Hitachi High-Technologies

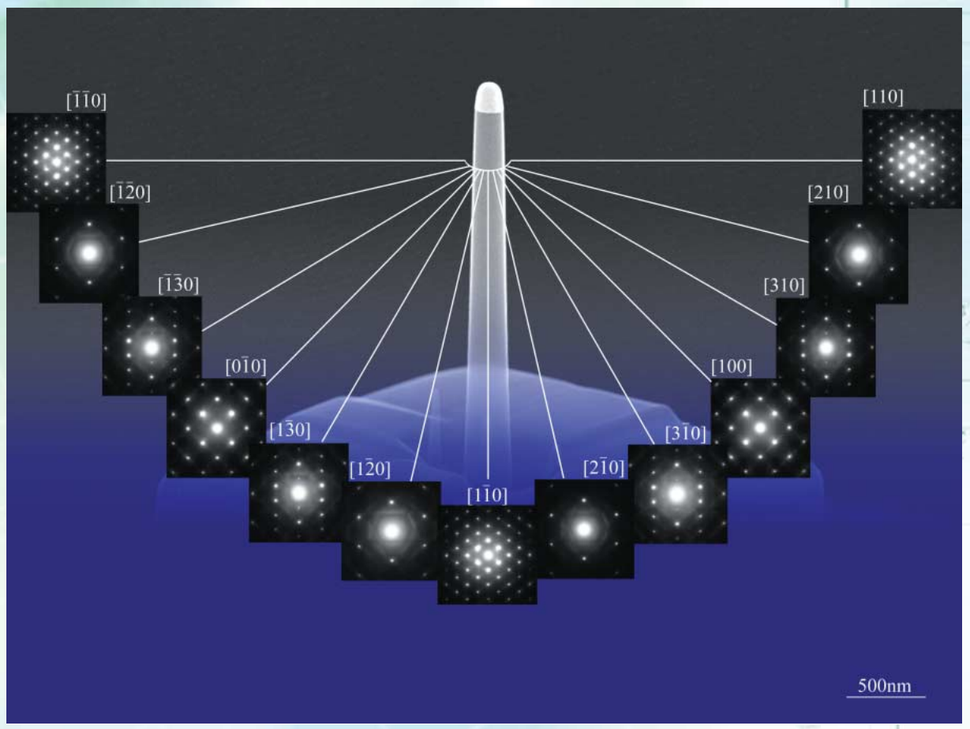
Transmission Electron Microscope

H-9500

HITACHI

Atomic resolution 300kV transmission electron microscope

Atomic resolution electron microscopy is becoming increasingly important and indispensable for the R&D of semiconductors and advanced materials where micro-fabrication technologies have entered into the sub-nanometer realm. In response to this high demand, Hitachi High Technologies, Inc. has developed the H-9500 transmission electron microscope with field proven high performance in high resolution transmission electron microscopy in addition to a number of user-friendly unique functions. The latest digital technology is incorporated to facilitate obtaining atomic level structural information in a timely manner.



Panorama Diffraction Pattern
(an award winning micrograph in the 2005 (61st) micrograph contest of the Japanese Society of Microscopy)

Specimen: Single crystal silicon (Si)
Accelerating voltage: 300kV
Diffraction camera length: 0.5m

Note: Images on the FPD (flat panel display) are simulated.
* Windows® is a resistered trademark of Microsoft Corp., USA and other countries.

Features

1. User-friendly operation
- *Windows®* compatible GUI design*
- *High specimen throughput, 1 minute for specimen exchange, and 5 minutes for voltage ramp up (300kV) and beam on.*

2. Stable high resolution microscopy
- *Point-to-point resolution of 0.18nm and lattice resolution of 0.1nm*
- *A stable 5-axis eucentric goniometer stage*

3. Excellent performance reliability
- *Field-proven 10-stage accelerator gun design*
- *High voltage resistor cable design*

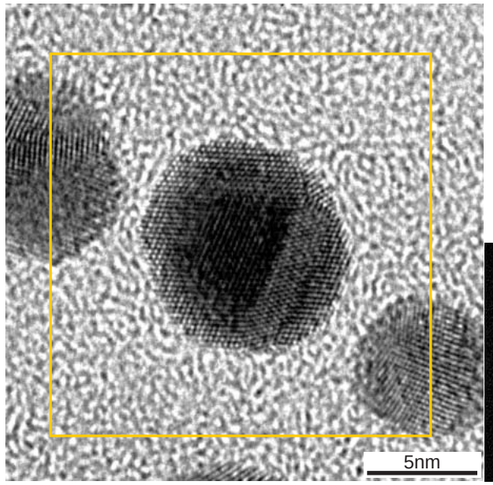
4. Valuable optional accessories
- *Compatible specimen holder for use with Hitachi TEM, FIB and STEM systems*
- *A variety of specimen holders that provide heating, cooling, and gas-injection capabilities for atomic resolution dynamic studies.*

