

Results in a snap – overview of the newest SEM and DualBeam technologies

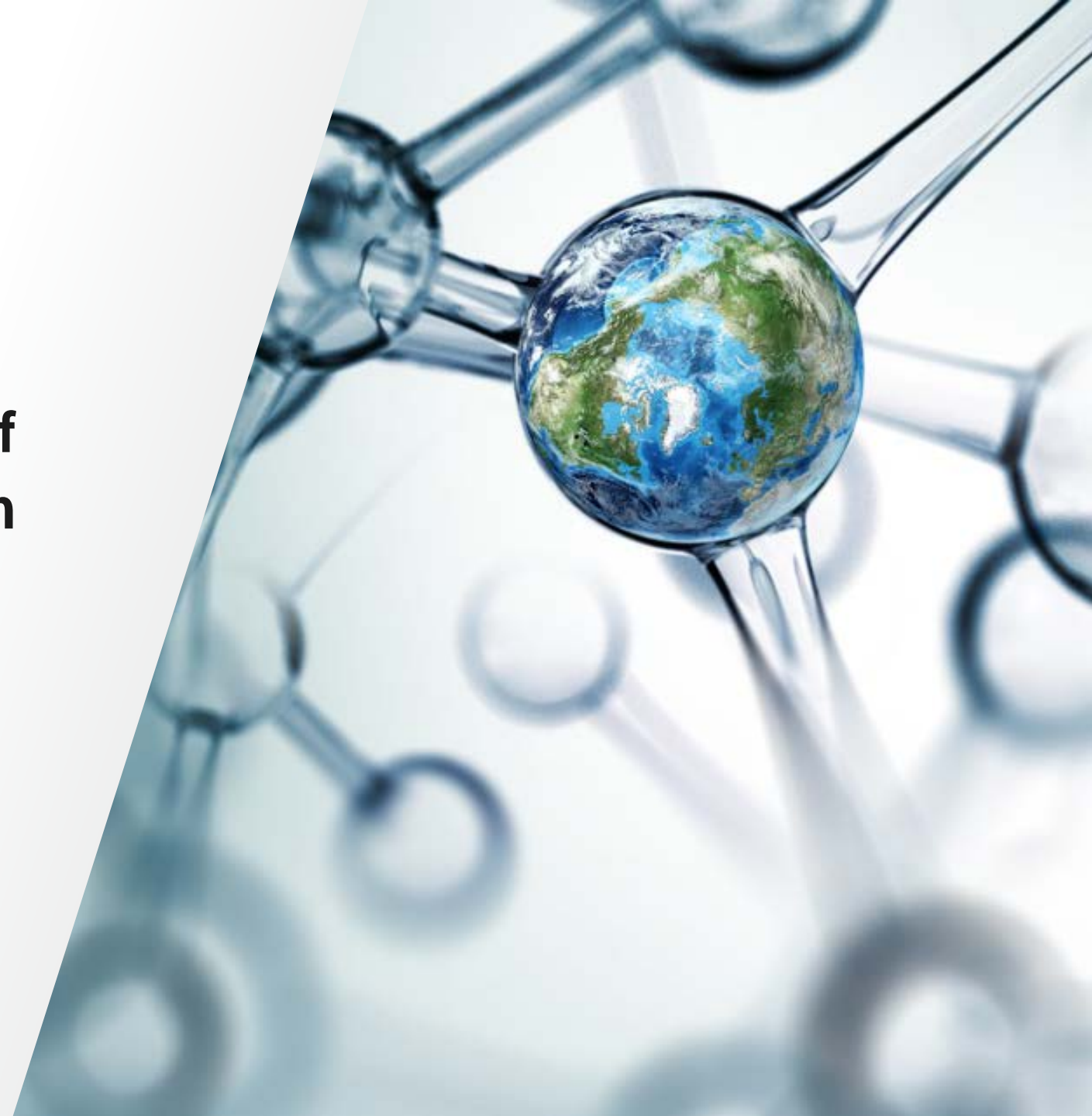
Daniel Phifer

Sr. Product Specialist For SEM, ESEM, DualBeam and MicroCT
EMEA Region

GN-MEBA Décembre 2020

03 DEC 2020 18:00h

 The world leader in serving science



Thermo Scientific SEM and DualBeam changes in 2020

- SEM Updates

- ColorSEM – an easier way to collect elemental information
- Axia ChemiSEM – “Industrial ease of use” SEM
- Apreo 2 – Electrostatic/compound optics in an in-lens FEG SEM
- Verios 5 – Ultimate-resolution in-lens monochromated FEG, no more SEM alignments
- Maps – Tiling and stitching, optional image/data correlation
- Avizo 2D – Artificial intelligence for data analysis
- AutoScript – Python 3.x interface

- DualBeam Updates

- AutoTEM 5 – Guided or automated TEM sample preparation
- Helios 5 Hydra – Multiple ion species FIB for both large cuts and the ultimate clean TEM samples

2020 SEM Product Portfolio

ThermoFisher
SCIENTIFIC

Desktop



Phenom ProX

Fastest time to data for routine SEM imaging & analysis



Phenom XL

Fastest time to data for large or multiple samples per load cycle



Phenom Pharos

Fastest, highest resolution desktop SEM for imaging & analysis

Floor Model



Prisma E

Flexible, configurable SEM for the widest range of applications with optional ColorSEM technology



Quattro C / S

Versatile FEG SEM with unique environmental mode and optional ColorSEM technology



Apreo 2 C / S

Versatile, high performance SEM with optional ColorSEM technology



Verios 5 UC / HP

eXtreme high-resolution SEM for nanomaterials research

Industrial



Axia ChemiSEM

Flexible, complete cost-effective SEM for the widest range of industrial applications

Thermo Fisher launches ColorSEM Technology



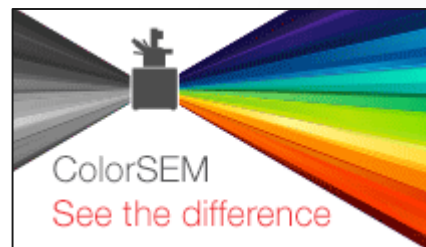
SEM

+

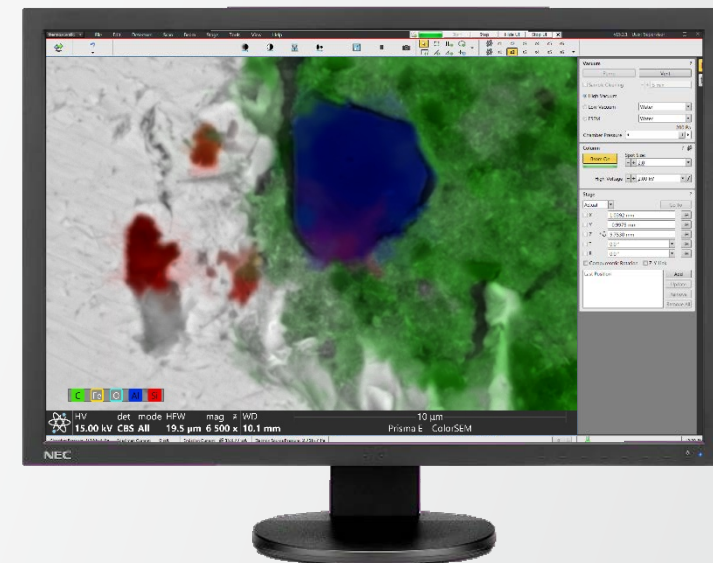


EDS detector
10 / 30 / 60 mm²

+



ColorSEM™ Technology

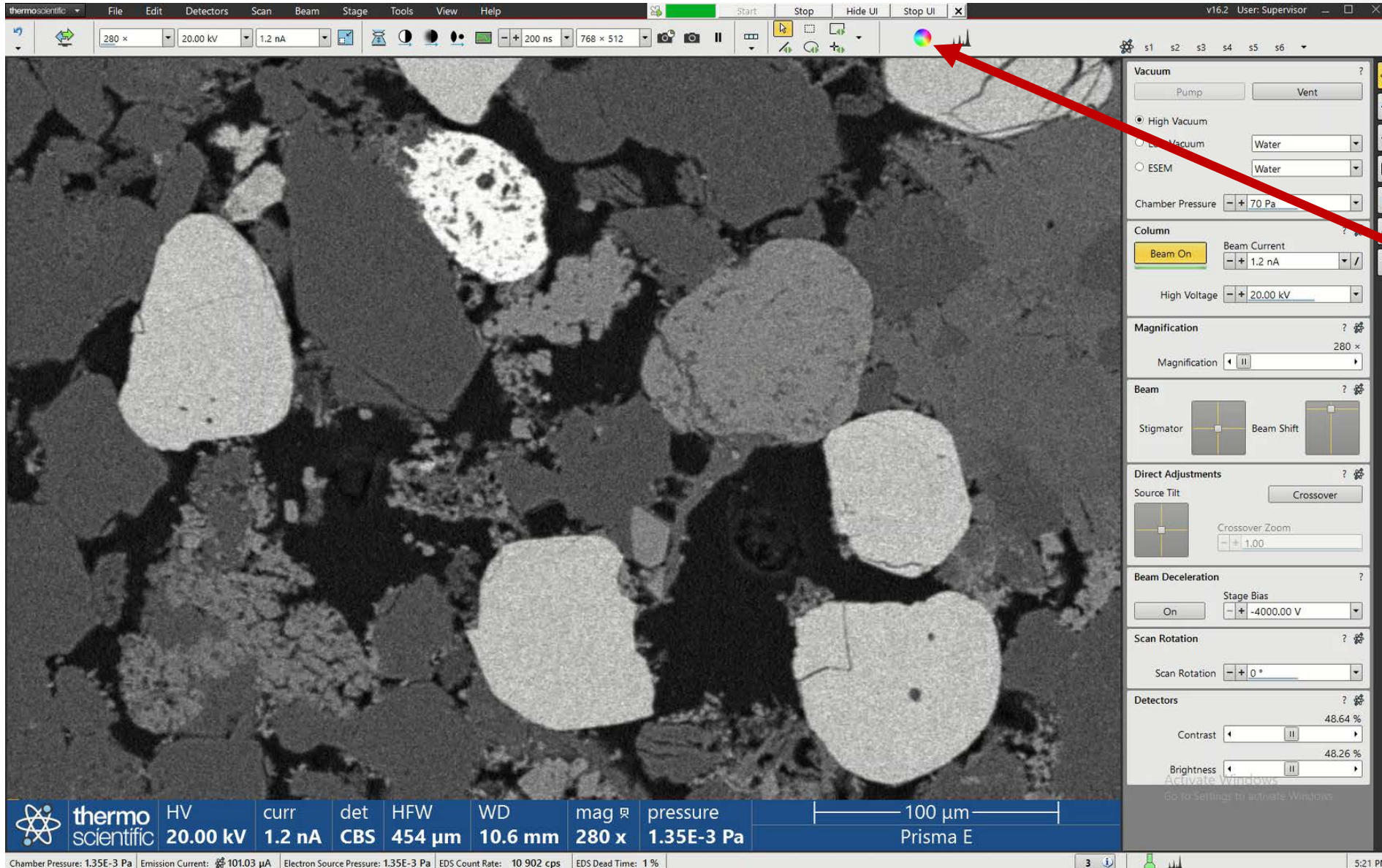


*Two patents describing some ColorSEM technology can be found here:
US 8748816 B2 & EP 2 546 638 B1*

ColorSEM

- ☺ Fully integrated: no need to switch UI
- ☺ Super fast with **live color imaging**
- ☺ No hassle: only one vendor
- ☺ Most intuitive elemental analysis

