

# Helios 5 UX DualBeam for Semiconductors

## Enabling breakthrough innovations in the semiconductor industry with DualBeam Technology

The Helios 5 UX DualBeam sets new standards in sample preparation and three-dimensional characterization through 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 DualBeam is designed to closely meet the needs of failure analysis engineers. The Helios 5 UX DualBeam combines the innovative Thermo Scientific Elstar™ Electron Column with high-current UC+ technology (for extremely high-resolution imaging and high materials contrast) with the Thermo Scientific Phoenix™ Ion Column (with excellent low-voltage performance) for fast, easy, and precise high-quality sample preparation. In addition to advanced electron and ion optics, the Helios 5 UX DualBeam incorporates a suite of industry-leading technologies that enable simple and consistent high-resolution S/TEM sample preparation, as well as high-quality subsurface and 3D characterization, even on highly challenging samples.

### High-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 fast and easy preparation of site-specific, ultra-thin, high-resolution (scanning) transmission electron microscopy (S/TEM) samples for a wide range of materials. In order to obtain high-quality results, final polishing with very low energy ions is required to minimize surface damage on the sample. Our advanced Phoenix Focused Ion Beam (FIB) Column not only delivers high-resolution imaging and milling at high voltages but extends high-quality 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

Fast and easy preparation of high-quality, site-specific, ultra-thin TEM samples thanks to the excellent low-voltage performance of the Phoenix Ion Column

Quickly obtain extremely high-resolution nanoscale information using the innovative Elstar Electron Column

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

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

Access high-quality, multi-modal subsurface and 3D information with precise targeting of the region of interest using optional Auto Slice & View 4 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 the 150 mm Piezo stage and in-chamber navigation camera

Artifact-free imaging based on integrated sample cleanliness management and dedicated imaging modes such as SmartScan and DCFI

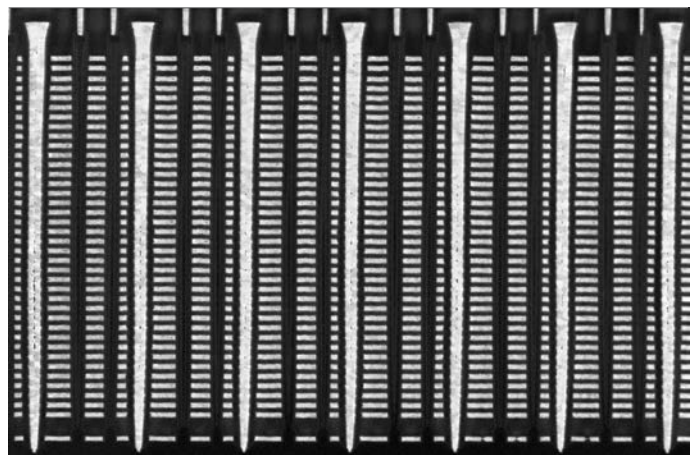


Figure 1. Low-voltage cross-section image of a VNAND device produced with the Helios 5 UX DualBeam.

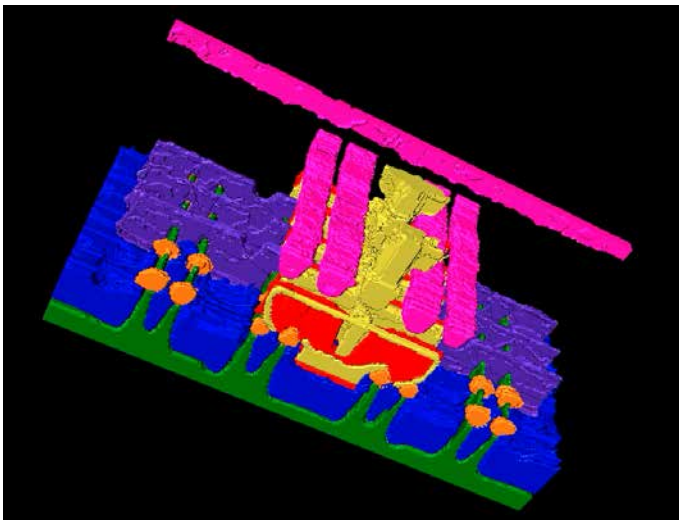


Figure 2. 3D reconstruction of a 14-nm FinFET device generated with Avizo Software. Individual images were acquired with a Helios 5 DualBeam and Auto Slice & View 4 Software.

