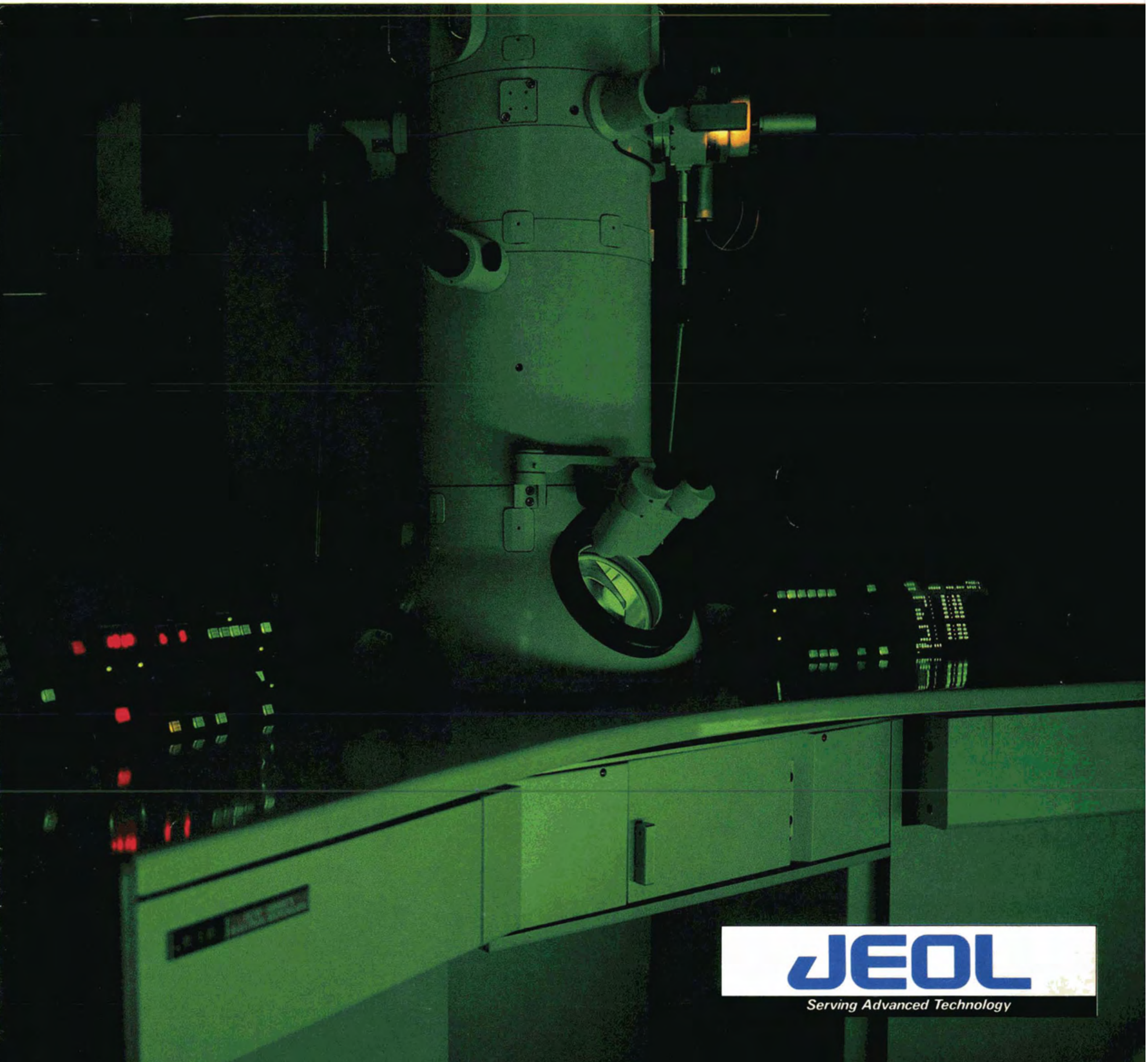
JEM-4000FX

Electron Microscope



Serving Advanced Technology

The Merits of 400kV Are Given the Fullest Play in This Next-Generation EM.