ColorSEM also collects X-rays in the background, providing an immediate result



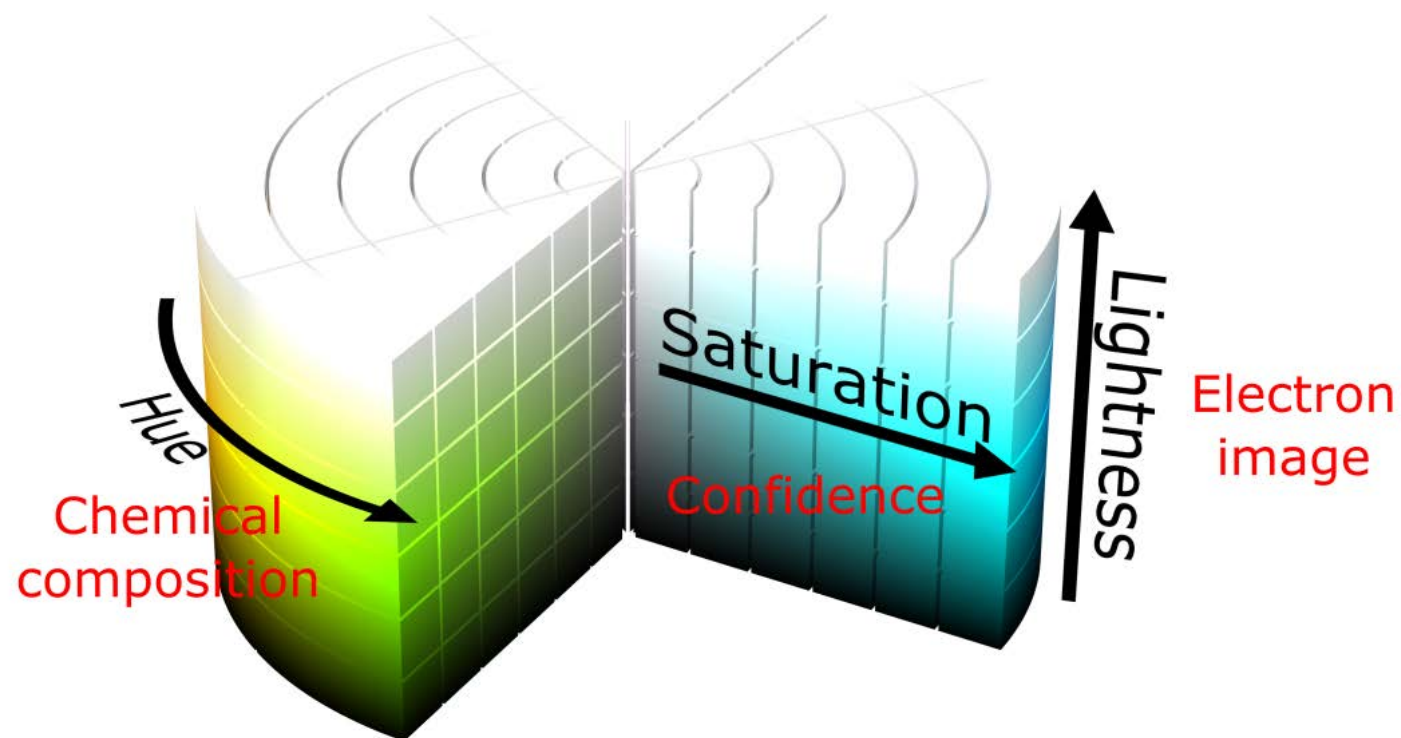
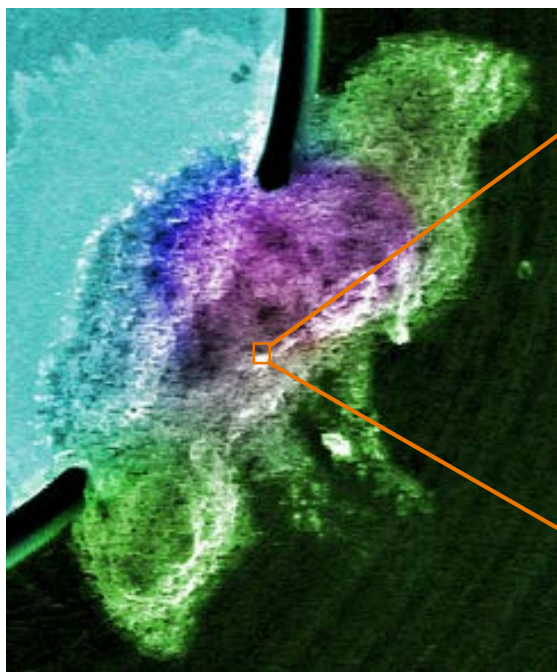
Actions:

1. Focusing the image...
2. Click on Color button
3. See the composition

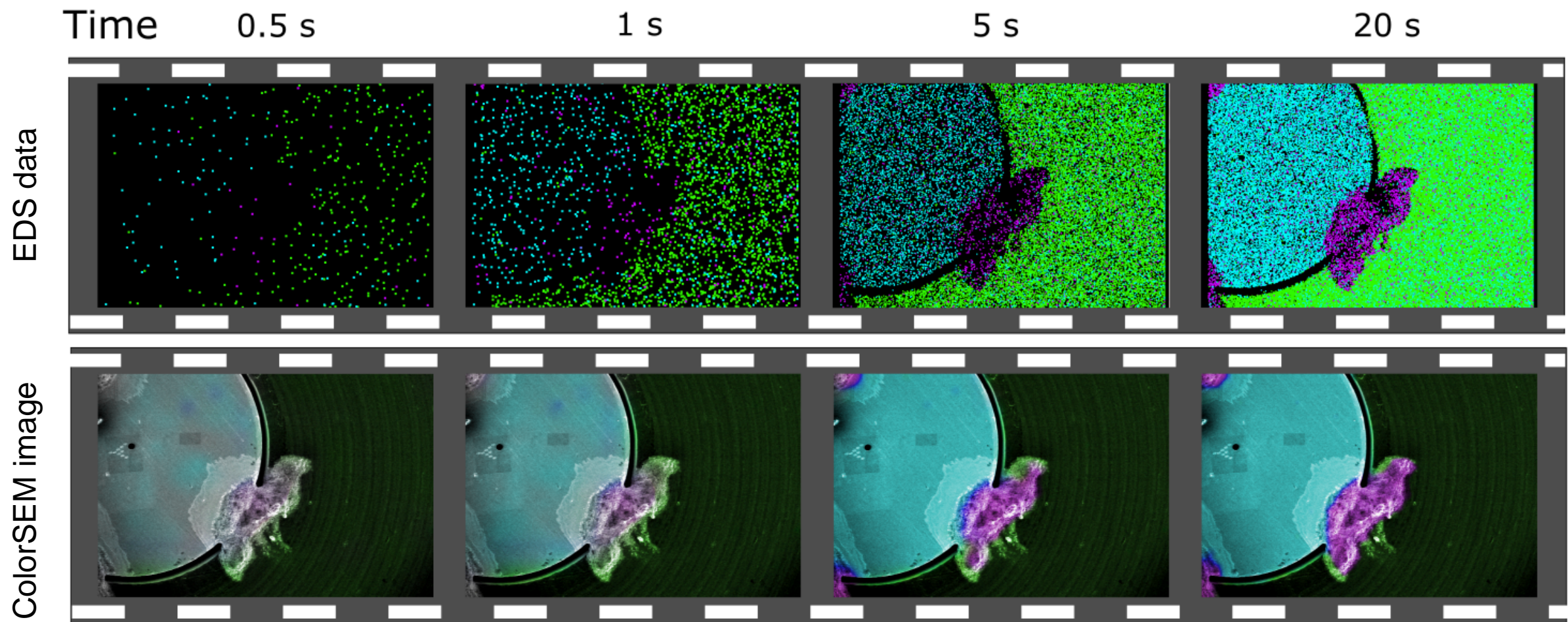


What is new about this “coloring”?

In each and every pixel of the color image, we encode the material/multi-modal information, but also the confidence in the information given by the quality of the data.



Example: hierarchical processing for EDS data

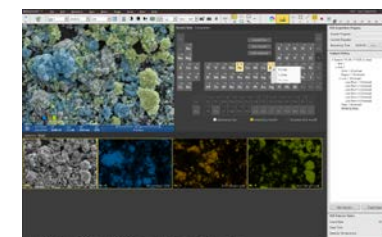
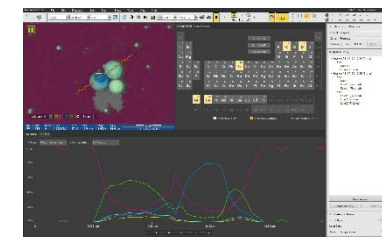
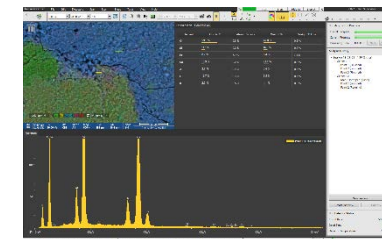


ColorSEM comes in a complete package: live color + traditional EDS functionality

Live composition-based color imaging

Traditional EDS functionality,
in a state-of-the-art implementation

- Point and ID
- Region
- Linescan
- Mapping
- Data reporting
- Job history manager



Introducing the Axia ChemiSEM

The Workhorse SEM designed to make materials characterization painless

- **Most Flexible**
 - Avoid extended sample prep / cutting with easy sample loading through the door and heavy sample support (**up to 10 kg**)
 - **Removeable stage** axes for accommodating large samples
- **Most productive ← ChemiSEM EDS is standard!!!**
 - EDS as **easy to use and as fast as electron detection**
 - Move from discovery to quantitative chemical analysis **two times faster** than other SEM-EDS Approaches
- **Easiest to Use**
 - **Alignment Free** and easy/repeatable imaging with advanced auto-functions
 - Highly accessible with sample-based **User Guidance**

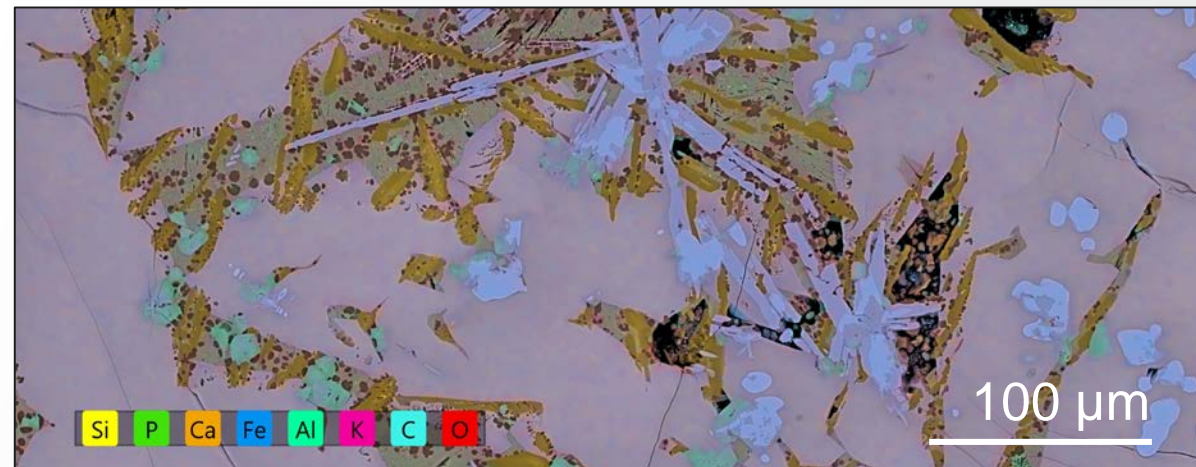
Axia (HiVac) includes 5 standard detectors (LoVac 6)

Backscatter electron imaging (materials contrast)

