Transmission Electron Microscopes
HT7800 Series

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HT7800 Series

Transmission Electron Microscopes

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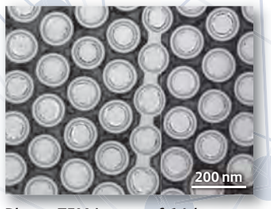
HTD-E297 2023.7

Connecting the world through the HT7800 Series TEMs

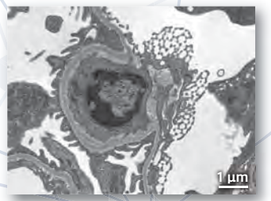
Connecting private sectors

Connecting medical institutions

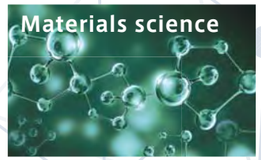
Connecting educational institutions

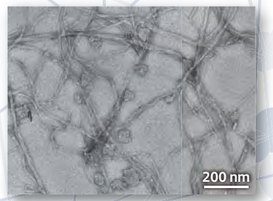


Planar TEM image of 64-layer 3D NAND flash memory



Observation example of mouse kidney





Observation of cellulose nanofibers using ionic liquids

120-kV TEM systems supporting diverse applications spanning a wide range of fields in science and technology

1 Simultaneously providing high resolution and high contrast over large fields of view

Hitachi's proprietary dual-mode objective lens enables various lens modes for a wide variety of observations. Low magnification provides easy navigation across the entire grid, High Contrast (HC) observation allows increased contrast over a large field of view, and High Resolution (HR) observation reduces the focal length for enhanced resolution.

2 A versatile lineup of instruments to satisfy the needs of users of all experience levels in a wide variety of fields

Depending on the application, an optimal model can be selected.

Instrument models	HT7800	HT7820	HT7830
Field	Medicine, Biology, Soft Materials		
		Electronic Materials, Semiconductors, Nanomaterials	
Required technology	High-contrast observation Wide-field observation 3D tomography Cryo-TEM observation	High-resolution observation (HR)	Ultrahigh-resolution observation (UHR)
		EDS analysis*, STEM*, Limited-area diffraction*, Hollow-cone observation	

Note: Asterisks denote optional components.

3 Comfortable operating environment

The HT7800 offers a fully integrated workflow in one intuitive guided user interface (GUI). Both image navigation, using the wide field-of-view screen camera, and image acquisition, using the high-resolution camera, are carried out in one software platform. Combining an effortless workflow with sophisticated automation capabilities allows users of any experience level to achieve high-throughput, high-quality data acquisition.

4 Support for remote operation in a broad range of scenarios

The digitized operation of the instrument, from searching for the field of view to capturing images, is compatible with remote environments. It provides an assortment of beneficial applications, some of which include simultaneously sharing and exchanging captured TEM images at multiple points.

5 Capabilities to support a broad range of analytical techniques

The HT7800 comes standard with various features such as image-navigation capabilities to automated image acquisition, as well as wide-area automatic image capture, 3D tomography, and more. The system also supports a variety of optional capabilities, including a CLEM system*, STEM*, and EDS elemental analysis.

Note: Asterisks indicate optional features

6 Environmentally conscious design

As part of Hitachi High-Tech's commitment to advance the United Nation's Sustainable Development Goals, the HT7800 is designed to reduce environmental impact and ensure a clean vacuum environment, achieving a 30% reduction in CO_2 emissions (compared to previous instrument models H-7650, 2010) through lower power consumption, a smaller footprint, and the installation of turbo molecular pumps as standard components.

TEM observation workflow

The basic workflow of transmission electron microscopy (TEM) is: **searching → observation → analysis → data processing**. To allow operation for users of any experience level, the HT7800 Series offers a multitude of capabilities designed to improve operations of each workflow phase in order to produce high-quality data.

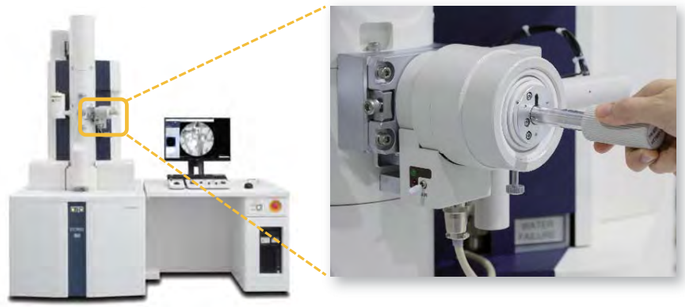
Specimen exchange: around 1 minute → **Searching** → **Observation** → **Analysis** → **Post processing**

- Searching
  - ·High-precision screen camera
  - ·Full field-of-view capturing (Whole view)
  - ·Microtracing
  - ·Stage memory
  - ·Auto drive
  - ·Seamless zoom*
- Observation
  - ·Autofocus
  - ·Auto pre-irradiation (API)
  - ·Drift correction
  - ·Automated image acquisition (image navigation)
  - ·Automatic capture of stitched images (AMF)
  - ·Automatic particle detection*
  - ·Image capture with reduced damage to specimen (low dose)
  - ·3D tomography
  - ·2-axis tomography*
- Analysis
  - ·Scanning transmission electron microscope*(STEM)
  - ·EDS elemental analysis*
  - ·EDS element mapping*
  - ·Nano analysis
  - ·Diffraction analysis*
  - ·Hollow cone dark-field observations
- Post processing
  - ·EMIP EX
  - ·Thumbnail display
  - ·Report generation

