JEM-2100F

Field Emission

Transmission Electron Microscope

(JEOL Ltd. / Japan)

Contents

- Introduction
- Features of JEM-2100F
- JADAS software
- SerialEM software
- Digital Image (CCD) and Cryo Transfer holders
- Service Support
- Conclusion
This is how it looks!

![Microscope Image]

### Specifications

<table>
<thead>
<tr>
<th>Configuration</th>
<th>HR (High Resolution P/P)</th>
<th>CR (Cryo P/P)</th>
<th>HC (High Contrast P/P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution Point Lattice</td>
<td>0.23nm</td>
<td>0.27nm</td>
<td>0.31nm</td>
</tr>
<tr>
<td></td>
<td>0.1nm</td>
<td>0.14nm</td>
<td>0.14nm</td>
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<tr>
<td>Acceleration Voltage</td>
<td>200, 160 kV</td>
<td>Opti on 120, 100 kV</td>
<td></td>
</tr>
<tr>
<td>OL Focal Point</td>
<td>2.3mm</td>
<td>2.8mm</td>
<td>3.9mm</td>
</tr>
<tr>
<td>OL Cs</td>
<td>1.0mm</td>
<td>2.0mm</td>
<td>3.3mm</td>
</tr>
<tr>
<td>OL Cc</td>
<td>1.4mm</td>
<td>2.1mm</td>
<td>3.0mm</td>
</tr>
<tr>
<td>Minimum Step</td>
<td>1.4nm</td>
<td>2.0nm</td>
<td>5.2nm</td>
</tr>
<tr>
<td>Magnification Range</td>
<td>X50 to X1.5M</td>
<td>X50 to X1.0M</td>
<td>X50 to X800K</td>
</tr>
<tr>
<td>Specimen Tilt W/914</td>
<td>50 degrees</td>
<td>80 degrees</td>
<td>80 degrees</td>
</tr>
<tr>
<td>Specimen Tilt W/626</td>
<td>22 degrees</td>
<td>70 degrees</td>
<td>70 degrees</td>
</tr>
<tr>
<td>Specimen Tilt W/3500TR</td>
<td>20 degrees</td>
<td>50 degrees</td>
<td>50 degrees</td>
</tr>
</tbody>
</table>
Thermal Field Emission Gun for Analytical TEM

ZrO/W(100) Schottky Type

- Higher brightness, 100 times greater than LaB6 gun
- Higher coherency
- Higher energy resolution, 0.7 to 0.8 eV
- Higher stability emission over cold FEG
- Longer life time 2 to 4 years (guaranteed time: 5,000 hours)

Features of the JEM-2100F

1. Full PC Control Operation control system:
   - Simple GUI: Excellent easy of use.
   - Reliable system design
   - Independence Network System
   - High resolution and full Digital STEM and

2. Piezo control stage: Piezoelectric element built in as standard Min. move step=0.04 nm/step

3. Anti-vibration system: New designed Flame and Passive type air-mount (2100/2100F), Easy to replace of Active type vibration isolator.

4. Integrated with analytical tools such as EDS, CCD, GIF...etc. Excellent easy of use.

5. Two OL Apertures system.
Operation window

High voltage control window

Graphic User Interface

Column condition display window

STEM image display window

STEM control window

Image control window
Stage control window  Specimen position display window

Control Knob Set

Fast, Easy and Intuitive Operation

Left panel  Right panel

All functions can be controlled via the PC.
Vacuum display window

2PC Kit for Integrated Control

Monitor 1 for TEM/STEM/EDS
Monitor 2 for EDS/CCD cameras/GIF
Monitor 3 available

Operation in one keyboard and mouse
Reliable System Design

- Intelligent main CPU controls the entire system
- Still operational when PC has hung-up
- PC provides only operation GUI
- Independence Network System

Mechanically Minimal Interference

- Hard X-ray aperture
- EDS detector
- Specimen holder
- OL in-gap aperture
- OL aperture for EDS analysis with high contrast image
Exceedingly, Effectively, Traps Contamination Around the Specimen

Anti-Contamination Device (ACD)

High Precision 5-Axis Motor Driven Goniometer Stage

Piezo Actuator for Sub-Angstrom Movement

- Piezo actuator for high magnification imaging
- Minimum move step: 0.4 Angstrom
- No back lash
- Double O-ring for clean vacuum
- Minimal drift for heat/cooling experiment
- Versatile holders available
- Built-in baking function
Newly Designed Base Frame

- Higher Performance for Isolation of Floor Vibration
- More Stable than Ever, than Any Others
- Passive Air Mount Locates As Close As Possible to the Center of the Gravity

For presentation purpose, the 3D drawing above is simplified.

JADAS

- The JEOL Automated Data Acquisition System
What is JADAS?

- A software system to automate routine works of TEM data collection.