Retractable, 2-segment BSED

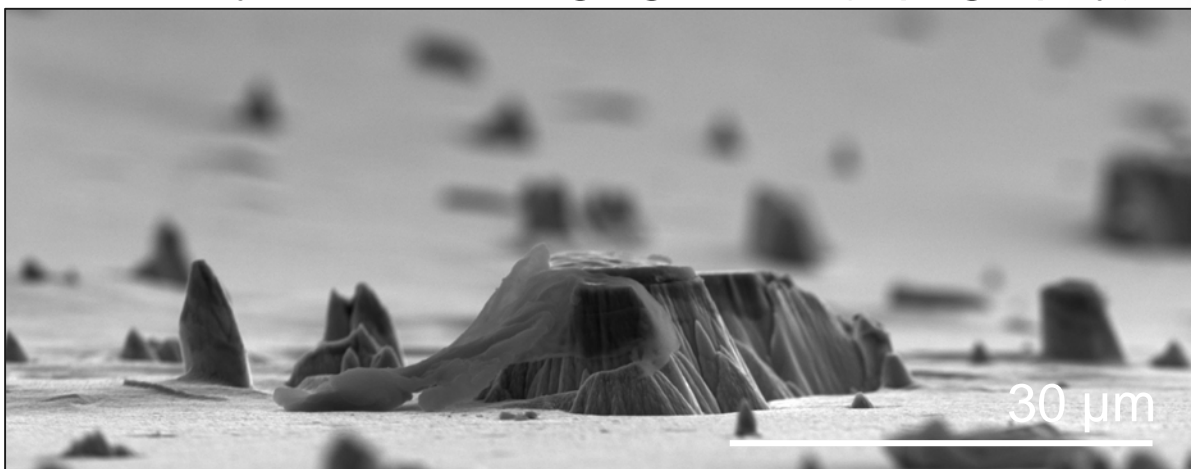
30 μm

Live quantitative EDS mapping (chemistry)



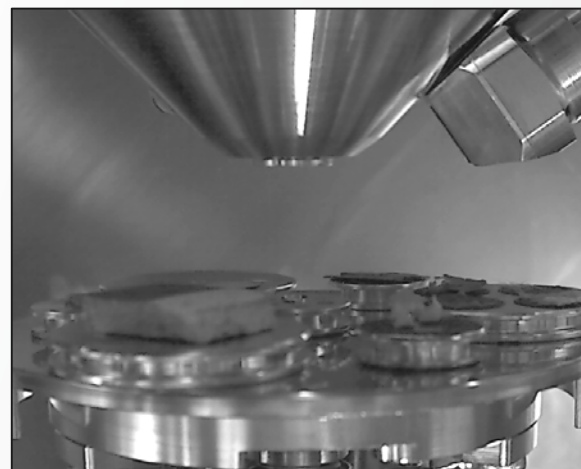
100 μm

Secondary electron imaging - ETD (topography)



30 μm

Chamber view



Navigation

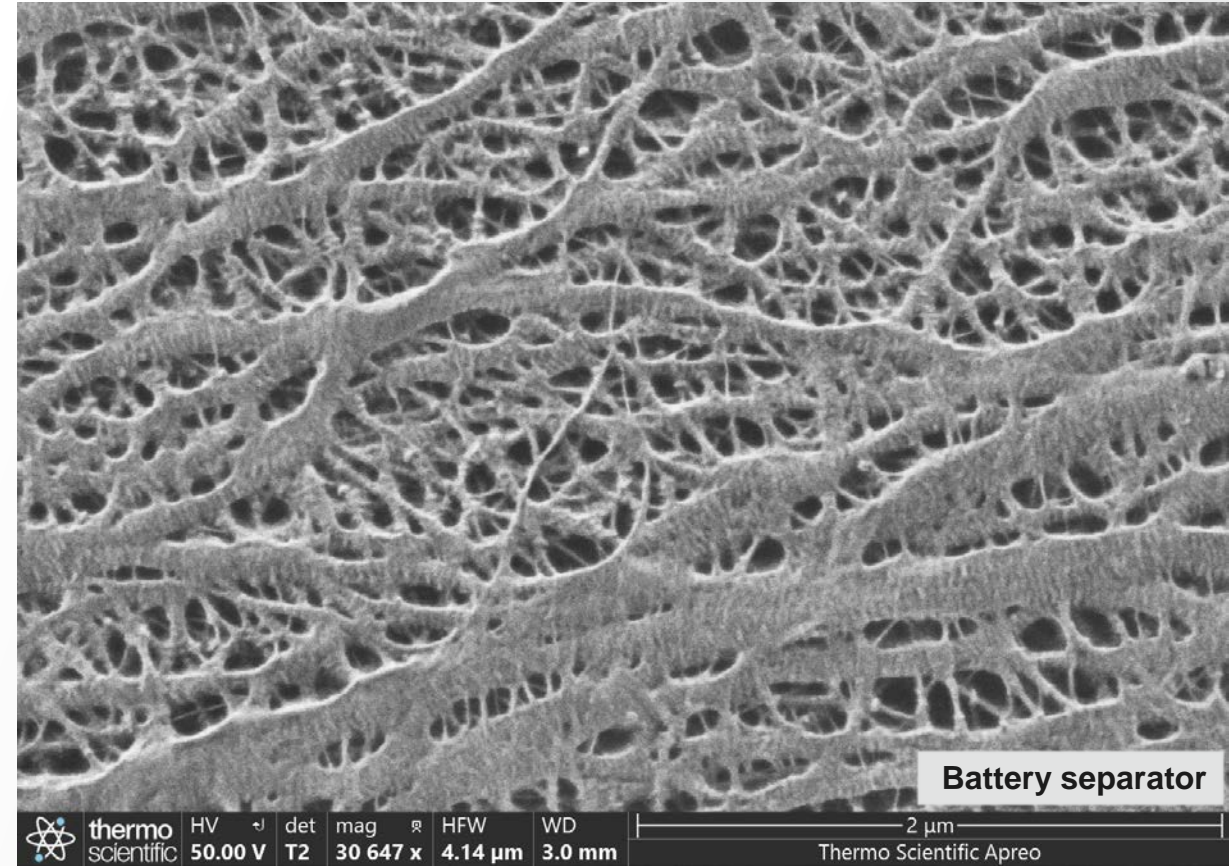
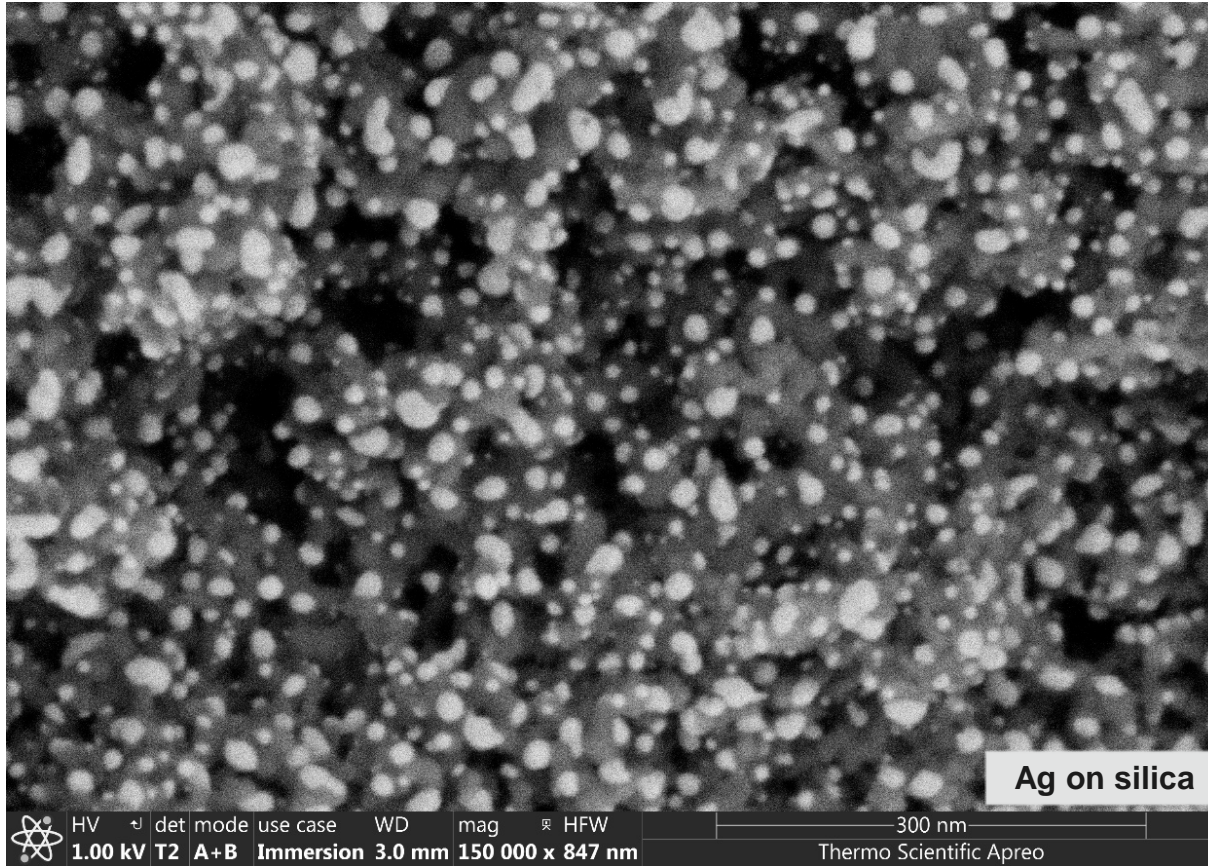


Apreo 2 lets you focus on your research...

...rather than the performance of the microscope

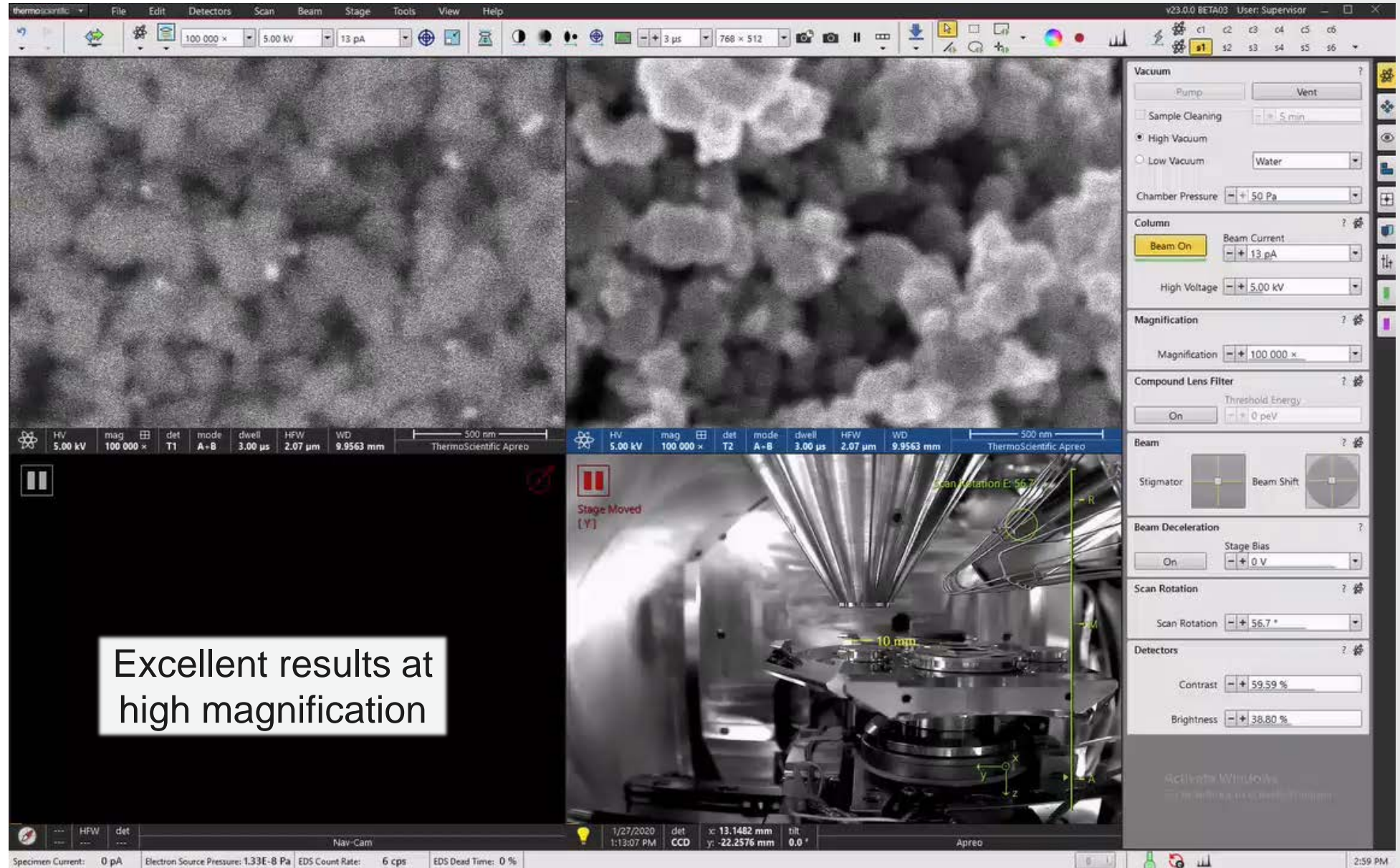
- Excellent image quality
 - Up to three in-lens **Trinity™** detectors
 - Compound lens option ← electrostatic and adjustable immersion
- Quality results for all users
 - Automated SEM alignments with **SmartAlign™**
 - **FLASH™**: auto focus, lens-align and stigmator
- Shortest time to elemental information
 - Optional **ColorSEM™** technology
- Advanced automation to boost productivity
 - Unattended acquisition, large area mapping with **Maps™**
 - Automation and customization with **Autoscript™** Python API
 - AI image analysis with **Avizo 2D™**

Excellent performance on nanomaterials



Improved low-kV resolution: 0.8 nm at 1 kV (Apreo S)

Easy image optimization for all users: FLASH Technology



One button snappy...

