

Hitachi High-Tech

Hitachi Spherical Aberration Corrected STEM

HD-2700



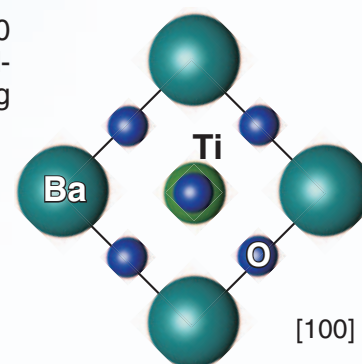
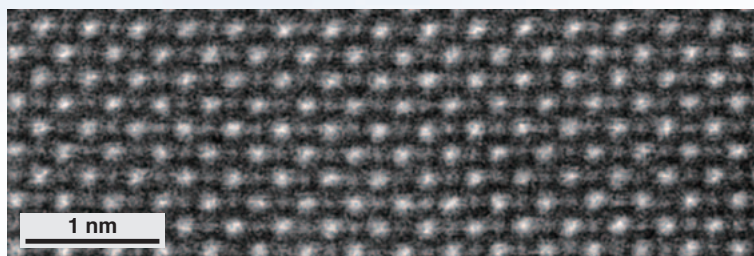
HITACHI

Features

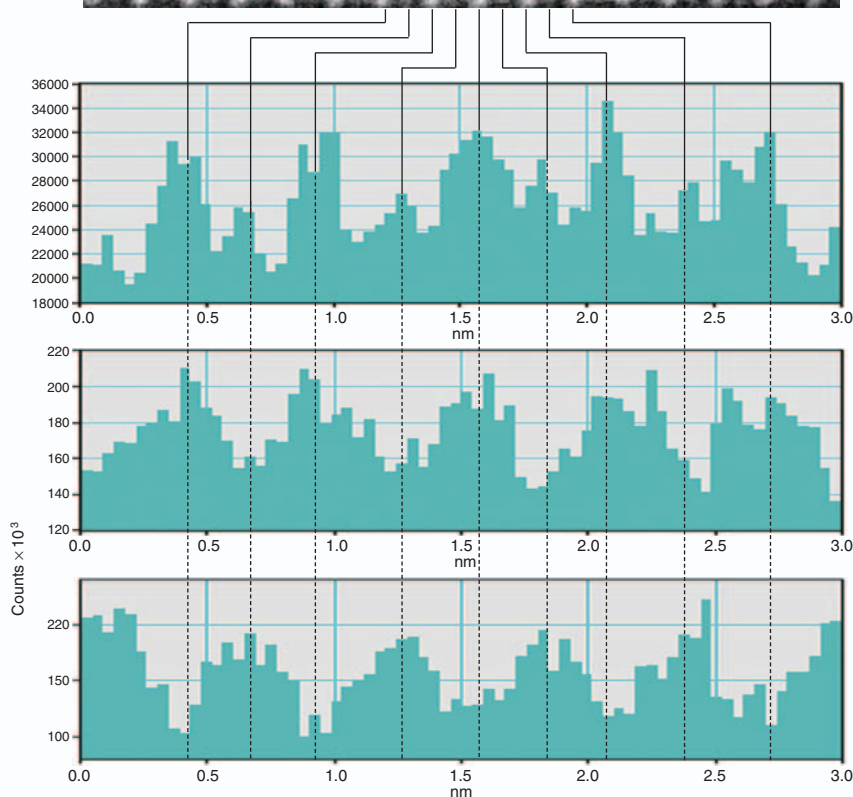
- Superior image resolution
- High speed, High spatial resolution, and High sensitivity analysis
- Automated, user-friendly operation

Atomic column-by-column EELS* elemental imaging

The ultra fine electron probe with large probe current of HD-2700 equipped with Cs-corrector can visualize the elemental distribution according to the individual atomic columns by using EELS spectrum imaging method.



HAADF-STEM image



Signal intensity profile in a HAADF-STEM image

Integrated intensity profile extracted from EELS spectrum at Ba-M edge

Integrated intensity profile extracted from EELS spectrum at Ti-L edge

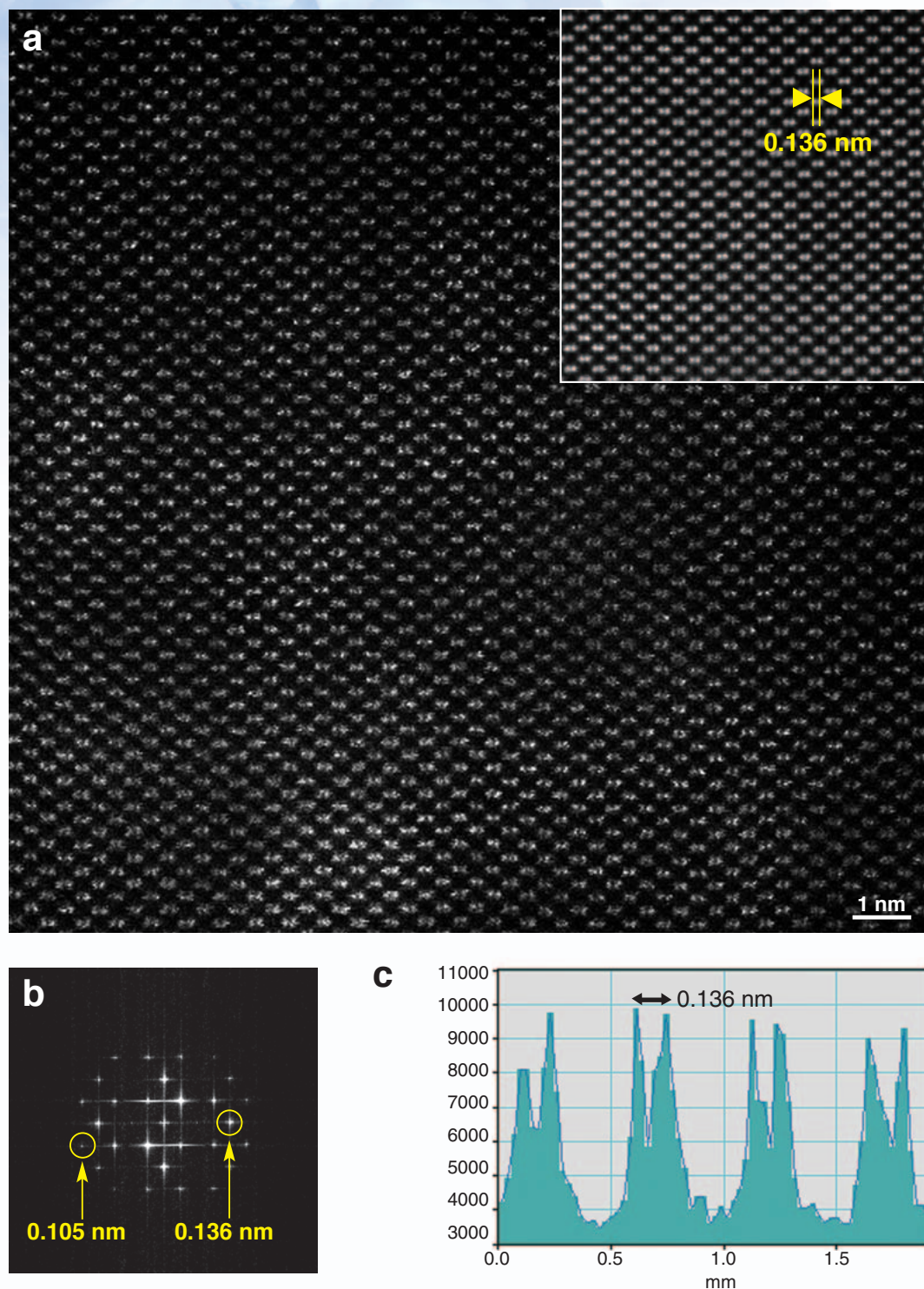
HAADF-STEM image of BaTiO₃ viewed along [100] zone axis (accelerating voltage is 200 kV) (Top image). Intensity profiles extracted from EELS spectrum at Ba-M edge and Ti-L edge coincide the HAADF image intensity profile (Acquisition time 70s) (Bottom three profiles).

w/ Cs-corrector, Schottky gun, Std. lens

*: Available as an option

Ultra-high resolution imaging using a Cs-corrector*

The standard HD-2700 guarantees 0.14 nm resolution in the high angle annular dark-field (HAADF) STEM imaging mode. 0.105 nm information limit is achievable with a high-resolution objective lens pole-piece*.



(a) Si <110> zone-axis HAADF image (raw data) and the filtered image (noise reduction) (Accelerating voltage 200 kV, cold FEG, Cs corrector, 10s acquisition time), (b) FFT of (a), and (c) intensity profile of (a), showing the Si atom dumbbells of 0.136 nm distance.

