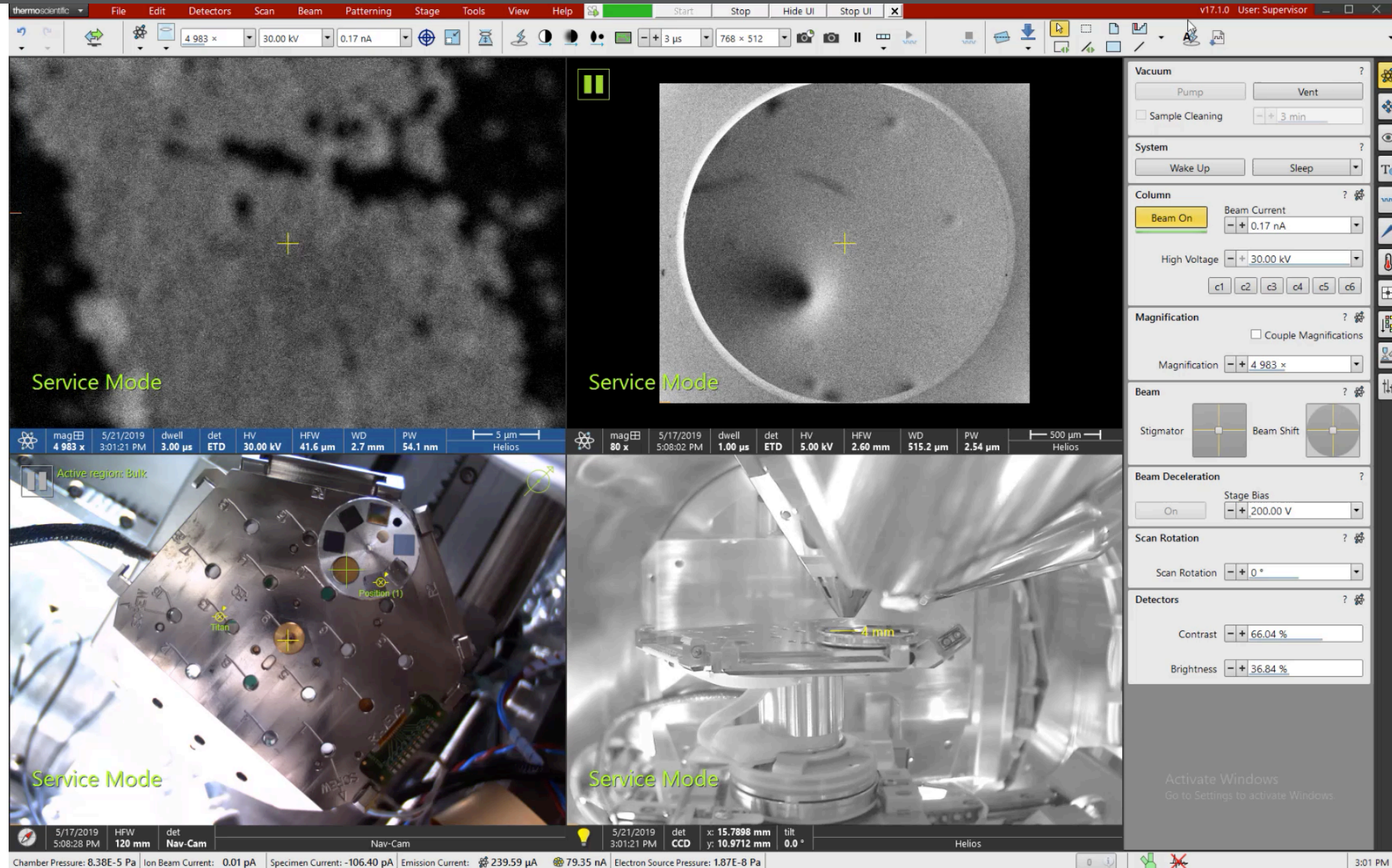
Image quality using Flash <20 sec



10x times faster, the same high-quality images for users with any experience



Helios 5 Flash: Automated image tuning



Helios 5 – No user alignments with SmartAlign

Mesoporous SiO₂ imaged at 1 kV, 3 pA with TLD

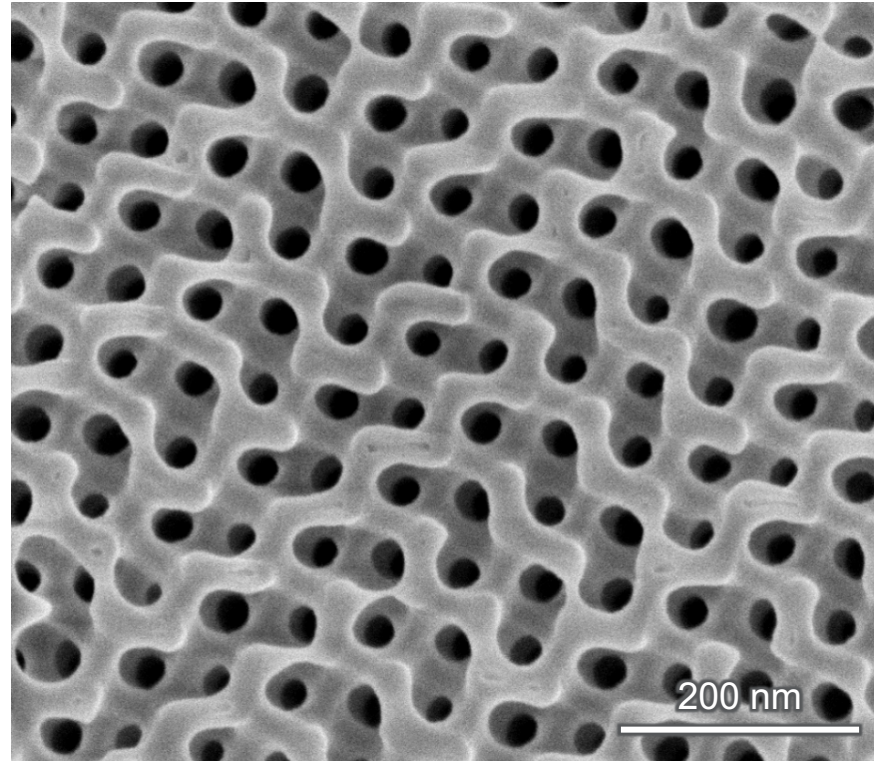
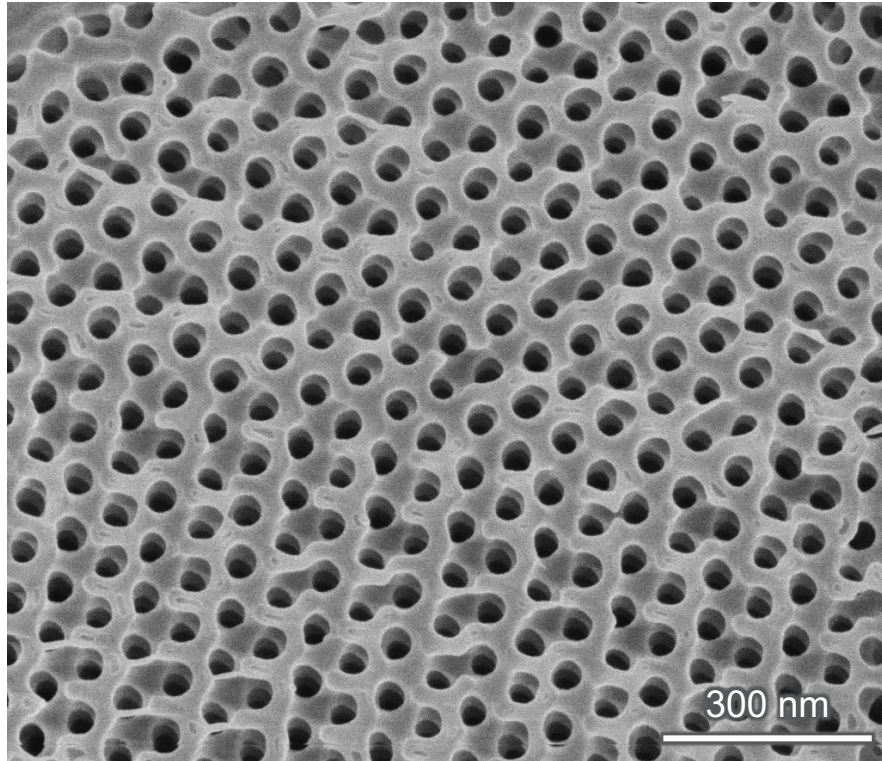
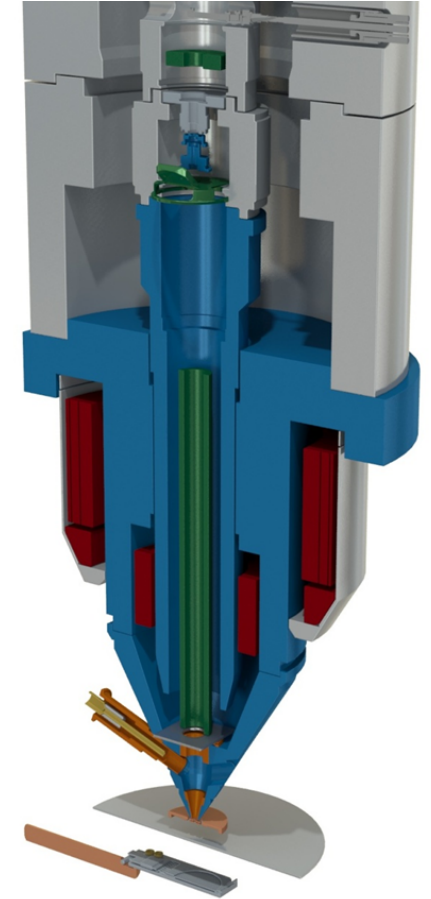