- Focus
- X/Y Stig.
- Lens Align (wobble)

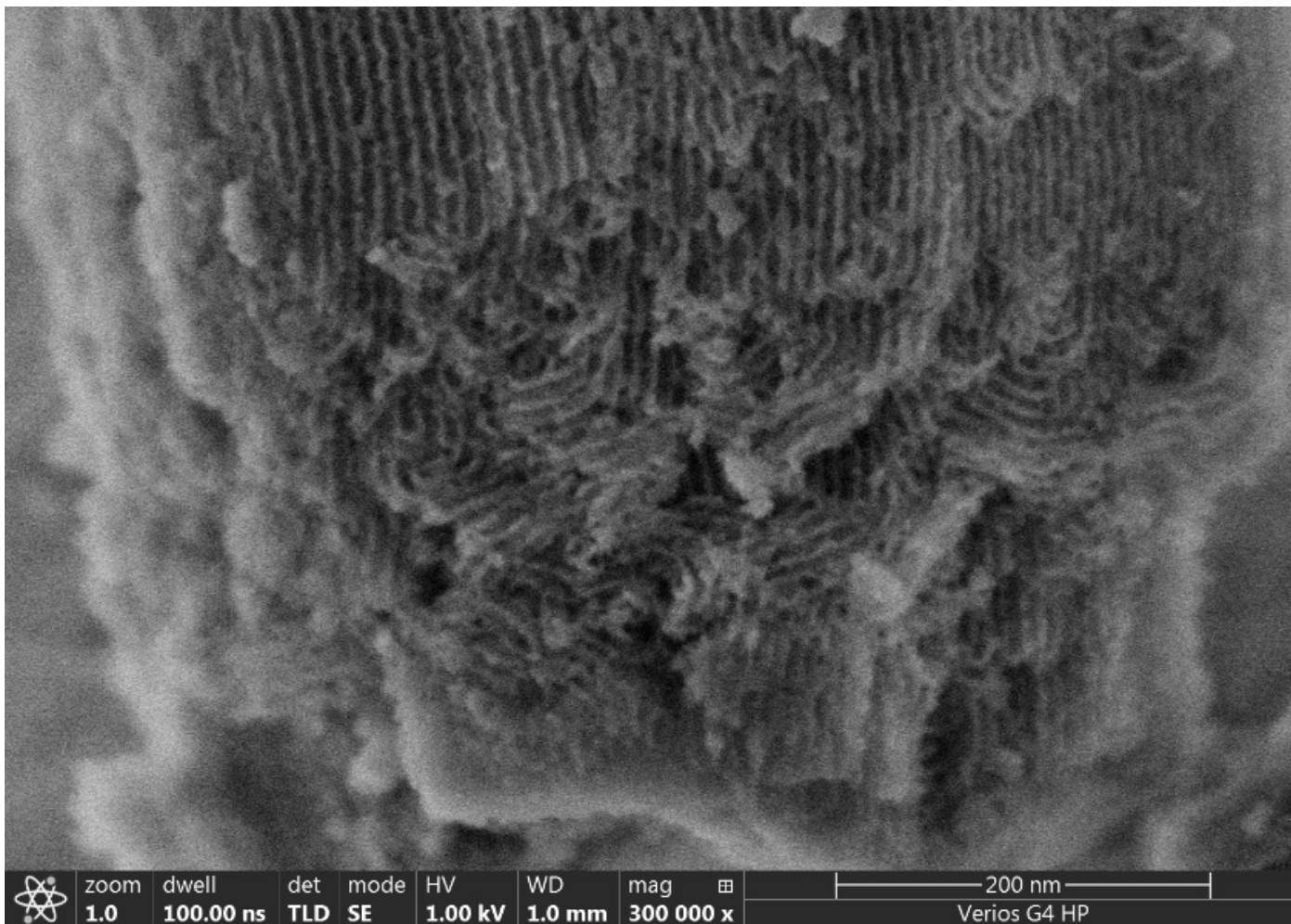
Excellent results at high magnification

Verios 5 – the highest resolution, most accurate, most stable SEM

- **Ultra high-resolution imaging**
 - Resolution: 0.6 nm from 2 kV to 15 kV
 - Excellent results on beam sensitive and non-conductive materials
 - Enabled by unique UC+ (monochromator)
- **High and precise contrast**
 - Refined signal filtering by angle and energy
 - Enabled by TLD / MD / ICD, DBS
 - STEM3+ for enhanced structural and compositional data
- **No compromises on flexibility and ease of use**
 - Clean, accurate and fast observation and navigation
 - Great analytics platform (large current, high analytical resolution)
 - Latest xT UI (with column presets, Flash & SmartAlign)
 - Large sample chamber from DualBeam



Revealing the finest details on beam sensitive, contaminating or non-conductive samples

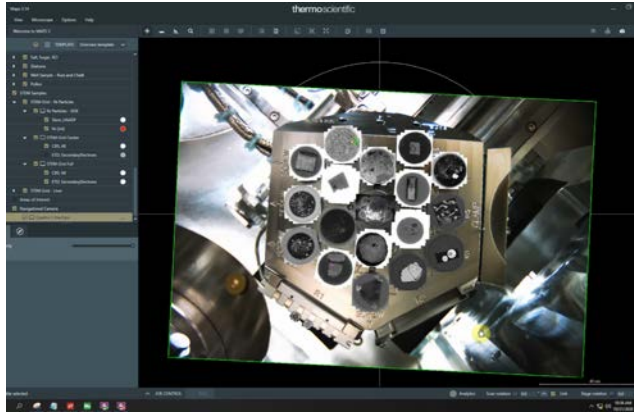


Mesoporous SiO₂: SBA-15

Image courtesy: Romaine Isaacs, Thermo Fisher Brno

Excellent performance at low beam energy and low beam current enables Verios to image beam-sensitive SBA-15 at very high resolution without any sample damage

Expandability with modern software enables automation



Maps tiling and stitching

- Unattended acquisition of overview and areas images
- Set multiple parameters for acquisition needs
- Create “virtual samples”
- Optionally upgrade to Maps Correlation



```
path = "./images/"
os.makedirs(os.path.dirname(path), exist_ok=True)

microscope = SdbMicroscopeClient()
microscope.connect()

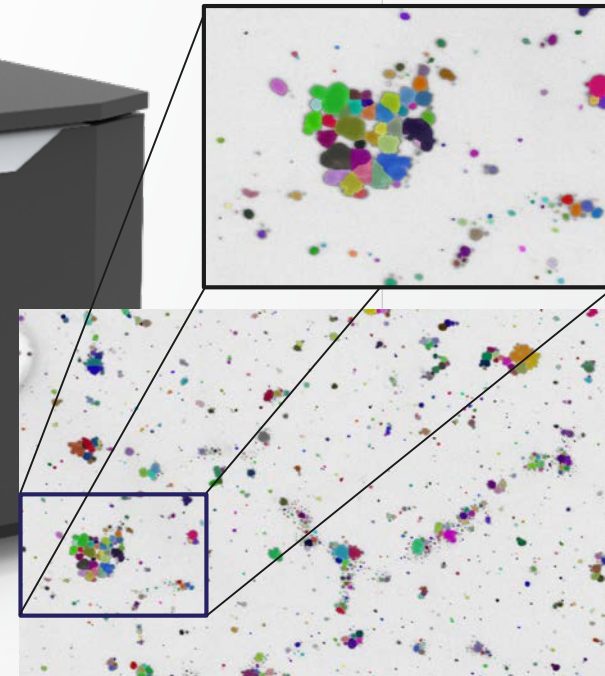
HorizontalFieldWidth = 25.4e-5
microscope.beams.electron_beam.horizontal_field_width=HorizontalFieldWidth
microscope.
```

beams	SdbMicroscopeClient
connect (self, host, port)	SdbMicroscopeClient
auto_functions	SdbMicroscopeClient
specimen	SdbMicroscopeClient
imaging	SdbMicroscopeClient
detector	SdbMicroscopeClient
disconnect (self)	SdbMicroscopeClient
gas	SdbMicroscopeClient
patterning	SdbMicroscopeClient
state	SdbMicroscopeClient

Ctrl-Down and Ctrl-Up will move caret down and up in the editor 22

AutoScript enables unique automation

- All aspects of the SEM are scriptable
- Python ecosystem code exist for many needs



Avizo 2D

- AI (artificial intelligence) trainable image analysis
- Many pre-defined workflows can be customized

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2020 DualBeam Product Portfolio



Scios 2

Most versatile high performance DualBeam for sample preparation and 3D characterization

- Fast and high-quality sample preparation
- Improved performance:
 - Flexible experimentation
 - Work with challenging samples



Helios 5



Highest performance for the most demanding and challenging tasks in sample prep and nanoprototyping

- Easiest preparation of highest quality samples
- Improved performance:
 - Nanoprototyping