Transmission Electron Microscope

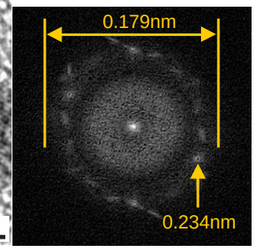
H-9500

0.18nm point-to-point resolution guaranteed

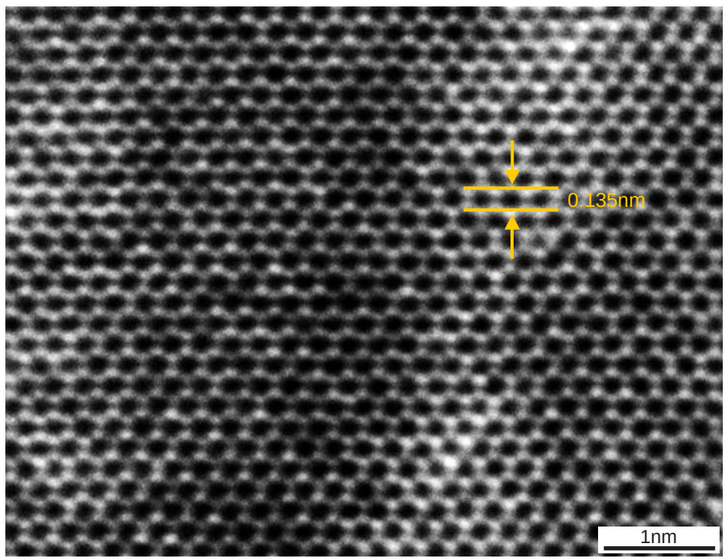
The H-9500 has a guaranteed point-to-point resolution of 0.18nm and a lattice resolution of 0.1nm. Below shows an ultra high resolution micrograph of evaporated gold particles on a carbon film, the corresponding optical diffractogram shows a point resolution of 0.179nm. Also below shows an atomic structural image of silicon with a lattice resolution of 0.135nm, the image was recorded utilizing a digital CCD-camera (option)



Specimen: Evaporated gold particles on a carbon film



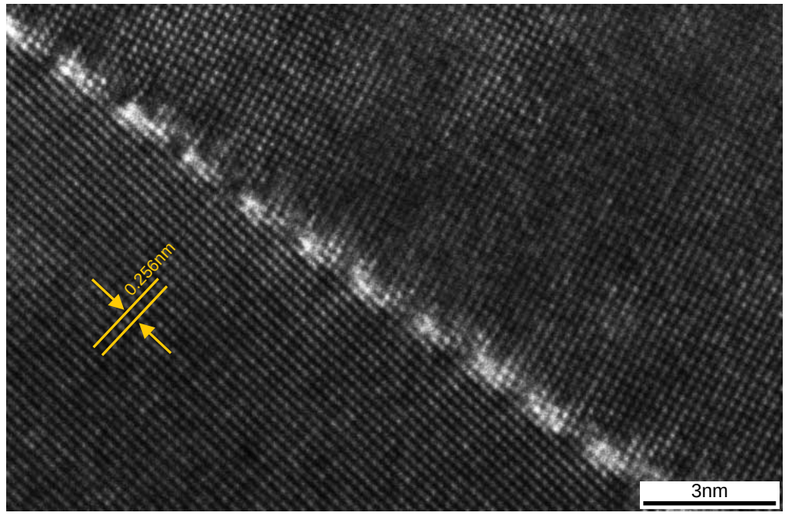
An optical diffractogram showing a point resolution of 0.179nm



Specimen: Silicon
Direct magnification: 1,000,000×

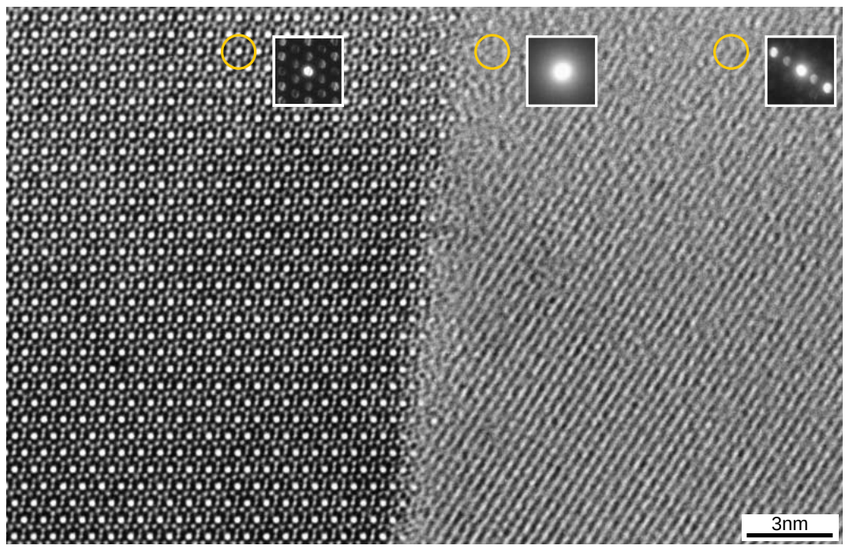
Fast and easy high resolution electron microscopy for advanced materials development

High resolution image of crystal grains and grain boundary



Specimen: Zirconium oxide, courtesy of Prof. Dr. Yuichi Ikuhara, Institute of Engineering Innovation, School of Engineering, The University of Tokyo, Japan

High resolution images and nano-area electron diffraction patterns from the circled ares with a probe diameter of approximately 1nm.