Image courtesy: Devin Wu, Thermo Fisher Shanghai

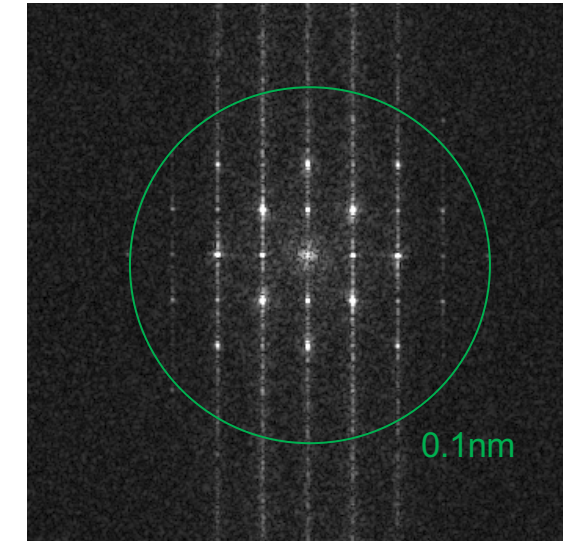
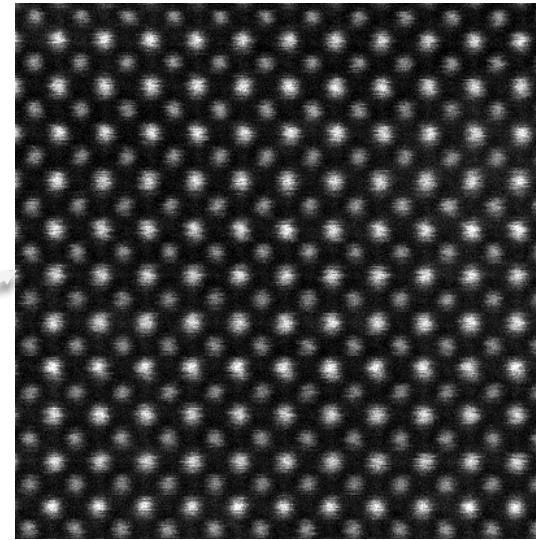
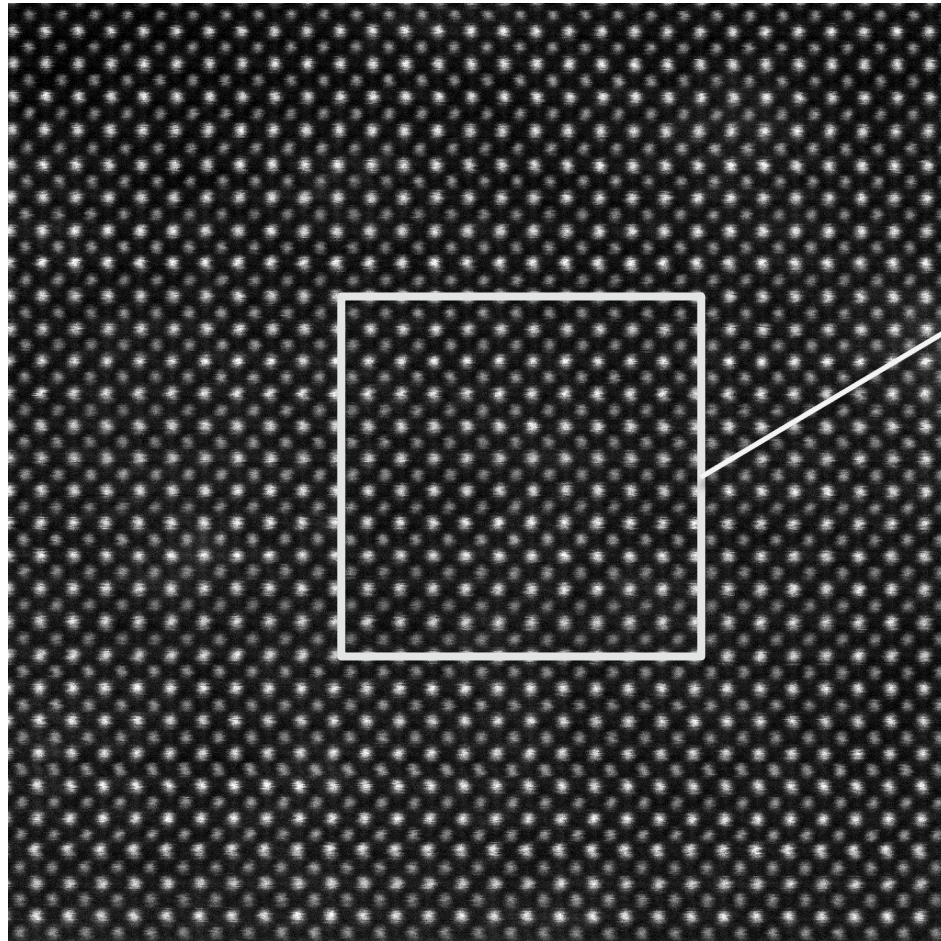


Helios 5 saves up to 6-8 hours per week and ensures the SEM is always in the optimized state

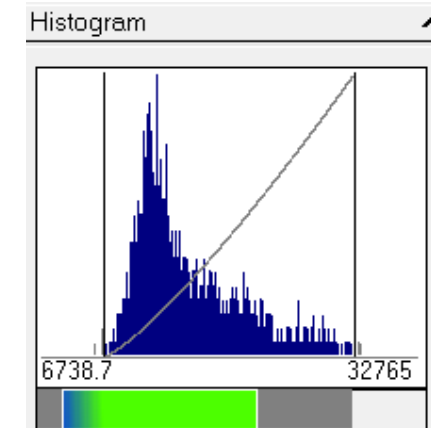
**Fastest, easiest and the most automated preparation
of highest quality samples for HR S/TEM and APT**

Great TEM results start with sample preparation...

Example: preparation of the highest quality ultra-thin STO <100> sample in DualBeam



Energy resolution : 0.25eV
Conv. Angle : 40mrad
Beam current :10pA
CL:115mm

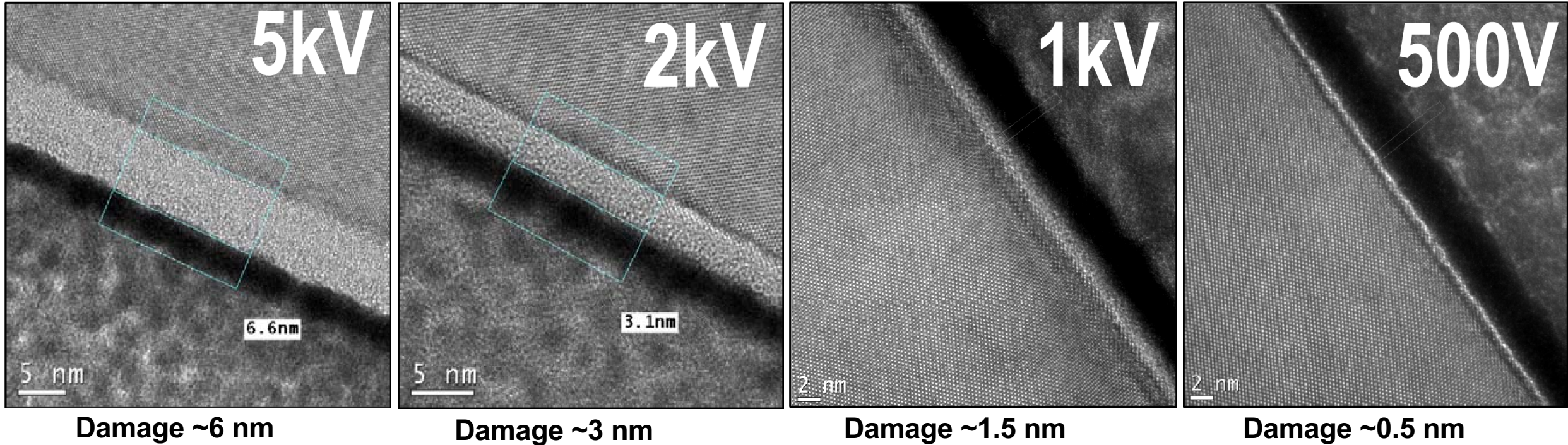


SCORR **60 keV** STEM S-TWIN 5.4 mm pole piece gap

Helios 5 UX – Phoenix ion column with unmatched low voltage performance

Why is low voltage FIB cleaning important?

