

# Helios 5 UX DualBeam

## Enabling breakthrough failure analysis with DualBeam technology—faster and easier than ever before

The Helios 5 UX DualBeam sets new standards in sample preparation and three-dimensional characterization through the most advanced focused ion- and electron-beam performance, exclusive software and an unprecedented level of automation and ease of use.

The Thermo Scientific™ Helios™ 5 UX is the fifth generation of the industry-leading Helios DualBeam™ family. It is designed to closely meet the needs of failure analysis engineers, combining the innovative Thermo Scientific™ Elstar™ Electron Column with high-current UC+ technology for extreme high-resolution imaging and highest materials contrast with the best-in-class Thermo Scientific™ Phoenix™ Ion Column with superior low-voltage performance for the fastest, easiest, and most precise high-quality sample preparation. In addition to the most advanced electron and ion optics, the Helios 5 UX DualBeam incorporates a suite of state-of-the-art technologies that enable simple and consistent high-resolution S/TEM sample preparation, as well as the highest-quality subsurface and 3D characterization, even on the most challenging samples.

### Highest-quality, ultra-thin TEM sample preparation

Failure analysis engineers constantly face new challenges that require highly localized characterization of increasingly complex samples with ever smaller features. The latest technological innovations of the Helios 5 UX DualBeam, in combination with comprehensive, easy-to-use software and Thermo Fisher Scientific application expertise, allow for the fastest and easiest preparation of site-specific, ultra-thin HR-STEM samples for a wide range of materials. In order to achieve the highest-quality results, final polishing with very low energy ions is required to minimize surface damage on the sample. Our most advanced Phoenix Focused Ion Beam (FIB) Column not only delivers high-resolution imaging and milling at high voltages, but now also expands unmatched FIB performance down to accelerating voltages as low as 500 V, enabling the creation of ultra-thin TEM lamellae with sub-nm damage layers.

### Key benefits

**Fastest and easiest preparation** of the highest-quality, site-specific, ultra-thin TEM samples using the new Phoenix Ion Column with unmatched low-voltage performance

**Shortest time to extreme high-resolution nanoscale information** using best-in-class Elstar Electron Column

**Reveal the finest details** with the next-generation UC+ monochromator technology with higher current, enabling sub-nanometer performance at low energies

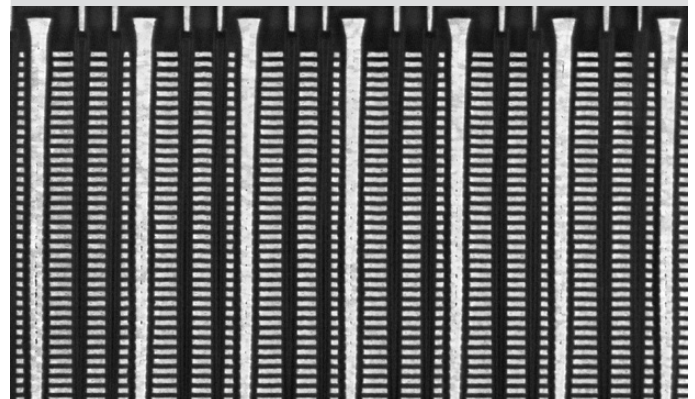
**The most complete sample information** with sharp, refined, and charge-free contrast obtained from up to seven integrated in-column and below-the-lens detectors

**Access the highest quality, multi-modal subsurface and 3D information** with the most precise targeting of the region of interest using optional Thermo Scientific™ Auto Slice & View™ 4 (AS&V4) Software

**Fast, accurate and precise** milling and deposition of complex structures with critical dimensions of less than 10 nm

**Precise sample navigation** tailored to individual application needs thanks to the high stability and accuracy of 150 mm Piezo stage and in-chamber Thermo Scientific™ Nav-Cam™ navigation camera

**Artifact-free imaging** based on integrated sample cleanliness management and dedicated imaging modes such as Thermo Scientific™ SmartScan™ and DCFI Modes



Low-voltage, cross-section image of a VNAND device produced with the Helios 5 UX DualBeam.