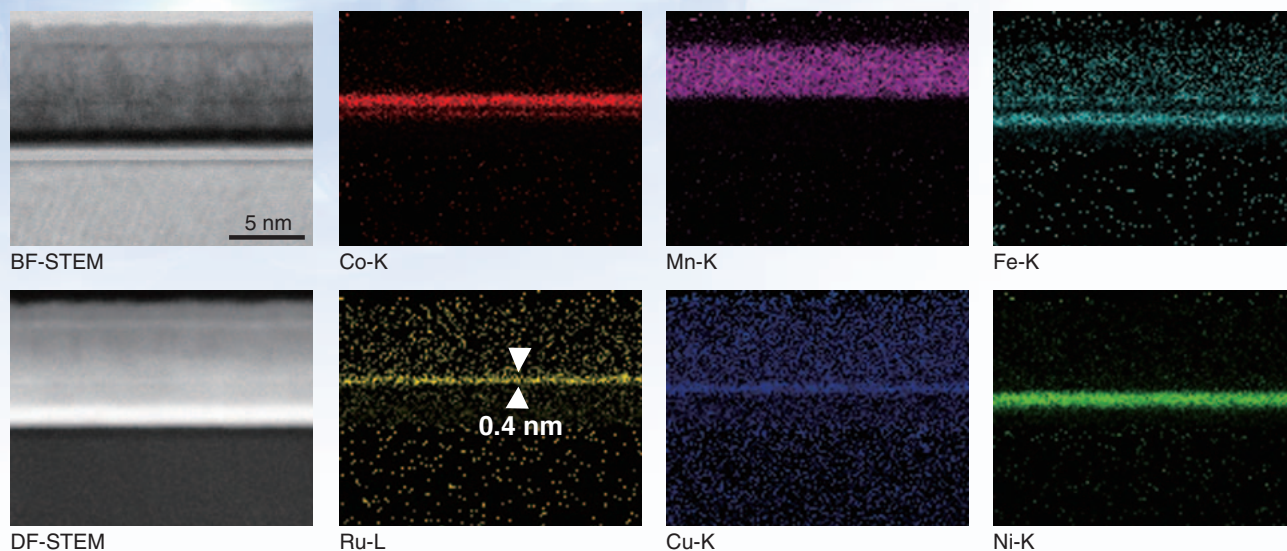
w/ Cs-corrector, Cold-FE gun, HR lens

*: Available as an option

High spatial resolution EDX* analysis benefited from Cs-correction

In addition to the high EDX sensitivity, adding a Cs corrector allows a large probe current generated into a finer electron probe. High spatial resolution X-ray analysis is therefore guaranteed.

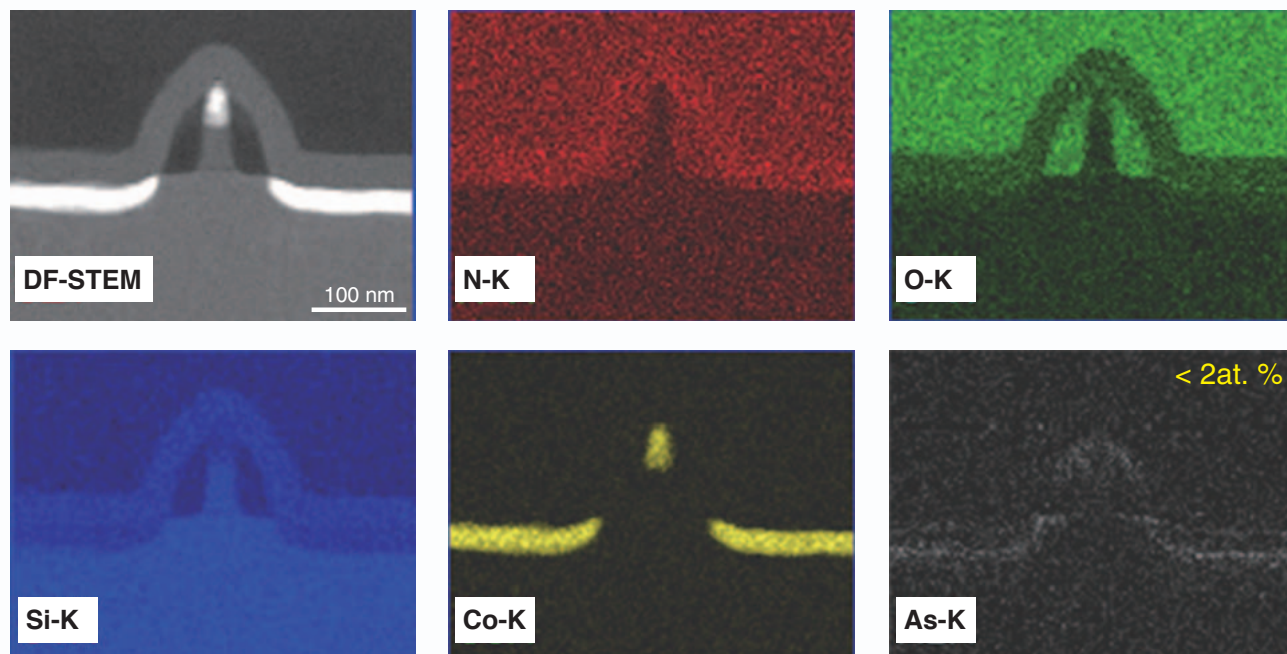
With benefit of Cs-corrector, a large probe current in a fine probe enables high speed / high spatial resolution / high sensitive EDX analysis.



BF and DF images of a GMR multiplayer specimen and corresponding EDX maps showing various elemental distribution. A 0.4 nm thick Ru layer is clearly seen.

Accelerating voltage: 200 kV. Total acquisition time: 20 minutes

w/ Cs-corrector, Schottky gun, Std. lens



DF STEM image of a Si-device specimen and corresponding EDX* maps showing various elemental distribution. The As distribution of <2 at.% concentration is clearly seen in the above EDX map.

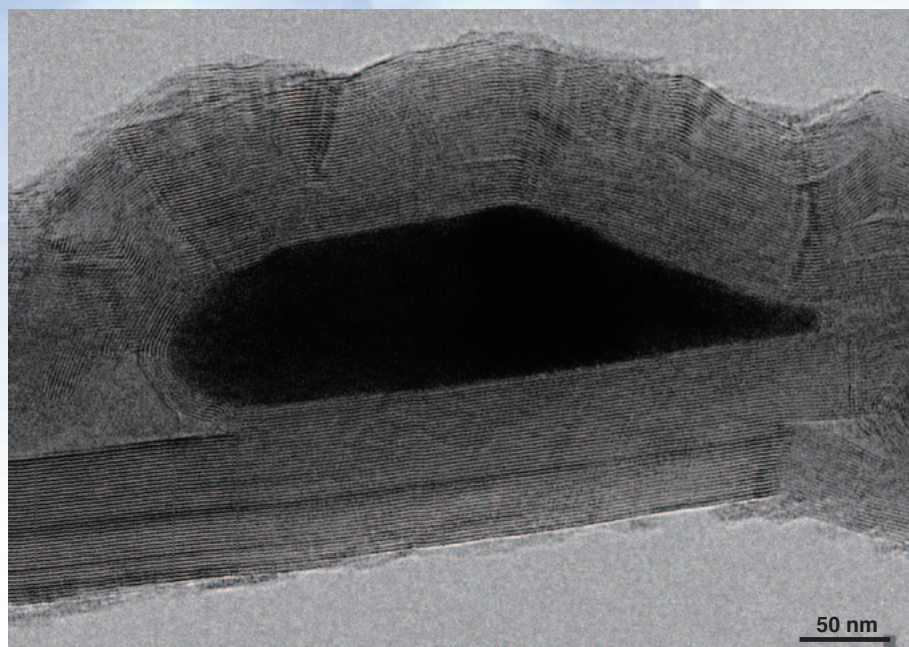
Accelerating voltage: 200 kV, Cs corrector. Total acquisition time: 20 minutes.

w/ Cs-corrector, Schottky gun, Std. lens

*EDX: Energy Dispersive X-ray spectroscopy
Available as an option

High resolution, high contrast imaging at 120kV*

BF-STEM lattice image of a multiple layer carbon nanotube filled with metal.

