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DATASHEET

Spectra 300 S/TEM for Materials Science

The ultra-high-resolution, “all-in-one” solution for atomic scale materials characterization

The Spectra 300 S/TEM is the highest resolution imaging and spectroscopic platform from Thermo Fisher Scientific. With its wide-gap pole piece and an accelerating voltage range of 30–300 kV, it also serves the widest range of materials investigations.

The highest-resolution structural and chemical information at the atomic level

The Thermo Scientific™ Spectra 300 S/TEM combines:

- Redesigned, high-stability base
- New ultra-high resolution (X-FEG UltiMono) source or a ultra-high brightness (X-CFEG) source
- Image and 5th order probe aberration correction (S-CORR)
- Single electron sensitive STEM detection
- Sensitive energy dispersive X-ray (EDX) detectors

By synchronizing these technologies through our advanced software and automation modules, the Spectra 300 S/TEM makes accessing the highest-resolution atomic-scale information more efficient, easy and repeatable than ever.

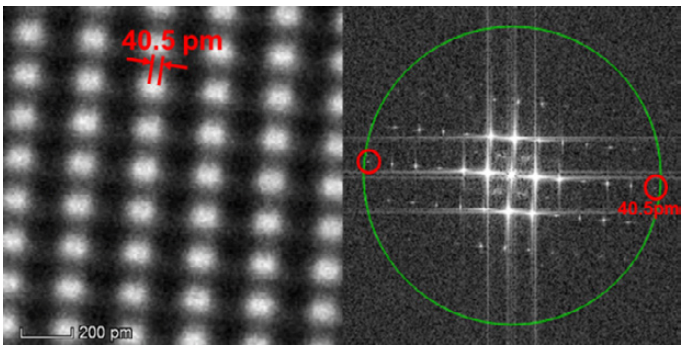

Figure 1. HAADF (DCFI) STEM image of GaN [212] at 300 kV showing 40.5 pm Ga-Ga dumbbell splitting and 39 pm resolution on a wide gap (S-TWIN) pole piece.

Key Benefits

Best atomic characterization. Optimized electron optical performance and ultra-sensitive detection enables the best combination of atomic imaging and analysis in 2D and 3D.

Most repeatable data. Sophisticated software automation routines such as OptiSTEM+ and OptiMono+ optimize the system to its peak performance, resulting in more repeatable and quantifiable data.

Optimum EDS performance. Guaranteed by a portfolio of symmetric detector geometries, which contributes to our unique quantification capability, in combination with an ultra-high brightness X-CFEG to provide rapid EDS mapping across the widest range of materials.

Best *in situ* and dynamic research. Fast cameras, chemical detectors, smart software and our wide gap S-TWIN lens enable *in situ* data acquisition with no compromise on resolution and analytical capabilities.

Best environmental stability. The redesigned enclosure and ultra-stable Spectra 300 S/TEM base with passive and (optional) active vibration isolation (with iVIS) minimize external environmental influences and ensure the highest-quality data from long-term and short-term experiments.

Widest range of materials science research in one platform. The best combination of optics, ultra-sensitive detection and wide- gap pole piece, ensures that even the lightest, most sensitive materials can be characterized at the atomic scale.

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Investigate the widest range of materials at the atomic scale

With the combination of its large-gap objective lens (the Thermo Scientific S-TWIN lens), superior optics and analytics, the Spectra 300 S/TEM delivers both performance and flexibility in one tool. The six-fold astigmatism (A5) probe corrector (S-CORR) enhanced Spectra 300 S/TEM delivers the highest commercially available STEM resolution specification at 300 kV (50 pm) and 60 kV (96 pm) and provides *in situ*, dynamic and 3D EDS tomography capability without the need for non-standard holders or sample types. When equipped with an X-FEG UltiMono, the same fully flexible system can achieve ultra-high energy resolution in the <25 meV regime.

Our powerful and advanced software allows specialized techniques like integrated differential phase contrast (iDPC) imaging for the study of magnetic and electrical properties and for optimized Z-contrast imaging from hydrogen to uranium. Higher quality atomic characterization data is available from more materials types than ever before.

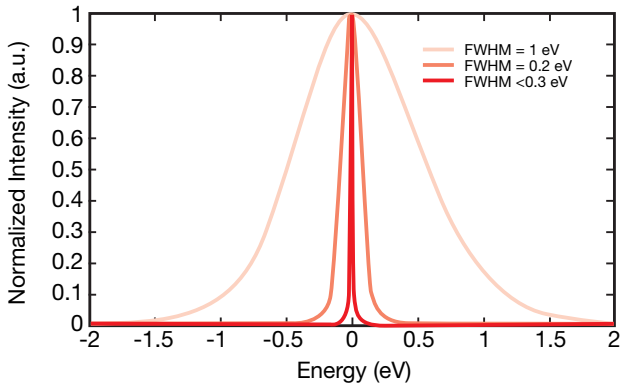

Figure 2. The energy resolution of the X-FEG UltiMono can be flexibly tuned between <25 meV and 1 eV.