*Optional

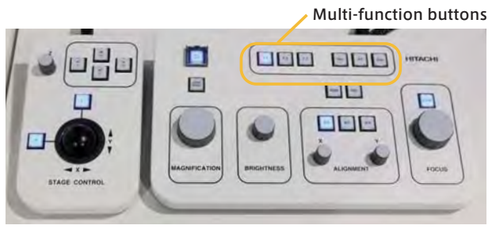
Speedy specimen exchange

Exchange evacuation completes within 30 seconds after inserting the specimen holder



Centralized control panel

The redesigned control panel features a new intuitive interface that allows for both TEM and STEM operations all in one. Additionally, commonly used features can be assigned to the muti-functional buttons to allow quick execution from the ergonomic control panel



Common control panel for TEM/STEM

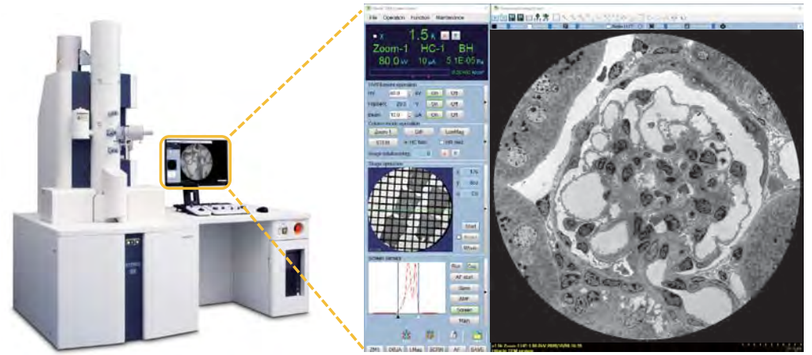
High-sensitivity screen camera allows intuitive operation

The HT7800 comes equipped with a digital CMOS fluorescent screen camera. CMOS cameras provide high sensitivity, high framerates, and high precision in order to locate the region of interest quickly and efficiently.

- Carry out all TEM observation workflow steps, including axis adjustment and image searching, in luminous laboratory environment
- A complete digital system provides greater sensitivity than the naked eye, reducing electron-beam damage during image searching
- The screen camera can be used for different automated features such as autofocus and view shifting to expedited throughput. View shifting allows the user to double click anywhere on the viewing screen to move the stage to that specified position.

Features enabled by screen camera:

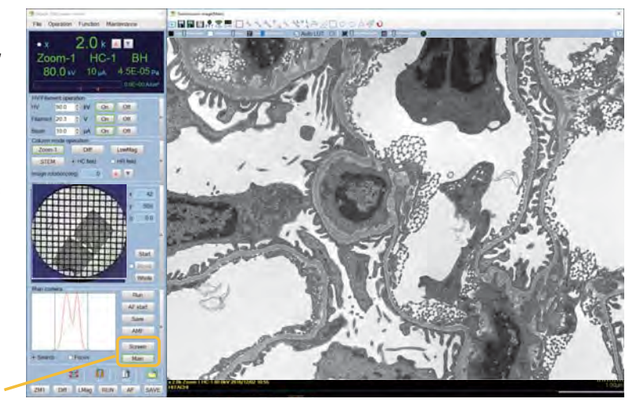
1. **Autofocus**
2. **View shift** (center field of view at clicked point)
3. **Live measurements**
4. **Acquire image or movie**



screen camera image

Intuitive operations with an easy-to-use GUI

The GUI displays observation conditions—including magnification, observation mode, accelerating voltage, emission current, and vacuum strength—and streamlines instrument operation by offering a sequence of functions and buttons for common operations in the main menu at the top of the screen. The display may be switched from screen camera to main camera with just a click of the mouse.

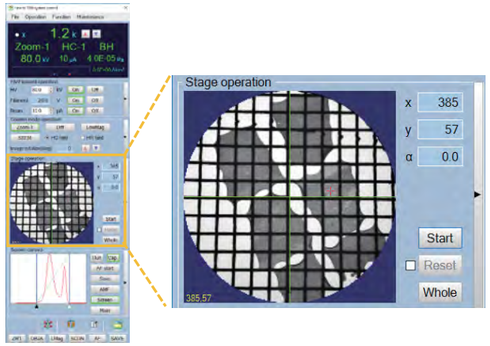


Main camera image

Field-of-view searching to find regions or structures of interest in specimens is the most time-consuming step in TEM observations. The HT7800 Series TEMs offer a variety of features for efficiently finding targeted regions and beginning observations.

Full field-of-view capturing (Whole view)

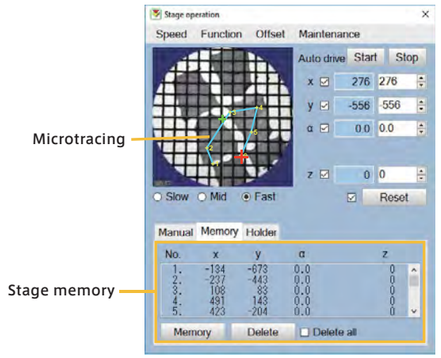
The "Whole view" feature captures an overall image of the specimen grid. The captured Whole-view image is automatically populated into the stage operation GUI window. The user can specify any position on the displayed Whole view image to automatically move the stage to that desired point.