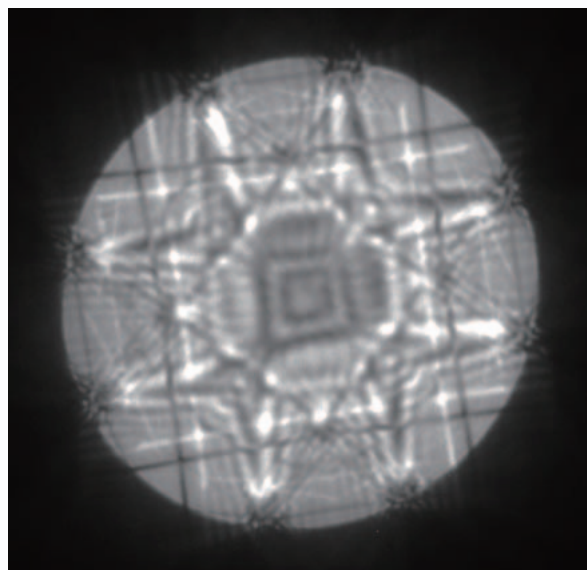


Specimen: metal-encapsuled
carbon nanotube

Observation condition
Accelerating voltage: 120 kV

w/ Cs-corrector, Schottky gun, Std. lens

Observation of electron diffraction patterns using CCD camera

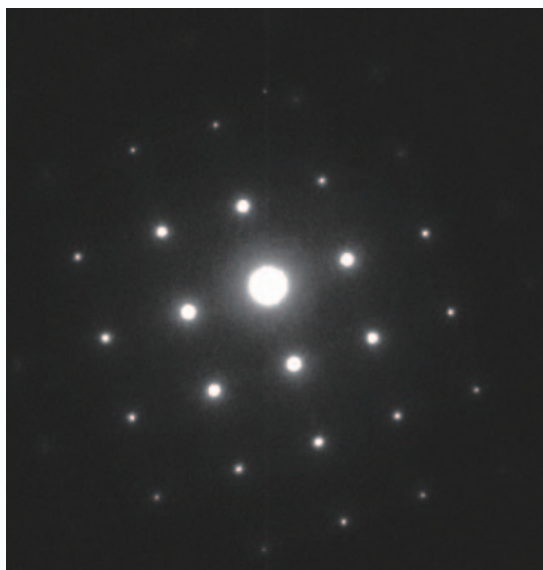


A convergent beam electron diffraction pattern

Specimen: Si (100)

Observation condition

Accelerating voltage: 200 kV



A parallel nano-beam electron diffraction pattern

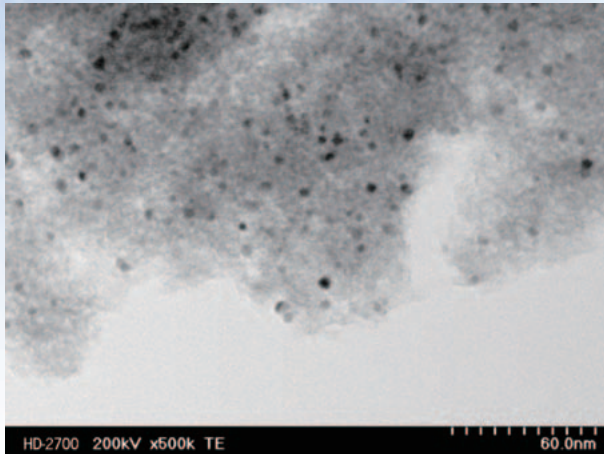
w/ Cs-corrector, Cold-FE gun, HR lens

*: Available as an option

A wide variety of imaging capabilities

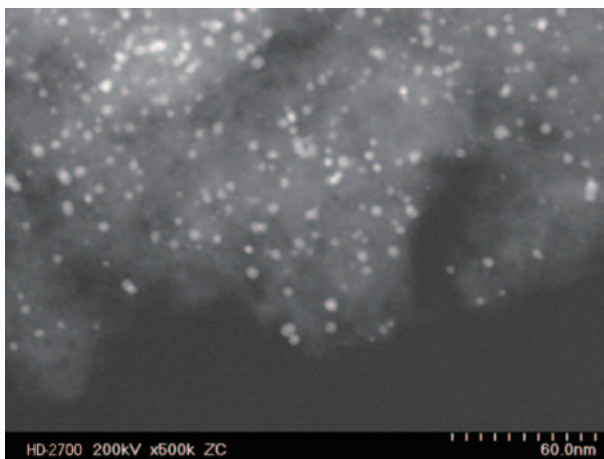
The HD-2700 allows bright-field (BF), high-angle annular dark-field (HAADF), secondary electron (SE) imaging, and electron diffraction, as well as imaging at 200 kV and 120 kV.

An example of catalyst nano-particles



BF imaging mode

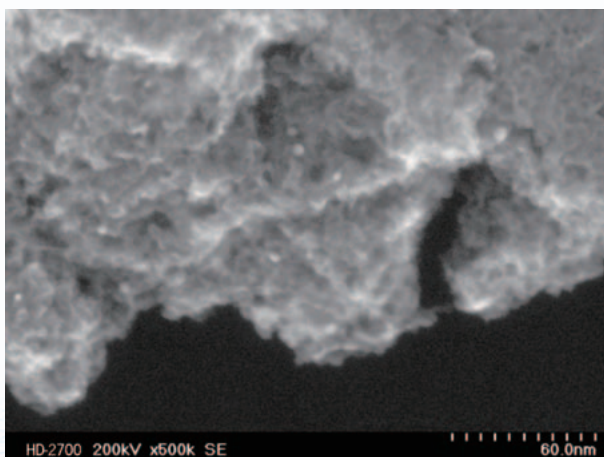
The BF STEM imaging mode allows imaging of structures on the basis of phase contrast similar to a typical transmission electron microscope imaging.



HAADF imaging mode

The HAADF-STEM imaging mode collects high-angle scattered electrons with an annular dark-field detector.

The image contrast is proportional to the atomic number (Z-contrast image), therefore composition dependence with respect to the image contrast is presented.



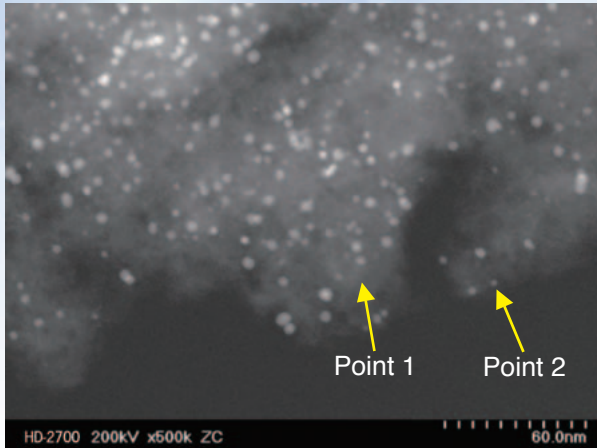
SE imaging mode

Secondary electrons generated from the surface and inside of specimen by the incident electron beam are collected utilizing an SE detector for high resolution imaging for surfaces and internal structures.

w/o Cs-corrector, w/ Schottky gun, Std. lens

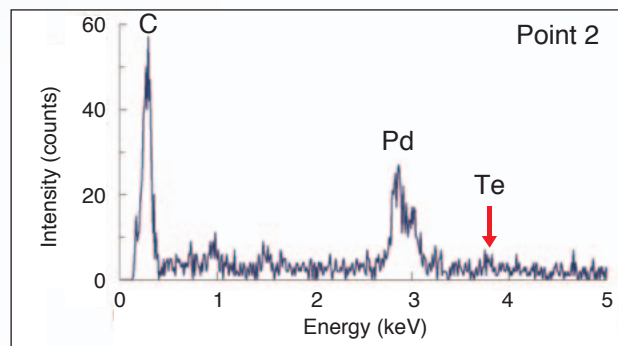
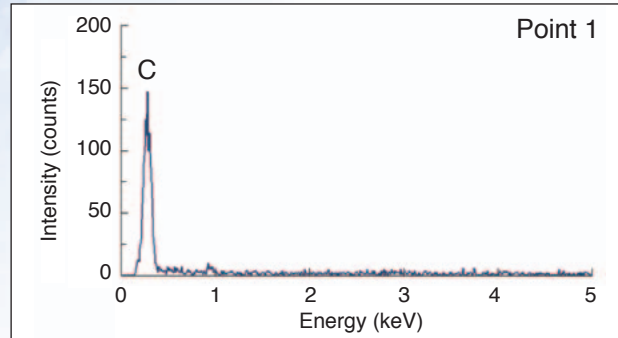
High sensitivity and fast EDX* chemical analysis

The HD-2700's X-ray detection geometry permits a solid angle of 0.3 sr or greater, resulting in high sensitivity EDX analysis for small areas (<1 nm) and elemental mapping at very high S/N ratios.