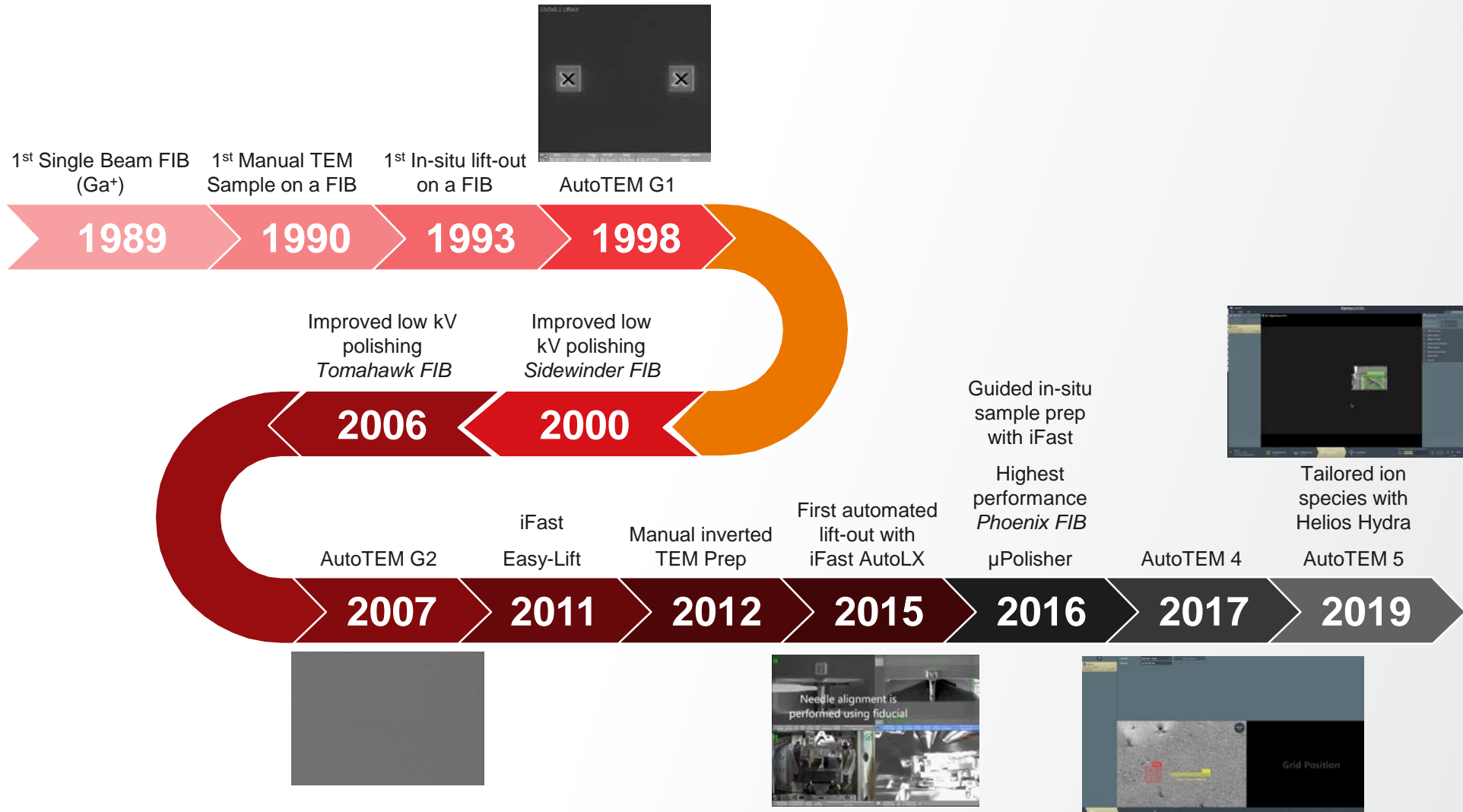
Helios 5 PFIB & Hydra



Highest quality large volume 3D characterization and Ga-free sample prep

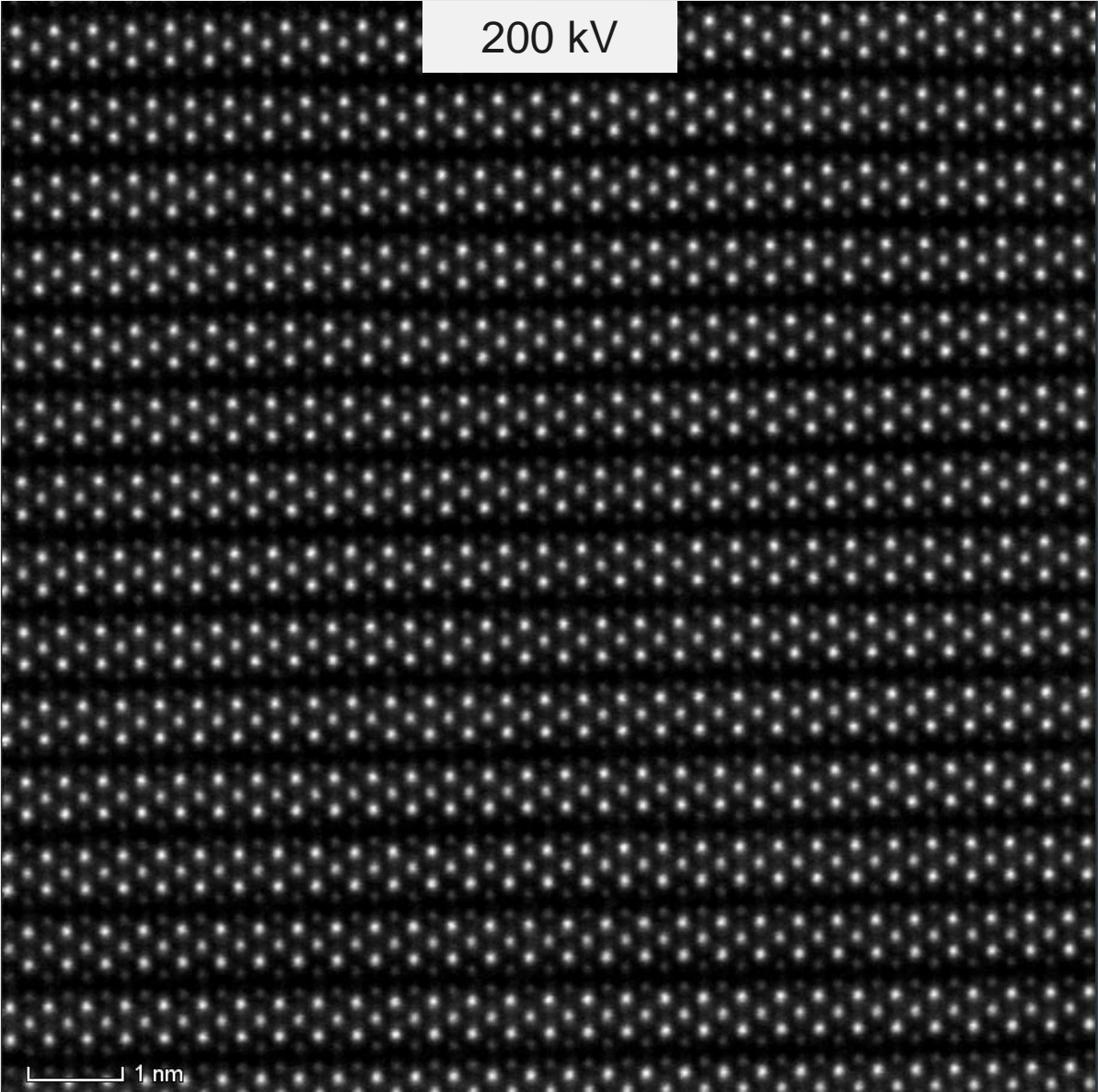
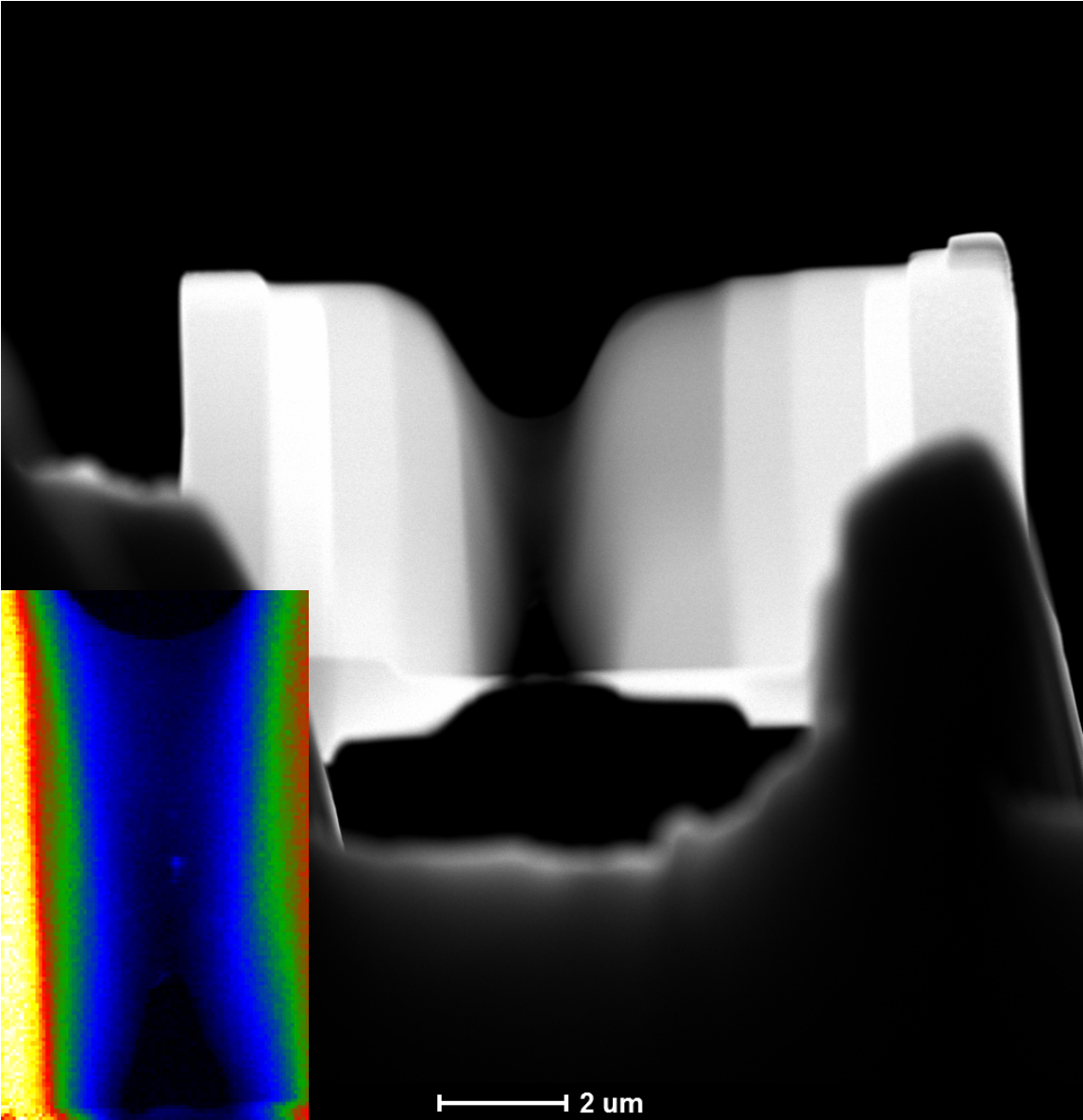
- Highest quality Ga-free sample preparation
- Improved performance:
 - Large volume processing

Industry Leader in TEM sample preparation



2020 – Celebrating the 30th anniversary of TEM sample preparation with FIB

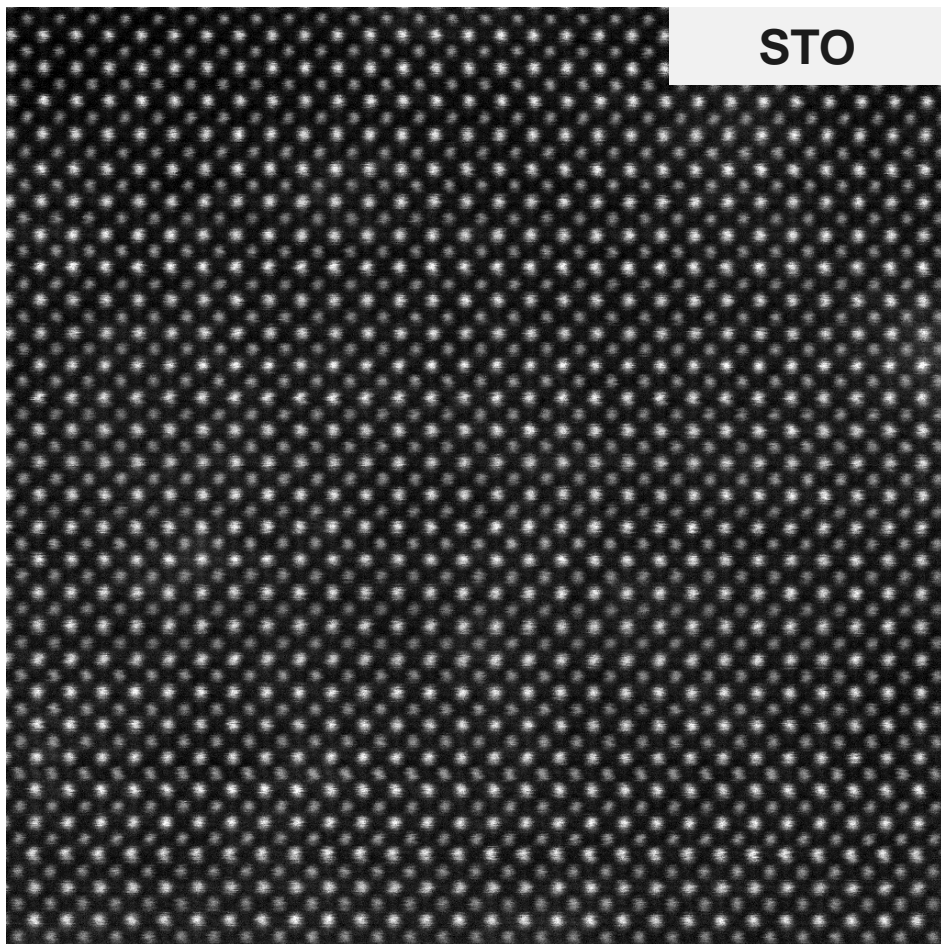
Scios – High quality S/TEM sample preparation