Microtracing and stage memory

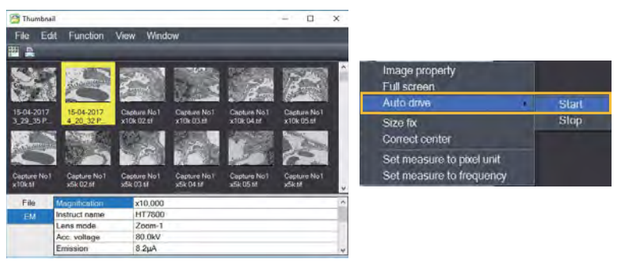
Microtracing displays the trajectory of the specimen-stage motion. This allows previously observed regions to be clearly distinguished from unobserved regions.
Stage memory stores the XYZ* coordinates of the specimen stage and the specimen tilt angle in memory; settings for as many as 100 observation points may be saved.
Recalling a saved specimen-stage position automatically moves the stage to that position.

Note: Z-axis requires 5axis stage option.



Auto drive

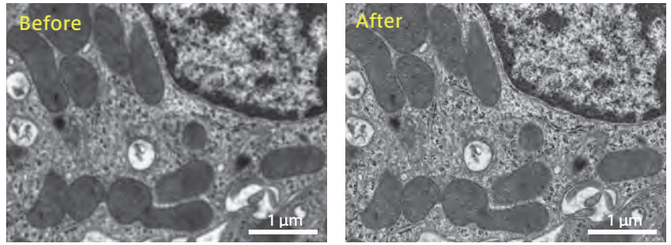
Saved images are displayed as thumbnails. Clicking a thumbnail and selecting Auto drive automatically moves the stage to the position at which that image was captured.



The HT7800 Series TEMs are equipped with a range of automation features to assist users in all fields to capture high-quality TEM images. By taking advantage of these features, even novice instrument users will find it easy to capture TEM images.

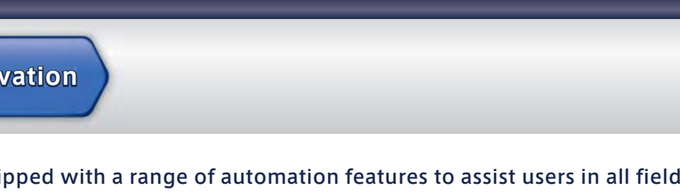
Autofocus

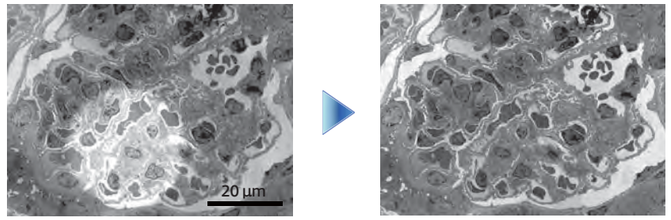
Focus alignment is one of the most crucial tasks, and Hitachi was the first instrument manufacturer to develop autofocus techniques. The autofocusing capabilities of the HT7800 Series instruments allow automated adjustment for optimal images with just a single click of the mouse. Autofocusing may be performed on either the main camera or screen camera.



Auto pre-irradiation (Auto Pre-Irradiation: API)

Electron-beam irradiation may damage specimens and induce specimen drift.
Auto pre-irradiation mitigates these effects by combining various scan modes (whole, frame, area) to ensure that electron-beam irradiation of the specimen is maximally effective.



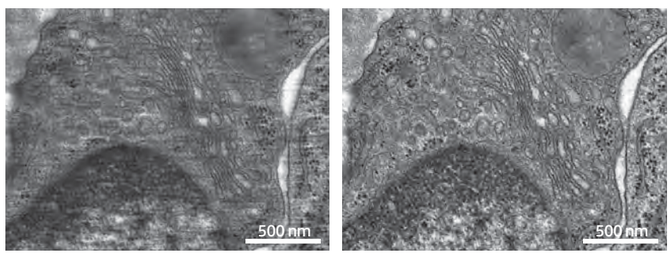


Before API (TEM image)

After API (TEM image)

Drift correction

Factors such as damage to specimens, and non-uniform specimen thicknesses may cause image drift. The HT7800 is equipped with special functionality for automatically correcting image drift to yield clear images.



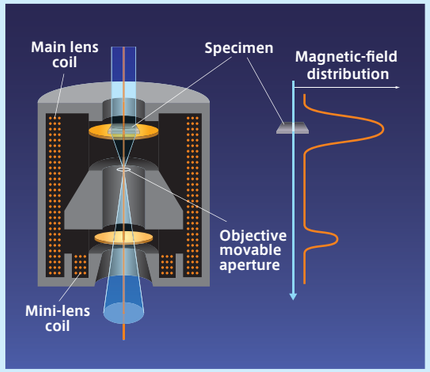
drift correction OFF

drift correction ON

Dual-mode objective lens

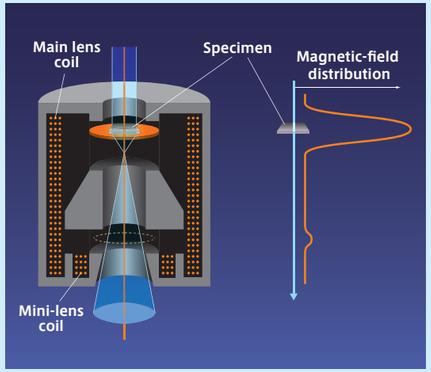
- The HT7800 is equipped with Hitachi's proprietary dual-mode objective lens, which is a single objective lens system supporting both long-focal-length and short-focal-length electron-optics modes.
- HC mode (long-focal-length lens) supports observations for low magnification, large fields of view, and high contrast. HR mode (short-focal-length lens) supports observations for high magnification and high resolution. Users can switch between these two observation modes with just a click of the mouse.

