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DATASHEET

Metrios AX S/TEM

Designed exclusively for the semiconductor industry using a suite of automated productivity-enhancing workflows

The Thermo Scientific Metrios AX S/TEM provides fast, precise and reliable data using Thermo Fisher Scientific's trusted Spectra platform. Handle anything that comes your way with unparalleled imaging, tomography, spectroscopy and metrology.

The Thermo Scientific™ Metrios™ AX S/TEM is a 60-200 kV scanning/transmission electron microscope (S/TEM), designed from the ground up to deliver repeatable TEM- and STEM-based imaging, analytics and gauge-capable metrology results at an unprecedented throughput level. With a suite of software that supports everything from productivity-enhancing auto-functions to machine-learning-based navigation and 24/7 automation, the Metrios AX S/TEM ensures success with your challenges today while providing the roadmap to your peace of mind tomorrow.

A is for automation

The Metrios AX is a first-of-its-kind S/TEM that uses machine learning to democratize automation in its application user interface (UI). The system removes barriers to automation by providing an intuitive workflow (Smart Automation) that is operable at the technician level. This enables robust data acquisition on new samples in less than 4 hours for defined use cases. Machine learning (i.e. neural networks) makes the process of defining regions of interest (for runtime navigation) as simple as digitally tracing out a feature in a set of representative images. The traced images (called segments) are then sent to a computer that learns what to recognize. This recognition is robust, easy to set up, and can be extended to larger changes in variability or contrast than current edge-finder based technology. The short cycle time needed to automate on new samples increases the number of job requests amenable to automation.

A key component of robust automation is maintenance of application-critical microscope alignments. With its Smart Alignment software, the Metrios AX S/TEM tracks current alignment state and compares this to the stability window (maintained in the background) to keep the tool aligned and consistently operating at specification. This ensures high quality data and prevents losses in productivity due to runtime errors

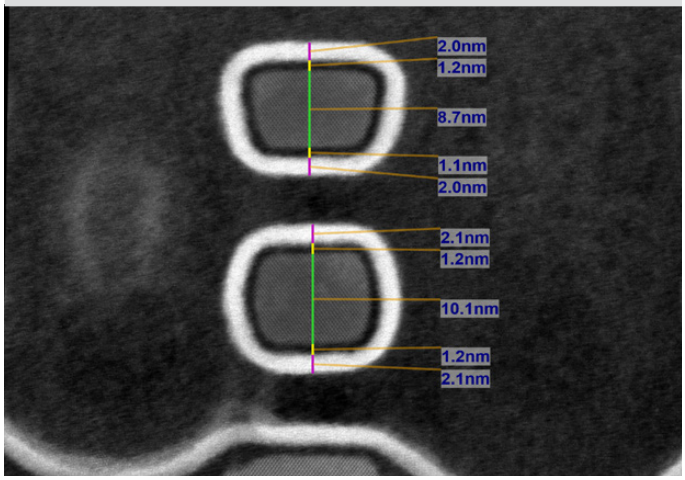
Key Benefits

Consistent, repeatable, and precise. Designed for the semiconductor industry to deliver automated TEM- and STEM-based imaging, analytics and gauge capable metrology

Guaranteed metrology accuracy. Less than 0.75% combined error in distortion and magnification calibration for both TEM and STEM

Automated EDS and EFTEM acquisition. Automatically acquire, quantify and measure EDS data. Use elemental contrast on key critical dimensions to extend your STEM analysis

Workflow connectivity. Critical process data is tracked through sample preparation, 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



Automated metrology measurements applied to a high-angle annular dark field (HAADF) image of a gate-all-around (GAA) horizontal nanowire (NW) transistor to highlight support of < 7 nm technology node processes. Measurements target the Si channel, SiO_2 dielectric insulator, and the high-K gate oxide HfO_2.

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or excursions found after data has already been collected. Metrology accuracy is guaranteed to <0.75% through automated distortion and calibration alignments of the column.

With a unique combination of automation technology and innovative new hardware, the Metrios AX S/TEM is the platform of choice for semiconductor environments where there is a need for higher volumes of accurate, reliable and precise measurements on increasingly complex structures with shrinking geometries.

