thermo scientific

DATASHEET

Themis Z S/TEM

Uncompromised atomic characterization across the widest range of materials

Low damage, high sensitivity imaging and analysis of materials in 2D, 3D and 4D. Themis Z S/TEM delivers it all with sub-Angstrom STEM resolution from 60–300kV.

Easy and Fast Access to Atomic Information

The combination of proven technologies such as our constant power lens design, monochromator, piezo enhanced stage, CETA™ CMOS camera, sensitive Energy Dispersive Spectroscopy (EDS) detectors and our latest generation S-CORR probe aberration corrector, delivers an ultra stable imaging and spectroscopic platform. By synchronizing these technologies through our advanced software and automation modules, the Thermo Scientific™ Themis Z scanning transmission electron (S/TEM) microscope makes accessing atomic scale information more rapid, efficient, and repeatable than ever.

Widest Range of Materials Research at the Atomic Scale

With the combination of a wide gap objective lens (the Thermo Scientific Super Twin), superior optics and analytics, the Themis Z S/TEM delivers both performance and flexibility in one tool. The S-CORR probe corrected Themis Z S/TEM, for example, delivers the highest (60 pm) STEM resolution at 300kV and 96pm at 60kV as well as providing *in situ*, dynamic and 3D EDS and tomography imaging without the need for non-standard holders or sample types. Higher quality atomic characterization data is available from more materials types than ever before.

Our powerful and advanced software allows specialized techniques like our integrated Differential Phase Contrast (iDPC™) imaging for the study of magnetic and electrical properties and for optimized Z contrast across the whole of the periodic table and in particular low Z materials — replacing ABF as the industry standard. OptiSTEM and OptiMono are new Thermo Scientific packages which enable users with fully automated access to the highest STEM and energy resolution experiments that the system is capable of achieving. The highest quality atomic level chemistry and bonding state research on sensitive materials is enabled by simultaneous EDS and electron energy loss spectroscopy (EELS) with speeds up to 1000 spectra/s.

Key Benefits

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

Most repeatable data. Sophisticated automated routines such as OptiSTEM and OptiMono minimize variable data acquisition allowing focus on research instead of the tool.

Optimum EDS performance. Guaranteed by offering a portfolio of detector geometries to suit the specific research requirements of the widest range of specimens and experiments.

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

Best environmental stability. Features like the large (weekly fill) liquid nitrogen dewar and ultra stable base minimize external environmental influences ensuring the highest quality data from long and short term experiments.

Widest range of materials science research covered in one tool. Best combination of optics, chemical detection and the wide gap pole piece ensure that the even the most difficult, lightest and most sensitive materials can be characterized at the atomic scale.

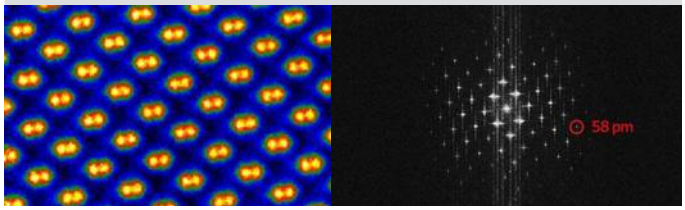

Figure 1. HAADF STEM image of [211] oriented GaN at 300kV.

ThermoFisher SCIENTIFIC

Best Atomic Characterization

The new S-CORR Six-fold astigmatism (A5) probe CORRector by Thermo Scientific provides sub-Angstrom imaging resolution at 60kV as specification and an order of magnitude improvement in optical stability. The S-CORR is capable of correcting A5 for all accelerating voltages. Combined the new CEOS alignment SW for fully automated correction of high order aberrations, with drift corrected frame imaging (DCFI) ensures the most repeatable, high quality, atomic resolution images are possible on Themis Z. Recursive mapping capabilities also guarantees the best chemical analysis. Our look back functionality within our acquisition software ensures that you never miss anything since results can be stored and analyzed later.

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 a quantitative and reliable imaging and analysis performance. The Faraday cup measurement guarantees experimental repeatability on different Thermo Scientific tools.

Ultimate Performance for Materials Science Challenges

The truly multi modal capability enabled by our company's advanced, integrated software allows scientists the most complete set of characterization workflows in one tool configuration. Delivering multi signal detection from up to four signals simultaneously and at very fast speeds enables new scientific data to be obtained from sensitive samples which have typically been very difficult to characterize with an S/TEM.

Specifications

Themis 200

	Energy spread	Information limit	STEM resolution
Image corrector	0.8 eV	90 pm	164 pm
Probe corrector	0.8 eV	110 pm	80 pm
Uncorrected	0.8 eV	110 pm	164 pm

Note: All specifications are at 200 kV. For a list of specifications of other acceleration voltage please contact your sales representative.

Themis 300

	Energy spread*	Information limit	STEM resolution
Image corrector	0.8 eV	80 pm	136 pm
Probe corrector	0.8 eV	100 pm	80 pm
Uncorrected	0.8 eV	100 pm	136 pm
X-FEG/monochromator + image corrector	0.2–0.3 eV**	80 pm	136 pm

* For X-FEG (monochromated systems) unless otherwise specified.
** Depending on energy filter option.
Note: All specifications are at 300 kV. For a list of specifications of other acceleration voltage please contact your sales representative.