## Highest resolution with the most precise materials contrast

Helios 5 UX DualBeam features an ultra high-brightness electron source with next-generation UC+ monochromator technology to reduce the beam energy spread below 0.2 eV for beam currents up to 100 pA. This enables sub-nanometer resolution and highest surface sensitivity at low landing energies. The innovative Elstar Electron Column provides the foundation of the system's unprecedented high-resolution imaging capability. It offers the best nanoscale details, using the widest range of working conditions, whether operating at 30 keV in S/TEM mode to access structural information or at lower energies to obtain charge-free, detailed information from the surface. With its unique triple-detection system located inside the column and its immersion mode, the system is designed for simultaneous detector acquisition for angular and energy-selective SE and BSE imaging. Fast access to the most detailed nanoscale information is guaranteed, not only top-down, but also on tilted specimens or cross sections. Additional below-the-lens detectors and a beam-deceleration mode ensure the fast and easy simultaneous collection of all signals to reveal the smallest features in material surfaces or cross sections. Fast, accurate, and reproducible results are obtained thanks to Elstar Electron Column's unique design, which includes advanced auto alignments, constant power lenses for higher thermal stability and electrostatic scanning for higher deflection linearity and speed.

## Highest-quality subsurface and 3D information

Subsurface or three-dimensional characterization is often required to better understand the structure and properties of a sample. The Helios 5 UX DualBeam with optional Auto Slice & View Software allows for the highest-quality, fully automated acquisition of multi-modal 3D datasets, including, among others, BSE imaging for maximum materials contrast, energy dispersive spectroscopy (EDS) for compositional information and electron backscatter diffraction (EBSD) for microstructural and crystallographic information. Combined with Thermo Scientific™ Avizo™ Software for visualization, it delivers a unique workflow solution for advanced 3D characterization and analysis at nanometer scale.

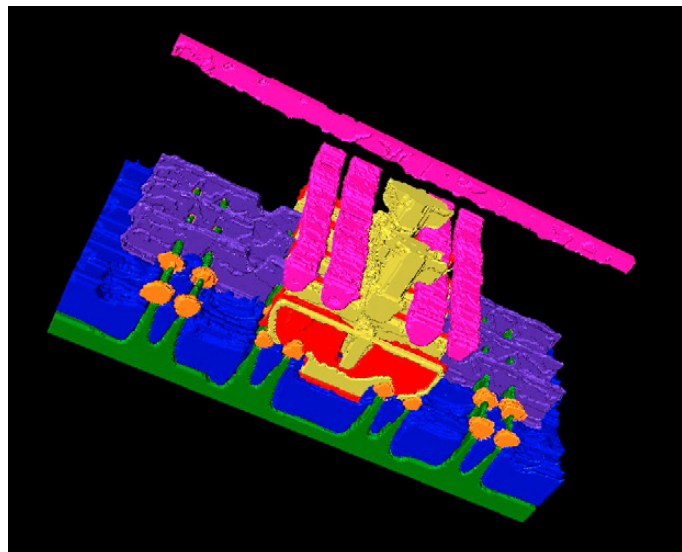
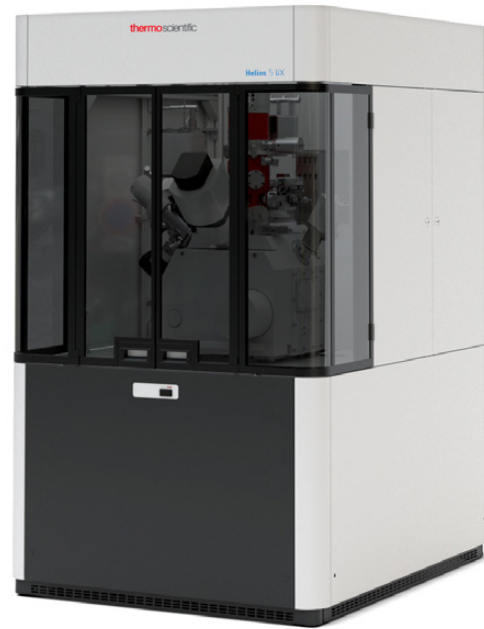


Figure 2. 3D reconstruction of 14 nm Fin Fet device completed using the Avizo™ software. Individual images were acquired with a Helios 5 utilizing Auto Slice&View software.



## Productivity for all users

Failure analysis engineers of all experience levels will benefit from the Helios 5 UX DualBeam's streamlined performance. The Helios 5 UX DualBeam includes the most advanced workflows from Thermo Fisher Scientific, including a Thermo Scientific™ QuickLoader™ Vacuum Technology-compatible QuickFlip holder for high-throughput, inverted TEM sample preparation workflow and advanced auto alignments and system optimizations, ASV4 Software, automated multi-site cross-section sample preparation and imaging and our semi-automated guided TEM sample preparation, liftout and attach workflow for unmatched ease of use and throughput. This interactive recipe guides users through the process of creating high-quality samples in less than an hour for top-down, inverted or plan-view sample preparation workflows.

## Enabling Flexibility

Smart Alignments actively maintain the system for optimum performance, ready to deliver the highest performance for all users. Patterning improvements ensure the highest quality depositions at any condition, and an extensive automation suite make the Helios 5 the most advanced DualBeam ever assembled— all backed by Thermo Fisher expert application and service support.