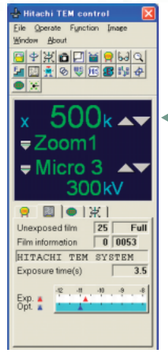


Specimen: Silicon nitride

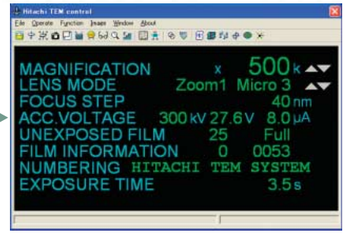
Easy operation with PC control

TEM operation control display

Tab operation is used for the frequently used operations of digital CCD camera, film camera and stage. Brief information about accelerating voltage, and magnification conditions are displayed on the TEM control window for a quick and convenient access. Expanded view of the TEM control can also be accessed for more detailed operation information.



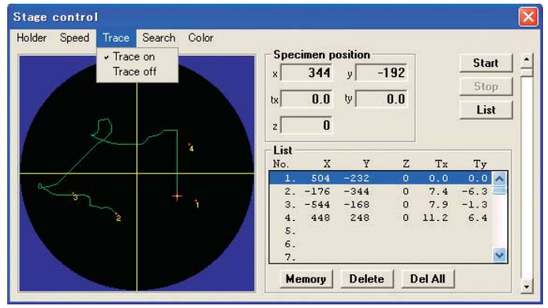
TEM control screen



Expanded view

Specimen stage control

Specimen stage positions (X, Y, Z, Tilt, Azimuth) are displayed in a digital format. The trace function stores and displays changes of specimen positions, and marks the observed and unobserved points on the specimen. Up to 100 specimen positions can be memorized. The stored positions can be recalled later to precisely bring the stage back to the desired points for review and detailed characterization.



Control panel

Two operation panels with accelerating voltage switches and other main function control buttons are located on the main operation table of the microscope, one on the right and another one on the left side of the operator. These panels can be repositioned for a convenient access by individual operators.

Specimen stage

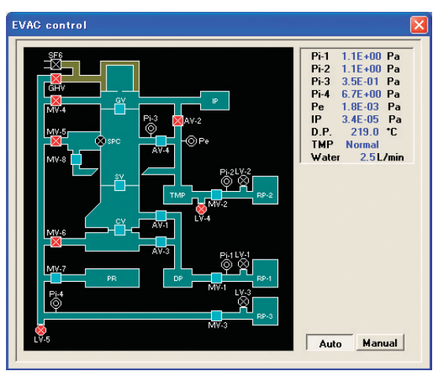
Hitachi's 5-axis eucentric Hiper goniometer stage is utilized by the H-9500. The linear actuator drive design of the goniometer allows a linear, proportionate and stable movement of the stage. The excellent stability against mechanical and acoustic vibrations guarantees high performance for atomic resolution electron microscopy. Specimen exchange is quick and easy. The specimen airlock is pumped by a high speed TMP (turbo-molecular pump) reducing specimen exchange time to approximately 1 minute.

Electron emitter

A stable high voltage operation is accomplished utilizing a 10-stage accelerator and Hitachi's renowned high voltage resistor cable design. The built-in automated gun lift allows changing of the electron emitter and maintenance work to be an effortless task.

Vacuum system

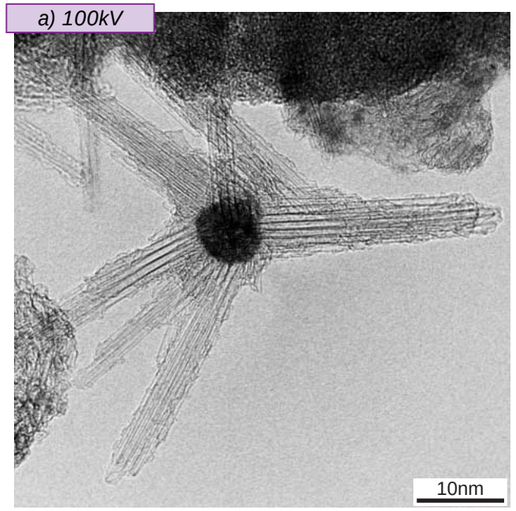
The H-9500 vacuum system is fully automated. Operating conditions are displayed on the monitor screen as shown at the right side. Valve conditions, operating vacuum, cooling water and other conditions of the system are simultaneously displayed. The electron gun area is evacuated using an ion pump, while the specimen chamber is pumped by a high speed magnetically levitated TMP (turbo-molecular pump) and the camera chamber with a diffusion pump.



High performance at various accelerating voltages

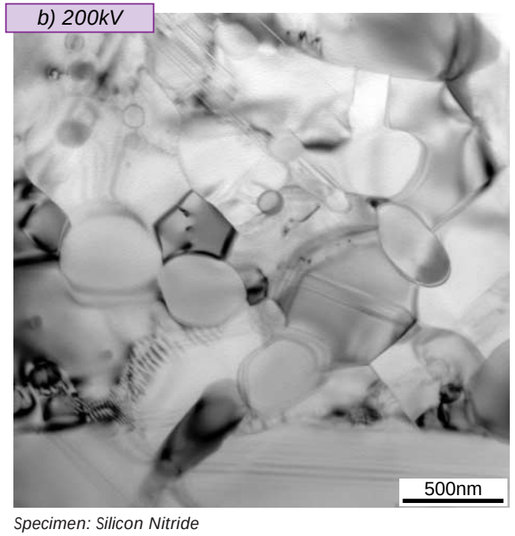
The H-9500 is optimized to operate at 300kV, 200kV and 100kV* voltages to meet the various requirements from material science and industry applications. Shown below are some typical applications taken at 100kV*, 200kV* and 300kV respectively.*

