Spectra 200 (S)TEM for materials science

The high-throughput platform for atomic-scale materials science investigations

Combining high throughput with uncompromised resolution in imaging and spectroscopy, the Spectra 200 (S)TEM delivers high-quality data for a wide range of materials science applications. An ultra-high-brightness X-CFEG source and a wide-gap pole piece with "room to do more" make the Spectra 200 (S)TEM a leading atomic-resolution materials-characterization tool.

High-throughput atomic-resolution STEM analysis and imaging platform

By combining an ultra-high-brightness X-CFEG source, a completely redesigned scanning transmission electron microscopy (STEM) detection and data processing infrastructure and a suite of energy dispersive spectroscopy (EDS) detectors optimized for different applications, the Thermo Scientific™ Spectra™ 200 (S)TEM is our highest throughput STEM analytics platform available.

High-resolution, high-contrast STEM imaging for all accelerating voltages from 30-200 kV, without the need for gun monochromation, is now straightforward due to the combination of X-CFEG with the six-fold astigmatism (A5) probe aberration corrector (S-CORR).

Adding these capabilities to our new, ultra-stable platform with advanced passive and, optionally, active vibration isolation, piezo-enhanced stage, advanced software and automation modules, the Spectra 200 (S)TEM can access high-quality STEM analytics and imaging data faster and easier than ever before.

High-quality atomic characterization

With the new S-CORR integrated into the Spectra 200 (S)TEM, sub-angstrom STEM imaging resolution from 60 to 200 kV is easily achievable. Compared to the previous generation DCOR, the S-CORR 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.

Key Benefits

High-quality atomic characterization. Optimized STEM electron optical performance with S-CORR and ultra-sensitive detection enables high-quality imaging and nalysis in 2D and 3D.

Optimized EDS performance. Guaranteed by the combination of an ultra-high-brightness X-CFEG and two different detector configurations to suit a wide range of specimens and experiments.

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

***In situ* and dynamic research.** Fast cameras, sensitive detectors, smart software and our wide-gap lens enable *in situ* data acquisition with minimal compromise to resolution and analytical capabilities.

High environmental stability. The redesigned enclosure and ultra-stable Spectra 200 base with passive and (optional) active vibration isolation (with iVIS) minimize external environmental influences, ensuring the high-quality data from long-term and short-term experiments.

A wide range of materials science research in one platform. Our unique combination of constant power optics, ultra-high brightness X-CFEG, sensitive detection and the wide-gap pole piece ensure that even highly difficult, light, and/or sensitive materials can be characterized at the atomic scale.

The S-CORR is also capable of correcting (resolution limiting) A5 aberrations for all accelerating voltages and each Spectra 200 (S)TEM is delivered with A5 already corrected for all ordered accelerating voltages. This means that you can reproducibly access high-resolution imaging conditions without having to repeatedly tune the highest-order aberrations.

Further, each Spectra 200 (S)TEM is delivered with the new Auto S-CORR software from CEOS for fully automated correction of high-order aberrations. Optionally, the Spectra 200 (S)TEM can also be ordered with OptiSTEM+, which provides fully automated “single-click” correction of 1st and 2nd order aberrations on the specimen being investigated (with no need for a specialized specimen). This gives you an optimization tool to quickly and efficiently maintain the highest possible STEM resolution during your experiment while minimizing electron dose and any associated sample damage.

Combining the powerful and easy-to-use S-CORR with the built-in, ultra-high-brightness X-CFEG, takes the Spectra 200 (S)TEM to the next level of high-contrast, high-quality, reproducible STEM imaging at the atomic level.

This performance is further enhanced by Thermo Scientific Velox™ Software, which seamlessly integrates drift-corrected frame imaging (DCFI) to ensure repeatable, high-quality, atomic-resolution imaging. Our unique integrated differential phase contrast imaging (iDPC) capability, which is fully embedded into Velox Software, enables the study of magnetic and electrical properties as well as optimized Z-contrast, from hydrogen to uranium, at the atomic scale, replacing annular bright field (ABF) as the industry standard.

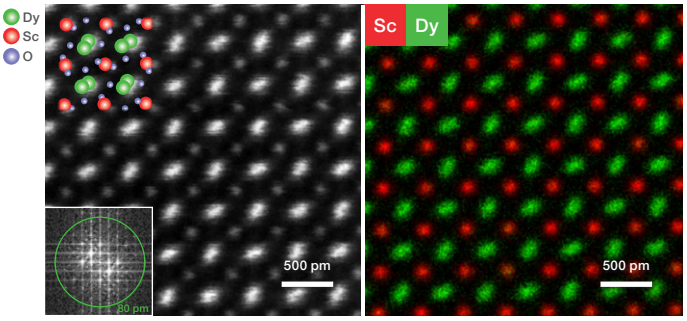


Figure 1. EDS maps of $DyScO_3$ specimen investigated with a Spectra 200 (S)TEM. The combined ultra-high brightness of the X-CFEG, resolving power of the S-CORR and large solid angle (1.76 Sr) of the Dual-X detectors results in high signal to noise ratio, atomic resolution, raw and unfiltered EDX maps, here with 90 pm resolution. Sample courtesy Professor L.F. Kourkoutis, Cornell University.