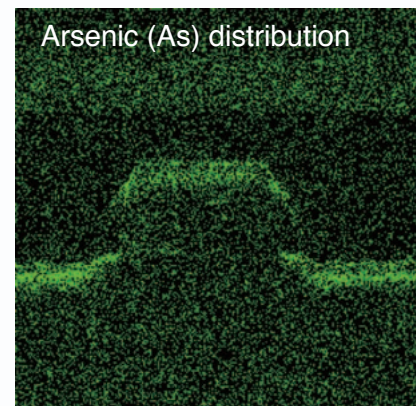
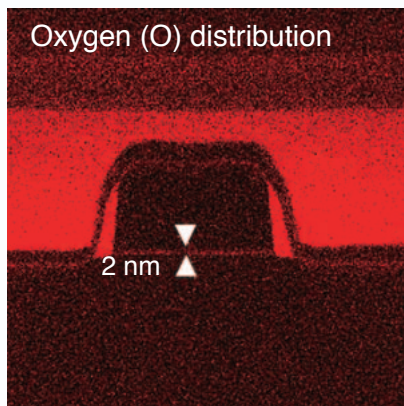
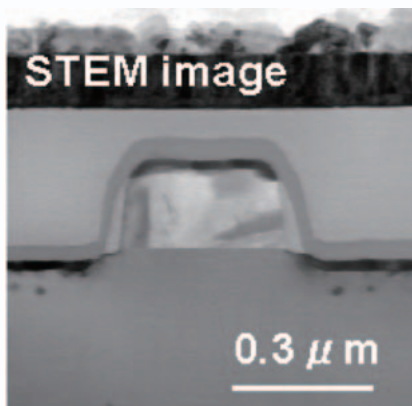


Point analysis of Pd-Te catalytic particles.

Probe diameter: 1 nm
Acquisition time: 20 sec.



w/o Cs-corrector, w/ Schottky gun, Std. lens



Elemental mapping of a Si-device.

Probe diameter: 1 nm

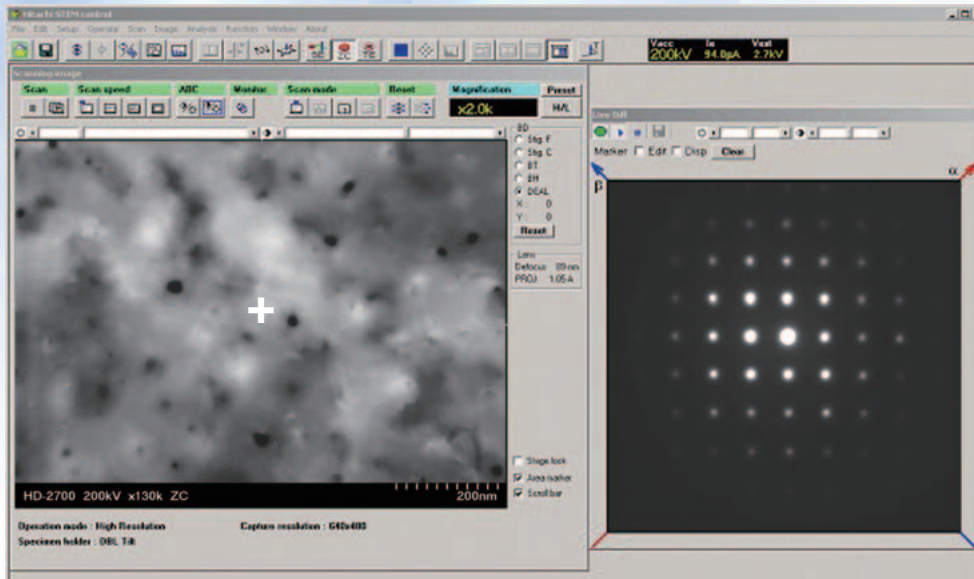
Oxygen (O) and Arsenic (As) distributions are shown together with a bright-field (BF) STEM image (left). A 2 nm-thick oxide layer at the gate is shown in the oxygen map. The As map of a 0.5 at.% concentration was obtained in a long term acquisition by using specimen drift compensation function.

w/o Cs-corrector, w/ Schottky gun, Std. lens

*EDX: Energy Dispersive X-ray spectroscopy
Available as an option.

Nano area characterization using electron diffraction pattern

Hitachi's live diffraction unit* allows acquisition of live electron diffraction pattern from a small area (2 mrad) and display simultaneously with HAADF STEM image.



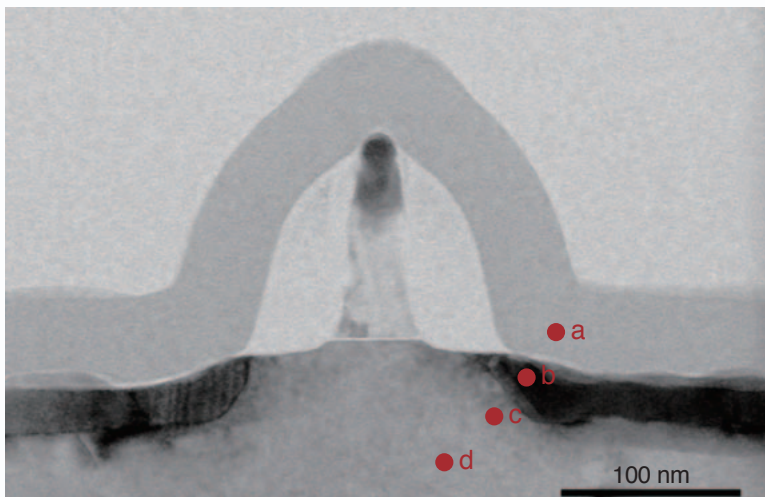
Images:

Left: DF-STEM image of Au (100) thin film

Right: electron diffraction pattern from the specimen at the cursor position

Simultaneous display of a dark-field STEM image and a corresponding electron diffraction pattern

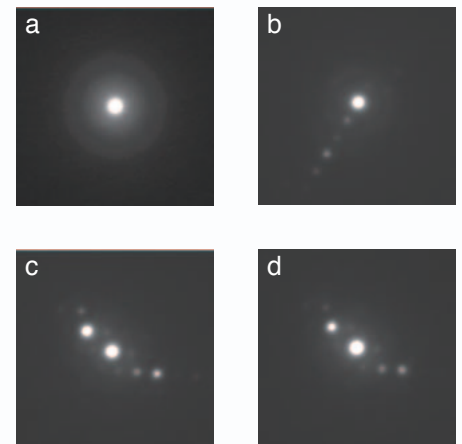
w/o Cs-corrector, w/ Schottky gun, Std. lens



Bright field STEM image and electron diffraction pattern corresponding to the superimposed points a, b, c and d of a Si-device.

Observation condition

Accelerating voltage: 200 kV

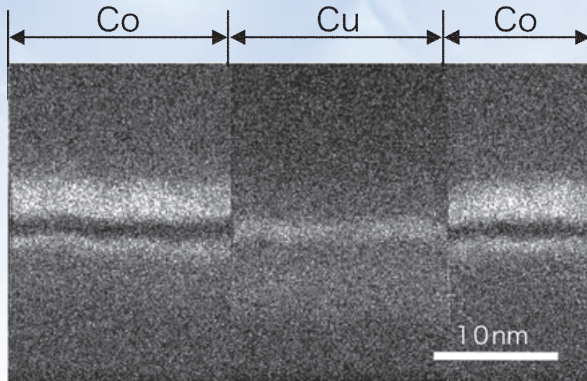


w/o Cs-corrector, w/ Schottky gun, Std. lens

*: Available as an option

Real-time EELS elemental mapping Hitachi EV3000 EELS spectrometer

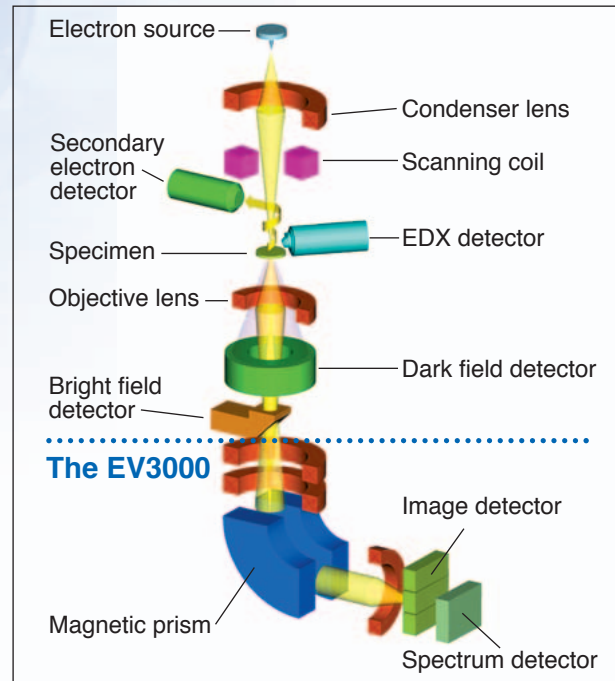
Also available on the HD-2700, the new Hitachi EV3000 spectrometer* allows mapping of elemental distribution in real-time at nanometer resolution. Switching element of interest during the mapping acquisition is readily accomplishable.



Switching between elements of interest is done easily at any time during the mapping acquisition.