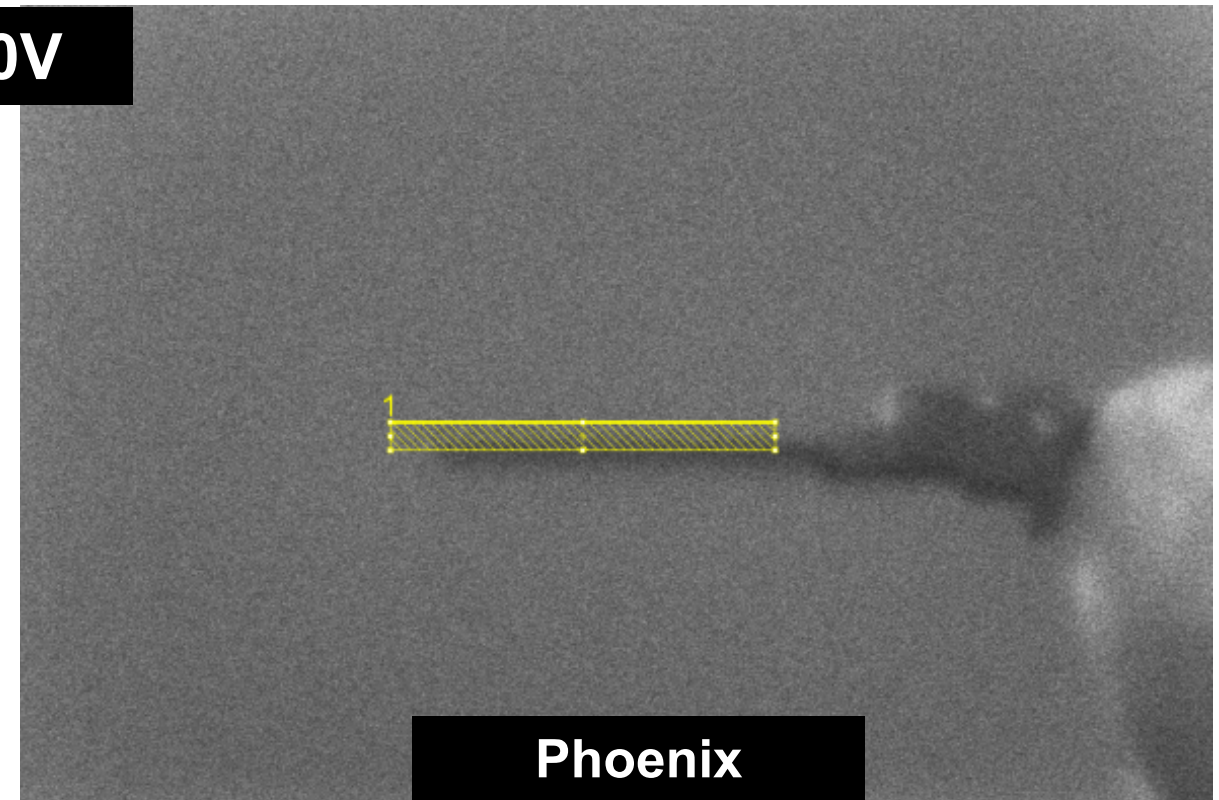
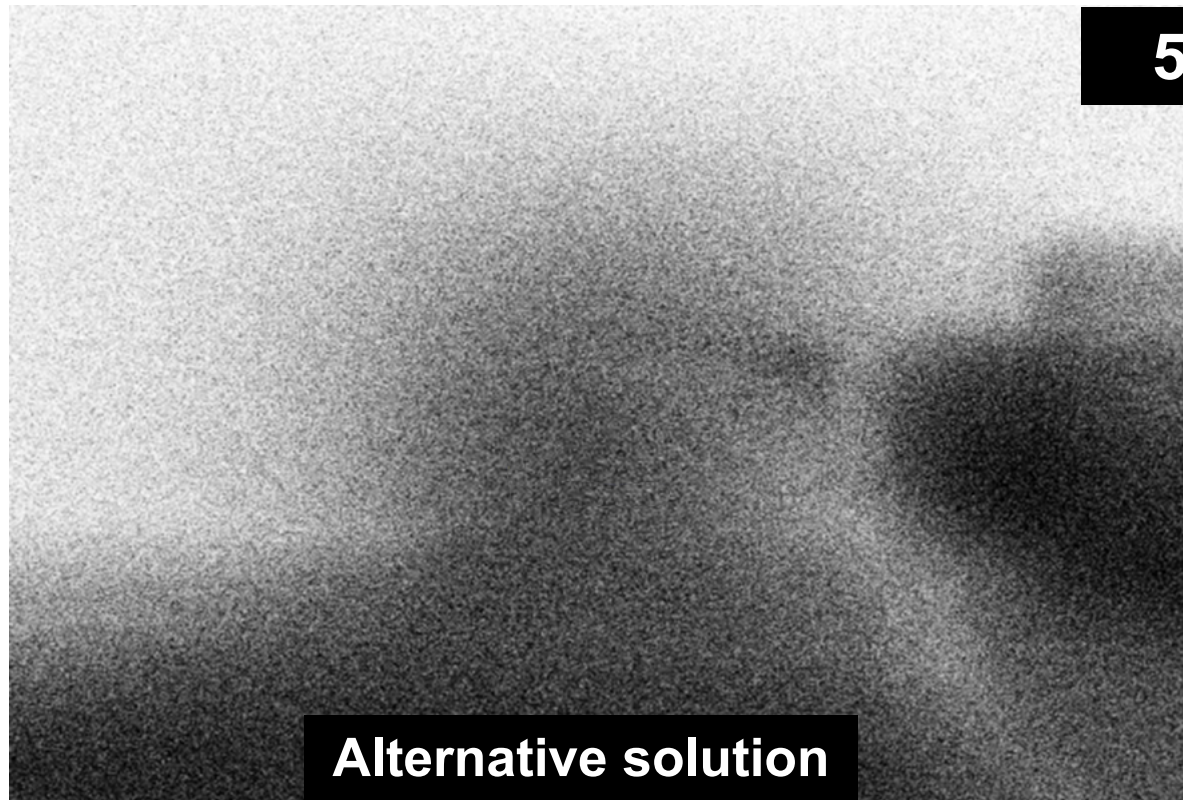
Cross section of a Si thinned sample at various kV



Phoenix delivers the lowest available energy (500 eV)
for **the highest quality** samples even on the most sensitive material

Helios 5 UX – Phoenix ion column with unmatched low voltage performance

Why is low voltage performance important?

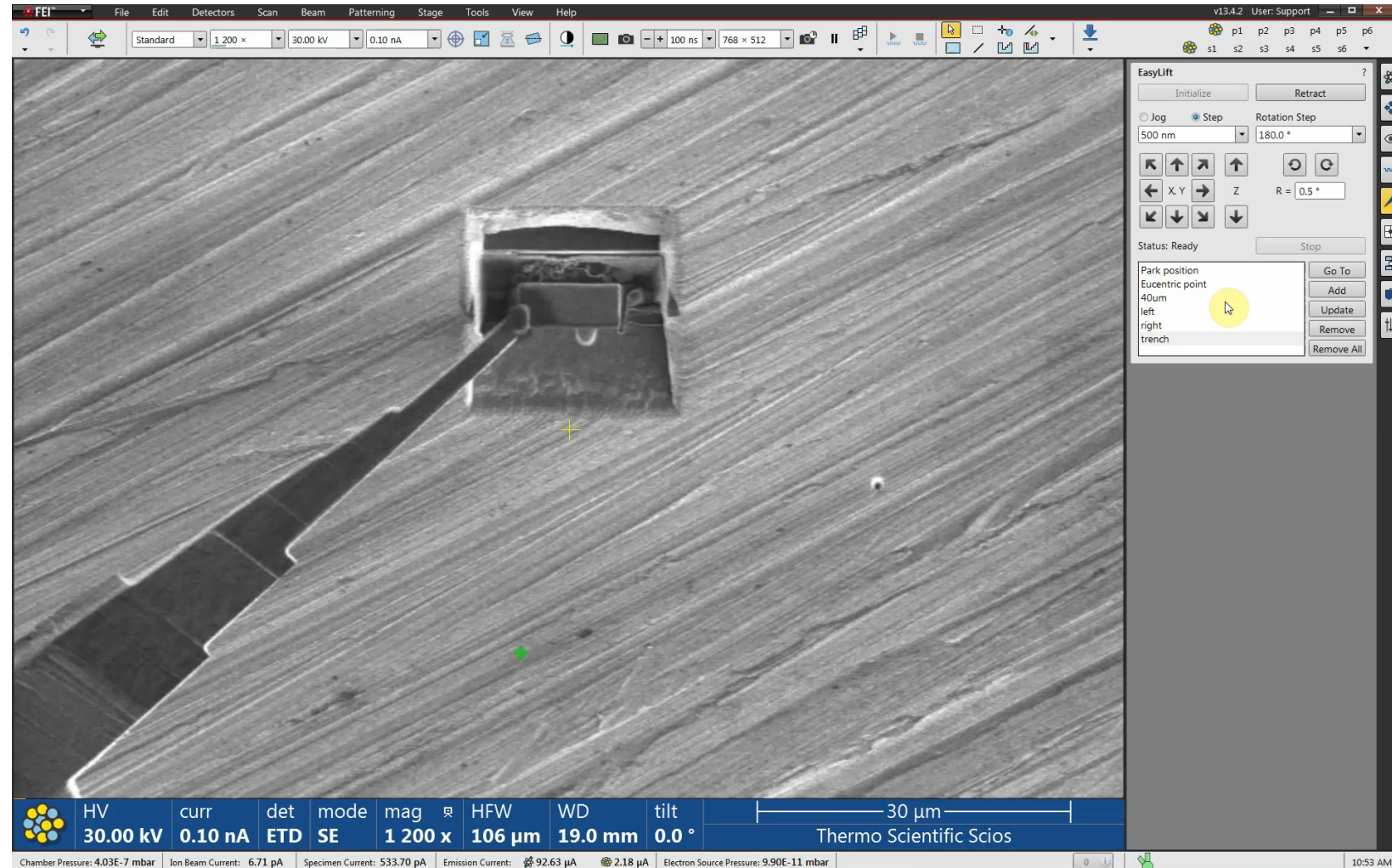


Phoenix delivers best-in-class low voltage performance for **the easiest preparation** of the highest quality samples.