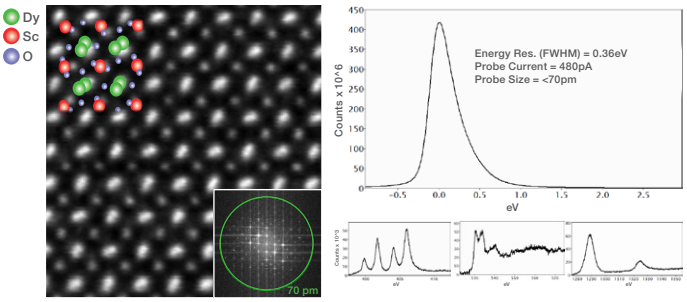


Figure 2. EELS of $DyScO_3$ specimen investigated with a Spectra 200 (S) TEM. The combined ultra-high brightness of the X-CFEG, intrinsically lowenergy spread of the source (<0.40 eV) and resolving power of the S-CORR results in high signal to noise ratio, Sc, O and Dy core loss EELS edges with a sub-70 pm STEM probe. Sample courtesy Professor L.F. Kourkoutis, Cornell University.

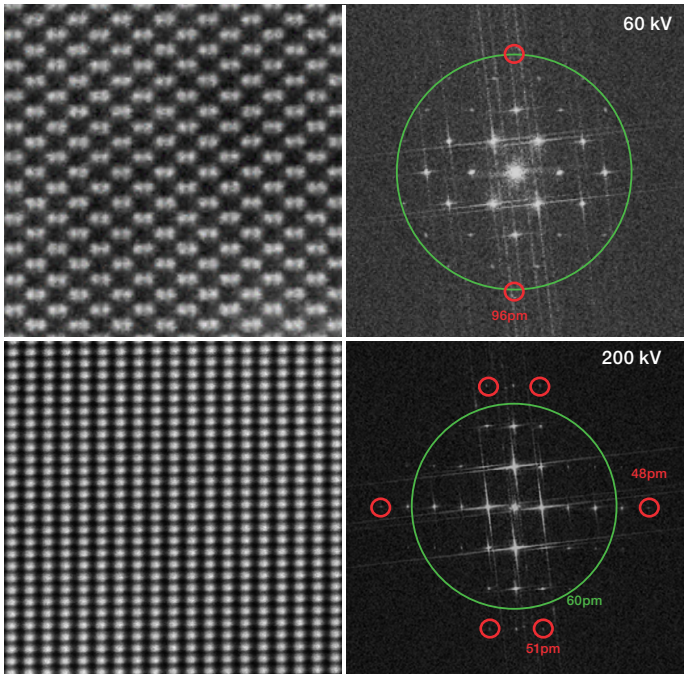


Figure 3. Si [110] and GaN [212] taken on a Spectra 200 (S)TEM showing the specified resolution on a wide-gap analytical S-TWIN pole piece (green circle) and achievable resolution (red circles). At 60 kV, 96 pm resolution is specified and at 200 kV, 60 pm is specified with an achievable resolution of <48 pm.

More reliable and quantitative analysis and imaging

The integrated Faraday cup provides an accurate calibration of the beam current measurement. These currents are pivotal for quantitative and reliable imaging and analysis. The Faraday cup measurement guarantees experimental repeatability on different Thermo Scientific tools.

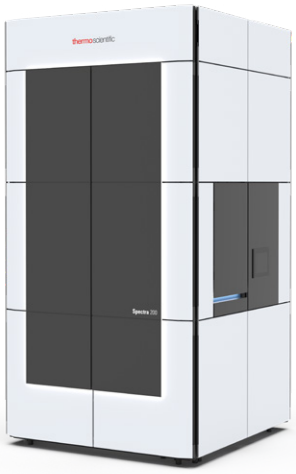
The Panther Detector: the next generation in low-dose STEM imaging

The Spectra 200 (S)TEM is equipped with an entirely new, segmented STEM detection and data infrastructure unit. Thermo Scientific Panther 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, and an X-CFEG capable of reproducibly producing atomic-scale probes with currents less than 1 pA, new possibilities are enabled for imaging dosesensitive samples which have typically been very difficult to characterize with a TEM.