High-contrast (HC) mode: Long-focal-length lens



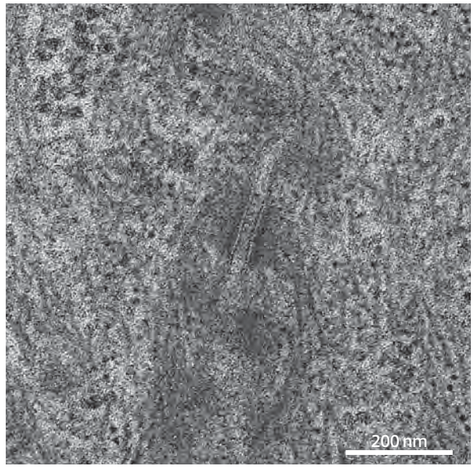
In HC mode, the main lens and mini lens have equal polarity, the main lens has a long focal length, and scattering contrast is enhanced by the movable objective aperture positioned at the optimal point.

High-resolution (HR) mode: Short-focal-length lens



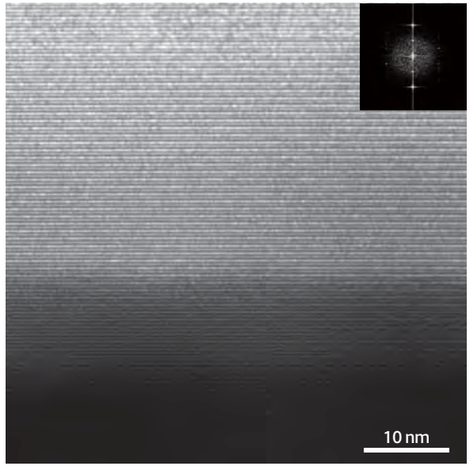
In HR mode, the main lens and the mini lens have opposite polarities; the main lens can have a shorter focal length for the same specimen position used in HC mode, supporting high-resolution observation.

High-contrast observation (HC mode)



Specimen: Rat cornea resin-embedded section(Lead stained)
Observation instrument: HT7800
Accelerating voltage: 80 kV
Magnification: × 30,000
Specimen courtesy: Prof. Akira Sawaguchi,
Faculty of Medicine, University of Miyazaki

High-resolution observation (HR mode)

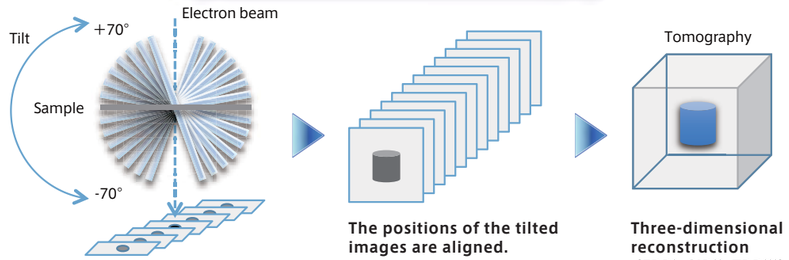


Specimen: Asbestos (Crocidolite)
Observation instrument: HT7800
Accelerating voltage: 120 kV
Magnification: × 400,000

3D tomography

The HT7800 Series TEMs include, as a standard feature, automated electron-beam tomography acquisition by using sequentially tilted images. The standard feature also includes software to reconstruct 3D structures from these images (via the FBP method*) with minimal user intervention. The highly stable hyperstage goniometer design allows maximum tilt angles of up to ±70°.
The use of Hitachi's proprietary reconstruction software (optional, based on the TBR method***) greatly suppresses artifacts arising from restrictions on tilt angles, yielding high-quality 3D reconstructed images.

Tomography workflow



A sequence of images at various tilt angles is captured automatically.

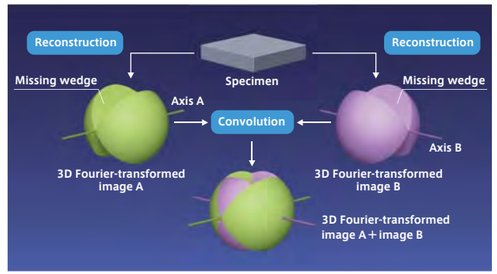
The positions of the tilted images are aligned.

Three-dimensional reconstruction (FBP*, SIR**, TBR***)

FBP method*: Filtered Back-Projection, SIR method**: Simultaneous Iterative Reconstruction Technique
TBR method***: Topography Based Reconstruction

Two-axis tomography (option)

Two-axis tomography combines reconstructed sequences of images captured at various tilt angles around the X and Y axes to yield high-precision reconstructed images.
In two-axis tomography, two reconstructed images are combined, partially compensating for gaps in information due to restrictions on specimen tilt angle, to form a reconstructed tomogram with greater precision than a single-axis tomogram.