### High-resolution with precise materials contrast

The Helios 5 UX DualBeam features an ultra-high-brightness electron source with next-generation UC+ monochromator technology that reduces the beam energy spread below 0.2 eV for beam currents up to 100 pA. This enables sub-nanometer resolution and high surface sensitivity at low landing energies. The Elstar Electron Column provides the foundation of the system's high-resolution imaging capability. It offers excellent nanoscale details across a wide 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 secondary electron (SE) and backscattered electron (BSE) imaging. Access detailed nanoscale information, not only top-down, but also on tilted specimens or cross-sections. Additional below-the-lens detectors and a beam-deceleration mode ensure simultaneous collection of all signals to reveal nanoscale features in material surfaces or cross-sections. Fast, accurate, and reproducible results are obtained from the Elstar Electron Column's unique design, which includes advanced auto-alignments, constant power lenses for higher thermal stability, and electrostatic scanning for high deflection linearity and speed.

### High-quality subsurface and 3D information

Subsurface or 3D characterization are often required to better understand the structure and properties of a sample. The optional Thermo Scientific Auto Slice & View™ 4 Software for high-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, the Helios 5 UX DualBeam delivers a unique workflow solution for advanced 3D characterization and analysis at nanometer scale.

### Productivity for all

Failure analysis engineers of all experience levels will benefit from the Helios 5 UX DualBeam's streamlined performance, and our most advanced workflows such as Thermo Scientific™ QuickLoader™ Vacuum Technology, Auto Slice & View 4 Software, and our semi-automated TEM sample preparation workflows.

QuickLoader Technology is compatible with QuickFlip holders for high-throughput, inverted TEM sample preparation workflows, advanced auto-alignments, and system optimizations.

Auto Slice & View 4 Software offers automated multi-site cross-section sample preparation and imaging.

Our semi-automated, guided TEM sample preparation, lift-out, and attach workflows enable excellent ease of use and throughput. The interactive recipe guides you 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 in an optimal state to deliver high performance for all users. Patterning improvements ensure high-quality depositions at nearly any condition, and an extensive automation suite make the Helios 5 DualBeam one of the most advanced FIB-SEM instruments ever assembled—all backed by expert application and service support from Thermo Fisher Scientific.

### Full 200-mm wafer capability

The high-precision 150-mm stage with  $\leq 1 \mu\text{m}$  accuracy allows for safe, precise, and automated XY and rotation navigation across the whole  $\leq 200\text{-mm}$  wafer area, including inspection of wafer edges. Combining Thermo Scientific™ iFast™ Software with the “Wafer Defects Navigation” package extends navigational functionality with automated recipes for SEM imaging, cross-section or lift-out sample preparation, and serial-sectioning tomography (Slice & View).



## Specifications

### Electron optics

- Elstar extreme high-resolution field emission SEM column with:
  - Magnetic immersion 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 of larger samples
- Automated heated apertures to ensure cleanliness and touch-free aperture exchange
- 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
- Minimum 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 (ICD)
- At coincident point:
  - 0.6 nm at 15 kV
  - 1.0 nm at 2 kV

### 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
- Max horizontal field width: 0.7 mm at beam coincidence pt.
- Min source lifetime: 1,000 hours to eucentric point
- Max sample weight at 0° 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

### 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 in-chamber electron and ion detector (ICE) for secondary ions (SI) and electrons (SE)\*
- In-chamber Thermo Scientific™ Nav-Cam™ Camera for sample navigation
- Retractable, low-voltage, high-contrast, directional, solid-state backscatter electron detector (DBS)\*
- Retractable STEM 3+ detector with BF/ DF/ HAADF segments\*
- Integrated beam current measurement