## Electron optics

- Elstar Column for extreme high-resolution field emission SEM:
  - Immersion magnetic objective lens
  - High-stability Schottky field emission gun to provide stable high-resolution analytical currents
  - UC+ monochromator technology
- 60-degree dual objective lens with pole piece protection allows tilting larger samples
- Automated heated apertures to ensure cleanliness and touch-free aperture changes
- Electrostatic scanning for higher deflection linearity and speed
- Thermo Scientific™ ConstantPower™ Lens Technology for higher thermal stability
- Integrated Fast Beam Blanker
- Beam deceleration with stage bias from 0 V to -4 kV
- Minimal source lifetime: 12 months

## Electron beam resolution

- At optimum WD:
  - 0.6 nm at 30 kV STEM
  - 0.6 nm from 30 kV to 2 kV
  - 0.7 nm at 1 kV
  - 1.0 nm at 500 V
- At coincident WD:
  - 0.6 nm at 15 kV
  - 1.0 nm at 2 kV
  - 1.2 nm at 1 kV

## Electron beam parameter space

- Electron beam current range: 0.8 pA up to 100 nA
- Accelerating voltage range: 350 V–30 kV
- Landing energy range: 20 eV–30 keV
- Maximum horizontal field width: 2.3 mm at 4 mm WD

## Ion optics

Phoenix Ion Column with superior high-current and low-voltage performance

- Ion beam current range: 1 pA–65 nA
- Accelerating voltage range: 500 V–30 kV
- Two-stage differential pumping
- Time-of-flight (TOF) correction
- 15-position aperture strip
- Maximum horizontal field width: 0.7 mm at beam coincidence point
- Minimum source lifetime: 1,000 hours

Ion beam resolution at coincident point

- 4.0 nm at 30 kV using preferred statistical method
- 2.5 nm at 30 kV using selective edge method
- 500 nm at 500 V using preferred statistical method

## Detectors

- Elstar in-lens SE/BSE detector (TLD-SE, TLD-BSE)
- Elstar in-column SE/BSE detector (ICD)
- Elstar in-column BSE detector (MD)
- Everhart-Thornley SE detector (ETD)
- IR camera for viewing sample/column
- High-performance ion conversion and electron (ICE) detector for secondary ions (SI) and electrons (SE)
- In-chamber Nav-Cam™ Camera for sample navigation
- Retractable, low-voltage, high-contrast, solid-state backscatter electron detector (DBS)\*
- Retractable STEM 3+ detector with BF/ DF/ HAADF segments\*
- Integrated beam current measurement

## Stage and sample

Stage type: High-precision, five-axis motorized, with XYR axis Piezo-driven:

- XY range: 150 mm
- Z range: 10 mm
- Rotation:  $n \times 360^\circ$  (endless)
- Tilt range:  $-10^\circ$  to  $+60^\circ$
- XY repeatability: 1  $\mu\text{m}$
- Max sample height: Clearance 55 mm to eucentric point
- Max sample weight at  $0^\circ$  tilt: 500 g (including sample holder)
- Max sample size: 150 mm with full rotation (larger samples possible with limited rotation)
- Eucentricity: Compucentric rotation and tilt

## Vacuum system

- 1  $\times$  210 l/s TMP
- 1  $\times$  PVP (dry pump)
- 4  $\times$  IGP (total for electron column and ion column)
- Chamber vacuum:  $<2.6 \times 10^{-6}$  mbar (after 24 hours pumping)
- Evacuation time:  $<5$  minutes

## Chamber

- E- and I-beam coincidence point at analytical WD (4 mm SEM)
- Angle between electron and ion columns:  $52^\circ$
- Ports: 21
- Inside width: 379 mm
- Integrated plasma cleaner for removing sample contamination

## Sample holders

- High-resolution, multi-stub mount holder
- Vise specimen holder to clamp irregular, large or heavy specimens to the specimen stage\*
- Universal mounting base (UMB) for stable, flexible mounting of many combinations of samples and holders, such as flat and pretilt stubs and row holders for TEM grids\*
- Various wafer and custom holders available by request\*

## Image processor

- Dwell time range from 25 ns–25 ms/pixel
- Up to  $6144 \times 4096$  pixels
- File type: TIFF (8, 16, 24-bit), BMP or JPEG standard
- Single view or 4-quadrant image display
- SmartSCAN™ Mode (256 frame average or integration, line integration and averaging, interlaced scanning)
- DCFI (Drift Compensated Frame Integration) Mode