Configuration

- Supported TEM models
  - JEM-1230, JEM-1400, JEM-2100, JEM-2100F and JEM-3200FSC

- Digital Camera
  - Gatan

- User interface
  - GUI on Windows XP operation system
Operation Flow

- Create a Recipe
- Global Search
- Parameter Setup
- Calibration
- Image Collection (Execute the recipe at each selected specimen position)

User interface
Recipe

- User-defined operation sequence

Global Search

- Select grid squares for image collection
Recipe Elements

- Interactive Search
- Automatic Search
- Auto-focusing
- Automatic adjustment of stigmatism
- Automatic drift compensation with piezo
- Digital camera capture
- Photographic film exposure
  and more...

A typical recipe

- Auto Search
- Auto Focus (Off-Axis)
- CCD Capture
An application result

- Single particle analysis on ice-embedded Epsilon 15 bacteriophage with JEM-3200FSC

Single particle analysis

- One of analytical methods of structural biology
- Reconstruct 3-D structure of a protein or a virus by integrating TEM images of 1,000 ~ 100,000 particles
Performance

- Single 8-hour session
  - including column alignment (~30min) and Liquid $\text{N}_2$ refill (~30min)
- Number of images: 155 were used for the reconstruction / 181 were automatically collected
  - using Gatan 4k x 4k Ultrascan camera
- 7,543 particles were picked
- The structure was resolved to 7.3 Å resolution

For details about the application

- Please refer to
  - J. Zhang et al. / Journal of Structural Biology 165 (2009) 1–9
SerialEM

- A free software for control TEM and integrated with CCD Camera
- Built-in Montage and Tomography acquire function

Tomography using SerialEM

- Developed by D. Mastronarde @ UC Boulder
- Freeware along with IMOD
- There is no licensing agreement on either SerialEM or IMOD!
- Ran on UC Boulder’s 1 MV JEOL
- First port to UCB 3100FFC
- Now installed on >30 TEMs
SerialEM Features

- Tasks (complex multi-step operations @ different magnifications):
  - Eucentricity (coarse & fine; capable of ~200 µm offset)
  - Beam centering
  - Walk-up to starting angle with retention of ROI
  - Reset of Image Shift w. stage movement
- Montaging:
  - Deflector- or stage-based
- Macro environment:
  - Extreme montaging
  - Conical tomography
  - User-programmable
- Tomography aspects:
  - Wobbler-based focusing at user-defined focii
  - Constant & Saxton-type tilting
  - Dose adjustment \( \propto 1/\cos^n \), n=1 thru 4
  - Series imaging (focus, energy-loss)
  - Montaging and tomography
  - PREDICTION

SerialEM Features II

- Low Dose:
  - Fully integrated and very powerful.
  - Grid mapping at low magnification
  - Montaging (w. tilt acquisitions)
  - Helps the user with off-axis setup
  - Keeps track of the dose
- Integrated support for energy filter
  - Omega & GIF
- Imaging modes:
  - Coreloss
  - ZL
## SerialEM Features III

- Transparent multi-camera Support:
  - Gatan, Tietz & AMT (still & video-rate cameras)
  - Integrated camera controls
  - Dual shuddering for flexible pre-exposures

### JEM-1400
Features of JEM-1400

- W or LaB₆ filament (40~120KV)
- Lattice resolution: 0.2nm with tilt 25°, up to 70° with High Tilt Retainer
- Wide view and full range magnification: X50 ~ X800K
- Windows XP Operating System
- Auto HT and filament heating
- Rotation free in Magnification and Diffraction
- Image Orientation System (IOS)
- Minimum Dose System (MDS)
- Integrated System with Digital Camera (Dual Monitors W/one K.M.)
- 5 specimens holder (Option)

High Contrast image

Frog retina (unstained) Submaxillary grand of rat
Contrast enhanced by different OL aperture

Application-BF/DF (Carbon black)
Large effective field of view on a film: 2 mm in dia. (@X50)

Simple Filament Exchange

Pre-center filament
TEM sample loading

Advanced Holder System for ultimate ease-of-use: provide versatile functions by only changing the holder tip.
Rotation Free Lens System

Zoom-in/out without undesirable rotation

Combination of Image Orientation Systems and Rotation-free Lens System
Minimum Dose System (MDS)

Search mode
(low mag)
Mag.
Brightness
Exp. time

Focus mode
Electronically shift (target)

Photo mode

JEM-1400

Software System
Wide view area for imaging, neatly designed control windows, low-profile tool bar and tabs

* GUI design may be changed without notice for improvement purpose.

The control panels promptly appear by only pointing the tabs by the cursor

* GUI design may be changed without notice for improvement purpose.
Specimen Stage Controller

* GUI design may be changed without notice for improvement purpose.