Themis Z

	Energy spread*	Information limit	STEM resolution
Image corrector	0.8 eV	70 pm	136 pm
Probe corrector	0.8 eV	100 pm	60 pm (96 pm @ 60 kV)
Uncorrected	0.8 eV	100 pm	136 pm
X-FEG/monochromator double corrected (probe + image corrector)	0.2–0.3 eV**	60 pm	60 pm

* For X-FEG unless otherwise specified.
** Depending on energy filter option.
Note: All specifications are at 300 kV (unless otherwise stated).

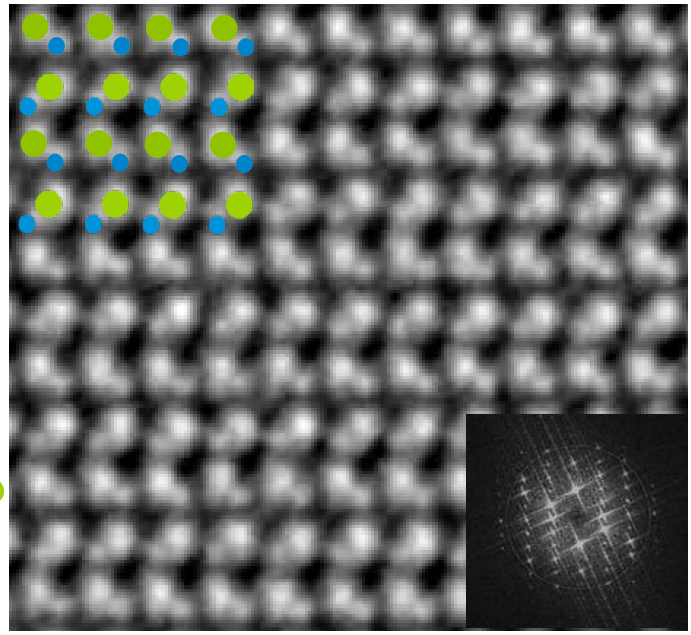

Figure 2. GaN[110] imaged with iDPC STEM at 60kV on a Themis Z with the S-CORR probe corrector. The Ga and N columns with a spacing of 112pm are clearly resolved. The FFT insert shows reflections corresponding to 78pm spatial resolution. The green circle indicates 1 Angstrom.

Technical Highlights

Source

- Ultra-stable, high brightness Schottky field emitter gun (X-FEG, for more details see separate product data sheet)
- Flexible high tension range
- Themis 300 S/TEM and Themis Z S/TEM: From 60 to 300 kV (60, 80, 120, 200, 300 kV). A 30kV alignment is also available by special request on Themis Z
- Themis 200 S/TEM: From 80 to 200kV (80, 120, 200 kV)
- Electron gun monochromator (tunable between <30meV and 1eV) for high energy resolution EELS and improved spatial resolution and contrast, especially at low kV in STEM mode

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 Six-fold astigmatism (A5) probe CORRector provides sub-Angstrom imaging resolution at 60kV as specification and an order of magnitude improvement in optical stability. The S-CORR is capable of correcting A5 for all accelerating voltages
- NewCEOS 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
- ConstantPower™ lens design for ultimate thermal stability in mode switches minimizes image drift
- Low hysteresis design to minimize cross-talk between optical components for ultimate reproducibility
- Symmetric Ruska-Rieke S-Twin objective lens with wide pole piece gap design of 5.4mm and “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 optimum TEM dark field application work
- Automatic apertures for remote control operation and reproducible recall of aperture positions during aperture change
- Field upgradeable probe Cs-corrector
- Rotation-free imaging for easy operation and clear orientation relationship between the imaging and diffraction
- Deep sub-Angstrom resolution or all accelerating voltages with low specimen drift
- Field-free imaging in Lorentz mode with 2nm resolution for magnetic property studies
- On special request Cs-corrected field free imaging in Lorentz with <1nm 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 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 for analytical double tilt holder to orientate the maximum amount of zone axes of one crystal in polycrystalline material. With tomography holder even ±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 unavoidable during *in situ* heating or cooling experiments

thermo scientific

Analytics and Detectors

- Either Super-X or Dual-X EDS options and advanced, integrated software provides, together with the Gatan Ultrafast EELS or DualEELS option, up to 1000sp/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 in-house developed Velox software which also incorporates dynamic correction of holder shadowing as a function of tilt angle for both **Super-X** and **Dual-X**
- **Super-X:** High-sensitivity, windowless EDX detector system based on SDD technology (patented)
  - 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 EDX (<1% spurious peaks)
- **Dual-X:** High solid angle and throughput, symmetric, windowless EDX detector system
  - Output count rate: up to 260kcps
  - Energy resolution
  - 130eV for Mn-Ka and 10 kcps (output)
  - <140eV 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 triple DF2/DF4/BF detectors
- Ceta 16M camera (optionally with Speed Enhancement)
- Gatan OneView/OneView IS cameras
- Gatan energy filter series

Software

- Differential phase contrast STEM technique (DPC) 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 ABF as the technique of choice for light elements. It is invaluable when applied to samples which typically damage under short exposures to the electron beam like Zeolites for example
- 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 <30meV
- 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 up to four STEM signals acquired simultaneously
- 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 with Themis Z
- New cold trap design for up to one week 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.

ThermoFisher SCIENTIFIC