Highest quality S/TEM sample preparation

Thermo Fisher **EasyLift**™

- Integrated & intuitive controls
- Stable & reliable operation
- Precise and repeatable motion

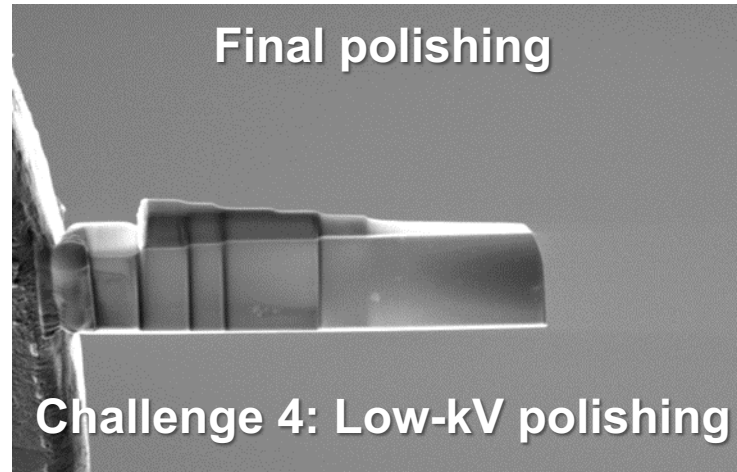
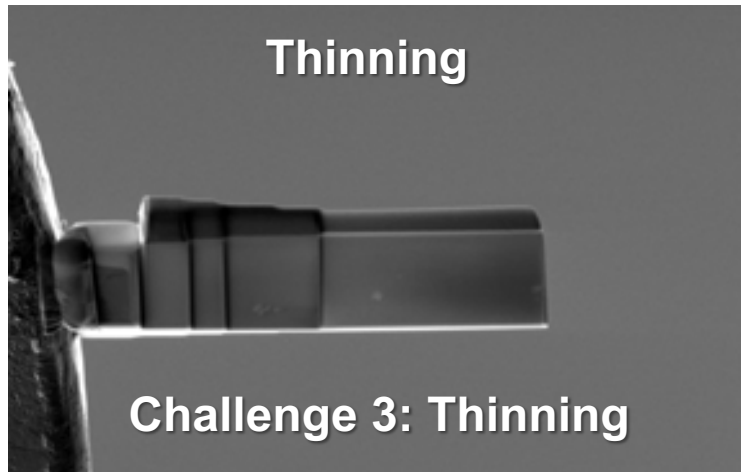
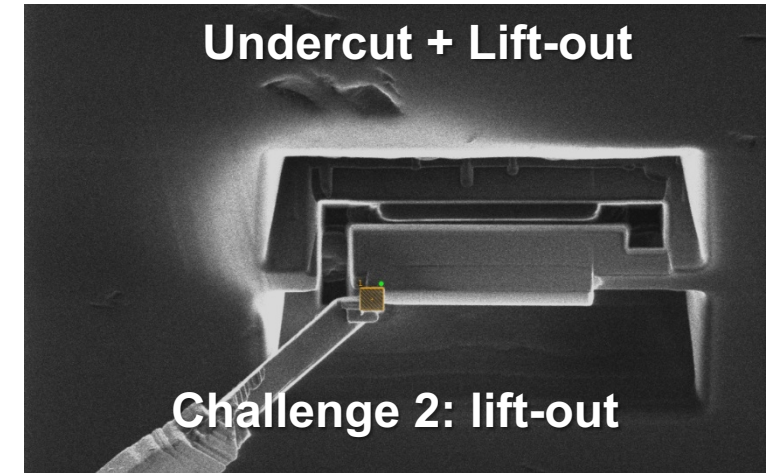
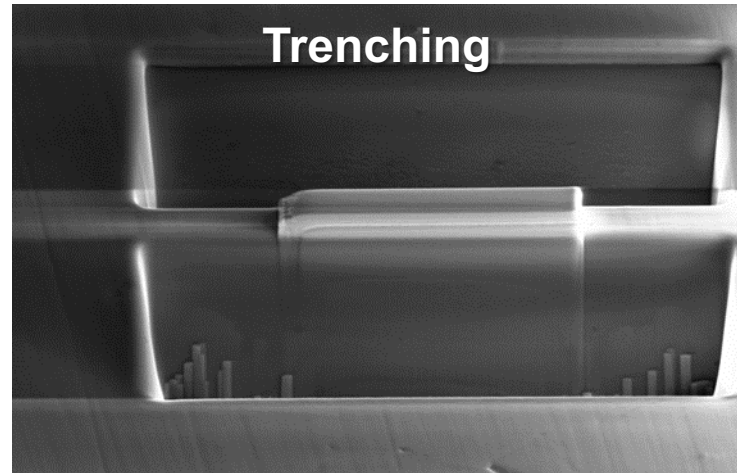


Consistently preparing high quality samples with EasyLift™ – fully integrated in-situ lift-out solution

AutoTEM 5

Unprecedented flexibility and speed
for fully automated S/TEM sample preparation

S/TEM Sample preparation workflow – Challenges

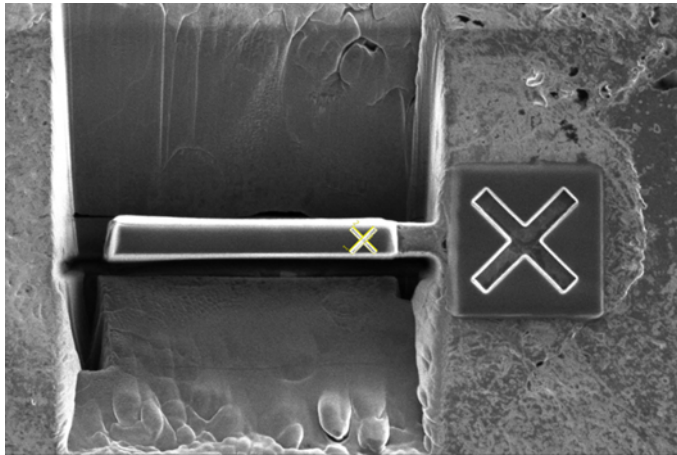


1. E-beam deposition
2. Lift-out
3. Final thinning
4. Low-kV polishing
5. Expert level operator is needed

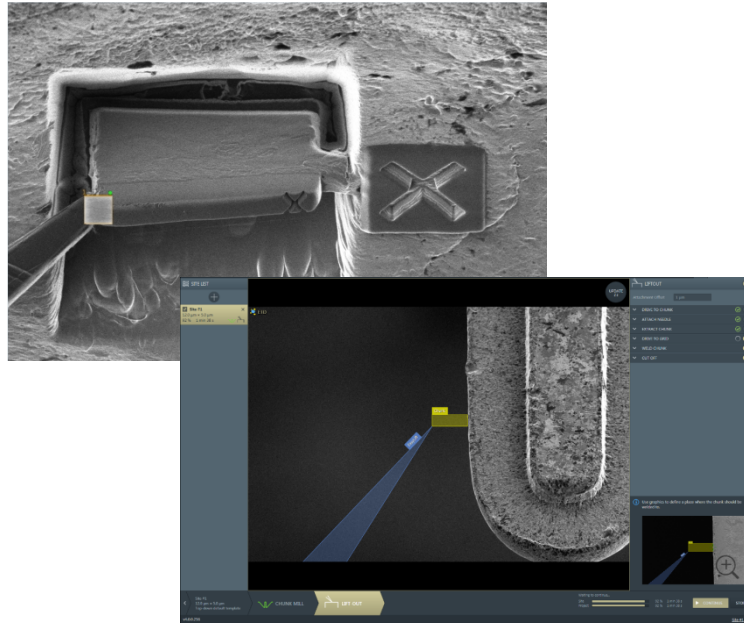
AutoTEM 5 offers complete, fully automated in-situ lift-out preparation process