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                         PAGE-1
MAG              X800K
ACC. VOLT     400.0KV
SPOT SIZE        3L
CURR DENS        0.2PA/cm2
EXP  TIME        2.0SEC M
FILM NO        FX1986
     TEXT      SI2N4
     SENS        9
     UNUSED     41
SPECIMEN      X= -422   Y=    -8
FOCUS              0   (3.5nm)
OK SP [ 5.E              ]
>_
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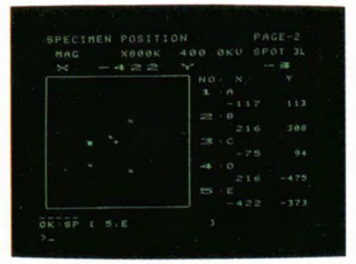

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SPECIMEN POSITION           PAGE-2
 MAG       X800K   400.0KV  SPOT 3L
 X    -422    Y        -8
                 NO. X      Y
                 1 A
                    -117    113
                 2 B
                     216    308
                 3 C
                     -75     94
                 4 D
                     216   -475
                 5 E
                    -422   -373
OK SP [ 5.E              ]
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                              PAGE-7
MAG                  X800K
ACC  VOLT         400.0KV
EXP  TIME            2.0SEC M
FILM
     UNUSED      41
     NO        FX1986
OK SP [ 5.E              ]
>_
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Why a 400kV electron microscope now?

What are required of today's electron microscopes are the observation of molecular- and atomic-level structures of biological specimens and solid materials, observation of their three-dimensional structures, and elementary analysis of specimen ultramicroareas and, if possible, the identification of individual atoms.

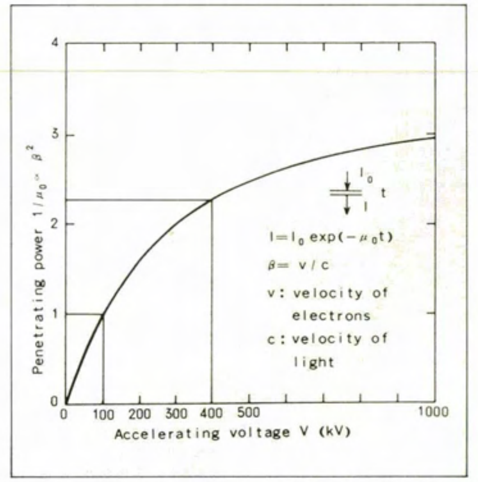
As a high resolution electron microscope

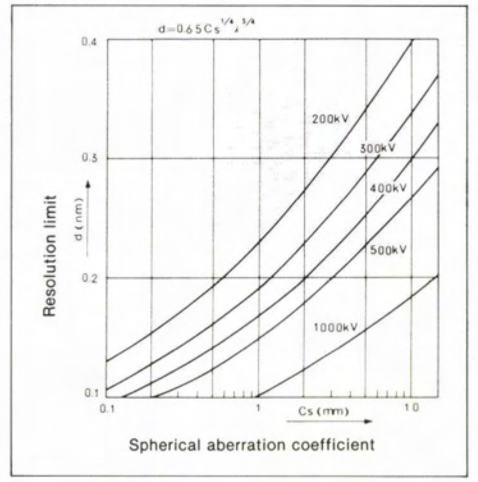
Theoretical resolution is higher in an EM of higher accelerating voltage which makes the wavelength (λ) of the electron beam shorter. With the increase of the accelerating voltage, however, the specimen is inevitably more damaged by beam irradiation. The highest possible voltage that is lower than the critical voltages which cause beam irradiation damage to many types of materials is 400 kV. The spherical aberration coefficient (Cs)—another important factor for theoretical resolution—inevitably becomes larger with the increase of the accelerating voltage. The 400 kV accelerating voltage is a rational one in that it practically minimized Cs λ^3 (theoretical resolution) in an analytical EM that effectively detects various types of signals generated by the interaction between the electron beam and specimen.

As an electron microscope with high penetrating power

The electron beam is subjected to nonelastic scattering and therefore to energy loss, thus resulting in image blur. The thicker the specimen, the more unclear appear its microstructures, thus reducing the amount of information obtainable on three-dimensional structures.

Theoretically, the penetrating power of the electron beam depends upon the velocity of the electron beam; therefore, an electron microscope with a higher accelerating voltage has a greater penetrating power. A 400 kV accelerating voltage is effective also for the observation of a thick specimen with a three-dimensional spread.