Specimen Holders

Specimen Holders for a Variety of Advanced Applications (optional)
In addition to various Hitachi holders (below), specialty holders for low temperature, heating, in-situ and other experiments are available from several manufacturers.

Single Tilt Holder	One Touch Single Tilt Holder	Double Tilt Holder
One Touch Three Specimen Holder	X-ray Analysis Holder	Rotation Holder

The HT7800 also features more sophisticated capabilities for automated image acquisition such as Automated Montaging and Image navigation. As standard, the HT7800 software includes auto montaging, also known as auto multiple frames (AMF), which is a process of capturing multiple images and then seamlessly stitching them together to generate a single image. As a result, a large field of view with a high pixel density is obtainable. Additionally, the HT7800 includes image navigation which creates a specimen map by layering captured images. Large regions of interest used for mapping can be created by taking montages.

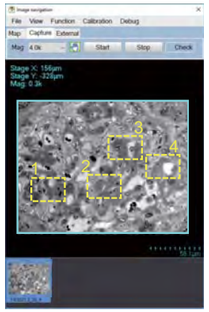
Automated image acquisition (Image navigation)

Automated image acquisition at points of interest

Field-of-view searching → Selection of automated imaging point → Automated image acquisition at selected point

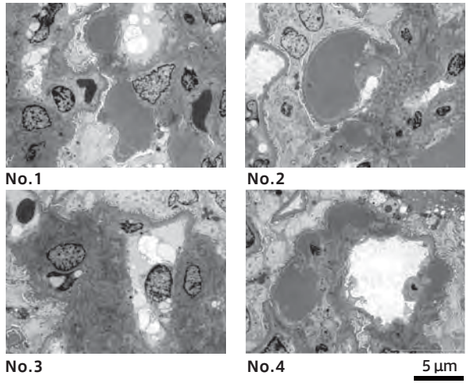
Whole view image (× 50)

The desired field of view is selected from the overall image grid captured using the Whole view feature.



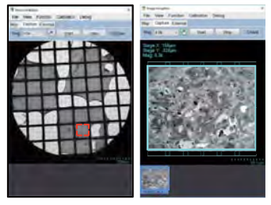
No.1-4: 4 images
Specified magnification: × 4,000

Specify multiple magnifications and fields of view for captured images.



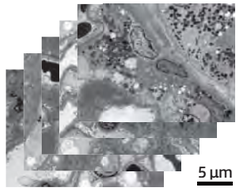
Automated capture of stitched images

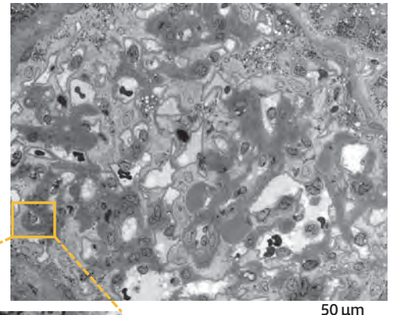
Selection of automated imaging area → Automated acquisition of sequential images → Automated stitching of subimages



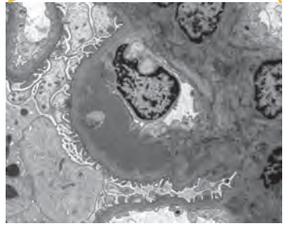
Imaged area: 6 (horizontal) × 7 (vertical)
Total: 42 images
Specified magnification: × 4,000

Select area of interest from Whole view image grid, then specify magnification.





Stitched image:
6 (horizontal) ×7 (vertical)
Total: 42 subimages



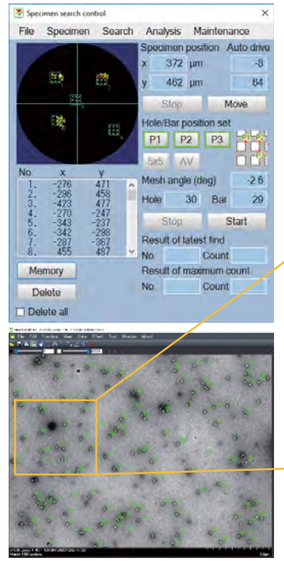
Enlargement of indicated region

5 µm

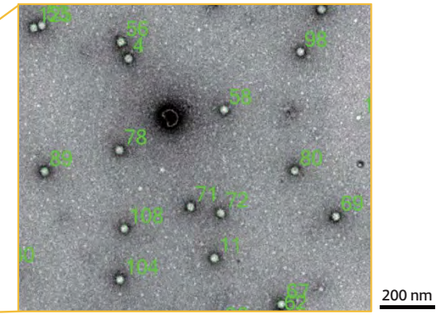
Specimen: Human kidney resin-embedded section (membranous nephropathy)
Observation instrument: HT7800
Accelerating voltage: 80 kV
Samples provided by courtesies of Dr. Kawamura Koichi
(Waseda Research Institute for Science and Engineering)

The HT7800 Series TEMs offer a variety of features to further simplify observation procedures and allow users to operate more efficiently.