AutoTEM 5 – Fully automated *in-situ* Lift-out Workflow

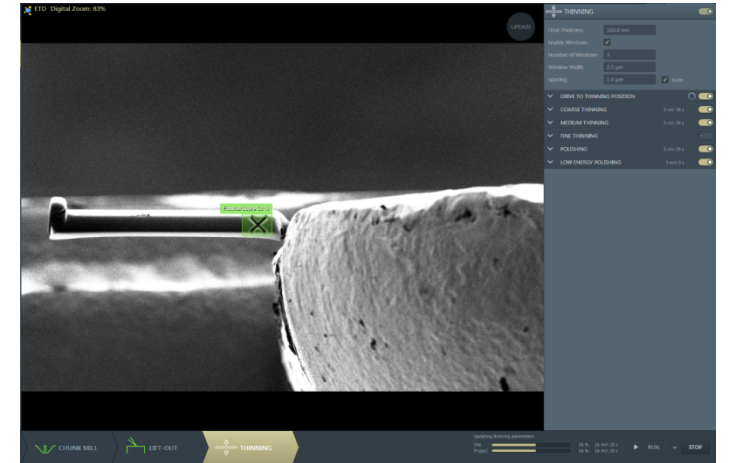
CHUNK MILL



LIFT-OUT

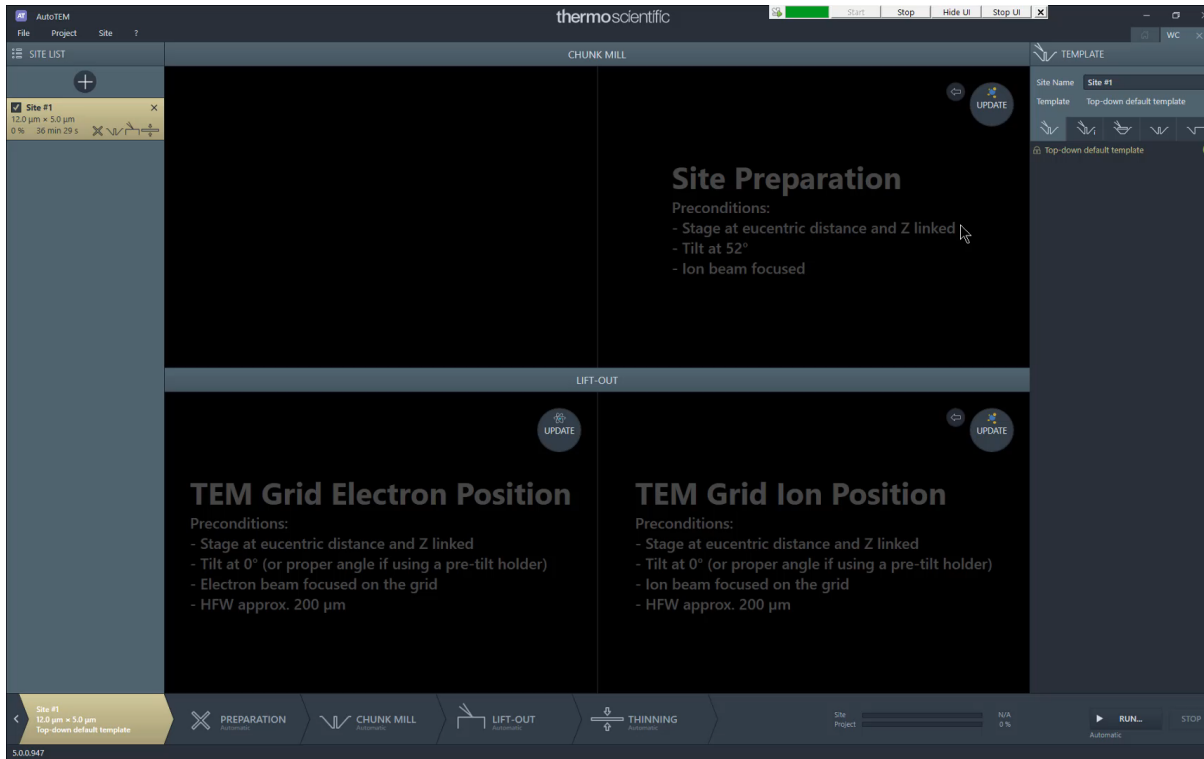


THINNING

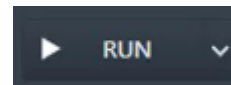


Fully automated, highest quality *in-situ* sample preparation

AutoTEM 5: Fast and simple start



1. Select template
2. Define position on the bulk
3. Define grid position



Traditional Procedure

- | | |
|--|--|
| 1. Switch to e-beam deposition 2 kV, high current | 27. Weld chunk to grid |
| 2. Find the ROI | 28. Release chunk from needle |
| 3. Select Pt e-dep application | 29. Retract probe |
| 4. Place pattern rectangle with right dimensions | 30. Switch to 1nA |
| 5. Start e-beam deposition | 31. Tilt to 53.5 degrees and remove re-deposited material from lift-out, clean up front |
| 6. Tilt towards ion beam | 32. Tilt to 50.5 degrees and clean up back until sample is ~0.5µm thick |
| 7. Switch back to SEM imaging conditions | 33. Reduce current to 300pA and tilt to 53.2 degrees. |
| 8. Set FIB parameters for deposition | 34. Clean front until 0.25µm thick |
| 9. Place pattern rectangle with right dimensions | 35. Change tilt to 50.8 degrees and clean back until 0.15µm thick |
| 10. Select Pt i-dep application | 36. Reduce current to 100pA and change tilt to 52.8 degrees. Thin sample until ~0.12µm |
| 11. Start i-beam deposition | 37. Change tilt to 51.2 degrees and thin sample until ~0.1µm thick or until Pt capping layers starts to be removed |
| 12. Locate area of interest | 38. Watch for bending or non-uniform thinning during entire process |
| 13. Bulk milling of trenches | 39. Change beam currents and tilts for any new material |
| 14. Undercut chunk | 40. Switch FIB energy to 5 kV |
| 15. Bulk cleanup | 41. Change tilt to 57 degrees |
| 16. Mounting manipulators to the stage (e.g. Kleindiek, SmarAct, etc...) | 42. Quickly take an image of the lamella to avoid adding re-deposition on the lamella surface |
| 17. Move manipulator needle to chunk for extraction from bulk | 43. Identify the thin part of the lamella only |
| 18. Insert GIS | 44. Define and place pattern over thin part only |
| 19. Set FIB parameters for deposition | 45. Change tilt to 47 degrees and repeat pattern |
| 20. Define deposition pattern and attach needle to chunk | 46. Switch FIB energy to 2 kV and repeat |
| 21. Set FIB parameters for milling | 47. Switch FIB energy to 1 kV or lower and repeat |
| 22. Define milling pattern and release chunk from bulk | |
| 23. Retract GIS | |
| 24. Retract needle | |
| 25. Find grid | |
| 26. Move needle to grid for attachment to grid | |