a) 100kV



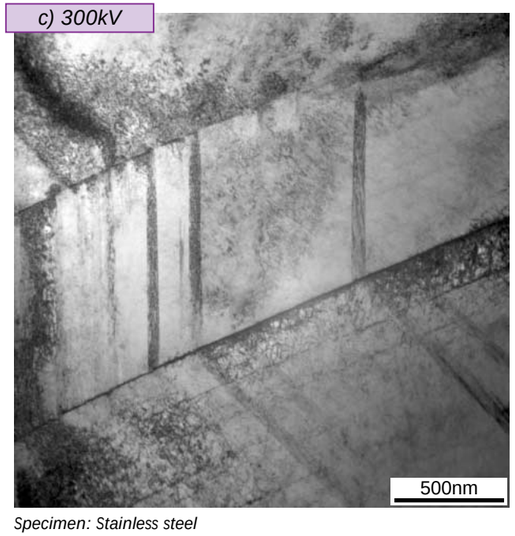
Specimen: Carbon nanotubes, courtesy of Prof. Dr. Kazuyuki Toji, Environmental research Lab., Tohoku University, Japan

b) 200kV



Specimen: Silicon Nitride

c) 300kV

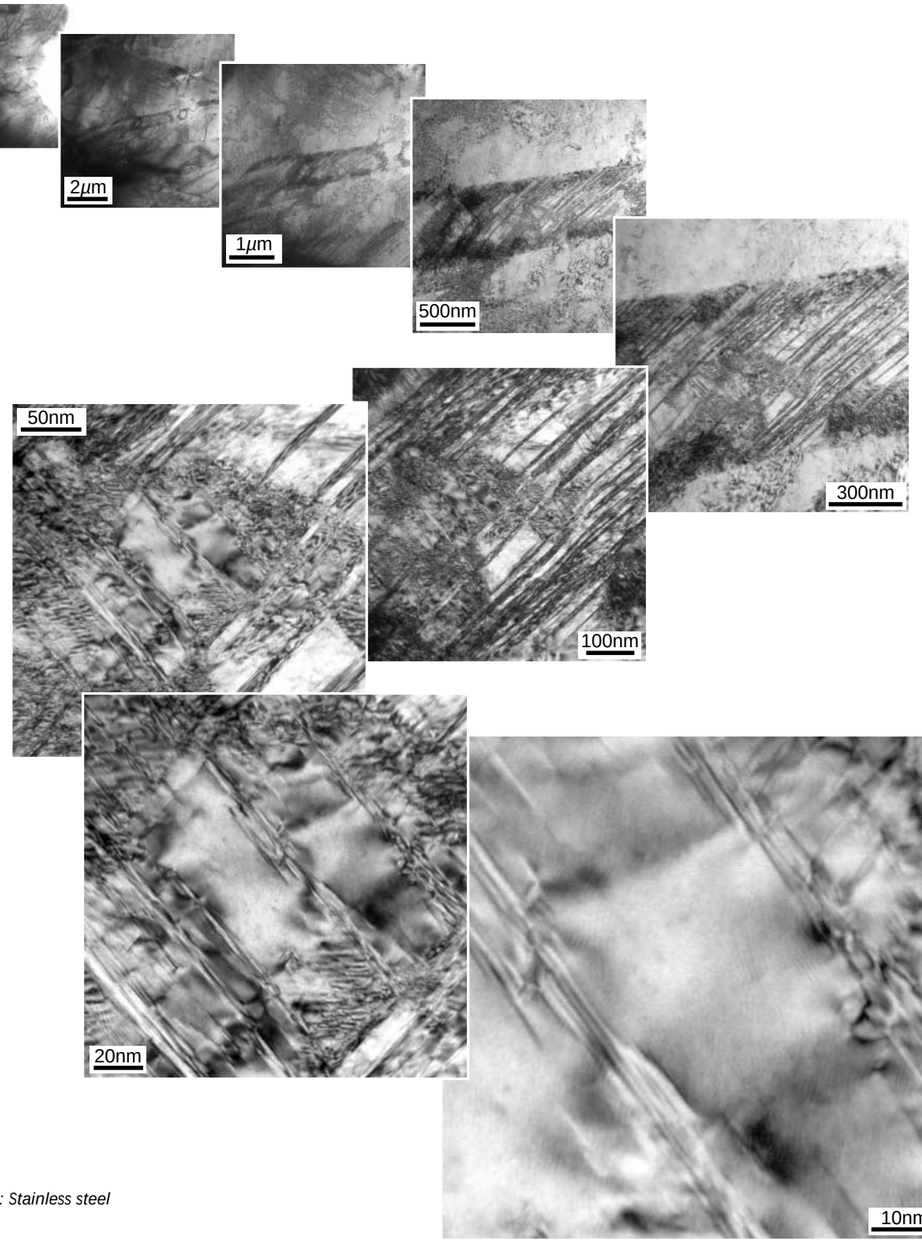


Specimen: Stainless steel

Calibrated magnifications available as an option.