Specimen Position Monitor

* GUI design may be changed without notice for improvement purpose.
Changes of field-of-view with specimen tilting

0°  30°  60°
70°  80°  90°

Method and flow of Tomograph auto-acquisition

1. Tilting
2. Image tracking
3. OL-focusing
4. Recording
5. Data saving
Operation window of Tilt-Images Auto-Acquisition System (Recorder)

- Storing Image Data
- Tilting Conditions
- Condition Setting
- Exposure Time Setting
- Image Display
- Start Button

Operation window of Reconstruction System (Composer)

- Original Data series
- Area for reconstruction
- Aligned data series
- Tilting axis
Operation window of Viewing System (Slicing)

<Imaging>
Acc. V : 200kV
Mag : ×20k
Tilting : +60° ~ −60° (2.5° Step, 49 Images)

<<Specimen>> Thickness : 100nm
RuO4 Stained
Specimen courtesy of Professor Nishi of University of Tokyo
Lamellar of Polycaprolactane
3D-Reconstructed (Slicing)

*Imaging*
Acc. V: 200kV
Mag: ×20k
Tilting: +60° ~ -60°
(2.5° Step, 49 Images)

**Specimen**
Thickness: 100nm
RuO4 Stained
Specimen courtesy of Professor Nishi of University of Tokyo

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Synapse of Spinal Cord of Frog
3D-Reconstructed

**Specimen**
Spinal Cord of Frog
(OsO4 Stained)
Thickness: 70 nm
Tilting: -60° ~ + 60° (1° Step)
Instrument: JEM-2010 / Auto-Acquisition System (AIA)
Acc. V: 200kV
**Synapse of Spinal Cord of Frog**

3D-Reconstructed (Slicing Display)

Specimen: Spinal Cord of Frog (OsO4 Stained)

Thickness: 70 nm

Tilting: -60°~ + 60° (1°Step)

Instrument: JEM-2010 / Auto-Acquisition System (AIA)

Acc V: 200kV

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**Synapse of Spinal Cord of Frog**

3D-Reconstructed

Specimen: Spinal Cord of Frog (OsO4 Stained)

Thickness: 70 nm

Tilting: -60°~ + 60° (1°Step)

Instrument: JEM-2010 / Auto-Acquisition System (AIA)

Acc V: 200kV
Digital Image System

Location of Digital Cameras

Attaching CCD Camera to TEM Column

Magnification on CCD

- Less than film (~70-75% less)
- Close to film (~30-40% more)

TEM Applications

- (35 mm Port)
- Large field of view
- Life science
- (Bottom)
- High resolution
- Materials science
**Field of View Comparison**

- **782/W-CCD**
- **782/W-CCD**
- **Film**
- **894-2K**
- **785/832W**

**Digital Camera models**

<table>
<thead>
<tr>
<th>Model</th>
<th>Scintillator</th>
<th>Cooling</th>
<th>CCD Size</th>
<th>Camera-Computer Interface</th>
<th>Magnification on CCD with respect to film</th>
<th>Dynamic range</th>
<th>View Area</th>
<th>Coupling System</th>
<th>CCD Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>895 (US4000)</td>
<td>Phosphor</td>
<td>Peltier</td>
<td>4080 x 4080 @15um</td>
<td>PCI</td>
<td>1.3 – 1.5x</td>
<td>16-bit</td>
<td>~45% of Film</td>
<td>HCR™ Fiber Optic</td>
<td>61.2 x 61.2</td>
</tr>
<tr>
<td>894 (US1000)</td>
<td>Phosphor</td>
<td>Peltier</td>
<td>2048 x 2048 @14um</td>
<td>PCI</td>
<td>1.3 – 1.5x</td>
<td>16-bit</td>
<td>~10% of Film</td>
<td>HCR™ Fiber Optic</td>
<td>33.7 x 33.7</td>
</tr>
<tr>
<td>782/ES500W</td>
<td>Phosphor</td>
<td>Peltier</td>
<td>1350 x 1040 @6.45um</td>
<td>IEEE 1394b</td>
<td>0.2 – 0.3x</td>
<td>12-bit</td>
<td>Film+33%</td>
<td>Lens Optics</td>
<td>2.7 x 2.7</td>
</tr>
</tbody>
</table>
Software - DigitalMicrograph Working Environment
Software function – Image output formats

The image can be exported as many formats such as JPEG, TIFF, BMP, etc.

Software function - Brightness/Contrast Adjustment

Before

After
1D Noise reduction

Original image

FFT

Inverse FFT

DigitalMontage - Enlarge photographic Area by software (Option)

These are 4 images in 1024x1024 size. This montage is 1953x1952 pixels.
**EM AutoTuning — Auto Focus by software (Option)**

Before Tuning

After Tuning

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**Digital Streaming Video for Network Meeting**

Collaboration using Digital Streaming Video
- Allows images from the TEM camera to be shared via the Internet/network connections as a video stream
- Using videoconferencing program (e.g., WebEx)

[Diagram showing network cloud connecting TEM camera, PC, Internet, and remote locations (e.g., Hospital, University, Researcher)]
Cryo-Transfer Holder

914

CT3500TR

626

914 Cryo-Transfer Holder

Workstation

Holder
Gatan 914 Cryo Transfer holder

- Minimum temperature attainable in the microscope: -170°C
- Minimum temperature attainable in the cryo-workstation: -185°C
- Cool down time to within 10°C of T min <15 minutes
- Typical specimen temperature rise during transfer to the TEM: <20°C
- Resolution at T min better than 0.5nm
- Tilt range (With CR and HC Pole Piece): ±80°
- Dewar capacity 4 hours

655 Pumping Station
655 Pumping Station

Thank you for your attention.