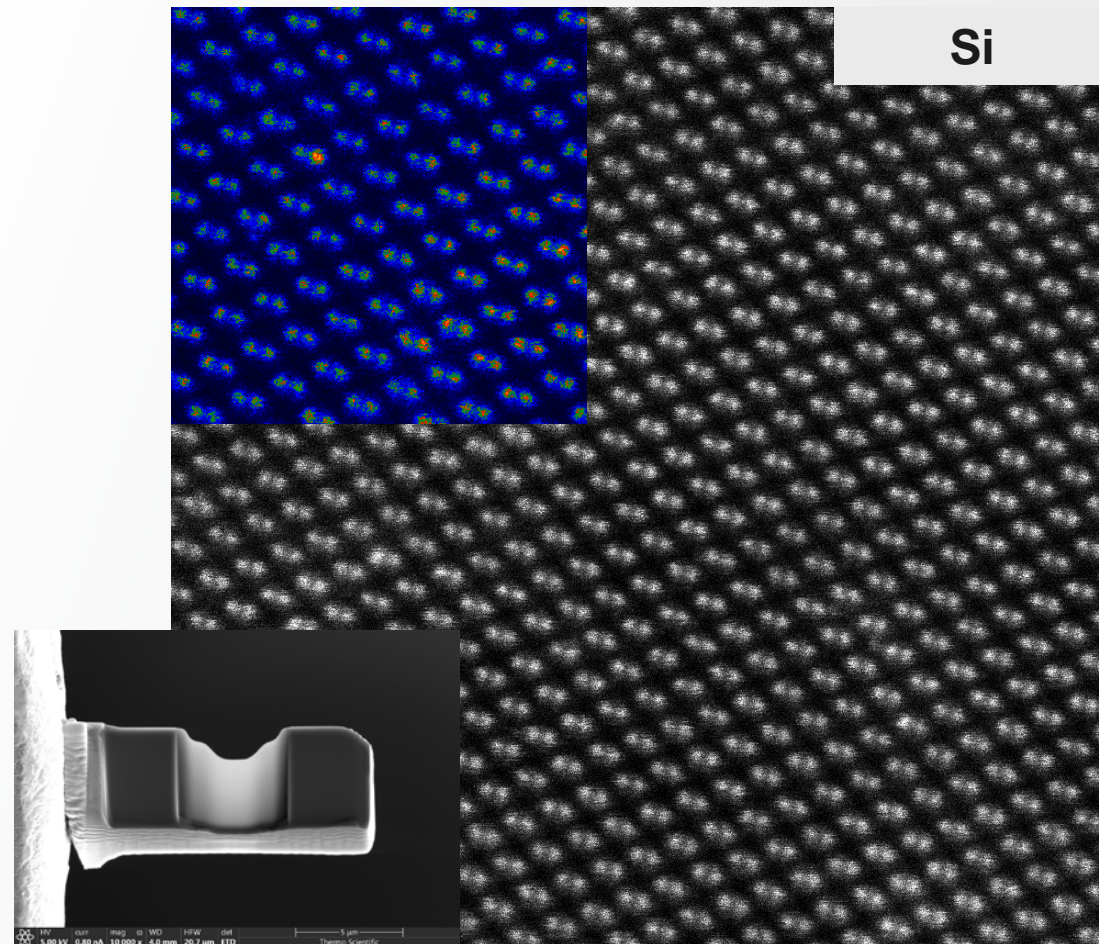
Sample: Cuprate

Great TEM results start with sample preparation...

DualBeams enable fastest and easiest, high quality S/TEM sample preparation



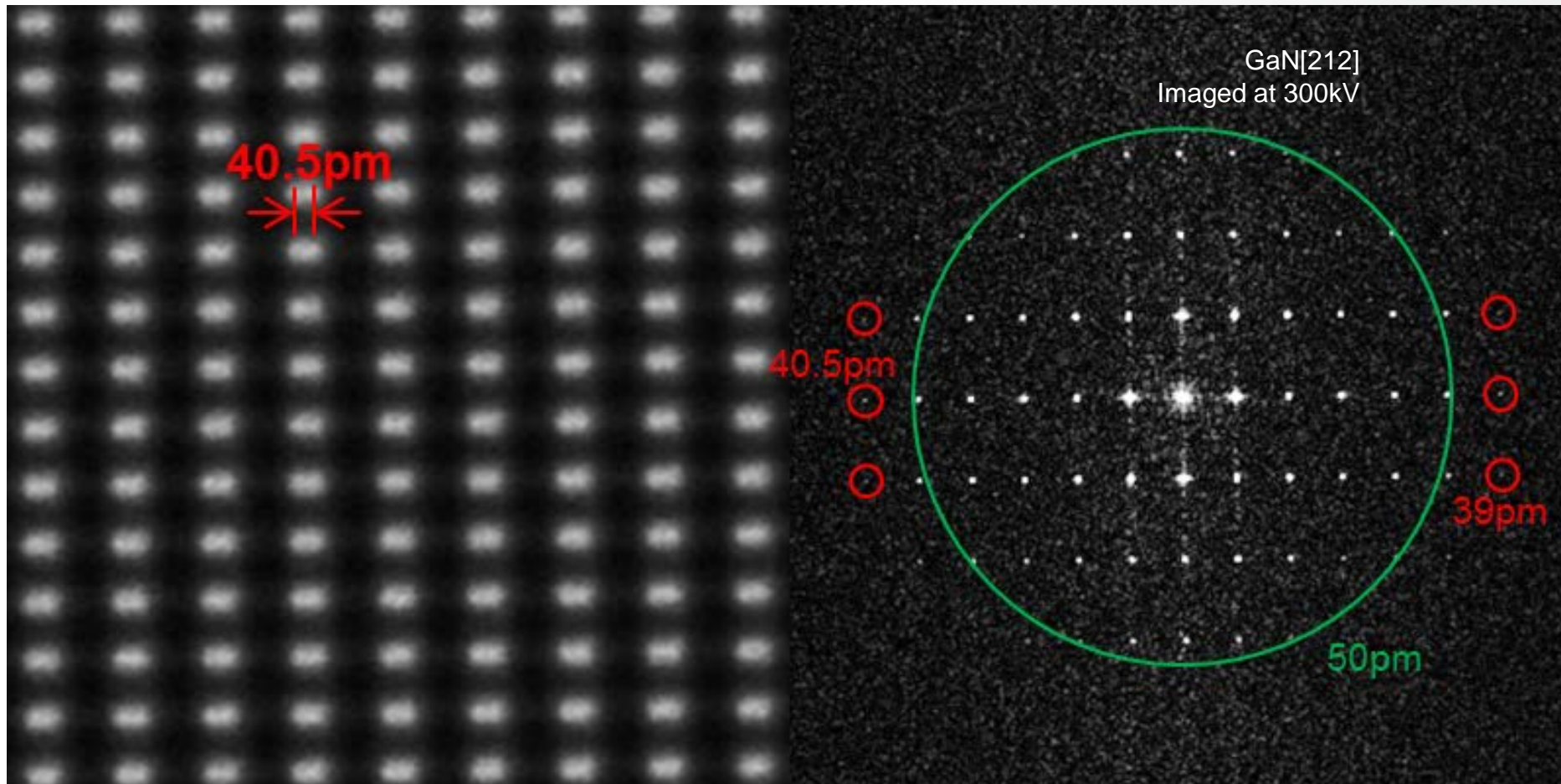
Prepared with Helios 5 DualBeam



Prepared with Helios Hydra DualBeam

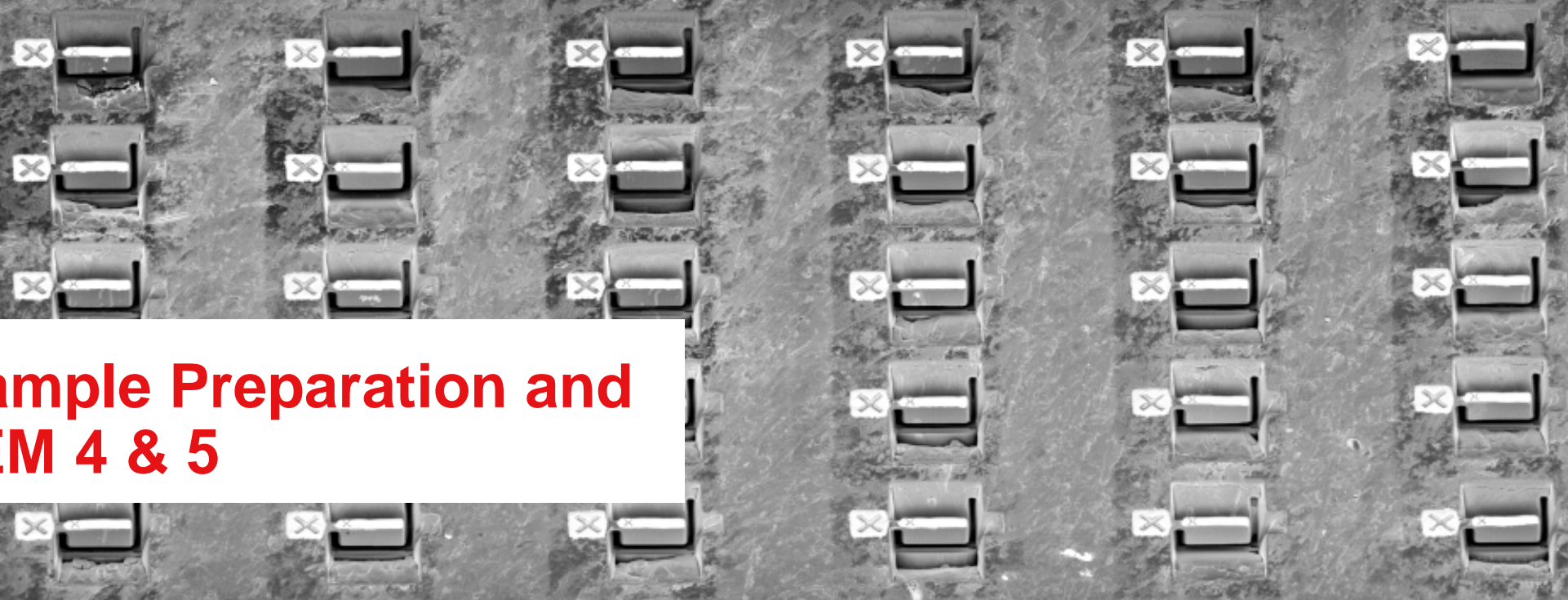
Great TEM results start with sample preparation...