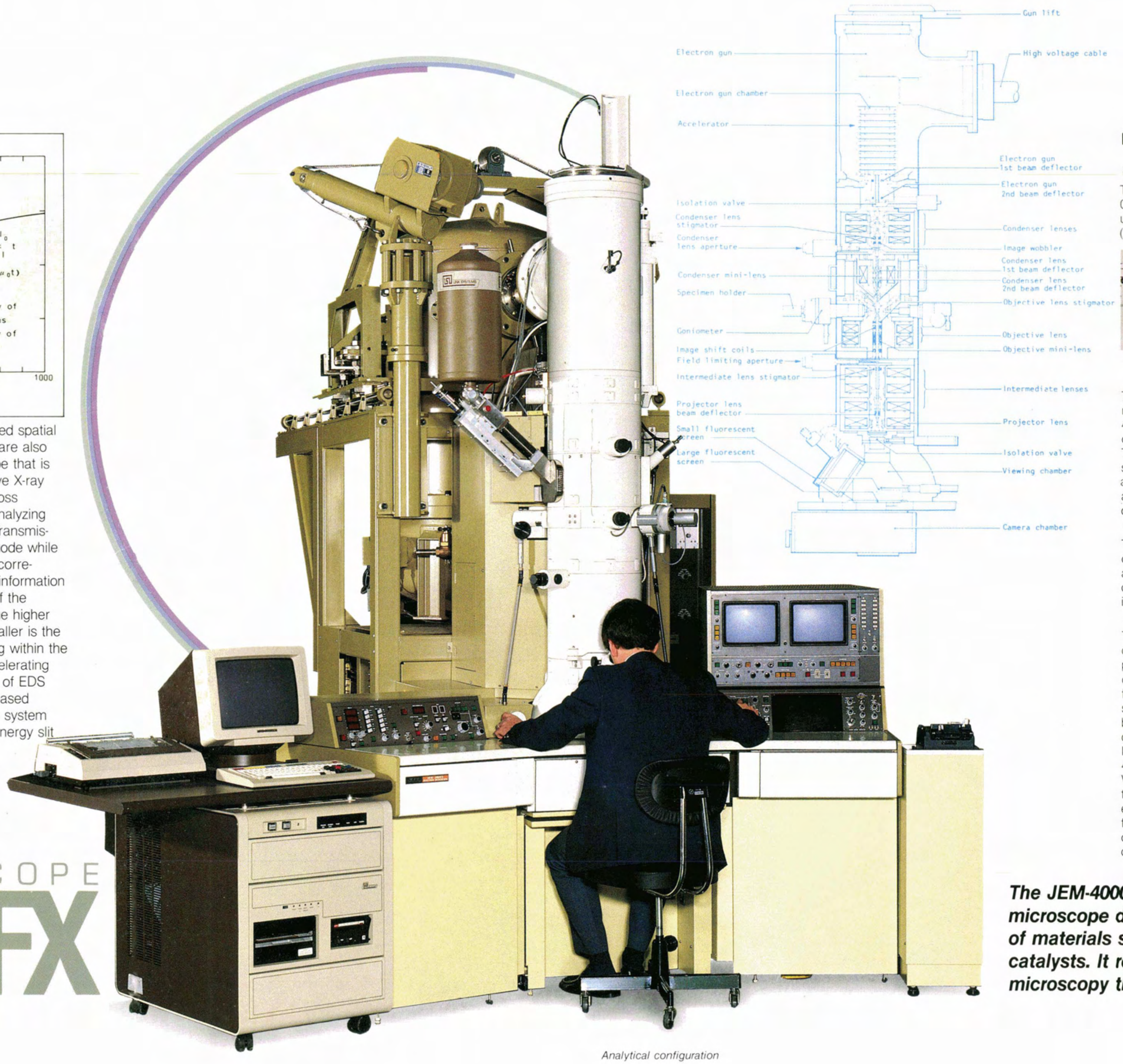




As an electron microscope with high-precision ultramicroarea analysis capability

The analysis of ultramicroareas is meaningless unless the correspondence between the fine structure under observation and that under analysis is obtained. Improved spatial resolution and improved P/B ratio are also essential to an electron microscope that is equipped with an Energy Dispersive X-ray Spectrometer (EDS) and Energy Loss Spectrometer (ELS), not only for analyzing specimen ultramicroareas in the Transmission Electron Microscope (TEM) mode while accurately maintaining the above correspondence, but also for obtaining information on the binding state of elements. If the specimen thickness is constant, the higher the electron beam energy, the smaller is the spread of electron beam scattering within the specimen. And the higher the accelerating voltage, the higher is the P/B ratio of EDS and ELS. On the other hand, increased accelerating voltage increases the system noise generated at the aperture, energy slit and other portions. Thus an accelerating voltage of 400 kV is ideally suited as the highest possible voltage that holds the system noise at the lowest level.

ELECTRON MICROSCOPE
JEM-4000FX

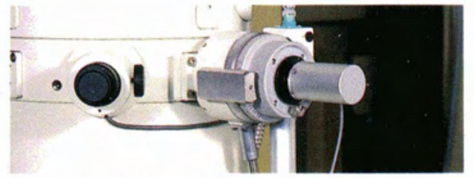


Analytical configuration

Features

● High resolution

The JEM-4000FX offers a theoretical resolution of 0.19 nm as an analytical electron microscope using a fully eucentric side entry goniometer (AHP40S).