## System control

- 64-bit GUI with Windows® 10, keyboard, optical mouse
- Up to four live images showing independent beams and/or signals. Live color signal mixing
- Local language support: Check with your local Thermo Fisher Scientific sales representative for available language packs
- Two 24-inch widescreen monitors (1920 $\times$ 1200 pixels) for system GUI and full-screen image
- Microscope controlling and support computers seamlessly sharing one keyboard, mouse and monitors
- Joystick\*
- Multifunctional control panel\*
- Remote control and imaging\*

## Supporting software

- Beam per view graphical user interface concept, with up to four simultaneously active quads
- Thermo Scientific SPI™, iSPI™, iRTM™ and FIB Immersion Modes for advanced, real-time SEM and FIB process monitoring and endpointing
- Patterns supported: alpha-numeric text, lines, rectangles, polygons, circles, donut, cross section and cleaning cross section
- Directly imported BMP file or stream file for 3D milling and deposition
- Material file support for minimum loop time, beam tuning and independent overlaps
- Image registration and sample navigation

## Accessories (optional)

- GIS (Gas Injection System) – Solutions:
  - Single GIS: up to five independent units for enhanced etching or deposition
  - Thermo Scientific™ MultiChem™: up to six chemistries on the same unit for advanced etching and deposition controls
- GIS – Beam chemistry options\*\*
  - Platinum deposition
  - Tungsten deposition
  - Carbon deposition
  - Insulator deposition II
  - Gold deposition
  - Enhanced Etch™ (iodine, patented)
  - Insulator enhanced etch (XeF<sub>2</sub>)
  - Delineation Etch™ (patented)
  - Selective carbon mill (patented)
  - Empty crucibles for Thermo Fisher Scientific-approved user supplied materials
  - More beam chemistries available upon request
- Manipulators:
  - Thermo Scientific™ EasyLift™ NanoManipulator for precise *in situ* sample manipulation

- Other manipulators available upon request
- FIB Charge Neutralizer
- Analysis: EDS, EBSD, WDS,
- QuickLoader Vacuum Technology: loadlock for fast sample transfer
- Cryo solution for DualBeam
  - Exclusive Thermo Scientific™ CryoMAT Upgrade for cryo applications
  - Solutions from external vendors
- Acoustic enclosure
- Thermo Scientific™ CryoCleaner Decontamination Device

## Software options\*

- Semi-automated TEM sample preparation workflow
- Thermo Scientific™ iFast™ Software advanced automation suite for DualBeam
- Thermo Scientific™ MAPS™ Software for automatic acquisition of large images and optional correlative work
- Thermo Scientific™ AutoTEM™ Software wizard automated sample preparation with section wizard
- Thermo Scientific™ NanoBuilder™ Software – advanced proprietary CAD-based (GDSII) solutions for FIB and beam deposition-optimized nanoprototyping of complex structures
- Auto Slice and View Software – automated sequential mill and view to collect series of image slices, EDS or EBSD maps for 3D reconstruction
- Avizo Software for 3D reconstruction and analysis
- Synopsis CAD Navigation Interface
- Web-enabled data archive software
- Advanced image analysis software

## Consumables (partial list)

- Replacement Ga-ion source
- Replacement Schottky electron source module
- Aperture strips for electron and ion columns
- GIS refill kit

## Warranty and training

- 1 year warranty
- Choice of service maintenance contracts
- Choice of operation/application training contracts

## Installation requirements

(Refer to preinstallation guide for detailed data)

- Power:
    - Voltage 100–240 V AC
    - Frequency 50 or 60 Hz (± 1%)
    - Power consumption: <3.0 kVA for basic microscope
  - Earth resistance: <0.1 Ω
  - Environment:
    - Temperature 20°C ± 3 °C
    - Relative humidity below 80% RH, 20°C
    - Stray AC magnetic fields: <75 nT a-synchronous, <225 nT synchronous for line times >20 ms (50 Hz mains) or >17 ms (60 Hz mains)
  - Minimum door size: 0.9 m wide × 2.0 m high
  - Weight: column console 950 kg
  - Dry nitrogen recommended for venting
  - Compressed air 4 to 6 bar, clean, dry and oil-free
  - System chiller
  - Acoustics: site survey required as acoustic spectrum relevant.
  - Optional system acoustic enclosure
  - Floor vibrations: site survey required as floor spectrum relevant
  - Optional active vibration isolation table
- ## Documentation and support
- On-line help
  - Prepared for Thermo Scientific™ RAPID™ Service (remote diagnostic support)

\* Optional

\*\* Some Beam Chemistries may be available only on the MultiChem or on the Single GIS

Find out more at [thermofisher.com/EM](http://thermofisher.com/EM)