Wide, continuously variable and image rotation-free magnifications ranging from 1,000× to 1,500,000×

Typical diffraction contrast electron micrographs for a stainless steel specimen

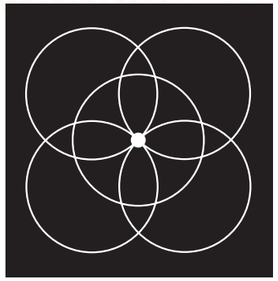


Specimen: Stainless steel

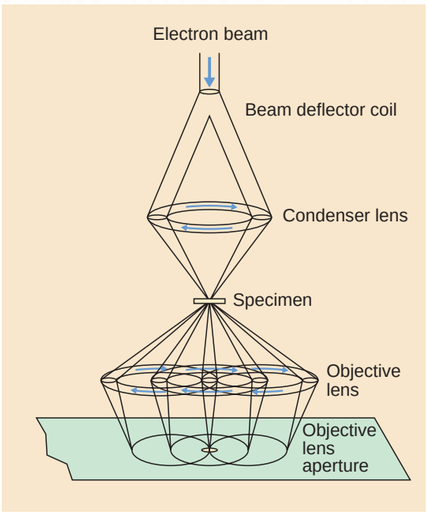
Dark-field imaging using hollow cone beam illumination

The H-9500 allows dark-field imaging using hollow cone beam illumination which is activated by the stigmonitor function. Dark-field images reflecting diffraction information in all orientations can be obtained from specific points of interest on a specimen.

Normal electron diffraction pattern



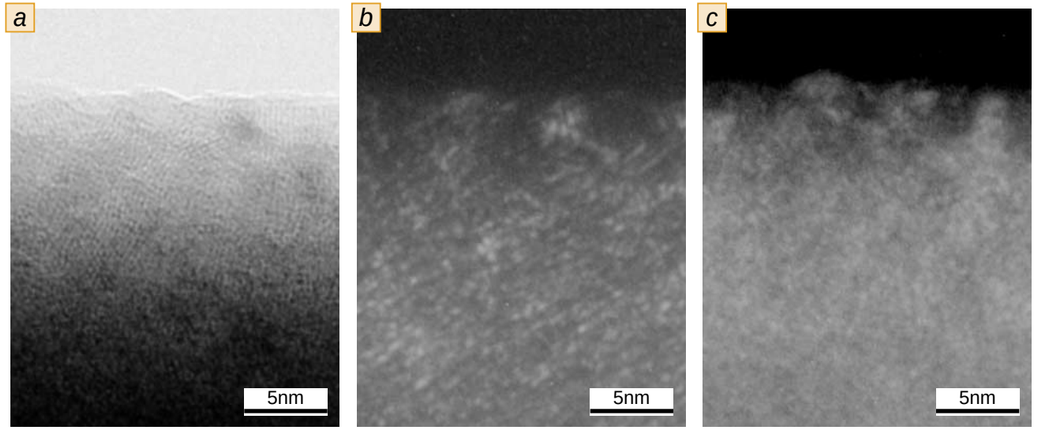
Electron diffraction pattern obtained using hollow cone beam illumination



Schematic ray diagram

Typical applications

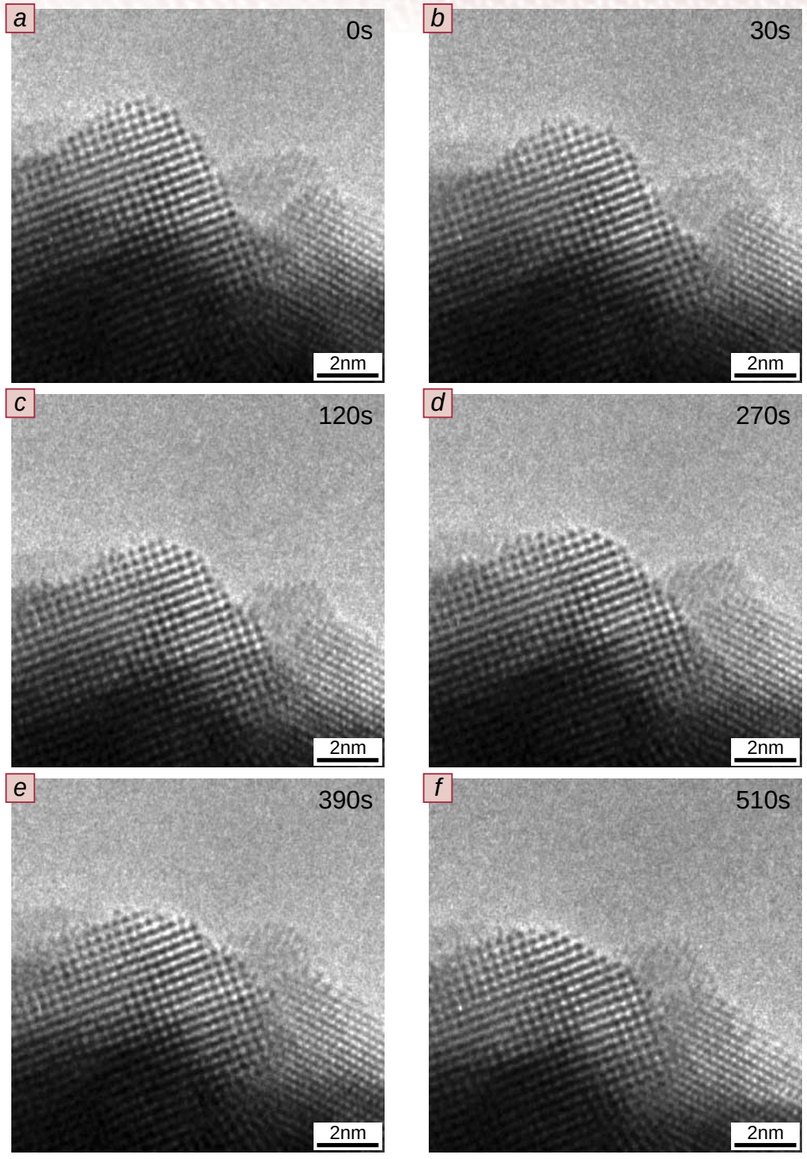
Shown below are comparisons between conventional dark-field and hollow cone beam dark-field images.
a) A conventional bright-field image of amorphous Fe-Nb-B specimen (annealed at 773k).
b) A conventional dark-field image of the same specimen area.
c) A hollow cone beam dark-field image for comparison.
The contrast of the crystallized area is brighter in the hollow cone beam dark-field image because all electrons diffracted from the crystallized area can pass through the objective lens aperture.