Automatic particle detection (option)



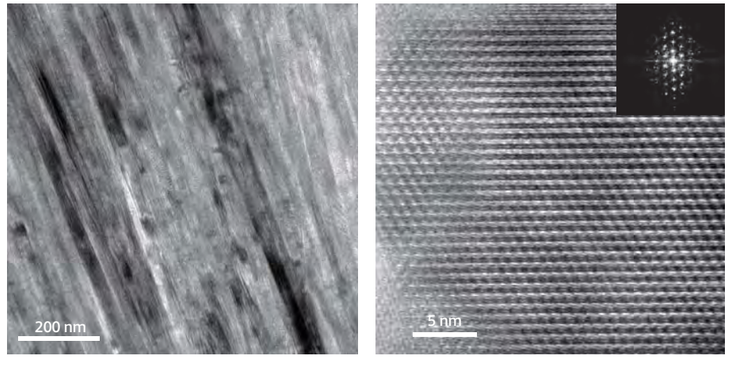
Automatic particle detection is a feature in which a specified area is automatically imaged and particles of preselected sizes are automatically detected in the resulting TEM images. The image below shows an application of automatic particle detection to a negative-stained norovirus specimen. The auto-detected norovirus particles are assigned individual numbers that may be exported together with other experimental results.



Specimen: Negative staining Norovirus,
Observation instrument: HT7800
Accelerating voltage: 120 kV, Magnification: × 10,000
Specimens provided by courtesies of Dr. Etsuko Utagawa
(Representative,Science Lab.Yokohama/Visiting Researcher,
National Institute of Infectious Diseases)

Image capture with reduced damage to specimen (low-dose conditions)

Samples susceptible to damage from electron-beam irradiation require the radiation dose be reduced as much as possible. The low-dose observation feature of the HT7800 operates by deflecting the electron beam to focus off the region of interest, and then returning to the observation point and acquiring images automatically. Below shows low-dose observations of a shark tooth fragment, which mainly consists of fluorapatite. The low-magnification image on the left shows an array of column-shaped crystals. The crystal lattice is clearly visible in the high-magnification image on the right. This example demonstrates the possibility of mitigating specimen damage due to electron-beam irradiation while observing specimens such as apatite containing large quantities of crystalline water.



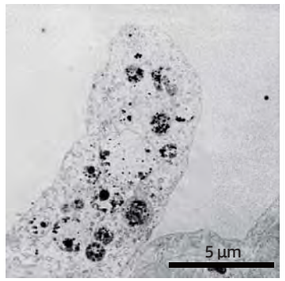
Specimen: Shark teeth
Observation instrument: HT7830
Accelerating voltage: 120 kV
Magnification:
(Left figure) ×40,000
(Right figure) ×1,000,000

The HT7800 Series TEMs can be used with energy-dispersive X-ray analyzer (EDS) systems for X-ray elemental analysis. Similarly, element-mapping images can be acquired using the optional elemental mapping function or scanning transmission electron microscopy (STEM) for higher resolution.

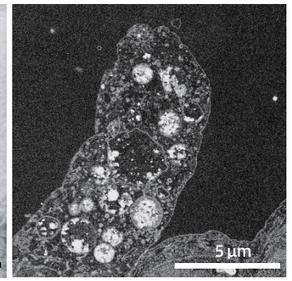
Scanning transmission electron microscopy (STEM)*
EDS elemental analysis*, EDS element mapping*

For STEM, BF-STEM (bright-field) images and DF-STEM (dark-field) images may be acquired simultaneously.
The images at the right are STEM images of the lymphatic vascular system of a zebrafish, imaged 24 hours after injecting a dye into the abdominal cavity.

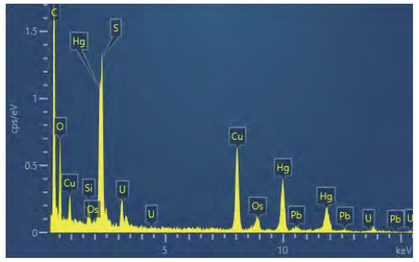
Specimen: Zebra fish
Observation instrument: HT7820
Accelerating voltage: 120 kV
Magnification: ×10,000
X-ray Analysis instrument: Oxford Ultim Max TLE
Specimens provided by courtesies of Prof. Erina Saito
(Hirosaki University Graduate School of Medicine)

