

Metrios DX TEM

High volume automated S/TEM imaging and metrology reimaged

Fast, accurate and precise data. The Metrios DX is an 80- 200kV scanning/transmission electron microscope designed from the ground-up to deliver repeatable TEM and S/TEM-based imaging, analytics and gauge capable metrology results at an unprecedented throughput level.

With a unique combination of proven technology and innovative new features, the Thermo Scientific™ Metrios™ DX TEM is the platform of choice for semiconductor and memory environments with a need for higher volumes of accurate and precise measurements on increasingly more complex structures and shrinking geometries.

Metrios DX TEM has been designed to provide “first-time-right” data, at a much lower cost per sample when compared to conventional S/TEM systems. The Metrios DX TEM provides the ultimate in throughput while minimizing beam damage. The exclusive 1.8 srad solid angle of the Thermo Scientific Dual-X™ EDS system doubles the x-ray counts over a Super-X system. The automated probe-corrector keeps 3rd and higher order aberrations stable for greater than 1 week, while fully automating focus, stigmation, coma, and 3-fold stigmation. Combined with full automation at 80kV the Metrios DX TEM delivers a 4X improvement in EDS throughput while drastically minimizing beam damage compared to Super-X running at 200kV.

In addition to new hardware, the Metrios DX TEM comes with new software features to improve time to data. Flexible Image Taker (FIT+) enables automation with minimum human interaction on any type of structure without any recipe modification. User can define regions of interest for TEM, S/TEM and EDS acquisitions on multiple samples and FIT+ will acquire the data automatically. This allows a single operator to run multiple tools in parallel, while the Metrios DX TEM collects the data and uploads to the Image Viewer database.

The Metrios DX TEM is designed with unprecedented ease of use, and is ideal for both experienced microscopists and

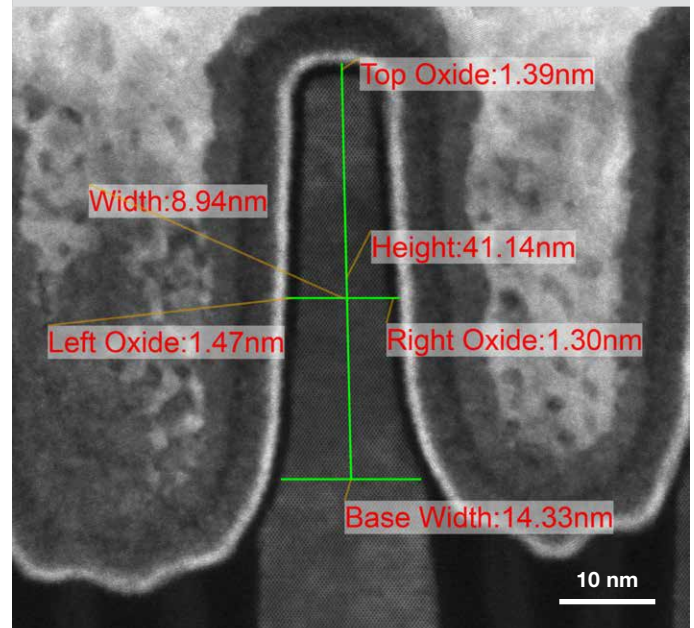
Key benefits

Consistent, repeatable, precise, designed from the ground-up to deliver repeatable TEM and S/TEM-based imaging, analytics and gauge capable metrology free of operator bias

Guaranteed metrology accuracy, less than 1% combined error in distortion and magnification calibration for both TEM and S/TEM

Automated EDS and hybrid metrology, acquire and quantify EDS data with automation. Use elemental contrast on key critical dimensions to extend STEM

Workflow connectivity, critical process data is tracked through sample prep, plucking, and imaging. Metrology can be applied offline to maximize tool acquisition time. All imaging and metrology data is consolidated in a web-based image viewer.





new users. The flexible user interface allows for recipe-driven fully automated metrology and acquisition, semi-automated operation, or manual data acquisition. The combination of automated image acquisition and automated metrology brings a significant improvement to data precision. Metrology can be performed either online or offline.

The Metrios DX TEM uses an automated preventative maintenance (APM) routine to keep the tool aligned and operating consistently at specification. Metrology accuracy is guaranteed to <1% through automated distortion and calibration alignments. The Metrios DX TEM also includes a complete suite of automated acquisition, quantification, and metrology tools that enable EDS metrology for crucial measurements on layers that exhibit poor contrast in TEM or S/TEM.