Best atomic characterization

The new S-CORR by Thermo Fisher Scientific provides specified sub-Angstrom imaging resolution from 60 to 300 kV and an order of magnitude improvement in the stability and lifetime of the corrected state, compared to previous generation DCOR technology. The S-CORR is capable of correcting A5 for all accelerating voltages. When combined with the new Auto S-CORR CEOS alignment software, the S-CORR can automatically tune all aberrations up to 5th order which is particularly important when the highest spatial resolution is required at accelerating voltages <120 kV. Furthermore, the probe profile can be tuned to suit the atomic-level experiment required; it can be optimized for ultra-high-resolution STEM imaging or high-throughput spectroscopy.

The highest-quality atomic-level chemistry and bonding-state research of sensitive materials is enabled by simultaneous EDS and electron energy loss spectroscopy (EELS), with speeds up to 1000 spectra/s.

More Reliable and quantitative analysis and imaging

Fully automated, single-click access to the highest-resolution STEM (<50 pm) and energy-resolution EELS (<30 meV) experiments are enabled for all users with new OptiSTEM+ and OptiMono+ software automation packages on the Spectra 300 S/TEM. Additionally, drift corrected frame integration (DCFI) ensures that the most repeatable, high-quality, atomic-resolution images are possible and that recursive mapping capabilities guarantee the best chemical analysis. Our “look back” functionality, available within our acquisition software, guarantees that you never miss anything, since results can be stored and analyzed later. An integrated Faraday cup provides an accurate calibration of the beam current measurement, which is pivotal for quantitative and reliable imaging and analysis. The Faraday cup measurement guarantees experimental repeatability between different Thermo Scientific tools.

Panther: the next generation in low dose STEM imaging

Spectra 300 S/TEM is equipped with Panther - 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. The entire signal chain has been optimized and tuned to provide unprecedented signal-to-noise-ratio-imaging capability with extremely low probe currents (<1 pA). When combined with sensitive STEM imaging techniques such as iDPC, new possibilities are enabled for imaging dose-sensitive samples which have typically been very difficult to characterize with a TEM. Additionally, the completely redeveloped data processing infrastructure offers the future capability of combining detector segments in arbitrary ways and a scalable interface to synchronize multiple STEM and spectroscopic signals.

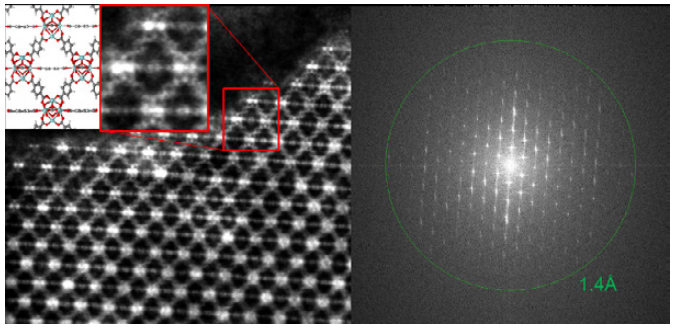

Figure 3. Extreme-low-dose imaging of the metal organic framework (MOF) UiO 66. A probe current of <0.5 pA was used in combination with iDPC and new sensitive STEM detectors to image atomic-level details in this highly dose-sensitive material. *Specimen courtesy of Professor Y. Han, King Abdullah University of Science and Technology.*

Spectra 300	Energy spread*	Information limit	STEM resolution
Image corrector	0.2–0.3 eV**	60 pm	136 pm
Probe corrector	0.2–0.3 eV**	100 pm	50 pm (125 pm @ 30 kV)
Uncorrected	0.2–0.3 eV**	100 pm	136 pm
X-FEG/monochromator double corrected (probe+image corrector)	0.2–0.3 eV**	60 pm	50 pm (125 pm @ 30 kV)
X-CFEG double-corrected (probe+image correction)	0.4 eV	60 pm	50 pm (125 pm @ 30 kV)

* For X-FEG unless otherwise specified.

** Depending on energy filter option.

Note: All specifications are at 300 kV (unless otherwise noted).