Specimen, courtesy of Prof. Dr. Yoshihiko Hirotsu, Institute of Scientific and Industrial Research, Osaka University, Japan

High temperature, high resolution in-situ electron microscopy

The TMP (turbo-molecular pump) which has a high pumping speed for inert gases maintains a good vacuum condition in the specimen chamber. The stable goniometer stage facilitates high resolution microscopy. These combined features permit high resolution, high temperature electron microscopy using variable types of Hitachi-patented heating specimen holders. Air-injection into the specimen chamber is also possible for dynamic in-situ observation. The images below demonstrate a typical in-situ heating application of a growth process of SnO_2 grains.



This series of in-situ high resolution images of Sn crystals were recorded at 200°C during oxidation in an air environment.

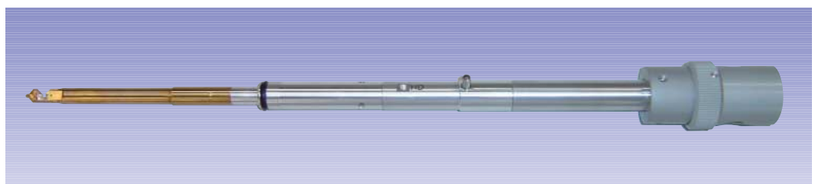
The Sn-particles were melted at an air pressure of 5 $\times 10^{-5}$ Pa and 250°C. The crystal growth of SnO_2 particles in the [110] plane and changes of structure has been clearly observed at the atomic resolution level. These images were acquired along the [001] zone-axis of SnO_2.

Transmission Electron Microscope H-9500

High throughput, high precision analysis with Hitachi H-9500/STEM/FIB

A compatible specimen holder works between all three EM systems without having to reposition the specimen.

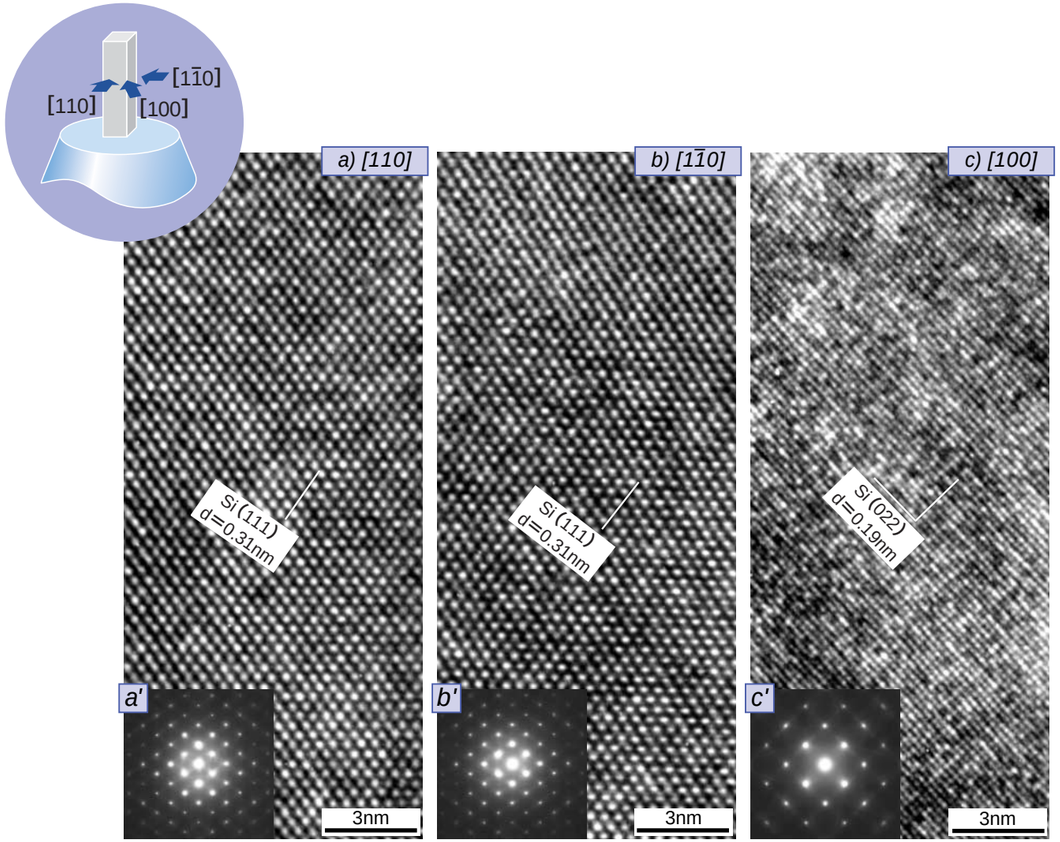
H-9500/ STEM/FIB compatible specimen holder