● Newly designed 5-stage illuminating system

The probe diameter can be changed over a wide range from 2 μm to 2 nm in the TEM mode using a 4-stage independent condenser lens and the condenser field of a condenser objective (C/O) lens. The illuminating system is equipped with the α-selector function that can change the illuminating angle at will while maintaining the prove diameter—a useful function in convergent beam electron diffraction (CBED).

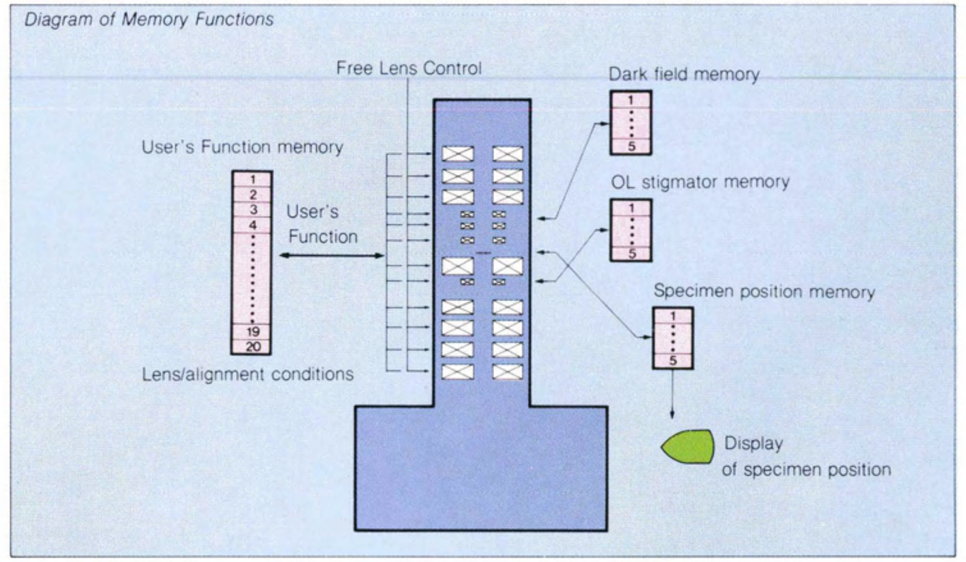
● Newly designed 6-stage imaging system

The newly designed 6-stage imaging system can change the magnification over a wide range from a very low magnification of 60x to a high magnification of 1,200,000x and provides a high quality image (AHP40S).

● Clean specimen environment

The JEM series electron microscopes have been developed and engineered with the design philosophy "Keep the specimen environment clean." Equipped with a 150ℓ/sec sputter ion pump for the specimen chamber, radial evacuation system, cylindrical anti-contamination trap, metal bellows, metal gasket seal, lens liner tube, differential pumping apertures for the projector lenses, and column bakeout mechanism, the JEM-4000FX provides a clean specimen environment. When it is not used at night or over the weekend, the specimen environment can be kept clean by the energy saving mode, in which only the ion pumps for the acceleration tube and the specimen chamber are run, with the pumps for the camera chamber and viewing chamber shut down.