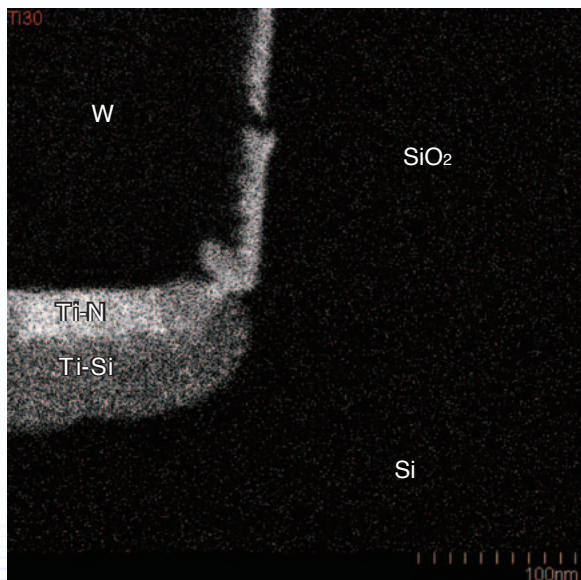
Accelerating voltage: 200 kV

w/o Cs-corrector, w/ Schottky gun, Std. lens



A configuration of the EV3000

Elemental mapping using Hitachi's real-time, 3-window EELS analysis technique



Ti-distribution image

This technique allows quantitative and real-time mapping of Ti distribution, a specific element of interest in this study. It is also possible to distinguish the imaging contrast difference caused by Ti-N and Ti-Si bonding, respectively.

Ti distribution map of Si device

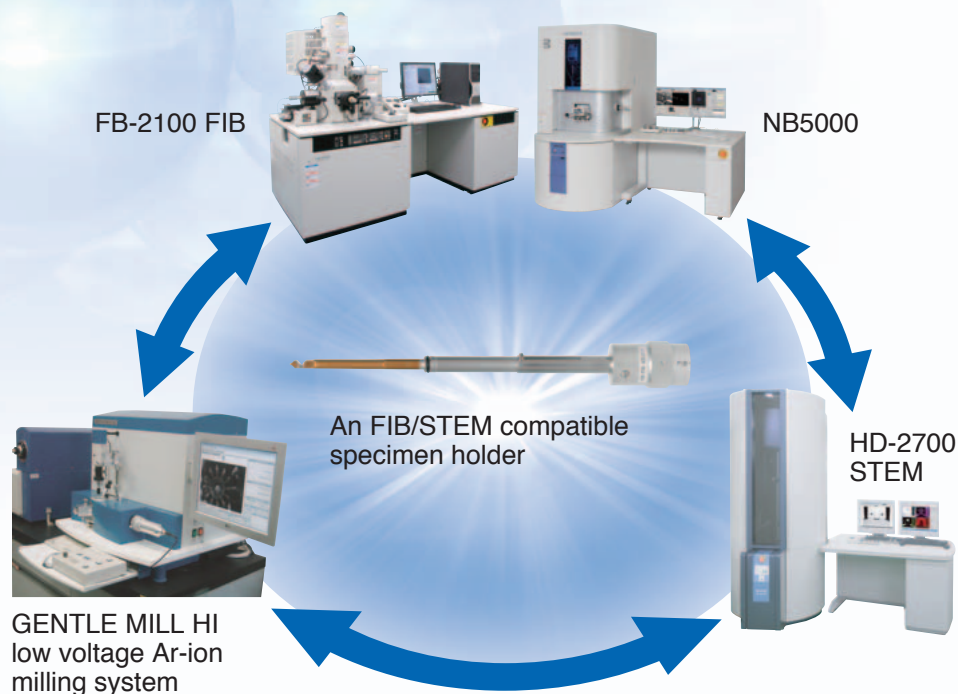
Accelerating voltage: 200 kV

w/o Cs-corrector, w/ Schottky gun, Std. lens

*: Available as an option

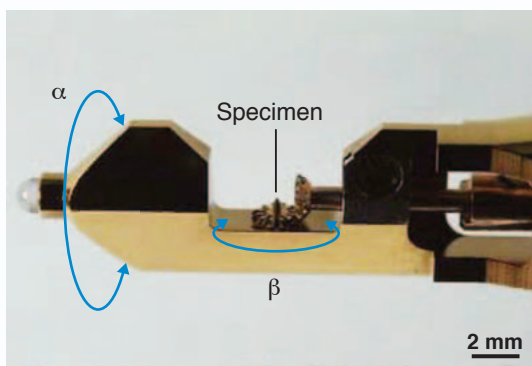
Compatible specimen holder design

The HD-2700 has a specimen holder which is compatible with an FIB and low voltage Ar-ion milling system. This specimen holder design allows operators to use the same specimen on an FIB, Ar-ion milling and the HD-2700 without remounting the specimen.

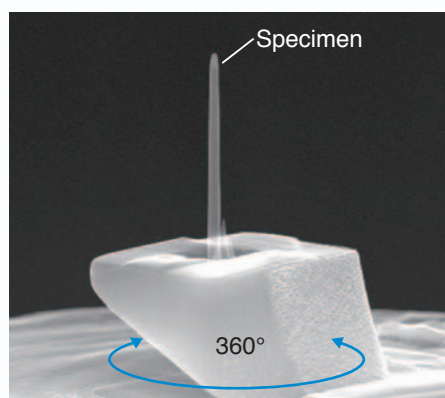


Full dataset 3D imaging in real-time

Hitachi's unique 3D sample holder* allows imaging and chemical mapping with a full 360° of specimen rotation. This complete dataset eliminates "missing angle wedge" artifacts suffered by 3D structural reconstruction from $\pm 70^\circ$ tilt dataset. At each rotation angle, BF, HAADF, SE images can be acquired, as well as EDX* and EELS* spectra. The data can be processed for 3D reconstruction using Hitachi EMIP* software. Users can also view the 3D structure in real-time while working with the HD-2700.



Tip of 360° rotation holder
 α : $\pm 20^\circ$ (Std. lens), $\pm 18^\circ$ (HR lens), β : 360°

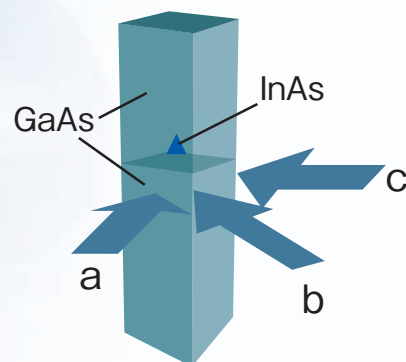
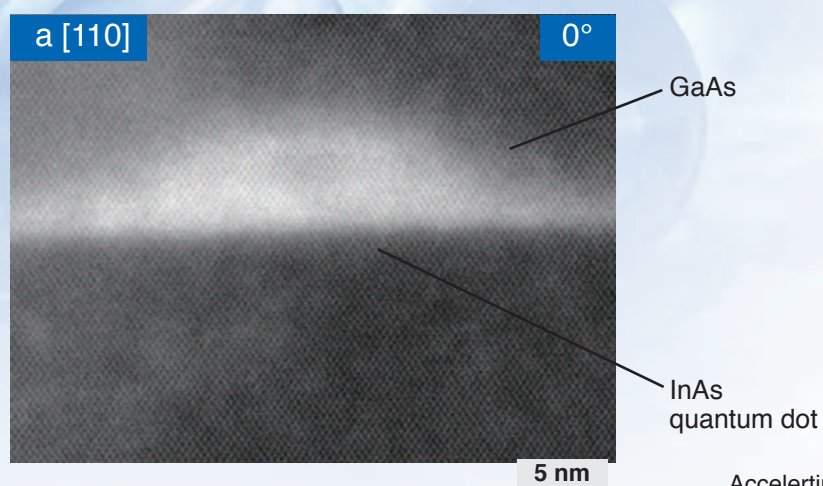


Pillar-shaped specimen milled by FIB

360° rotation holder for 3D imaging. The holder can be used with Hitachi focused ion beam (FIB) system and the HD-2700 STEM.