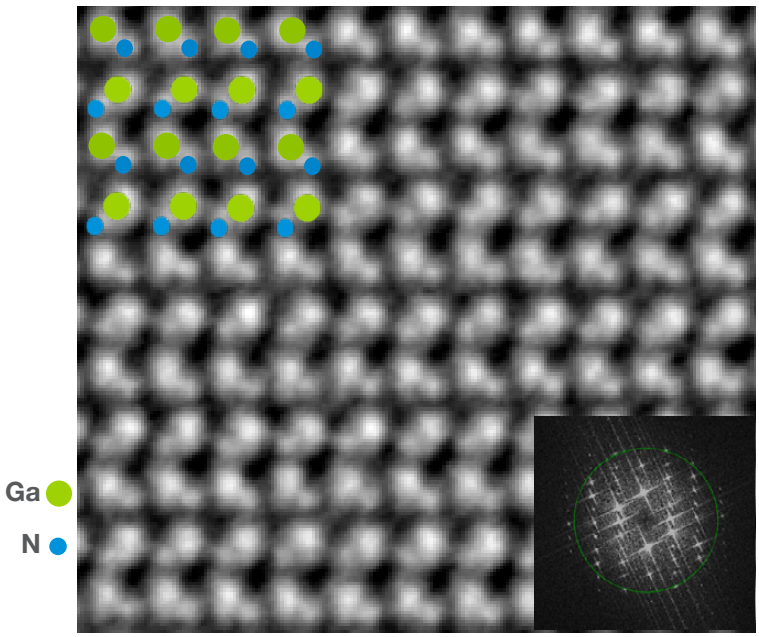

Figure 4. GaN[110] imaged with iDPC STEM at 60 kV with X-FEG/Mono on a wide gap S-TWIN pole piece. Both Ga and N columns are simultaneously revealed using iDPC 75 pm resolution as demonstrated in the FFT.

Technical highlights

Source

- X-FEG Mono: High-brightness Schottky field emitter gun and monochromator with a tunable energy resolution range between 1 eV and <0.2 eV
- X-FEG UltiMono: High-brightness Schottky field emitter gun with ultra-stable monochromator and accelerating voltage with a tunable energy resolution range between 1eV and <0.03 eV
- X-CFEG: Ultra-high brightness with an intrinsic energy resolution of <0.4 eV
- Flexible high-tension range from 30 -300 kV

Optical column and correctors

- Three lens condenser system with indication of convergence angle and size of illuminated area for quantitative measure of electron dose and illumination conditions
- New S-CORR provides sub-Angstrom imaging resolution at 60 kV as specification and an order of magnitude improvement in optical stability. The S-CORR simultaneously corrects A5 for all accelerating voltages
- New CEOS Auto S-CORR auto alignment software makes probe corrector tuning easy, faster, and fully automated up to high order aberrations
- Patented mechanical stacking of column modules minimizes instabilities caused by excessive deflector excitations
- Thermo Scientific ConstantPower™ Lens and corrector design for ultimate thermal stability in mode switches minimizes image drift
- Low hysteresis design to minimize crosstalk between optical components for ultimate reproducibility
- Symmetric S-TWIN objective lens with wide-gap pole piece design of 5.4 mm with “space to do more” allows the use of 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
- Field upgradeable probe and image Cs-corrector
- Rotation-free imaging for easy operation and clear orientation relationship between the imaging and diffraction
- Deep sub-Angstrom resolution for all accelerating voltages (60- 300 kV) with low specimen drift
- Field-free imaging in TEM Lorentz mode with 2 nm resolution for magnetic property studies
- Cs-corrected field free TEM imaging in Lorentz with <1 nm resolution for magnetic property studies
- 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 orientate the maximum amount of zone axes of one crystal in polycrystalline material. With tomography holder ±75 degrees to minimize the missing wedge in 3D reconstructions*
- Linear drift compensation provided by piezo stage can be used to mitigate limitations caused by thermal drift which is unavoidable during *in situ* heating or cooling experiments

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Analytics and detectors

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

EDX detector portfolio

- EDS quantification using the Thermo Scientific Velox™ Software (featuring dynamic correction of holder shadowing as a function of tilt for both Super-X and Dual-X)
- **Super-X:** high-sensitivity, windowless EDX detector system based on patented SDD technology
  - Output count rate: up to 800 kcps
  - Energy resolution
  - ≤136 eV for Mn-Kα and 10 kcps (output)
  - ≤140 eV for Mn-Kα and 100 kcps (output)
  - 0.7 srad solid angle
  - High P/B ratio (Fiori number) >4000
  - Excellent in-hole performance (<1% hole counts)
  - Low system background in EDS (<1% spurious peaks)
- **Dual-X:** 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
- On-axis solid state, 8 segmented BF and ADF detectors (16 segments in total)
- Thermo Scientific Ceta™ 16M Camera (optionally with speed enhancement)
- Gatan OneView/OneView IS cameras
- Gatan energy filter series
- Electron microscope pixel array detector (EMPAD)

Software

- Differential phase contrast (DPC) STEM technique enables live measurements of intrinsic magnetic and electric fields
- Integrated DPC (iDPC) software for ultimate imaging contrast in STEM on materials across the whole periodic table. This low-dose technique expands the use cases to the materials scientist and replaces annular bright field as the technique of choice for light elements. Invaluable when applied to samples that are typically damage under short exposures to the electron beam
- OptiSTEM+ software for single click correction of 1st and 2nd order probe forming aberrations to deliver the ultimate STEM resolution to all users on our probe corrected tools**
- OptiMono+ software for completely automated monochromator alignment and tuning to the highest achievable energy resolution on monochromated systems from 1eV down to <30 meV
- Thermo Scientific TrueImage™ Atlas focus series software for quantitative HR-TEM applications (For more details see separate product data sheet)
- Fully digital system for remote controlled operation using the SmartCam suite
- Advanced, integrated software enables fast and simultaneous signal acquisition (up to five STEM signals)
- Smart scanning technology for high image quality in STEM

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 to maximize up-time

Installation requirements

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

* Tilt range 35° with Super-X option.
** Ultimate performance guaranteed on corrected tools.

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

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