The Metrios AX S/TEM is the first commercial transmission electron microscope to utilize machine learning for automated navigation. Designed to provide “first-time-right” data at a much lower cost per sample compared to conventional S/TEM systems, the Metrios AX S/TEM provides superior throughput with a range of productivity-enhancing options. These include: OptiSTEM, push-button auto-functions, guided jobs for novice operators, Recipe Editor (a graphical programming toolbox UI for building automation recipes), and Smart Automation (a new application-based software, powered by machine learning) that allows operators to set up automation routines in <4 hours for selected workflows. Automation robustness and data quality metrics like distortion and magnification are ensured by Smart Alignment Software, which keeps track of application-based alignments. Smart Alignment Software automatically checks and corrects excursions as needed and provides an online viewer for tool-performance monitoring.

The Metrios AX S/TEM

Enhanced atomic characterization

Each Metrios AX S/TEM can optionally be configured with the new Six-fold astigmatism (A5) probe CORRector (S-CORR) and associated software to enable fully automated correction of high-order aberrations for truly sub-angstrom imaging.

With the new S-CORR probe corrector integrated into the Metrios AX S/TEM, sub-Angstrom STEM imaging resolution from 60 kV to 200 kV is easily achievable. Compared to the previous generation DCOR probe corrector, the S-CORR corrector provides an order-of-magnitude improvement in optical stability of low-order aberrations, which means that you can focus on collecting meaningful data, rather than optimizing the tool. The S-CORR corrector is also capable of correcting resolution-limiting A5 aberrations for all accelerating voltages. This means that you can reproducibly access high-resolution imaging conditions without having to repeatedly tune the highest-order aberrations.

All Metrios AX systems utilize throughput-enhancing software (e.g. OptiSTEM+ Software) to provide fully automated correction of 1st and 2nd order aberrations on the specimen being investigated. This gives you the power to quickly and efficiently maintain the highest possible STEM resolution during your experiments, whether they are manual or automated.

The next generation in STEM imaging of dose-sensitive specimens

The Metrios AX S/TEM is equipped with an entirely new, segmented STEM detection and data infrastructure unit. The new detector geometry offers access to advanced STEM imaging capability combined with the sensitivity and detectability to measure single electrons. When combined with sensitive STEM imaging techniques, such as integrated differential phase contrast (iDPC), new possibilities are enabled for imaging dose-sensitive samples. Until now these have typically been very difficult to characterize with TEM.

Productivity-enhancing automated workflows

The Metrios AX S/TEM is designed for unprecedented ease of use and is ideal for both experienced microscopists and new users. The flexible UI 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.

The Metrios AX S/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 STEM. Metrology and EDS quantification can be performed either online or offline with automation.

Fully automated metrology and data acquisition uses recipes created with the Recipe Editor Software based on Thermo Scientific iFAST™ Software, an automation product proven on Thermo Scientific DualBeam™ (FIB/SEM) Systems. This gives great cross-platform synergy, as current iFAST Software users will readily adapt to the recipe creation process on the Metrios AX S/TEM.

The Metrios AX S/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 an image viewer.

In addition to accepting a wide variety of TEM samples prepared by conventional techniques, the Metrios AX S/TEM is part of a fast, complete workflow that includes the Thermo Scientific ExSolve, Helios 1200, and TEMLink150™ Systems. The new centralized data services (CDS) extend 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.

As part of the workflow, the Metrios AX S/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; just load the sample and enter a grid ID. Once the grid ID is entered the Metrios AX S/TEM runs automatically with the information received, allowing the user to focus on other tasks.

Technical highlights

Source

- Ultra-stable, high-brightness Schottky field emission gun (X-FEG) and a flexible high-tension range from 300-200 kV (60-200 kV suitable for automation)