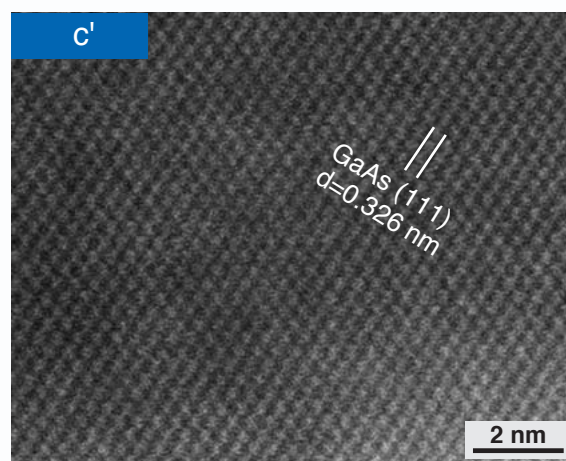
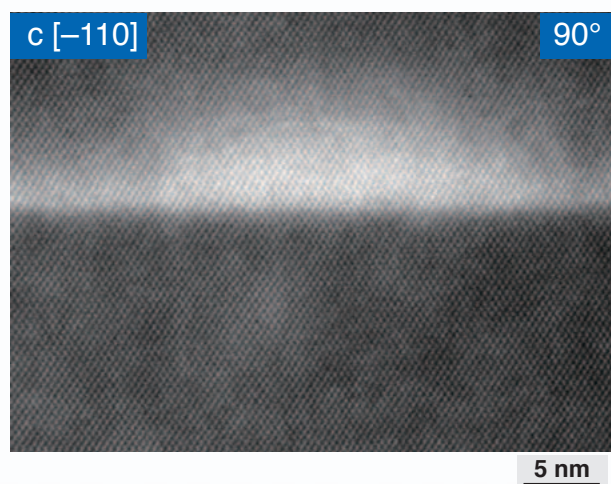
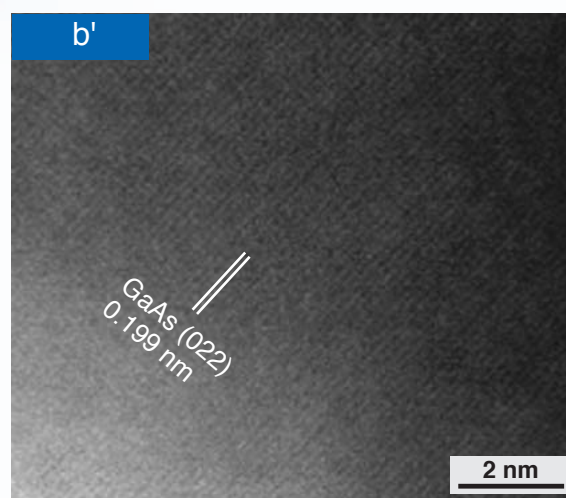
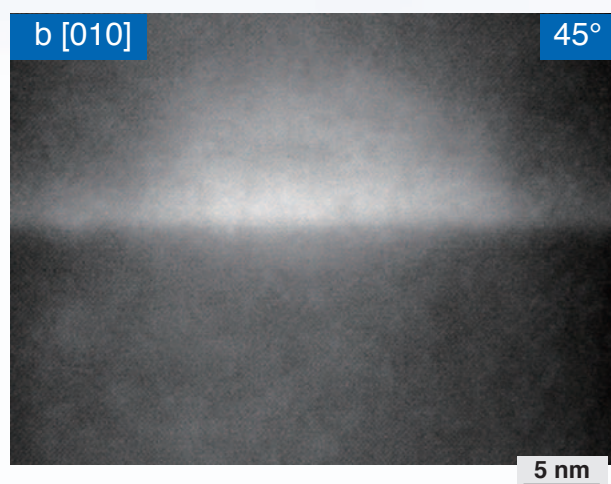
*: Available as an option

HAADF-STEM images of a single quantum dot observed from three different directions



A pillar-shaped specimen including a single quantum dot were observed from 3 different directions.

Accelerating voltage: 200 kV
Specimen size: 70 nm × 80 nm



(a) GaAs $\langle 110 \rangle$, (b) $\langle 010 \rangle$, (c) $\langle -110 \rangle$ zone-axis HAADF images
(b'), (c') : zoom-in images of (b), (c)

Specimen: single quantum dot, courtesy of
Prof. Takashi Kita, Kobe University, Japan

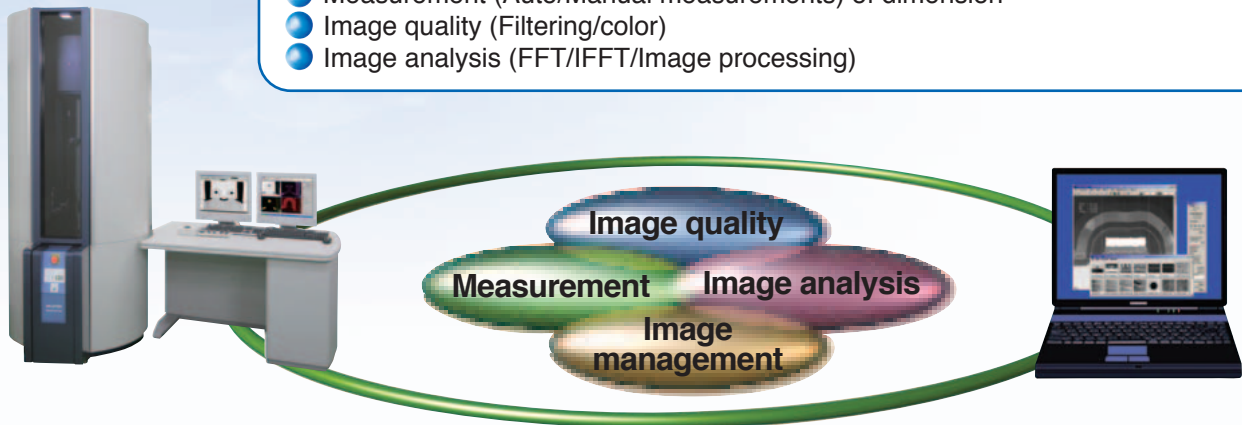
w/ Cs-corrector, Schottky gun, Std. lens

Image database / Measurement (EMIP* : Option)

We have image processing software which allows to process the HD-2700 images for better quality, or to do analysis, measurement and management using a PC. image size, JPG compression, etc. It is also possible to convert all images in a folders simultaneously. It is easy to search for can be selected images of interest and classify them. Shown below is an example of auto-measurement.

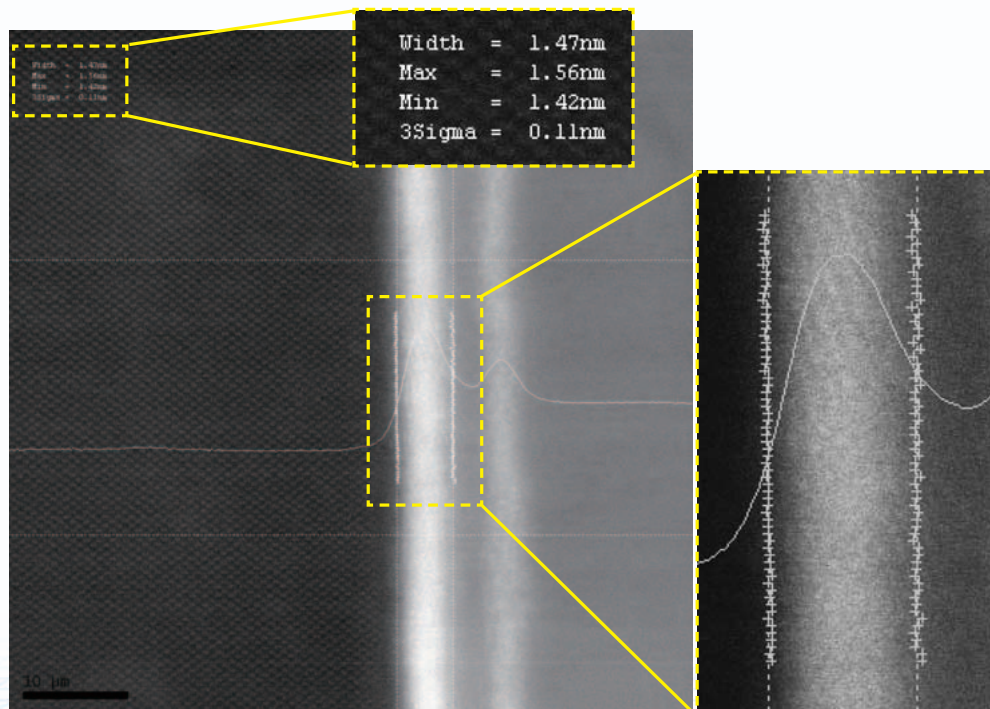
Functions of software include:

- Image management (Display and search of thumbnail images)
- Measurement (Auto/Manual measurements) of dimension
- Image quality (Filtering/color)
- Image analysis (FFT/IFFT/Image processing)



Combination of HD-2700's functions with EMIP* dimension

Combination of 'High precision magnification calibration'* and EMIP*, automatic edge-identification and dimension measurement a STEM image are possible.