~50 steps

AutoTEM 5 – Automated Chunk Mill

Auto Chunk Mill

CREATE FIDUCIAL

GROUND

PROTECTIVE LAYER

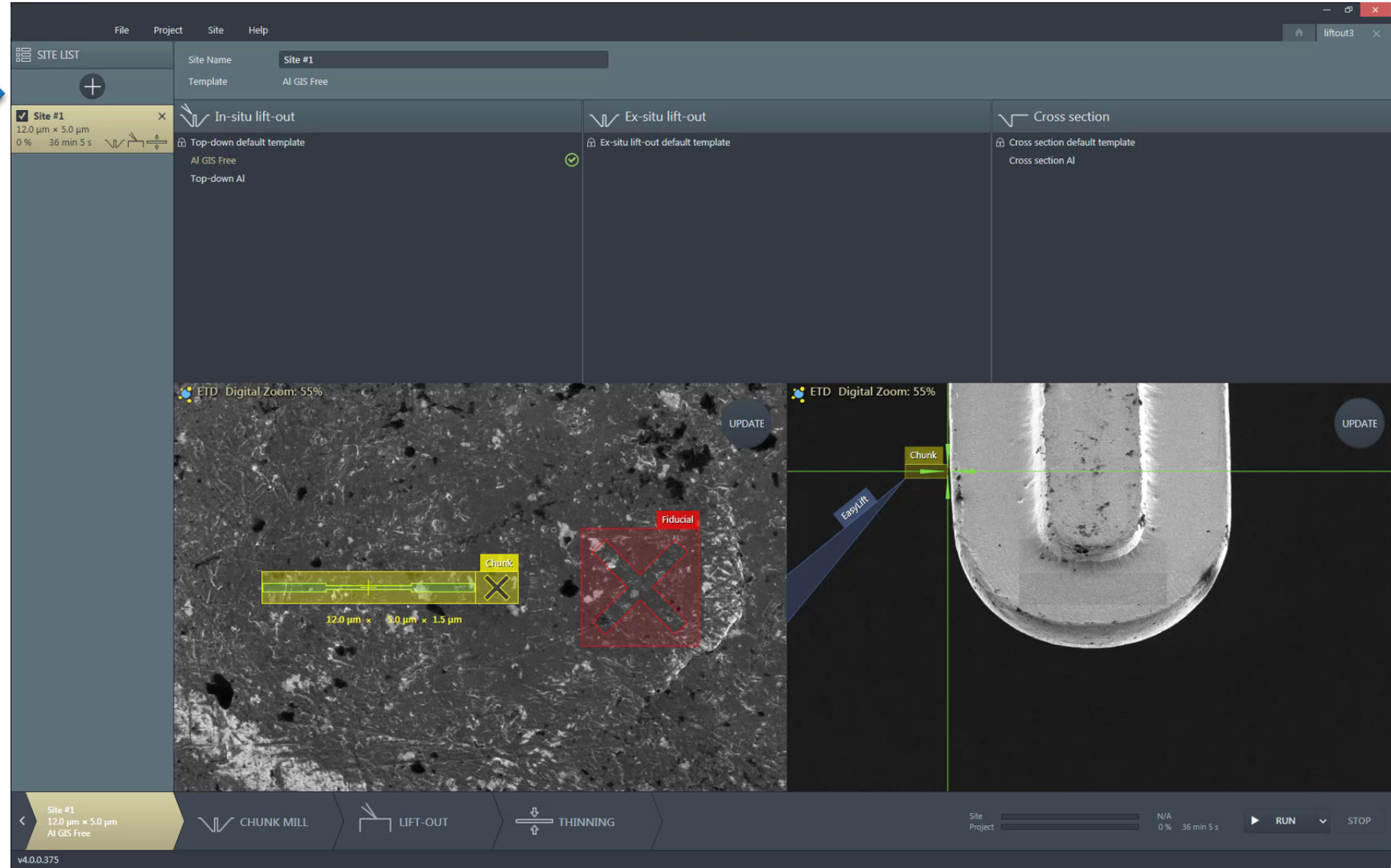
ROUGH MILLING

MEDIUM MILLING

CUTOUT

CLEANUP

CREATE THINNING FIDUCIAL



AutoTEM 5 – Automated In-situ Lift-out

Auto Lift-out

DRIVE TO CHUNK

ATTACH NEEDLE

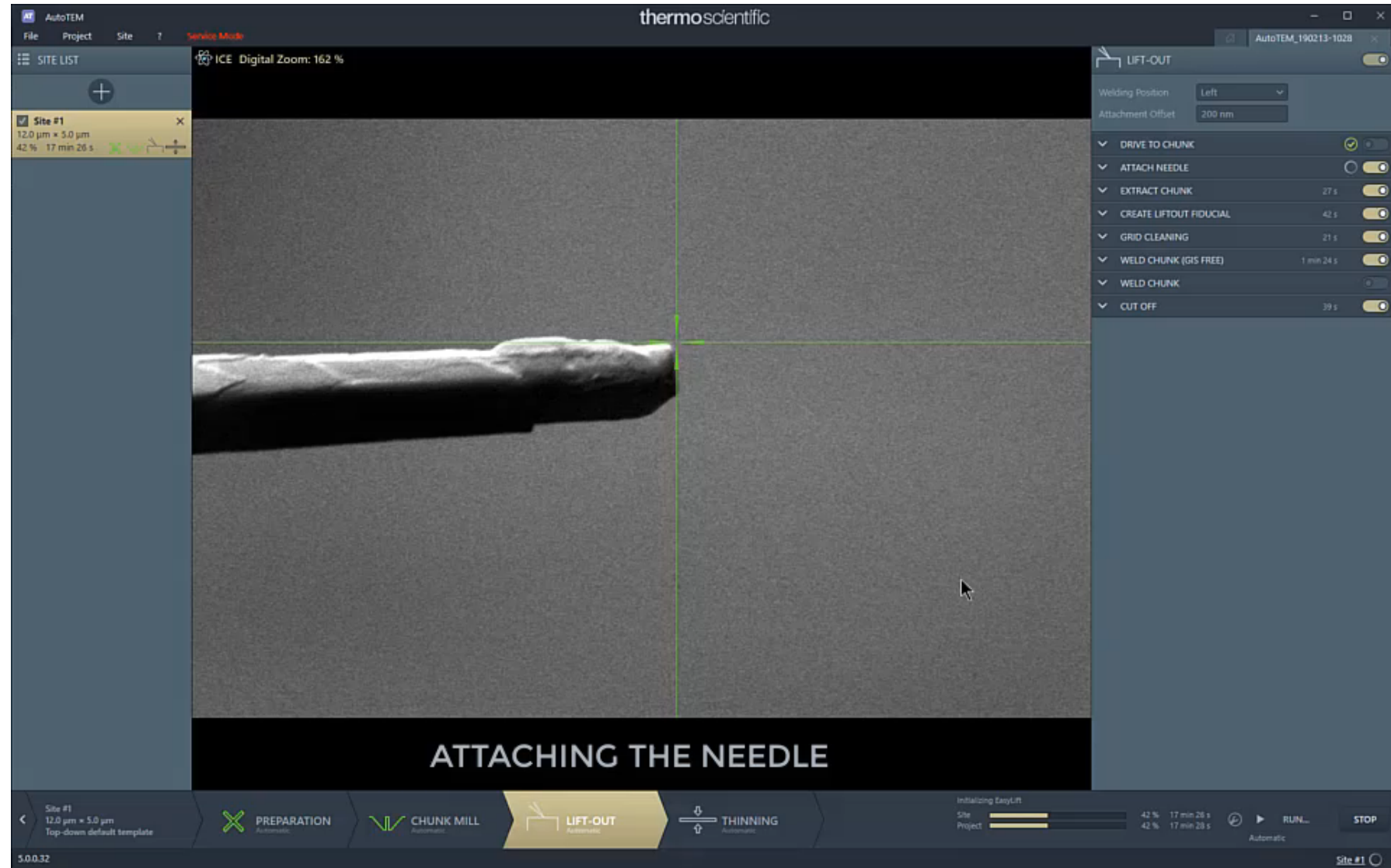
EXTRACT CHUNK

CREATE LIFT-OUT FIDUCIAL

GRID CLEANING

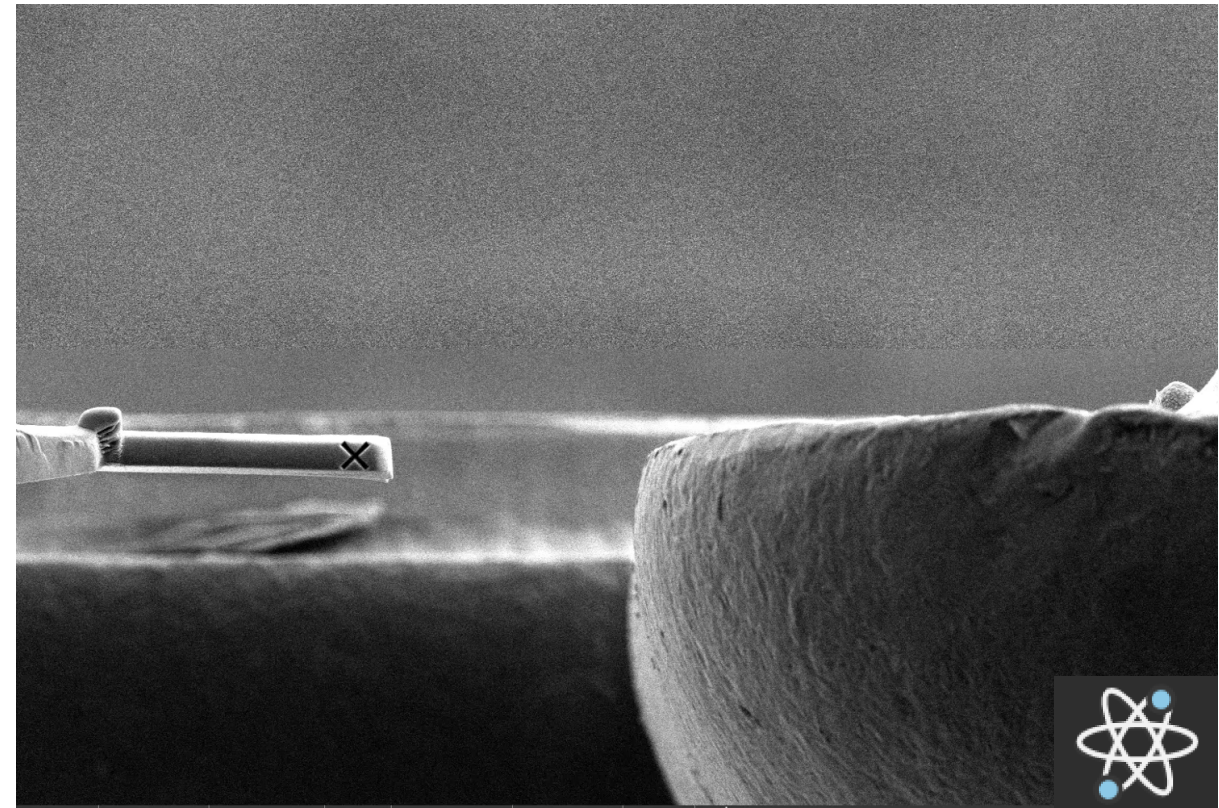
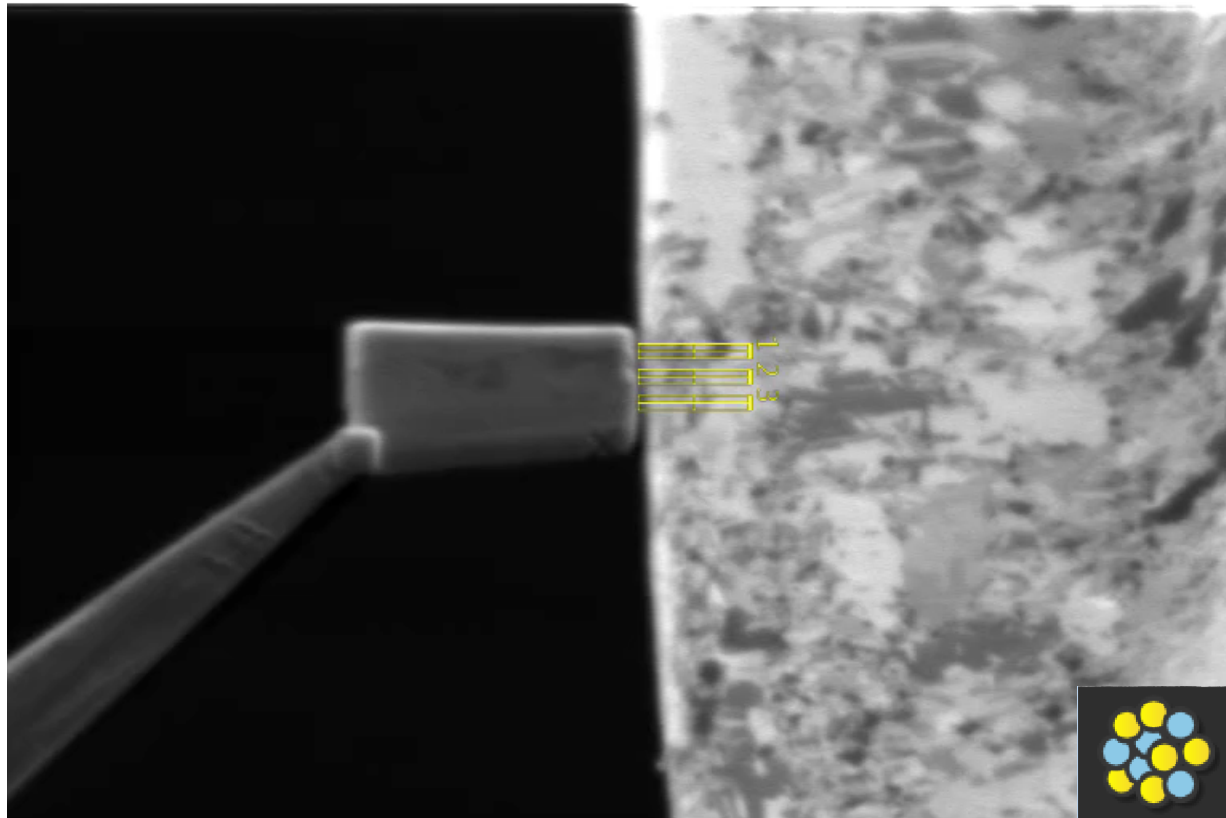
WELD CHUNK (GIS FREE)

CUT OFF



Auto GIS-free Attach

- Takes only several seconds to attach the chunk
- No inserting/retracting GIS
- Vacuum is stable