Additionally, the completely redeveloped data processing infrastructure allows segments to be addressed independently. Therefore, multiple STEM signals containing different information about the specimen can be generated from a single scan on a single detector, resulting in less dose on the specimen.

Spectra 200 (S)TEM	Energy spread	Information limit	STEM resolution
Probe corrector	0.4 eV	110 pm	60 pm (136 pm at 30 kV)
Uncorrected	0.4 eV	110 pm	164 pm

Note: All specifications are at 200 kV with an S-TWIN lens (unless otherwise noted).



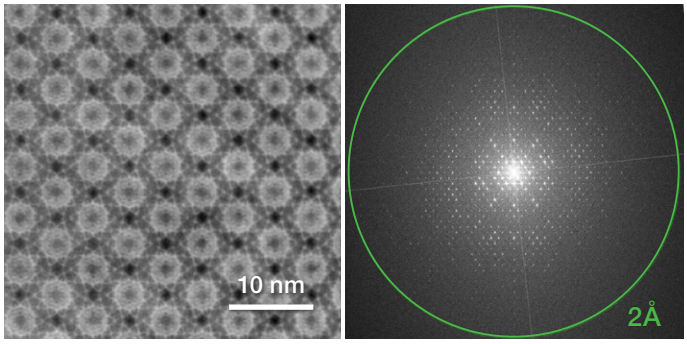


Figure 4. Metal Organic Framework (MOF) MIL-101 imaged with 0.5 pA of beam current in STEM with iDPC at 200 kV. The image is a single shot with a frame time of 23.5 seconds and the complex structure can be seen with 2 Å resolution. *Specimen courtesy of Professor Y. Han, King Abdullah University of Science and Technology.*

Technical highlights

Source

- X-CFEG: Ultra-high-brightness cold field emission gun with energy resolution of <0.4 eV
- Flexible high-tension range from 30–200 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 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
- Thermo Scientific ConstantPower™ Lens, designed for high thermal stability in mode switches, minimizes image drift
- Low hysteresis design to minimize crosstalk between optical components for ultimate reproducibility
- Symmetric S-TWIN or X-TWIN objective lens with widegap pole piece design of 5.4 mm with “space to do more,” allowing 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 optimized TEM dark field application work
- Automatic apertures for remote operation and reproducible recall of aperture positions during aperture change
- Field upgradeable probe Cs-corrector (S-CORR)
- Rotation-free imaging for easy operation and clear orientation relationship between imaging and diffraction
- Sub-angstrom resolution for all accelerating voltages (60–200 kV) with low specimen drift
- Field-free imaging in TEM Lorentz mode with 2 nm resolution for magnetic property studies, and option for Cs-corrected Lorentz with <1 nm resolution
- On special request: 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 a polycrystalline material. With tomography holder ±70 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

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

- Live peak identification and background fitting during ultrafast EDS acquisition
- Symmetric EDS detector design allows for tomographic EDS using all detectors in the EDX detector portfolio
- EDS quantification using Velox Software (featuring dynamic correction of holder shadowing as a function of tilt for both Super-X and Dual-X Detectors)
- **Super-X Detector:** 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)
- **Dual-X Detector:** symmetric, windowless EDX detector system with high solid angle and throughput
  - Output count rate: >23 kcps/nA/detector
  - Energy resolution
    - ≤130 eV for Mn-Kα and 10 kcps (output)
    - ≤140 eV for Mn-Kα and 100 kcps (output)
  - 1.8 srad solid angle
  - P/B ratio (Fiori number) > 2000
  - Excellent in-hole performance (<1% hole counts)
  - <2.5% spurious peaks system background in EDS

Available detector options

- HAADF detector
- **New Panther Detector:** ultra-low noise on-axis solid stage, 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

- The Electron Dose Control (EDC) module predicts beam current, dose, and dose-rate live based on gun and optics settings. The EDC calibration is done with a built-in Faraday cup. Users can set electron dose without knowledge of TEM optics. The beam current, dose, and dose-rate are reported in Velox Software along with image metadata.
- Differential phase contrast (DPC) STEM technique enables live measurements of intrinsic magnetic and electric fields
- Integrated DPC (iDPC) software for high imaging contrast in STEM on materials across the whole periodic table. This low-dose technique expands the use cases of the instrument in materials science and replaces annular bright field as the technique of choice for light elements. Invaluable when applied to samples that are typically damaged under short exposures to the electron beam
- OptiSTEM+ software for single-click correction of 1st and 2nd order probe-forming aberrations to deliver high STEM resolution to all users on our probe-corrected tools**
- 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 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 and 3rd party *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 30° with Super-X option.
** High performance guaranteed in combination with S-CORR probe corrector.

Learn more at **thermofisher.com/spectra200**

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