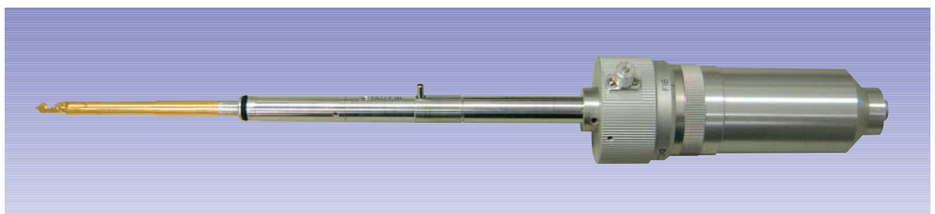
H-9500/STEM/FIB compatible specimen holder (option)

Hitachi-featured “360°-view specimen holder”

Shown below are high resolution TEM images of a pillar shaped specimen prepared using Hitachi's FIB system. The specimen was observed at three different crystal orientations as schematically illustrated, note the 90° angle between the [110] and the [1$\bar{1}$0] direction. Insets are the corresponding selected-area electron diffraction patterns from each orientation.



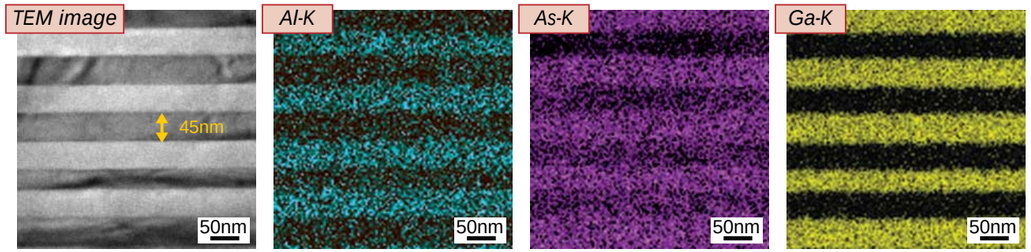
Specimen: Si
Accelerating voltage: 300kV



H-9500/STEM/FIB compatible 360°-view specimen holder (option)

Analytical capability with EDX system and TEM X-ray mapping

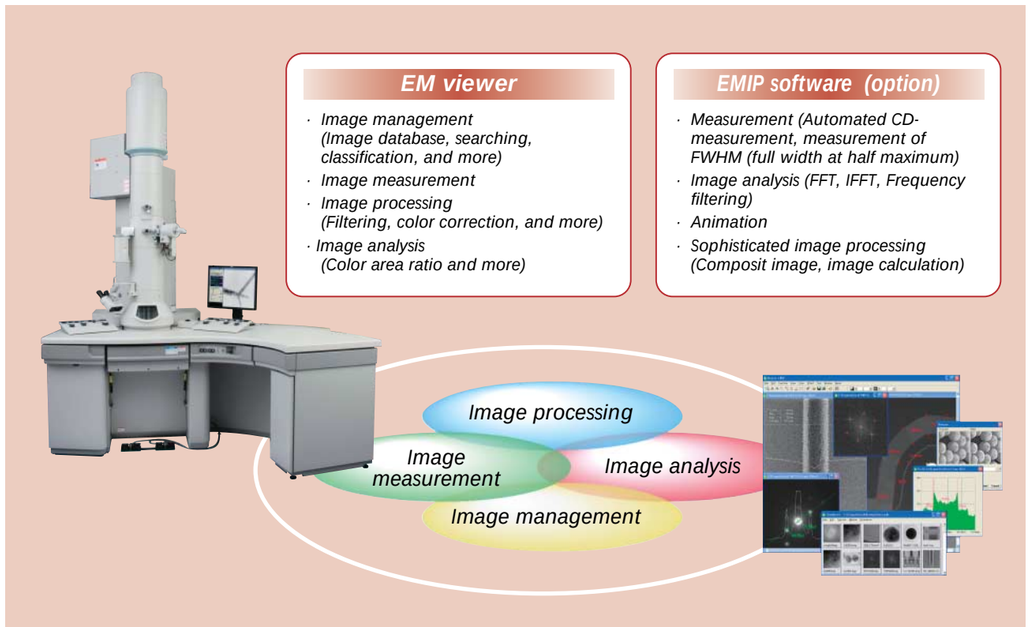
The H-9500 is designed to work with an EDX spectrometer for high sensitivity elemental analysis. With the use of an EDX kit (available as an option) spurious X-rays are minimized. Elemental mapping can be accomplished with TEM X-ray mapping unit (available as an option). Examples of typical elemental mapping images are shown below.