Optical column and correctors

- Three-lens condenser system with indicators for convergence angle and size of illuminated area; allows for quantitative measurement of electron dose and illumination conditions
- New S-CORR probe corrector provides sub-Angstrom imaging resolution at 60 kV as specification and an order of magnitude improvement in optical stability; the S-CORR corrector simultaneously corrects A5 for all accelerating voltages
- New CEOS Auto S-CORR Alignment Software makes probe corrector tuning easy, fast and fully automated up to and including 4th order aberrations
- Patented mechanical stacking of column modules minimizes instabilities caused by excessive deflector excitations
- Constant power lenses, designed for improved thermal stability in mode switches, minimize image drift
- Low hysteresis design minimizes crosstalk between optical components for enhanced reproducibility
- Symmetric X-TWIN objective lens with a wide pole piece gap of 5.4 mm for “space to do more,” to accommodate special holders such as heating, cooling and STM/AFM holders
- Objective aperture in the back focal plane of the objective lens for optimum TEM dark-field application work
- Automatic apertures for remote control operation and reproducible recall of aperture positions during aperture change
- Rotation-free imaging for easy operation and a clear orientation relationship between imaging and diffraction
- Sub-Angstrom resolution for all accelerating voltages (60-200 kV) with low specimen drift (manual)
- Integrated Faraday cup and calibrated fluscreen current readout is linear over whole beam current range

Stage

- Computerized 5-axis, ultra-stable specimen piezo stage for accurate recall of stored positions and tracking of the areas visited during sample navigation
- The piezo stage allows for movements as fine as 20 pm for centering of feature of interest in the field of view
- Tilt range ±40 degrees for analytical double tilt holder to orient the maximum amount of zone axes of one crystal in a polycrystalline material. With the tomography holder, ±75 degrees minimize the missing wedge in 3D reconstructions.
- Linear drift compensation provided by the piezo stage can be used to mitigate limitations caused by thermal drift, which is unavoidable during in situ heating or cooling experiments

Analytics and detectors

- Dual-X EDS, integrated software, and the Gatan Ultrafast EELS/DualEELS options together provide up to 1000 sp/s of simultaneous EDS and EELS data
- Analytics for live peak identification and background fitting during ultra-fast EDS acquisition
- Symmetric EDS detector design allows for combined tomographic EDS

EDS detector portfolio

- EDS quantification using Thermo Scientific Velox™ Software (featuring dynamic correction of holder shadowing as a function of tilt) or ESPRIT Software
- Dual-X Detector: symmetric, windowless EDX detector system with high solid angle and throughput
- Output count rate: up to 260 kcps
- Energy resolution:
  - 130 eV for Mn-Ka and 10 kcps (output)
  - <140 eV for Mn-Ka and 100 kcps (output)
- 1.8 srad solid angle
- High P/B ratio (Fiori number) > 2000
- In-hole performance (<1% hole counts)
- System background in EDS (<2.5% spurious peaks)

Available detector options

- HAADF detector (standard)
- On-axis solid state, 8 segmented BF and ADF detectors (16 segments in total) (standard)
- Thermo Scientific™ Ceta™ 16M Camera (optionally with speed enhancement)
- Gatan OneView/OneView IS Cameras
- Gatan Energy Filter Continuum Series
- Electron microscope pixel array detector (EMPAD) (stand-alone)

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Software

- Recipe Editor Software is a graphical programming language toolkit for building automation recipes
- Smart Automation Software allows operators to set up automation routines in <4 hours for selected workflows
- Smart Alignments Software maintains application-critical microscope alignments and ensures high quality data, preventing productivity loss due to runtime errors or collection of out-of-spec data
- The microscope data viewer is a database that collects, organizes, and displays all imaging, EDS and metrology data through a web browser. Smart alignments are also displayed through this portal.
- Differential phase contrast (DPC) STEM technique enables live measurements of intrinsic magnetic and electric fields
- Integrated DPC (iDPC) software for increased imaging contrast in STEM on materials across the whole periodic table
- Low-dose technique expands materials science use cases and replaces annular bright field as the technique of choice for light elements
- OptiSTEM+ Software for single-click correction of 1st and 2nd order probe forming aberrations; delivers enhanced STEM resolution to all users on our probe-corrected tools
- Fully digital system for remote-controlled operation using the SmartCam suite

Available holders

- Single-tilt holder
- Double-tilt holder
- Tomography holder
- Thermo Scientific *in situ* holders

Please ask for a list of functional holders

Other features

- Environmental enclosure to relax the acoustic and room temperature variation requirements
- Cold trap design for up to four days of operation, maximizing uptime

Installation requirements

Please contact your sales representative for a complete list of pre-installation requirements

Find out more at **thermofisher.com/EM-Sales**

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