Diagram of Memory Functions



● An abundance of functions to cope with a wide range of applications

Because of the employment of a 16-bit CPU and the state-of-the-art computer technology, the JEM-4000FX offers the following advantages: •Free Lens Control (option) that allows setting the desired lens excitation and alignment conditions •20-channel User's Function memory that can store those conditions for later readout, as necessary. •5-channel dark-field memory that allows easy comparison of low- and high-order darkfield images. •5-channel OL stigmator memory that facilitates the observation of magnetic materials. •5-channel specimen position memory that can store 5 specimen positions with comments.

● Upgradable into an analytical electron microscope

For the JEM-4000FX is available a large variety of attachments, such as the Scanning Image Observation Device (ASID), Energy Diepersive X-ray Spectrometer (EDS), Energy Analyzer (ASEA), and various types of specimen holders. The use of these attachments provides information carried by secondary electrons, backscattered electrons and X-rays from the specimen, and transmitted electrons that have undergone energy loss when transmitting the specimen.

● High-brightness electron gun

The acceleration tube consists of 12 electrodes. It is evacuated by a 75ℓ/sec sputter ion pump for its exclusive use and maintained in a clean vacuum, making it possible to use the standard high-brightness single crystal LaB_6 cathode. Also the emitter tip high-voltage stabilization method provides a highly stabilized electron beam even when the bias voltage is changed.

● Safety provision

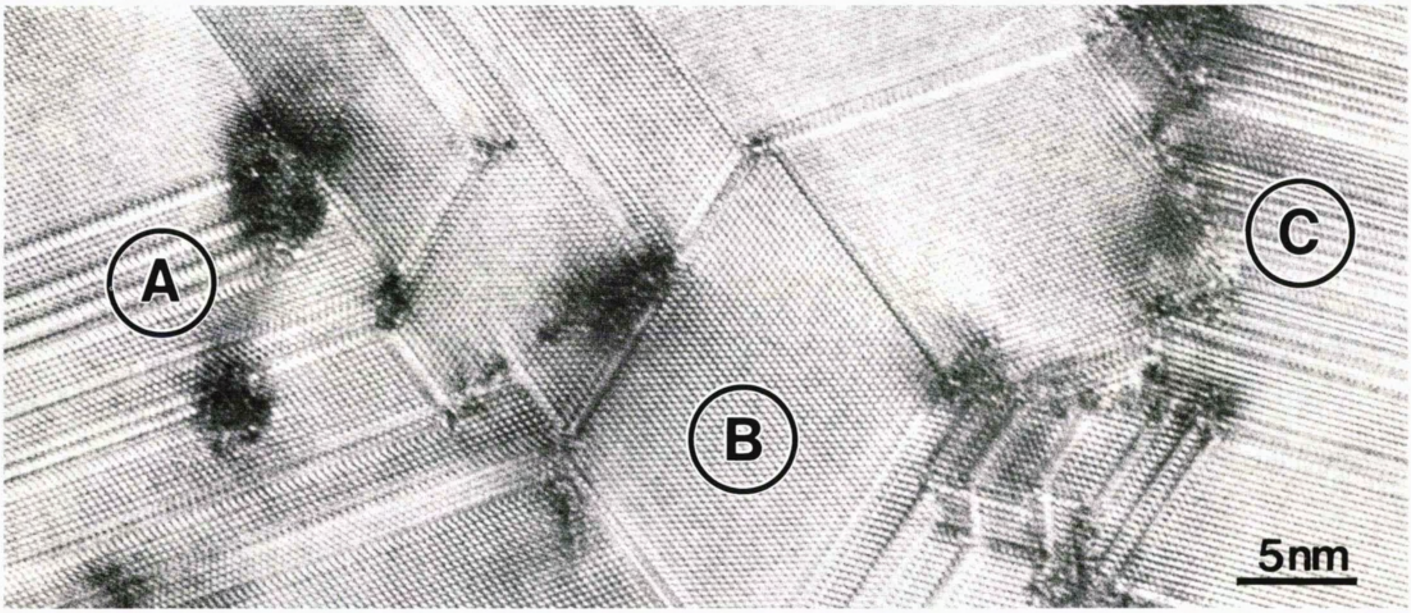
The JEM-4000FX is complete with safety devices against such troubles as power failure, water failure, and erroneous operation. For operator safety, X-rays are shielded in compliance with the IEC recommendations and pertinent Japanese laws and regulations. Also an area monitor (option) can be installed.