Example of automated measurement function

*: Available as an option

360° specimen rotation holder*, auto image acquisition function* and 3D reconstruction software* allow accurate tomography

Flow chart of 3D reconstruction

**Auto specimen tilting
and image acquisition**

**Auto image alignment
in dataset**

3D reconstruction

EMIP functions

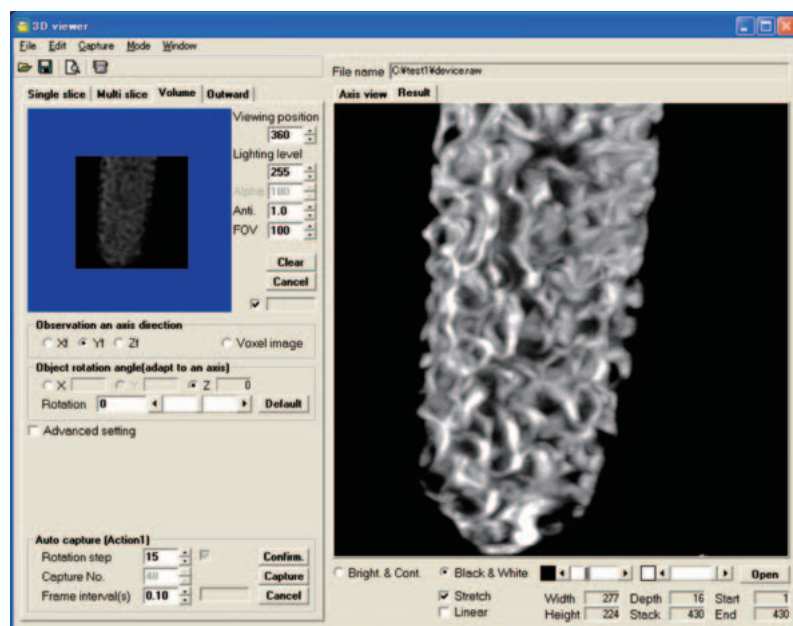
Specification of auto specimen tilting and image acquisition function

Instrument	HD-2700
Guaranteed magnification	Up to 100 kx
Accuracy of auto-focus	$\pm 1\mu\text{m}$ (with objective lens ^{*1})
Standard specimen	W coated carbon pillar ^{*2}
Acquisition time	Within 1 hour ^{*3}
Specimen holder	Screw type needle stub & 3D-analysis holder
Signal	ZC
Lens mode / aperture size	Normal / 10 $\mu\text{m}\phi$

*1 Auto-focusing at 5 μm of initial defocus

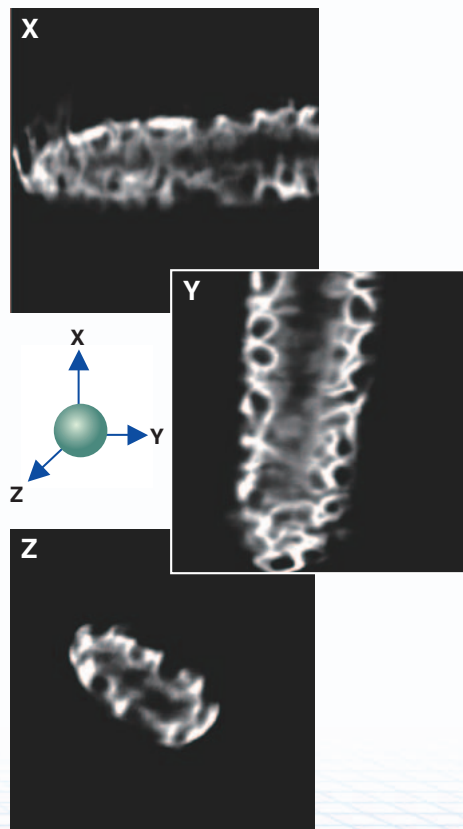
*2 Diameter: $300 \pm 100\text{ nm}$, length: $4 \pm 2\text{ }\mu\text{m}$

*3 37 data sets, rotation speed (3), capture mode "Fast".



GUI of EMIP

Cross sections along X, Y, Z axes



*: Available as an option

■ Specifications

Item	Description	
Image resolution	w/o Cs-corrector	0.204 nm guaranteed (at a magnification of $\times 4,000,000$)
	w/ Cs-corrector	0.144 nm guaranteed (at a magnification of $\times 7,000,000$)(Std. lens)
		0.136 nm guaranteed (HAADF image)
		0.105 nm guaranteed (by FFT)(at a magnification of $\times 7,000,000$)(HR lens)
Magnification	$\times 100 - \times 10,000,000$	
Accelerating voltage	200 kV, 120 kV (option)	
Imaging signal	Bright field STEM: Phase contrast image (TE image)	
	Dark field STEM: Z-contrast image (ZC image)	
	Secondary electron image (SE image)	
	Electron diffraction (option)	
	Characteristic X-ray analysis and mapping (option: EDX)	
Electron optics	EELS analysis and mapping (option: EV3000)	
	Electron source	Schottky emitter
		Cold field emitter (option)
	Illumination lens system	2-stage condenser lens
	Cs-corrector	Hexapole transfer lens design
	Scanning coil	2-stage electromagnetic coil
	ZC collection angle control	Projector lens design
Specimen stage	Electromagnetic image shift	$\pm 1 \mu\text{m}$
	Specimen movement	X/Y = $\pm 1 \text{ mm}$, Z = $\pm 0.4 \text{ mm}$
	Specimen tilt	Single-tilt holder: $\pm 30^\circ$ (Std. lens), $\pm 18^\circ$ (HR lens)
Vacuum system	Ion pump $\times 3$, TMP $\times 1$	
	Ultimate vacuum	10^{-8} Pa (Electron gun), 10^{-5} Pa (Specimen chamber)
Image display	PC/OS	PC/AT compatible, Windows [®] xp
	Monitor	19-inch LCD panel
	Image frame size	640×480 , $1,280 \times 960$, $2,560 \times 1,920$ pixels
	Scan speed	TV, Slow (0.5 – 320 s/frame)
	Auto data display	Recording No., accelerating voltage, micron bar Magnification, date, time

■ Optional accessories

Item	P/N	Description
Dry pump		For vacuum system of the HD-2700
Closed water circulator		Ditto
Air compressor	756-4530	For pneumatic valve control. Needed when no compressed air supply is available.
Cold trap	756-0419	For simultaneous order with the HD-2700* ¹⁴
Hi-Mouse	756-4517	For controlling EDX PC and HD-2700. PC using the same mouse. This is not available for the EV3000.
EDX kit	756-4519	Necessary item for EDX system
Live diffraction unit	756-4546	For electron diffraction from 2 – 3 nm areas of a specimen.
		For crystal orientations of a few nanometer areas.
Single-tilt holder	753-2175	Maximum tilt angle: $\pm 30^\circ$ (Std. lens), $\pm 18^\circ$ (HR lens)
Compatible revolver mesh holder	420-0171	A compatible holder for use on the side-entry stage of the FB-2100. Maximum tilt angle: $\pm 20^\circ$ (Std. lens), $\pm 17^\circ$ (HR lens)
Stub compatible revolver holder	420-0173	A compatible holder for use on the FB-2100 with a FIB micro-sampling stage. Maximum tilt angle: $\pm 10^\circ$
Double-tilt holder	753-4000	Maximum tilt angle: $\alpha = \pm 20^\circ$ (Std. lens at the stage center) $\beta = \pm 15^\circ$ $\alpha = \pm 13^\circ$ (HR lens at the stage center) $\beta = \pm 15^\circ$
Bulk plane holder	756-4540	No tilt
Specimen stub for bulk plane holder	756-2453	Stub dimension: $11 \times 5.5 \times 1.0 \text{ mm}$ Maximum specimen size: $7.5 \times 5 \times 0.7$ (thick) mm
High temperature specimen holder	757-0220	For powder specimen. EDX detector must be retracted when heating a specimen.
Magnification calibration (with Microscale)	753-4501	For calibrating magnifications
Precision magnification calibration	753-4500	For calibrating magnifications by using a microscale and a Si-specimen. This is performed at Factory prior to shipment of the HD-2700.
Low dose mode	756-4575	A function to minimize electron dose on a specimen when recording images.
EV3000 elements view		A real-time element mapping function.
EDX (Energy Dispersive X-ray)		EDX systems are available from various makes* ¹⁴ .
EELS (Electron Energy Loss Spectrometer)		Enfina by Gatan, U. S. A.
3D-analysis holder		0 – 360 degrees specimen rotation

*: HR lens is an option

■ Installation site conditions*14

Item	Description
Room temperature	15 – 23°C (Temperature fluctuation: 1°C/h or smaller)
Humidity	40 – 60% RH
Power (HD-2700)	Single phase AC 100 V $\pm 10\%$, 50/60 Hz*5, 7.5 kVA
Closed water circulator*1, 6	Three phase AC 200 V $\pm 10\%$, 50/60 Hz, 17.3 kVA*7, 8
3P-outlet*9	Single phase AC 100 V $\pm 10\%$, 50/60 Hz, 1.5 kVA
Grounding terminal	The 1st grade grounding (100 Ω or less) for the HD-2700*7
Cooling water*10	Temperature: 16 – 18°C (Temperature fluctuation: 0.1°C/min. or smaller) Flow: 2.0 – 2.2 L/min, Pressure: 50 – 200 kPa Quality: City water with residual chlorine 0.5 ppm or less Connector: Rc3 tapered female
Closed water circulator*1, 6, 8	Primary cooling water: 15 L/min. (20°C) – 40 L/min. (30°C)
Cooling capacity: About 3,900 W	Connector: Rc3/4 female Tubing: Metal tubes. No water leak*15 Circulating water: Distilled water
Compressed air*16	Air pressure: 350 – 500 kPa adjustable
Dry nitrogen*9, 11, 16	Gas pressure: 0 – 100 kPa regulated, with purity of 99.99%
SF6 gas*9, 11, 16	Gas pressure: 0 – 500 kPa regulated, with purity of 99.9%

Before placing order for the HD-2700, we suggest to check floor vibration, acoustic noise and magnetic flux in the installation room to confirm that the room is suitable for operation of the HD-2700.