AutoTEM 5 – Auto Thinning and Low Energy Polishing

Auto Thinning

DRIVE TO THINNING POSITION

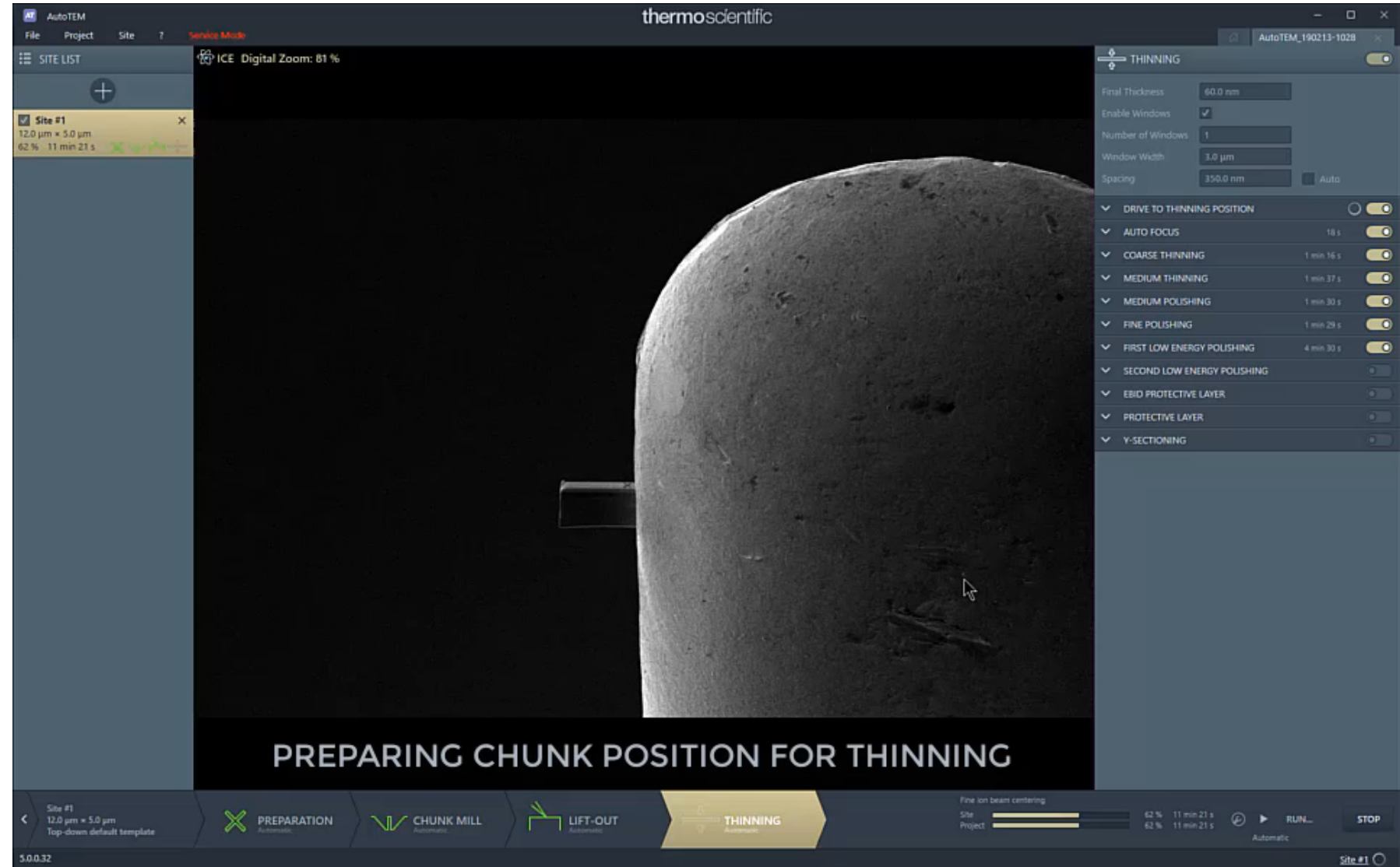
COARSE THINNING

MEDIUM THINNING

FINE THINNING

POLISHING

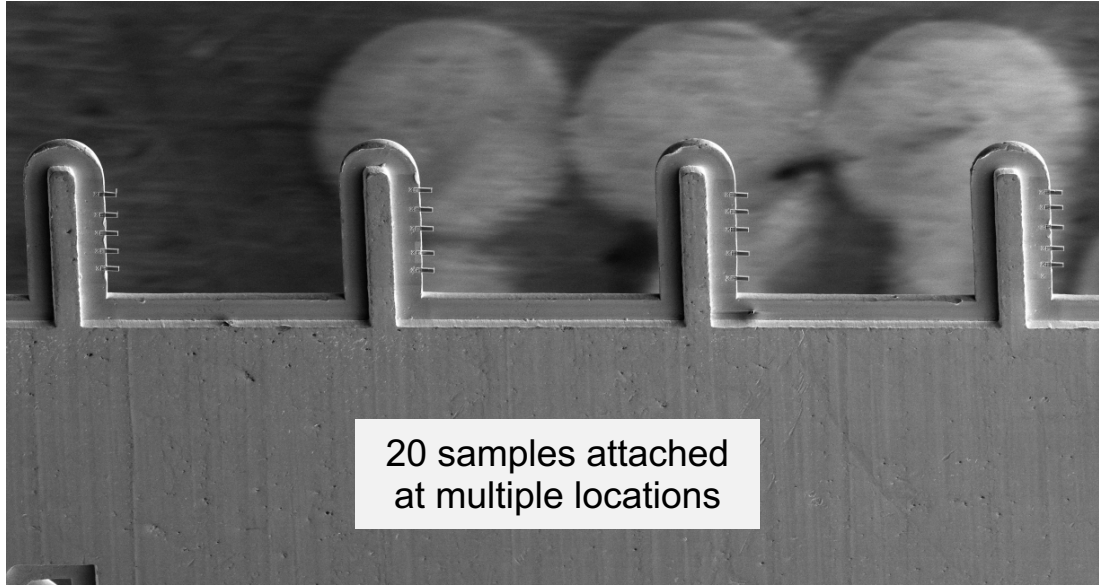
LOW ENERGY POLISHING



AutoTEM 5 – Unattended, fully automated sample preparation for everyone

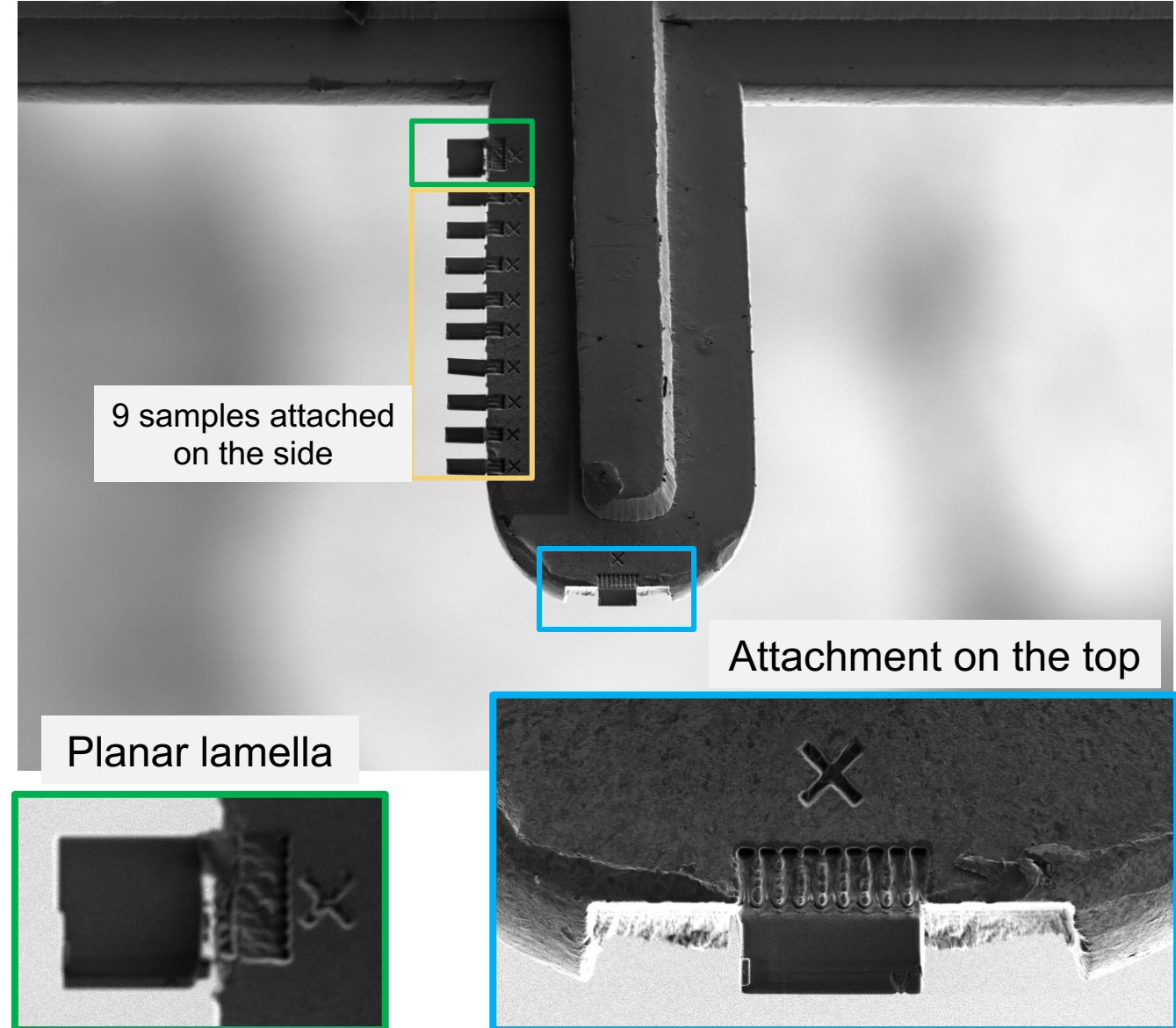


AutoTEM 5 – Highly Reliable Automation

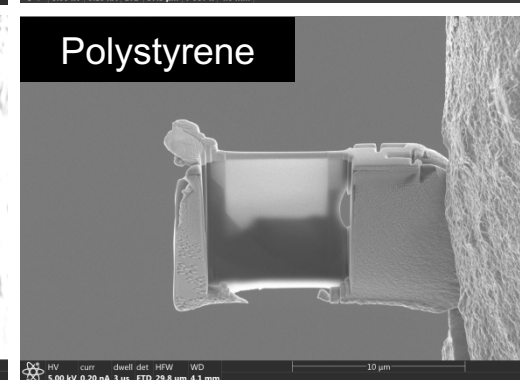
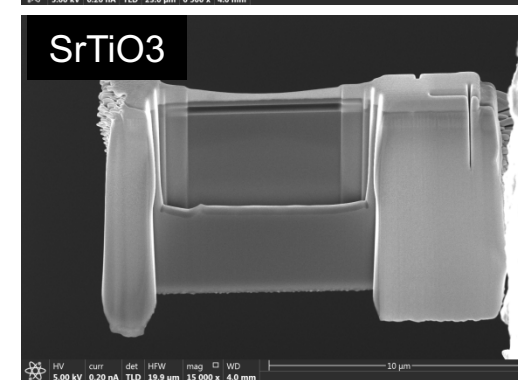
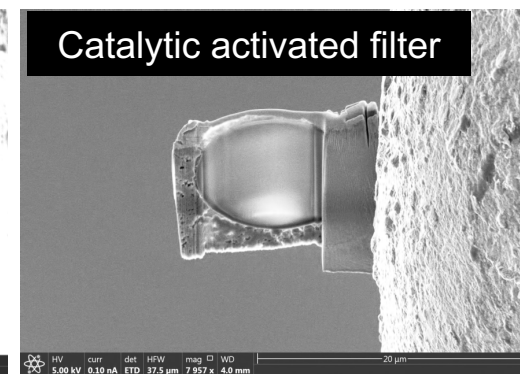
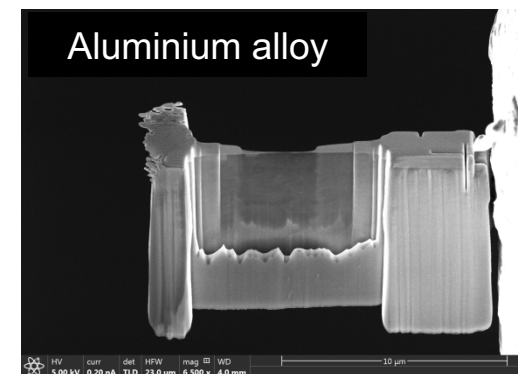
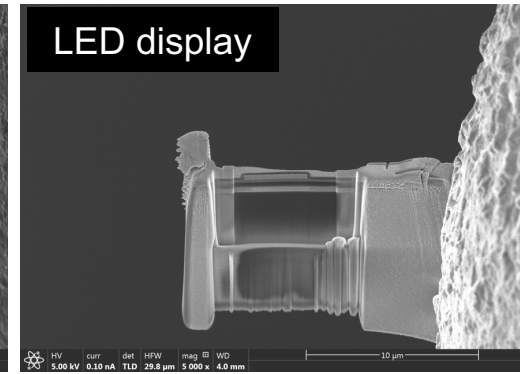
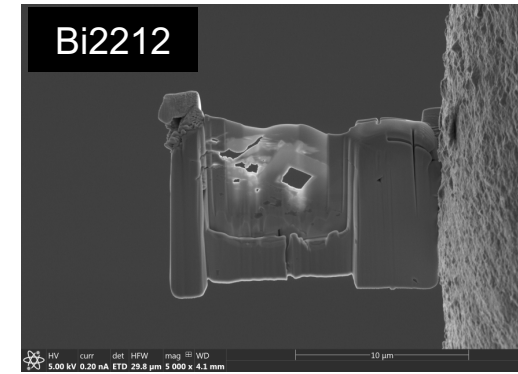
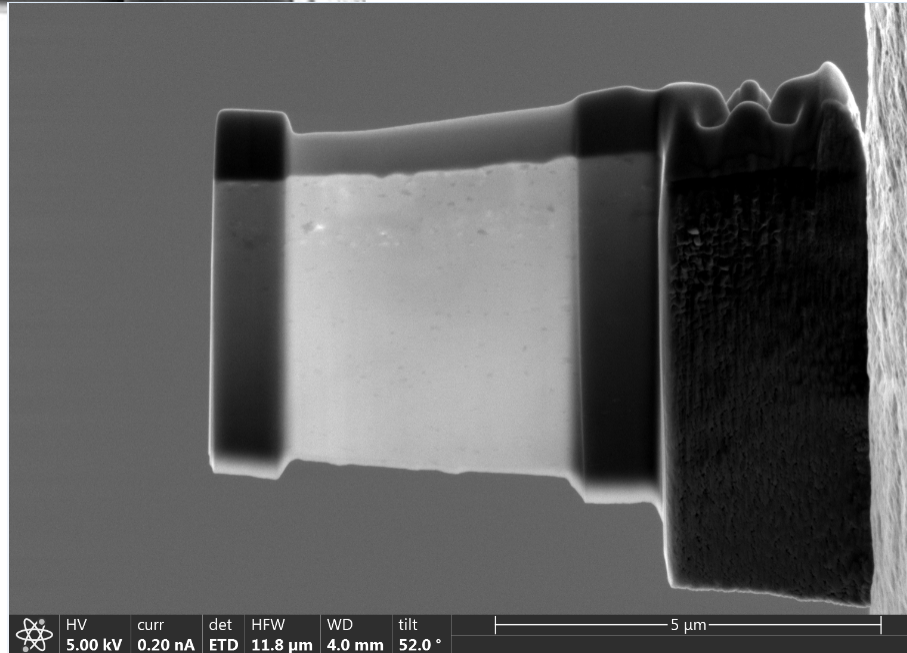
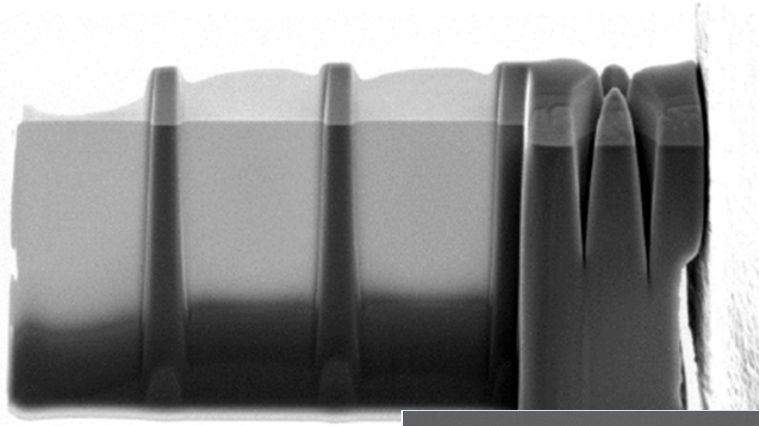


AutoTEM 5

- Full automation
- Highly reliable operation
- Automated multi-site capability
- Support of top-down, planar and inverted geometries
- Different attachment locations



AutoTEM 5 – Wide Range of Material Science Samples



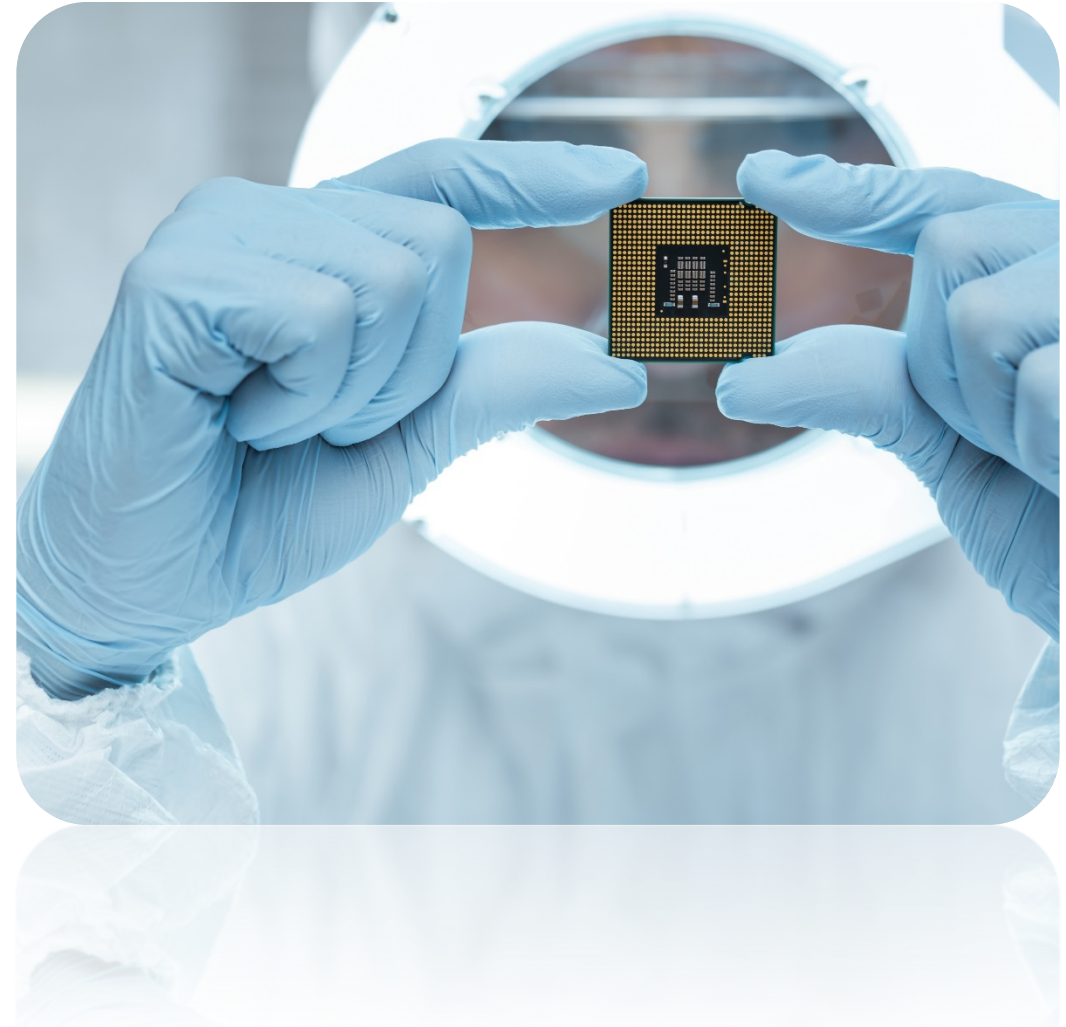
Robust, predictable results for a wide range of materials



Repeatable. Reliable. Results.



- ✓ Gain **expertise** on lamella or other **applications**
- ✓ Increase visibility to system **performance** with remote monitoring and consultations
- ✓ Optimize all elements of your **workflow** across the lifetime of your instrument





Applications Support and Training



System Remote Monitoring



Quarterly Performance Reviews



Optional Performance Guarantee



Comprehensive Maintenance

Helios 5 UX

Enabling breakthrough innovations with DualBeam™ — faster and easier than ever before



- **Fastest, easiest and the most automated preparation** of highest quality samples for HR S/TEM with AutoTEM 5
- **Access to extreme high-resolution imaging** with the most precise contrast **for users with any experience**
- **Easiest access to highest resolution**, multi-scale and multi-modal subsurface and 3D information
- **Fastest, most accurate, and precise** milling and deposition of complex structures with critical dimensions of less than 10 nm

A scanning electron micrograph (SEM) of a complex mechanical assembly, likely a Helios 5 instrument. The image shows various components, including a large, dark, cylindrical structure in the center, surrounded by smaller, metallic parts and a perforated metal mesh. The background is a light blue gradient.

Thank You!