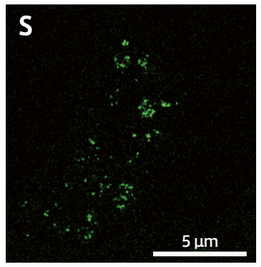


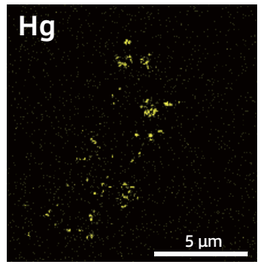
BF-STEM Image



DF-STEM Image

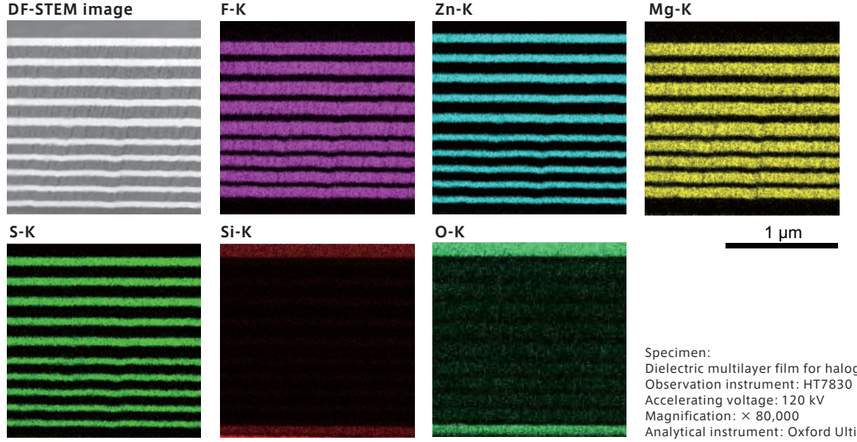






Reference:Saito, E. et al, : Intraperitoneal dye injection method for visualizing the functioning lymphatic vascular system in zebrafish and medaka Developmental Dynamics. 2020;249:679–692

The EDX mapping data below is of a multilayer dielectric thin film from a halogen lamp which was prepared using FIB-SEM. Element maps for F, Zn, Mg, and S indicate a layered structure with layer thicknesses of approximately 100 nm. Correlations between F and Mg and between Zn and S are also observed.

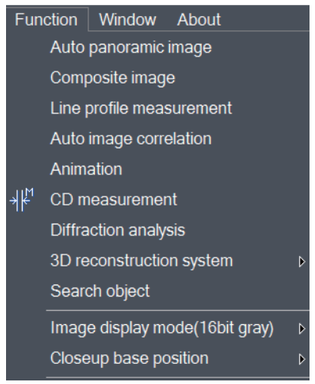


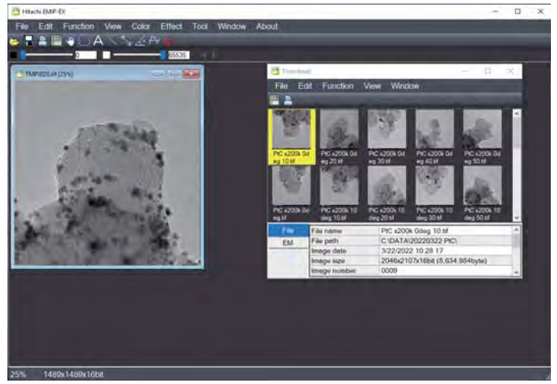
Specimen:
Dielectric multilayer film for halogen lamps
Observation instrument: HT7830
Accelerating voltage: 120 kV
Magnification: × 80,000
Analytical instrument: Oxford Ultim Max TLE

Hitachi's built-in EMIP software is a powerful integrated imaging processing platform that is designed for management, measuring, and processing of acquired images. The EMIP software provides users with more capabilities to overcome imaging challenges while enhancing throughput.

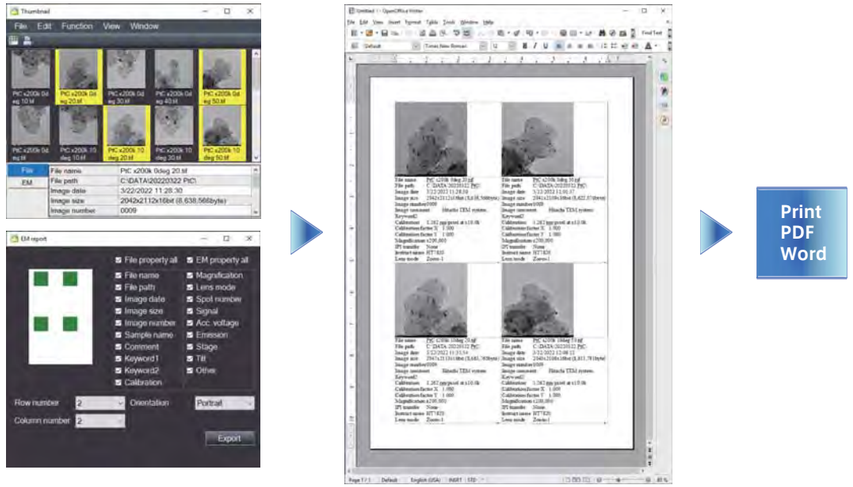
EMIP-EX (Image processing software)

To facilitate with image management, the software aids as a digital library that archives all saved images. Each saved image is automatically registered in a database with a thumbnail to ensure behind-the-scenes organization. Thumbnails provide file information (name, date, path, size, etc.) as well as EM conditions (magnification, voltage, stage coordinates, etc.). No need to hunt around — save time by easily accessing information.





Additionally, these thumbnails can be utilized for report generation. Quickly form an image EM report in EMIP by selecting the desired thumbnails and the preferred Layout settings. For measurement reports, easily export all measurements taken into a .CSV file.



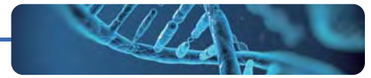
Application Data

Various application data are posted on our membership site "S.I.navi".