If you have any problems, please feel free to contact our representatives.

■ Main unit choice

	Gun	Std. lens	HR lens
w/ Cs-corrector	Cold-FE	Option	Option
	Schottky	Standard	–
w/o Cs-corrector	Schottky	Standard	–

- 1) Main unit with Schottky gun and Std. lens is a standard unit. With or without Cs-corrector is selectable.
- 2) Main unit without Cs-corrector is available only with the combination of Schottky gun and Std. lens.
- 3) HR-lens is only available for the main unit with Cs-corrector and Cold-FE gun.
- 4) Cs-corrector(option) is retrofittable to already-delivered HD-2700.

Notes :

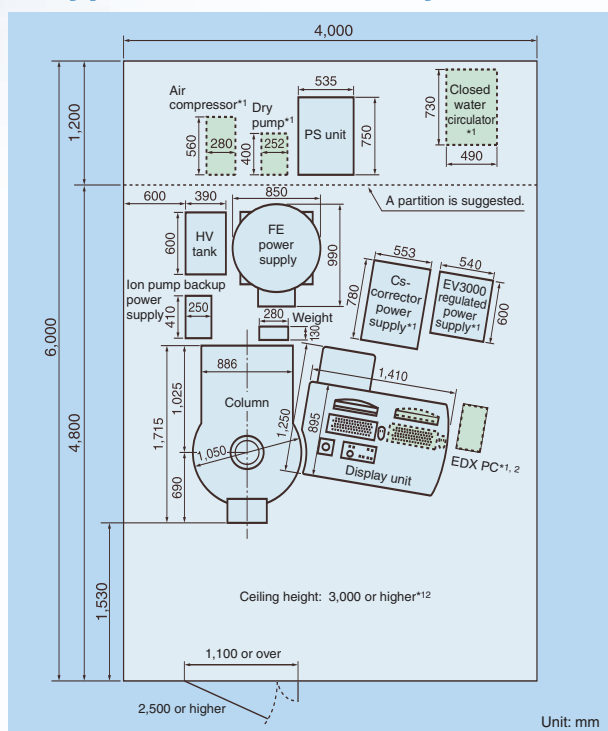
- *1: Available as an option
- *2: Available from EDX manufacturers
- *3: Maximum tilt angle is available with a standard specimen holder.
- *4: The ESDP12 (by EDWARDS, 100 V) requires maintenance service every 10 months. Use of dry pumps other than the ESDP12 needs to be consulted with us prior to purchase.
- *5: Specify 50 or 60 Hz at the time of order.
- *6: Select one from among air cooled, water cooled or air cooled separate types.
- *7: A separate grounding for a closed water circulator is needed. A grounding resistance of 100 Ω or less.
- *8: Applies to a water cooled closed water circulator.
- *9: Required at the time of installation and maintenance of the electron gun.

■ Dimensions and weight

Item	Width × Depth × Height (mm)	Weight (kg)
Column w/ Cs-corrector (w/o Cs-corrector)	1,050 × 1,715 × 2,330	1,900 (1,790)
Display unit	1,410 × 1,250 × 1,185	250
FE power supply	850 × 990 × 1,261	400
HV tank	600 × 390 × 965	170
PS unit	535 × 750 × 1,447	330
Weight	280 × 130 × 130	25
Dry pump*1, 4	252 × 400 × 336	25
Air compressor*1	560 × 280 × 625	26
Closed water circulator*1	490 × 730 × 1,580	200
Ion pump backup power supply	250 × 410 × 360	35
EV3000 power supply*1	540 × 600 × 1,070	110
EDX spectrometer*1, 2	180 × 410 × 360	12
Cs-corrector power supply*1	553 × 780 × 960	130

- 1) In case of main unit w/o Cs-corrector, Cs-corrector power supply is not included in the configuration of main unit.

■ Typical installation layout

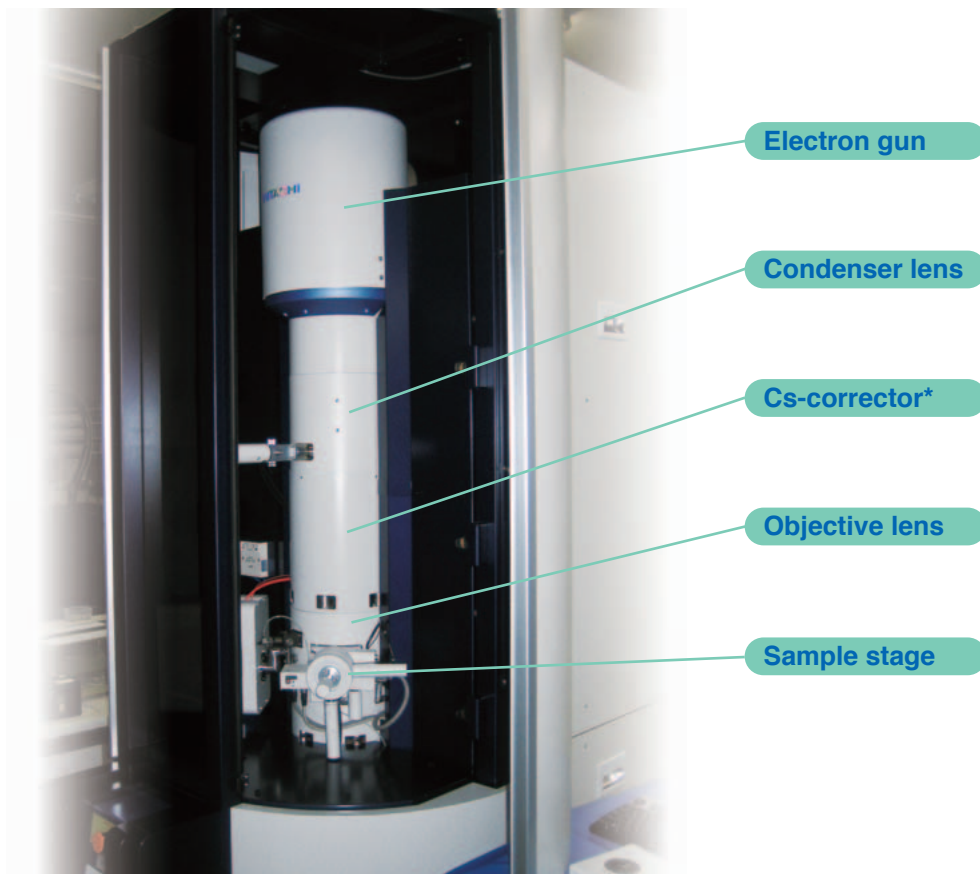


- 1) Dimension of the closed water circulator depends on manufacture.
- 2) A total weight of the above instruments is approximately 3,650 kg (w/o Cs-corrector : 3,410 kg).
- 3) The floor strength of the room (kg/m²) needs to be greater than 3 times of the total weight of the instruments (kg/m²).
- 4) In case of main unit w/o Cs-corrector, Cs-corrector power supply is not included in the configuration of main unit.

- *10: We recommend the used of a closed water circulator.
- *11: An oxygen concentration monitor is required for security.
- *12: When the floor vibration is a problem for proper operation of the HD-2700, a separate shock mount (placed on the floor) is available. It requires extra clearance between the microscope column and the ceiling of the installation room.
- *13: Windows XP Professional is a registered trademark of Microsoft Corp., U.S.A. Ethernet is a product name of Xerox Corp., U. S. A.
- *14: Liquid nitrogen is required for use of EDX and a cold trap. It needs to be prepared by users.
- *15: Users are requested to prepare a leak sensor and an emergency shutoff valve for water in the event of water leak from a primary cooling water line.
- *16: A pressure regulator is required.

Spherical aberration correction

Adding a Cs-corrector* significantly enhances the imaging and analytical capability. A Cs-corrector can either be delivered with the HD-2700 or added at a later date.



This column design was awarded the 2007 mechanical design prize in Japan.

*: Available as an option

NOTICE: For proper operation, please follow the instruction manual coming with the instrument.
Specifications in this brochure are subject to change without notice.

Bringing the frontier to the forefront.

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