Specimen: GaAs
Accelerating voltage: 300kV

Hitachi Integrated Image Processing Software

The H-9500 has, as standard, image processing software. The software includes an image database, measurement capabilities, and image analysis routines (EM Viewer). In addition, sophisticated image analysis software, automated measurement, animation function and other convenient programs (EMIP) can be added as an option. The EMIP software is capable of accessing data from a network to perform image processing and analysis as well as CD measurements of critical image features.



Specifications

Resolution	0.10nm (lattice) 0.18nm (point-to-point)
Accelerating voltage	300kV, 200kV*1, 100kV*1
Magnification	
Zoom mode	1,000 – 1,500,000×
SA mode	4,000 – 500,000×
Low mag. mode	200 – 500×
Electron gun	
Filament	LaB_6 (DC heating)
Filament exchange	Automated gun lift
High voltage cable	Resistor cable
Illumination system	
Lens	4-stage lens system
Condenser aperture	Click-stop 4-openings
Probe size	Micro mode: 0.05 – 0.2 μm (4 steps) Nano mode: 1 – 10 nm (4 steps)
Beam tilt	±3°
Imaging system	
Lens	5-stage lens system
Focusing	Image wobbler Astigmatism correction by stigmonitor Optimum focus
Objective aperture	Click-stop 4-openings
Selected area aperture	Click-stop 4-openings
Electron diffraction	Selected-area electron diffraction Nano probe electron diffraction Convergent-beam electron diffraction
Camera length	250 – 3,000mm
Specimen chamber	
Specimen stage	Eucentric 5-axis Hiper goniometer stage
Specimen size	3mm ø
Stage translation	X/Y = ±1mm, Z= ±0.3mm Motor drive by CPU control
Specimen position display	Auto-drive, Auto-trace
Specimen tilt	α = ±15°, β = ±15° (Hitachi double tilt specimen holder*2)
Anti-contamination	Cold block
Baking function	Mild baking function
Viewing chamber	
Fluorescent screen	Main screen: 110mm ø Focusing screen: 30mm ø
Optical viewer	7.5×
Camera chamber	
Field selection	Full/half exposure
Film	25 sheets (2 sets of film magazines)
GUI	OS: Windows XP ®*3
Monitor	19 inch monitor
Functions	Database, measurement, image processing
Digital CCD-camera*4	
Camera coupling	Lens coupling
Effective pixels	1,024 × 1,024 pixels
A/D resolution	12 bits
Vacuum system	
Electron gun	Ion pump: 60L/s
Column	TMP: 260L/s
Viewing/camera chamber	Diffusion pump: 280L/s Fore pump: 135L/min. × 3 sets

*1 Magnification is calibrated as an option
*2 An optional item
*3 Windows XP is a registered trademark of Microsoft Corp., in USA and in other countries
*4 This specification applies to an optional 1024 × 1024 pixel digital CCD-camera.

The above specifications are guaranteed at an accelerating voltage of 300kV

Optional accessories

- X-ray spectrometer (EDX system)
- TEM X-ray mapping function
- 1,024 × 1,024 pixel digital CCD-camera
- 2,048 × 2,048 pixel digital CCD-camera
- Beam stop
- Double tilt specimen holder
- High temperature specimen heating holder (powder samples)
- FIB compatible specimen holder
- STEM/FIB compartible 360°-view specimen holder
- Image analysis software

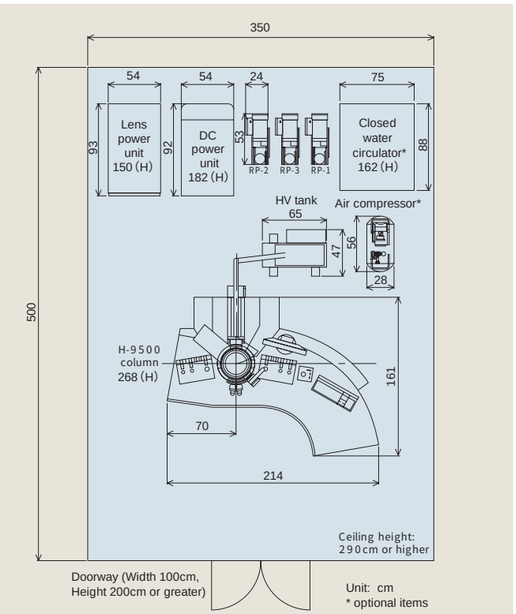
Installation site conditions

Temperature	15 – 25 °C
Humidity	40 – 60% RH
Power	Single phase AC 200V, 75A
Grounding	D-class or grounding resistance 100Ω or less
Cooling water	A closed water circulator*2 of 29.3MJ/h or greater is recommended

Dimensions

Column	214 × 161 × 268cm
DC power unit	54 × 92 × 182cm
Lens power unit	54 × 93 × 150cm
HV tank	47 × 65 × 73cm
Rotary pump	24 × 53 × 31cm × 3 sets
Air compressor	56 × 28 × 53cm

Typical installation site



NOTICE: For proper operation, follow the instruction manual when using the instrument.

Specifications are subject to change with or without notice.

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