Highest commercial STEM resolution **50pm at 300kV**



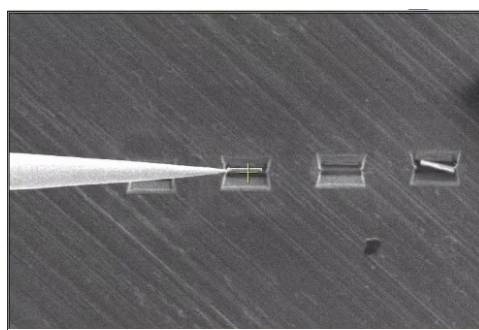
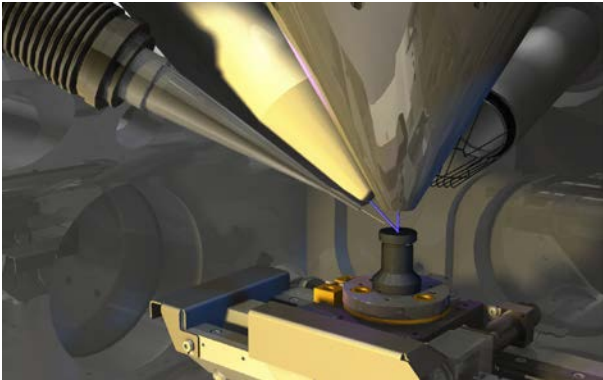
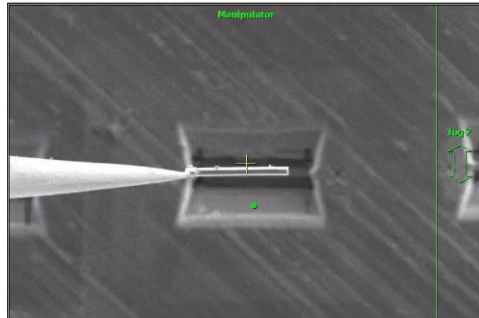
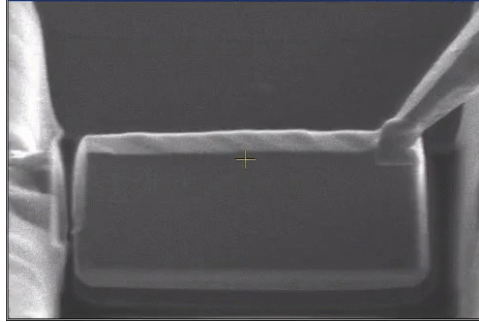
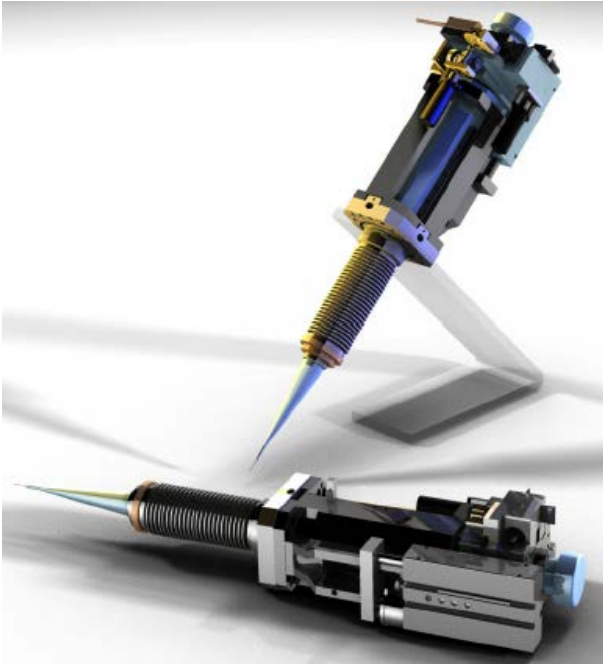
Prepared with Helios DualBeam

DualBeams enable fastest and easiest, high quality S/TEM sample preparation

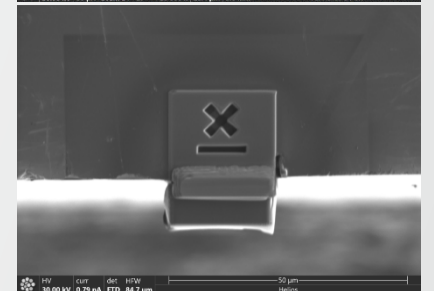
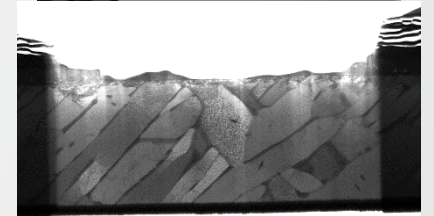
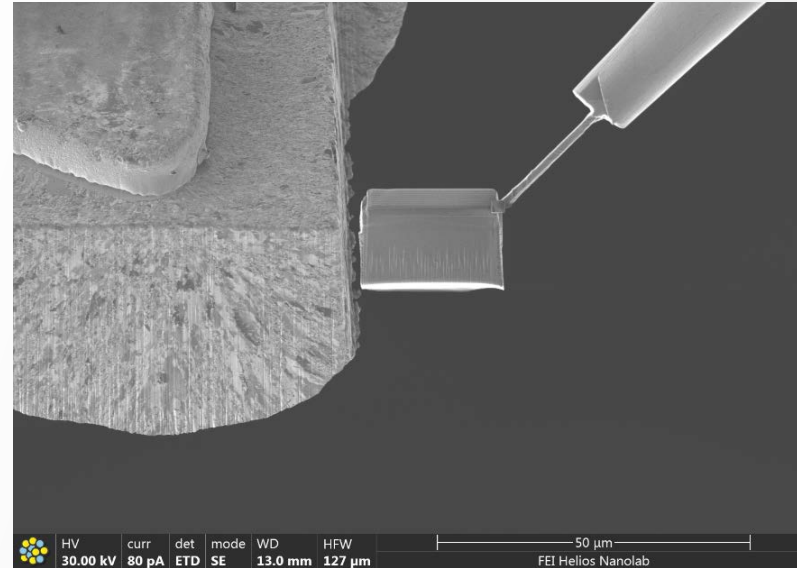


TEM Sample Preparation and AutoTEM 4 & 5

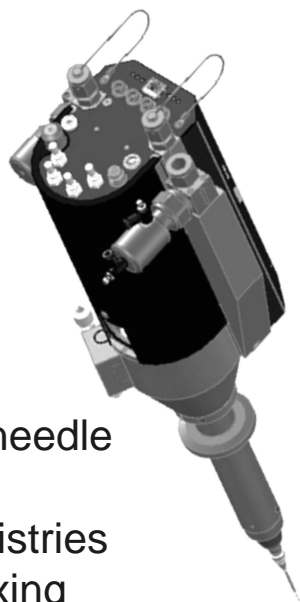
EasyLift



- ## EasyLift
- Fully integrated micromanipulator
 - Motorized XYZ, optional rotation
 - Precise, reliable movement
 - Controls built into the microscope UI
 - Simple needle exchange and alignment
 - Automation – Control incorporated into AutoTEM, iFast, and AutoScript



Gas Injection Systems: Single & MultiChem



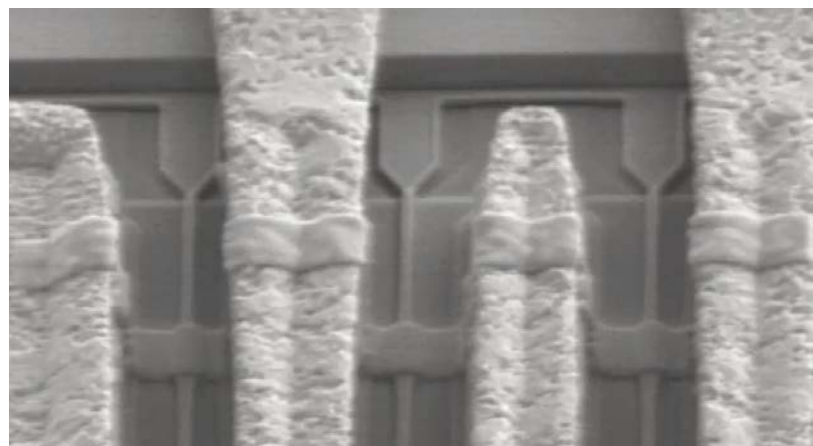
Multi-Chem

- Gas mixing
- Flexible, on-the-fly needle positioning
- Holds up to 6 chemistries
- Back pumped mixing chamber

Single GIS for dedicated applications

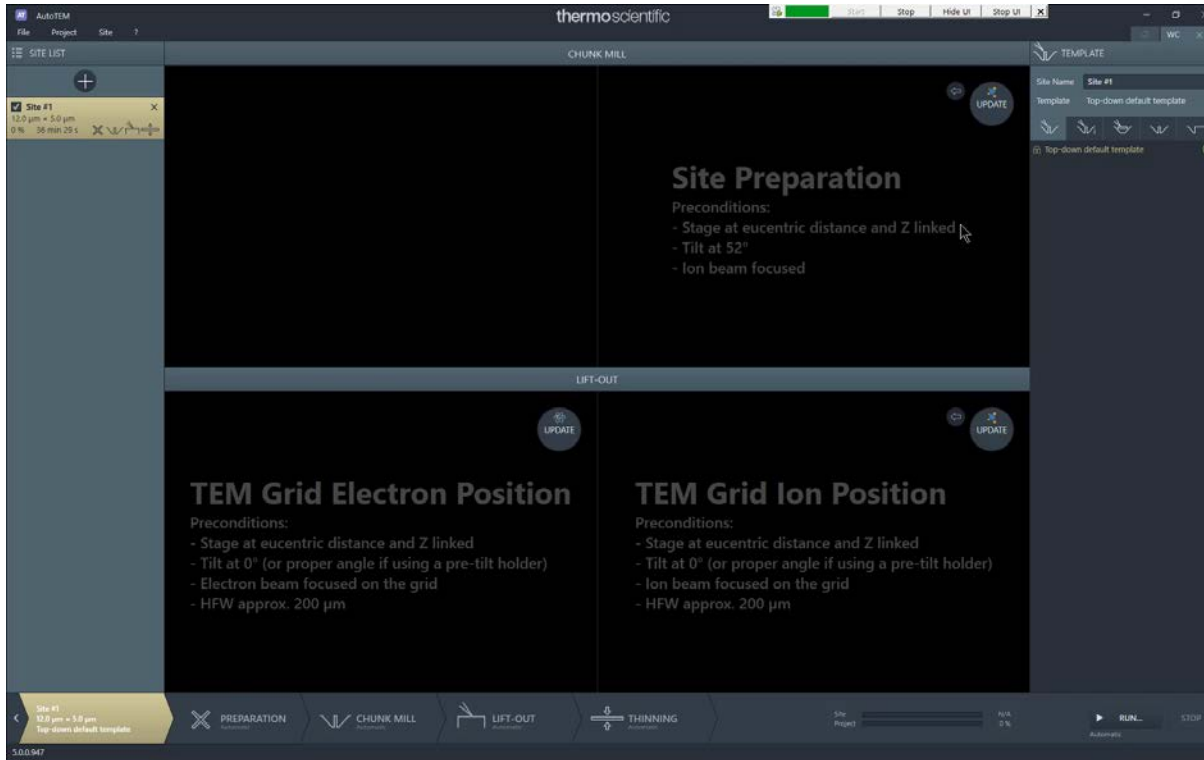


MultiChem	Single GIS
<ul style="list-style-type: none"> • Platinum Deposition • Tungsten Deposition • Carbon Deposition • Enhanced Etch • Insulator Enhanced Etch • Insulator Deposition II • Selective Carbon Mill • Delineation Etch • Dx • Oxygen Injection 	<ul style="list-style-type: none"> • Platinum Deposition • Tungsten Deposition • Carbon Deposition • Gold Deposition • Insulator Deposition II or III • Enhanced Etch • Insulator Enhanced Etch • Selective Carbon Mill • Delineation Etch • Dx
	<ul style="list-style-type: none"> • Cobalt Deposition • Palladium Deposition • Iron Deposition