Fully automated metrology is undertaken using recipes created with a recipe editor based on iFAST™ software, an automation product proven on our DualBeam™ (FIB/SEM) systems. This gives great cross-platform synergy, as current iFAST software users will readily adapt to recipe creation on the Metrios DX TEM.

The Metrios DX TEM also comes equipped with an extensive and highly customizable database utility. All images, EDS data, and metrology are stored, and can be searched, sorted and easily browsed using multiple criteria, both online and offline through Image Viewer. A new Centralized Data Services (CDS) extends the database to allow for complete job tracking from wafer to data by including the Thermo Scientific ExSolve™ and/or Helios™ 1200 System data. This minimizes the decision making time for the user by combining and reporting all the workflow data throughout multiple tools.

In addition to accepting a wide variety of TEM samples prepared by conventional techniques, Metrios DX TEM is part of a fast, complete workflow that includes ExSolve, Helios 1200, and the Thermo Scientific TEMLink150™ Systems.

As part of the workflow, the Metrios DX TEM receives critical job information such as recipe, wafer ID, Lot ID, sample ID and custom fields, from upstream sample prep tools. This capability minimizes human interaction to the bare minimum of just loading the sample and entering a grid ID. Once the grid ID is entered Metrios DX TEM runs automatically with the information received, allowing the user to focus on other tasks.

Additional Features:

- Ultra-stable, high brightness Schottky field emission gun (X-FEG, for more details see separate product data sheet)
- Flexible high tension range: from 80 to 200kV (80, 120, 200kV)
- Environmental enclosure to relax the acoustic and room temperature variation requirements
- Thermo Scientific ConstantPower™ lens design for ultimate thermal stability in mode switches
- Symmetric objective lens with 5.6mm wide pole-piece gap: “space to do more”
- Fully digital system with SmartCam for easy navigation and operation in a normally-lit room
- Automatic apertures for automated operation and reproducible recall of aperture positions during aperture change
- Computerized 5-axis specimen piezo-stage for accurate recall of stored positions, tracking of the areas visited during search, fine focusing, and low specimen drift
- The new piezo-stage allows for movements as fine as 20pm for centering of feature of interest in the field of view
- Tilt range ± 40 degrees in alpha and ± 30 degrees in beta for standard Metrios TEM double tilt holder enables correct orientation of sample substrate
- New cold trap design for up to one week of operation to maximize up-time with a new and convenient fast filling option
- A probe Cs-corrector can be added as an option

EDS Microanalysis Option:

- Dual-X: High-sensitivity, windowless EDS detector system based on SDD technology (patented)
- Detector efficiency: 46 kcps/nA on Si₃N₄ sample
- Energy resolution:
 - ≤ 130 eV for Mn-K α at 10 kcps (output)
 - ≤ 140 eV for Mn-K α at 100 kcps (output)
- 1.8 srad solid angle and 200 mm² total detector area
- Fast mapping: pixel dwell times down to 10 μ s
- High P/B ratio (Fiori number) > 2000
- Excellent in-hole performance (<2.5% spurious peaks)
- Detection of all elements down to boron

Detectors:

- Fischione HAADF STEM Detector (Standard)
- On-axis triple DF2/DF4/BF Detectors (Optional)
- Thermo Scientific Ceta™ 16M 4k × 4k CMOS Camera (Standard)
- Gatan energy filter series (Optional)

Holders:

- Automation-qualified double-tilt holder (Standard)
- Low-background double tilt holder (Optional)
- Tomography holder (Optional)

Installation Requirements:

Please contact your sales representative for a complete pre-installation requirement document!

Metrios DX

High Tension Range (kV)	80-200	
Information Limit 200 kV (nm)	0.11	
	Non-corrected	Probe Corrected*
STEM HAADF Resolution (nm) 200 kV	≤0.164	≤0.083
STEM HAADF Resolution (nm) 200 kV	≤0.31	≤0.11
Metrology precision on MetroCal wafer for horizontal and vertical	≤0.3 nm 3σ	
Electron source	X-FEG	
Ultra-stable electronics and High Tension	Included	
Acoustic enclosure	Included	
Constant power lenses	Included	
Piezo stage	Included	
Probe corrector compatible	Yes	

*For manual use. Specifications are subject to change.