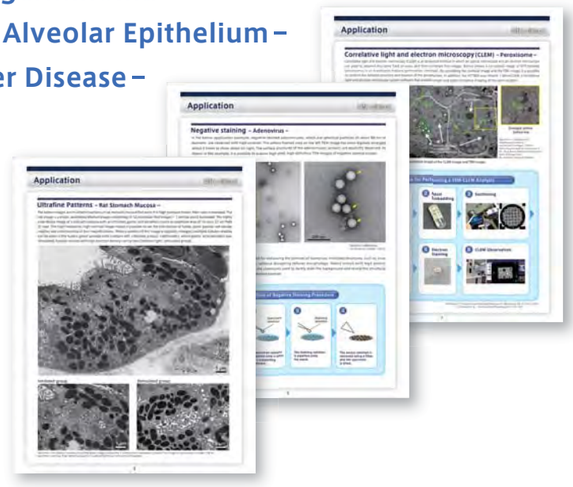
Click here for the HT7800 application data collections

Hitachi-Hightech HT7800

Life Sciences

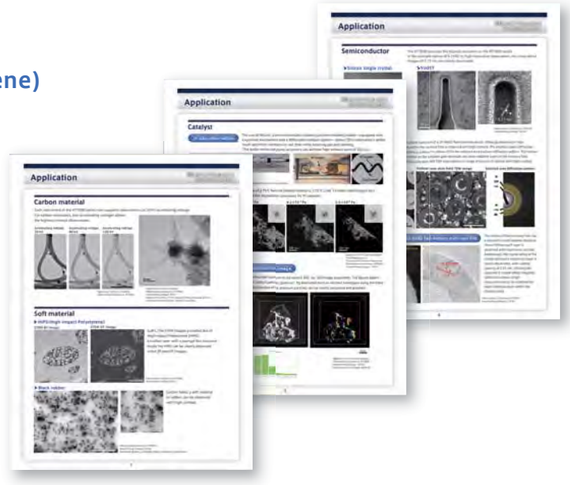


- Pathological Tissue –Dysgerminoma–
- Pathological Tissue –Rat Alveolar Epithelium–
- Pathological Tissue –Liver Disease–
- Ultrafine Patterns –Rat Stomach Mucosa–
- Negative staining –Adenovirus–
- Cryo-transfer Image –Liposomes–
- Correlative light and electron microscopy (CLEM) –Peroxisome–



Materials Science & Semiconductors

- Carbon materials
  - ▶ Carbon nanotube
- Soft materials
  - ▶ HIPS (High Impact Polystyrene)
  - ▶ Black rubber
- Catalysts
  - ▶ Hollow-cone dark-field observation
  - ▶ In-situ observation
  - ▶ The three-dimensional reconstruction image
- Semiconductors
  - ▶ Silicon single crystal
  - ▶ FinFET
  - ▶ 3D NAND flash memory



Essential specifications (TEM)

		HT7800	HT7820	HT7830
Resolution (lattice)*1		0.20 nm (Off-axis, 100 kV)	0.14 nm (Off-axis, 120 kV)	0.14 nm (off-axis, 120 kV) 0.19 nm (on-axis, 120 kV)
Accelerating voltage		20～120 kV (100 V/step variable)		
Magnification	Zoom (HC mode)	×200～×200,000	×200～×300,000	×1,000～×300,000
	Zoom (HR mode)	×4,000～×600,000	×4,000～×800,000	×4,000～×1,000,000
	Low-Mag	×50～×1,000	×50～×1,000	×100～×1,000
Maximum tilt angle (Using a Single tilt holder)		±70°	±30°	±10°

＊1:The resolution is guaranteed by the specified camera

Various optional accessories

Item	Function	HT7800	HT7820	HT7830	Remarks
TEM Observation	Pump	○	○	○	Select from Rotary pump or Diaphragm pump
	5 axis stage	○	○	Standard equipped	
	Pneumatic driven objective movable aperture	○	–	–	
	LaB6 filament	○	Standard equipped	Standard equipped	
STEM Observation	STEM	○	○	○	
Electron diffraction	Field limiting aperture	○	○	Standard equipped	
	Beam stopper	○	○	Standard equipped	
EDS system	Energy dispersive X-ray spectroscopy (EDS)	○	○	○	
	TEM Mapping	○	○	○	Cannot coexist with STEM
Image processing	Image processing EMIP-EX	Standard equipped*	Standard equipped*	Standard equipped*	Alignment for tomography and 3D reconstruction FBP method are standard equipment. ＊SIR method, TBR method, Tow-axis tomography are optional
	Diffraction analysis etc.	○	○	○	Please contact us for details.
Cryo-observation	Cold finger	○	○	○	
Automatic particle search	Automatic particle search function	○	○	○	
Nano analysis	Nano analysis function	–	○	○	

Installation site conditions

Power	Voltage	Single phase AC 100 V ±10 % (Step down transformer is required for AC 115, 200, 220 and 240 V:Optional)
	Frequency	50/60 Hz
	Capacity	4 kVA at most (with STEM)
	Grounding	Independent grounding with a resistance of 100 Ω or less
Cooling water (Use a circulator)	Temperature:15～20 ℃ (Stability at ±0.1 ℃ (for 30 minutes) Flow: 1.8～2.2 L/min, Pressure: Approx. 0.05～0.15 MPa Inlet/Drain: Rc 3/8 (1 each)	
Compressed Air	Air pressure	0.35～0.5 MPa
Stray magnetic field	Maximum 1.0×10^{-7} T or less	
Room	Installation floor space	300 cm wide× 250 cm deep
	Ceiling height	220 cm or more (height of instrumentation is 199 cm)
	Temperature	18～25 ℃
	Humidity	30～60 %RH