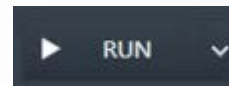


S/TEM Sample preparation workflow

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

AutoTEM 5 – Unattended, fully automated sample preparation for everyone



Requires:
Helios 5,
Piezo stage,
AutoTEM 5 &
Automation Science

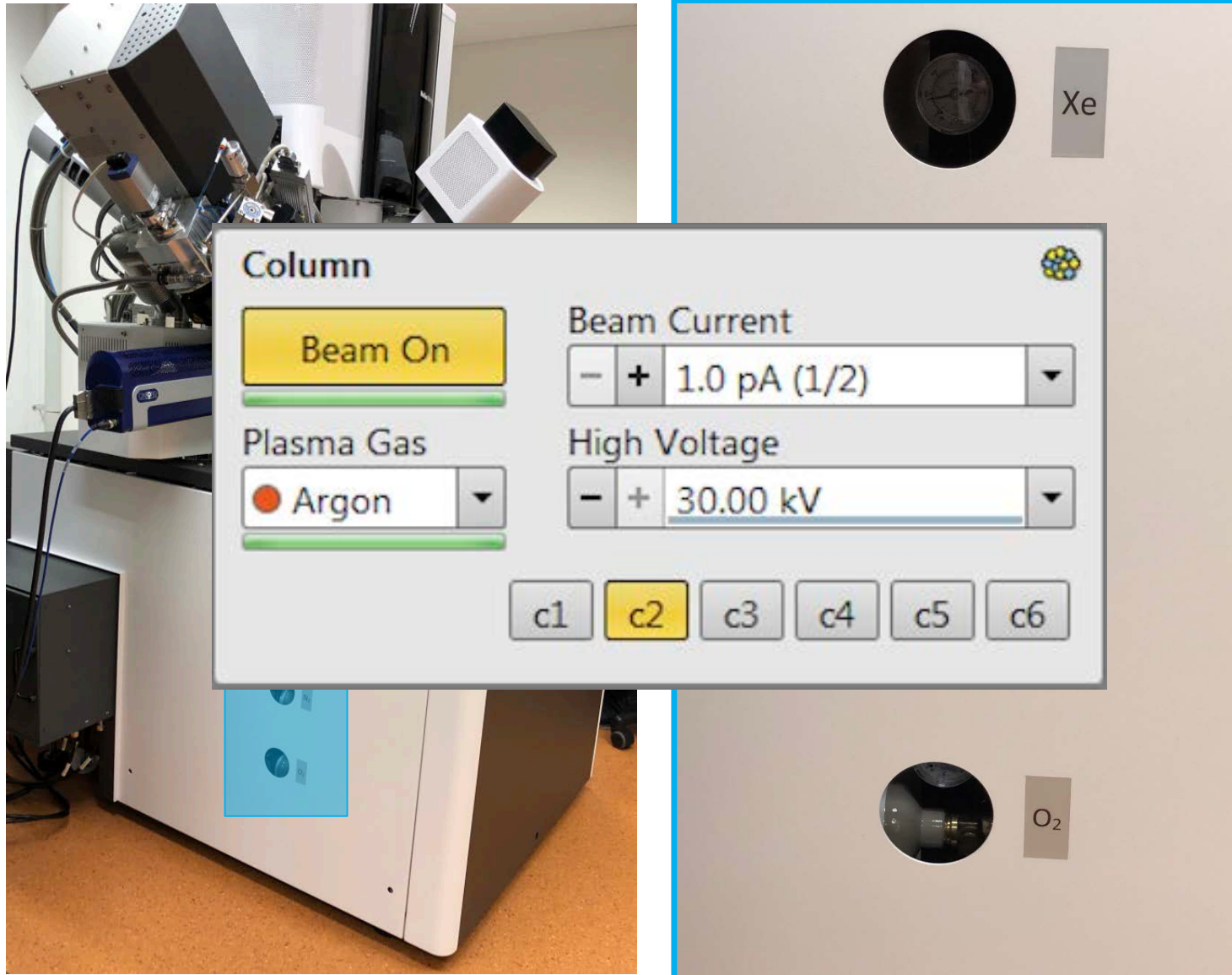
Helios 5 PFIB & Hydra continue to outperform

What is NEW?

- Upgrade to Helios 5 platform (Flash, SEM alignments, Automated FIB alignments to 65nA)
- Lowered FIB current to 500V, improving TEM sample quality
- Support AutoTEM 5 → Side/top of post attachment & automation
- Spin Mill holders and workflow



Helios Hydra DualBeam



Helios Hydra DualBeam

Helios G4 PFIB

- Monochromated SEM
- Highest performance Xe⁺ FIB
- Advanced automation capabilities

+

Multiple Ion Species technology

- Available ion species – Xe, Ar, O, N
- Gas switching is fully electronic
 - Fast switching <10min
 - Only software operation
 - Requires no mechanical actions

Helios Hydra – Highest quality Ga⁺ free TEM sample preparation

Supported by AutoTEM 5 as in other Helios

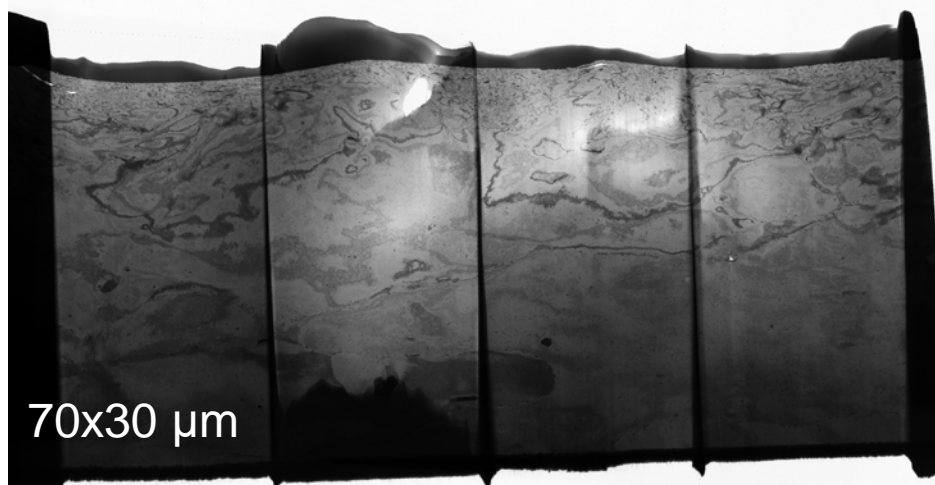
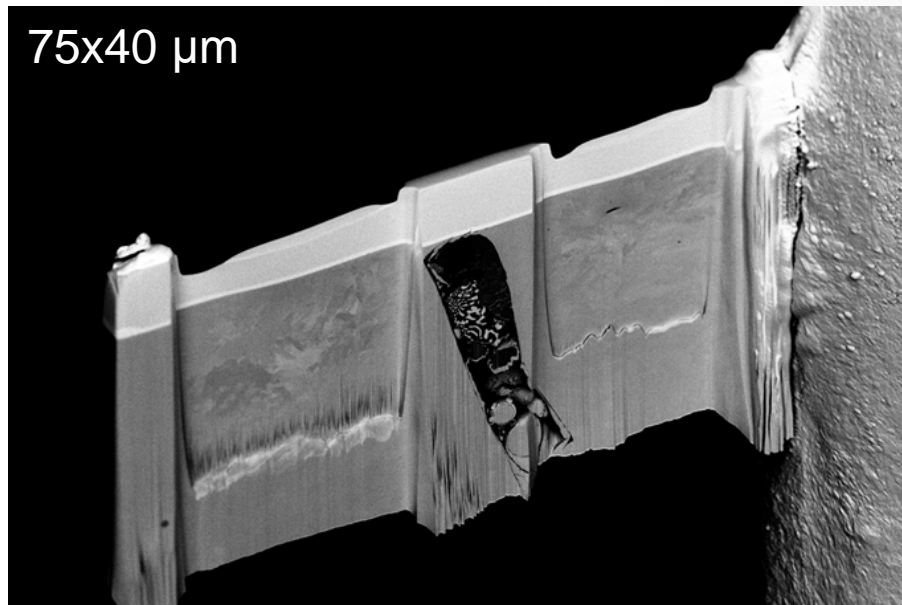
Wide range of materials:

- Si
- Diamond
- GaAs
- Single crystal GaN
- Al on Si
- GaN
- Steel
- Vanadium
- Al₂O₃
- BN/Al₂O₃/TiCN/AlN
- SrTiO₃
- La₂CoMnO₆
- AlTi alloys

And more...

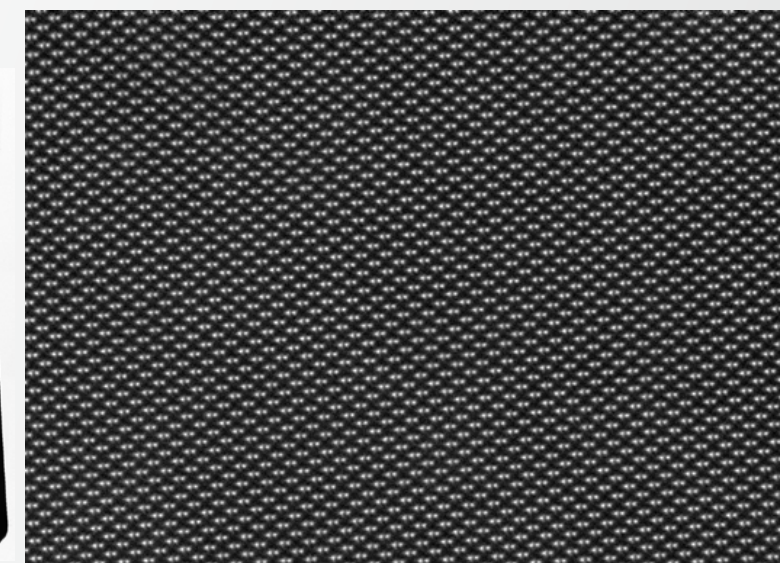
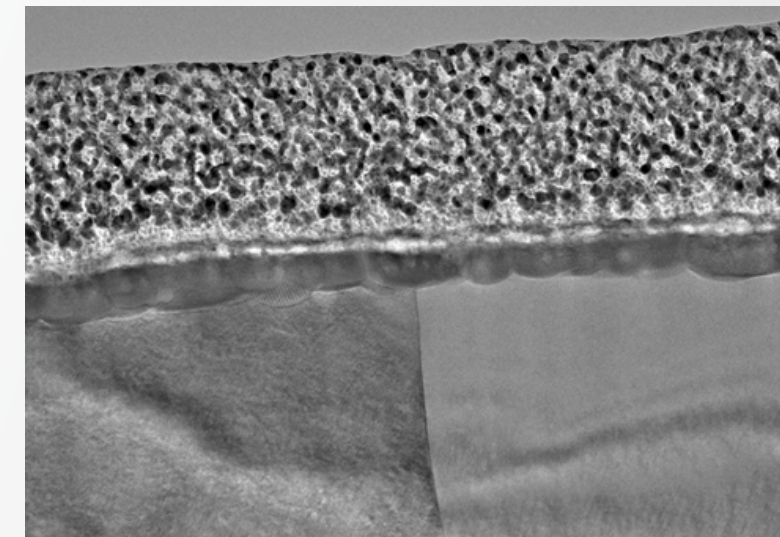
Large area samples, multiple windows

75x40 μm



70x30 μm

Highest quality Ga⁺-free TEM results



Helios Hydra – Comparison of S/TEM samples prepared by different ion species

Ga⁺



Xe⁺



Ar⁺



2 nm

Samples: GaAs. 300kV S/TEM results.

Highest quality Ga⁺ free TEM sample preparation using Xe⁺, Ar⁺ or O⁺ ions at 2kV

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- **Helios 5 Hydra** – Multiple ion species FIB for both large cuts and the ultimate clean TEM samples

Results in a snap:
Speeding up data acquisition
and improving data quality
for all users.

Veillez contacter

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Aurélien Kreis (aurelien.kreisz@thermofisher.com) ou
moi (daniel.phifer@thermofisher.com) pour plus
d'informations.

Thank you

