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Specifications are subject to change with or without notice.

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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 microfabrication 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.

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.

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
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).

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 areas 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.

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.

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

Specimen: Silicon Nitride

Calibrated magnifications available as an option.

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 stigmator 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](image1)

![Electron diffraction pattern obtained using hollow cone beam illumination](image2)

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.

![Typical applications](image3)

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 SnO₂ grains.

![High temperature, high resolution in-situ electron microscopy](image4)

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 SnO₂ 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 SnO₂.

Specimen, courtesy of Prof. Dr. Yoshihiko Hirotsu, Institute of Scientific and Industrial Research, Osaka University, Japan
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**
  - High specimen throughput
  - High resolution microscopy

- **FIB (FB-series)**
  - Site-specific specimen preparation

- **STEM (HD-series)**
  - High specimen throughput
  - High sensitivity elemental analysis

**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 [100] direction. Insets are the corresponding selected-area electron diffraction patterns from each orientation.

Specimen: Si
Accelerating voltage: 300kV

H-9500/STEM/FIB compatible 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.

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

<table>
<thead>
<tr>
<th>Resolution</th>
<th>0.10μm (lattice)</th>
<th>0.28μm (point to point)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerating voltage</td>
<td>300kV, 200kV, 100kV</td>
<td></td>
</tr>
</tbody>
</table>

- **Magnification**
  - Zoom mode: 1.000, 1.500, 2,000, 4,000
  - Low mode: 500, 1000, 2000
- **Electron gun**
  - Filament: Lamps (DC heating) or Au wires (resistor heating)
  - Filament exchange: Automated gun lift or manual replacement

### Optional accessories

- **EMIP software**
- **TEM X-ray mapping function**
- **SA mode**
- **Beam stop**
- **Double tilt specimen holder**

### Installation site conditions

- **Temperature**: 15 - 25 °C
- **Humidity**: 40 - 60% RH
- **Power**: Single phase AC 200V, 75A
- **Grounding**: Direct or grounding resistance 1000 or less
- **Cooling water**: A closed water circulator** * of 29.3Ml/h or greater is recommended

### Dimensions

- **Column**: 214 × 161 × 268cm
- **DC power unit**: 94 × 92 × 182cm
- **Lens power unit**: 54 × 93 × 150cm
- **HV tank**: 47 × 85 × 73cm
- **Rotary pump**: 24 × 53 × 31cm, 3 sets
- **Air compressor**: 56 × 28 × 53cm

### Typical installation site

**Image analysis software**

**GUI**

- **Canvas**: Adobe Photoshop
- **Application**: CorelDRAW
- **PowerPoint**: Microsoft PowerPoint
- **Database management**: Microsoft Access
- **Image analysis (FFT, IFFT, Frequency filtering)**

**Software license**

- **EMIP software**: 5 years
- **Hitachi High technologies**: 10 years

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Specimen: GaAs
Accelerating voltage: 300kV

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TEM image

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EMIP software (option)
Transmission Electron Microscope
H-9500

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