Metrios DX TEM and Nearline Workflow Enable Automated (S)TEM for Process Control and OCD model refinement.

Fast, reliable and large quantities of TEM data are needed in the FAB to reduce the total measurement accuracy (TMU) for OCD model refinement and process control. The data in Figure 1 highlights the power of the Nearline workflow to extend traditional laboratory measurements into in-Fab and near-Fab space using significantly less personnel. In this example, the post-etch process variation from EUV patterning was studied using photo resist type and EUV exposure at a constant focus as the independent variables, see Figure 2. A total of 42 lamellae were prepared on the ExSolve, plucked on the TEMLink, imaged on a Metrios DX system, and measured using an offline workstation in 21 hours. 13,000 critical dimensions from 1,890 devices were measured on a Metrios Offline workstation.

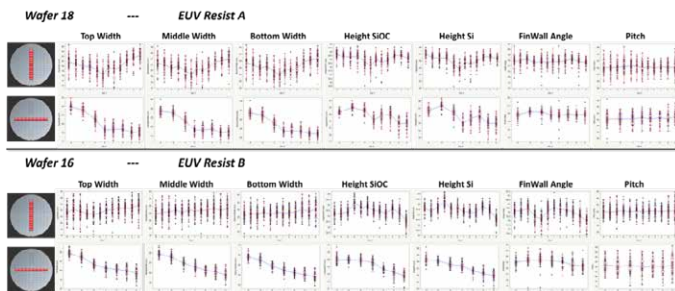


Figure 1: Each graph shows critical dimension measurements from two post-etch wafers that were processed using either a) EUV Resist A or B) EUV resist B. The exposure dose was increased from left to right at a constant focus on each wafer. The critical dimensions are plotted as a function of 21 different Die locations sampled from top to bottom and left to right. The data at each Die location represents a total of 45 devices resulting in 315 CDs per sample and over 13,000 data points.

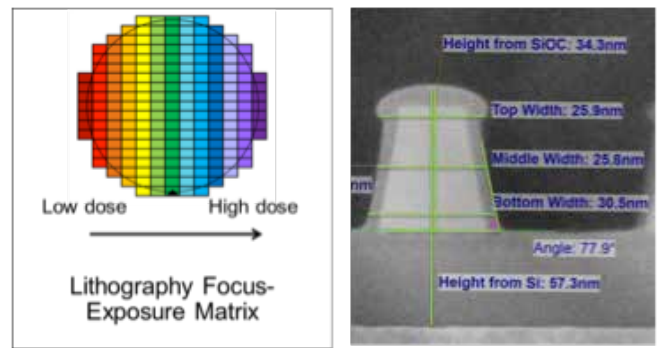


Figure 2: a) Map of increasing exposure from left to right at constant focus and b) a representative image of the 7 critical dimensions

Examination of the bottom width resulting from the EUV resist A process exhibits clear non-uniformity from edge to center at a constant focus compared to EUV resist B, see Figure 3. In addition, the dimensional response to exposure dose exhibits a step as opposed to a linear change compared with EUV resist B.

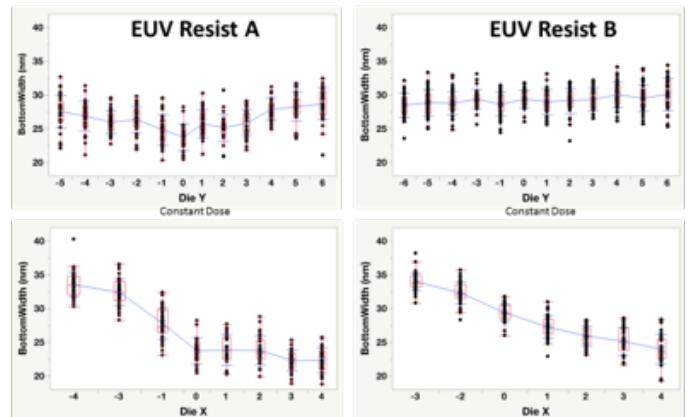


Figure 3: Variation of the bottom fin width as a function of Die location with increasing exposure dose from left to right at a constant focus.

When viewed in context to the manual use case which required over 120 hours and additional overhead (over 6x the time for the Nearline workflow) the increased time to data now makes statistically relevant (S)TEM metrology data a reality for process control of 3D devices and brings the laboratory one step closer to the FAB for faster time to decision and ultimately faster time to high volume manufacturing.