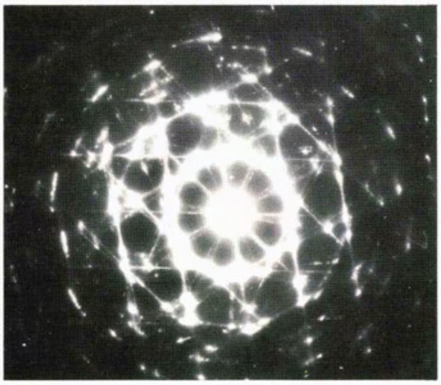
● Ease of installation, operation and maintenance

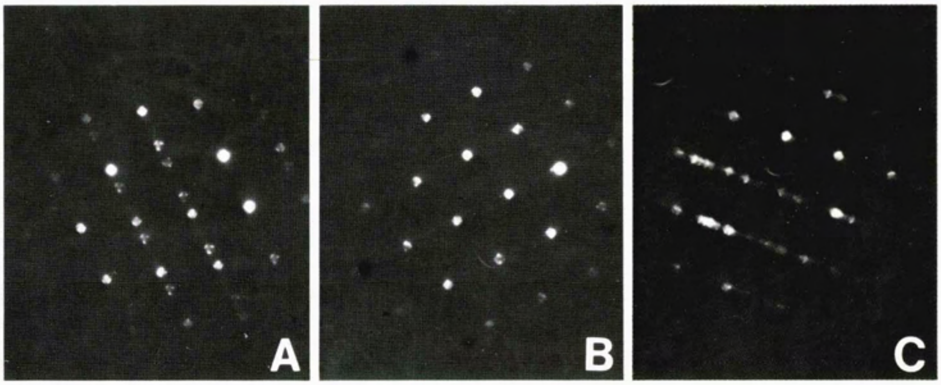
The JEM-4000FX is designed for ease of operation and maintenance. It can be installed in an ordinary room measuring 5 m wide × 7 m deep × 3.2 m high (ceiling) or more.

The JEM-4000FX is a new analysis-oriented 400kV electron microscope designed for researchers working in advanced fields of materials science, such as semiconductors, new materials, and catalysts. It represents JEOL's total capability of electron microscopy that has been acquired in the past over 30 years.