### Stage and sample

- High-precision five-axis motorized stage with Piezo-driven XYR axis:
  - XY range: 150 mm
  - XY repeatability: 1 µm
  - Max sample height: Clearance 55 mm
  - Z range: 10 mm
  - Rotation: 360° (endless)
  - Tilt range: -10° to +60°

### Vacuum system

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

### Chamber

- E- and I-beam coincidence point at analytical WD (4 mm SEM)
- 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/pixel to 25 ms/pixel
- Up to 6144 × 4096 pixels
- File type: TIFF (8-, 16-, 24-bit), BMP or JPEG standard
- Single view or 4-quadrant image display
- SmartSCAN Modes (256 frame average or integration, line integration and averaging, interlaced scanning)
- DCFI (Drift Compensated Frame Integration)

### 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 representatives for available language packs
- Two 24-inch widescreen monitors (1920×1200 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™ (simultaneous FIB patterning and SEM imaging), iSPI™ (intermittent SEM imaging and FIB patterning), iRTM™ (integrated real time monitor) 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, 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\*

- GIS (Gas Injection System) Solutions:
  - Single GIS: up to 5 independent units for enhanced etching or deposition
  - Thermo Scientific™ MultiChem™ Gas Delivery System: 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
  - Thermo Scientific™ Enhanced Etch™ Gas Chemistry Solution (iodine, patented)
  - Insulator enhanced etch (XeF<sub>2</sub>)
  - Thermo Scientific™ Delineation Etch™ Gas Chemistry Solution (patented)
  - Selective carbon mill (patented)
  - Empty crucibles for Thermo Fisher Scientific-approved user-supplied materials
  - More beam chemistries available upon request
- Thermo Scientific™ EasyLift™ NanoManipulator for precise *in situ* sample manipulation (other manipulators available upon request)
- FIB charge neutralizer
- Analysis: EDS, EBSD, WDS
- Thermo Scientific™ QuickLoader™ Vacuum Technology: Loadlock for fast sample exchange without breaking system vacuum
- Exclusive Thermo™ Scientific CryoMAT™ Kit for cryo applications
- Cryo solutions from external vendors
- Thermo Scientific™ Acoustic Enclosure
- Thermo Scientific™ CryoCleaner™ Decontamination Device

### Software options\*

- Semi-automated TEM sample preparation workflow
- Thermo Scientific™ iFast™ Software advanced automation suite for DualBeam including Wafer Defect Navigation
- 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™ AutoScript™ 4 Software: advanced

automation suite for DualBeams

- Thermo Scientific™ Maps™ Software for automatic acquisition of large images and optional correlative work
- Thermo Scientific™ NanoBuilder™ Software: advanced proprietary CAD-based (GDSII) solutions for FIB and beam deposition optimized nanoprototyping of complex structures
- Thermo Scientific™ Auto Slice and View™ 4 Software – automated sequential mill and view to collect series of image slices, EDS or EBSD maps for 3D reconstruction
- Thermo Scientific™ Avizo™ Software for 3D reconstruction and analysis
- Thermo Scientific™ NEXS for CAD navigation
- 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 ( $\pm$  1%)
  - Power consumption: <3.0 kVA for basic microscope
- Earth resistance: <0.1  $\Omega$

- Environment:
  - Temperature 20°C  $\pm$  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  $\times$  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

- Online user guidance
- User operation manual
- Prepared for Thermo Scientific™ RAPID™ Service (remote diagnostic support)

\* *Optional*

\*\* *Some beam chemistries may be available only on the MultiChem or Single GIS*

 Learn more at [thermofisher.com/helios-5](https://thermofisher.com/helios-5)

**thermo** scientific

For research use only. Not for use in diagnostic procedures. For current certifications, visit [thermofisher.com/certifications](https://thermofisher.com/certifications)

© 2022 Thermo Fisher Scientific Inc. All rights reserved. All trademarks are the property of Thermo Fisher Scientific and its subsidiaries unless otherwise specified. DS0285-EN-07-2022