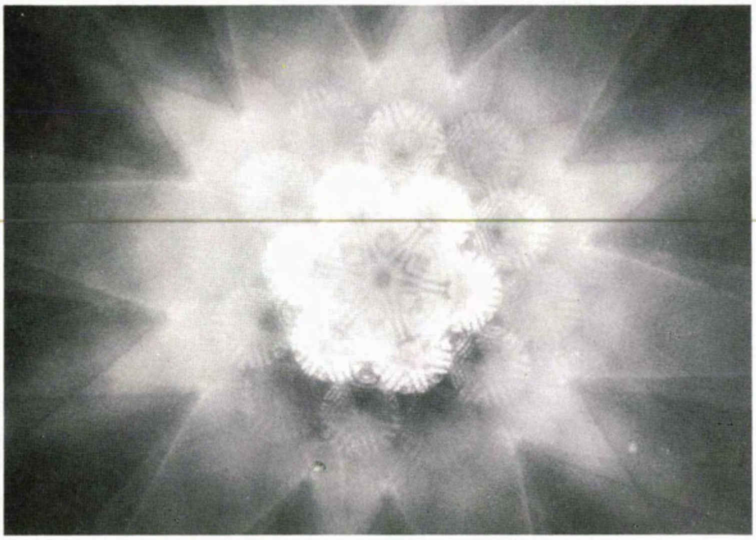
Specimen: polycrystalline silicon

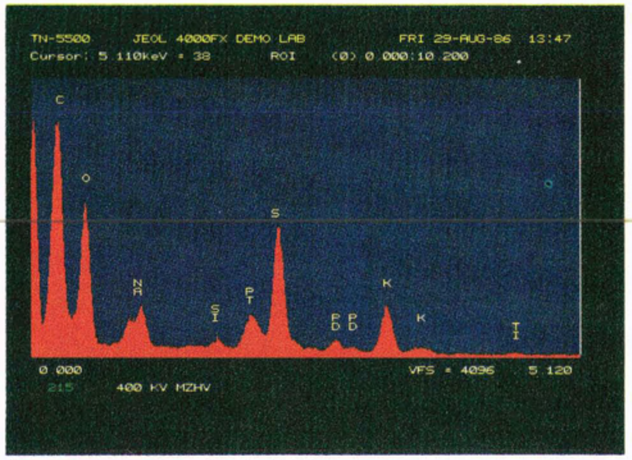



Selected area diffraction pattern



Micro beam diffraction pattern


Si(111) zone axis convergent-beam electron diffraction (CBD) pattern



X-ray spectrum of catalyst by UTW detector

JEM-4000FX Performance

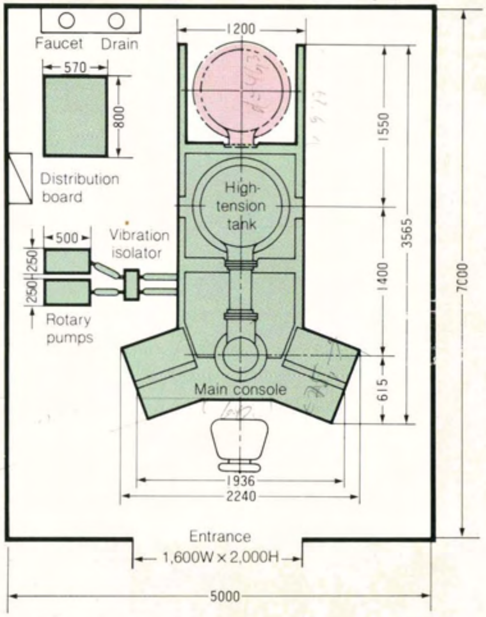
	AHP40S	AHP40L	
Guaranteed Resolution			
TEM Lattice image	0.14 nm	0.14 nm	
Point image	0.22 nm	0.26 nm	
STEM edge to edge	1 nm	1 nm	(option EM-ASID40)
SEM edge to edge	1 nm	2 nm	(option EM-ASID40)
Accelerating Voltage	200, 250, 300, 350, 400 kV	100, 150, 200, 250, 300, 350, 400 kV	
Min. step	100V	100V	
Stability	2×10^{-6}/min.	2×10^{-6}/min.	
Objective Lens			
Focal length	3.1 mm	4.4 mm	
Spherical aberration	1.8 mm	3.4 mm	
Chromatic aberration	2.2 mm	3.4 mm	
Min. focus step	1.5 nm	3.5 nm	
Stability	1×10^{-6}/min.	1×10^{-6}/min.	
Beam Diameter (steps)			
TEM L (Fine focus mode)	2 ~ 0.02 μmφ (8)	2 ~ 0.02 μmφ (8)	
S (Super focus mode)	50 ~ 2 nmφ (8)	50 ~ 2 nmφ (8)	
STEM/SEM	20 ~ 2 nmφ (3)	20 ~ 2 nmφ (3)	(option EM-ASID40)
Magnification (steps)			
TEM MAG	5,000 ~ 1,200,000X (25)	4,000 ~ 800,000X (24)	
TEM LOW MAG	60 ~ 3,000X (18)	60 ~ 3,000X (18)	
TEM SA MAG	25,000 ~ 250,000X (11)	20,000 ~ 200,000X (11)	
STEM MAG	2,000 ~ 800,000X (27)	2,000 ~ 800,000X (27)	(option EM-ASID40)
SEM MAG	2,000 ~ 800,000X (27)	2,000 ~ 800,000X (27)	(option EM-ASID40)
SEM LOW MAG	300X (1)	300X (1)	(option EM-ASID40)
Diffraction (steps)			
TEM SA DIFF	0.2 ~ 3 nm • mm (13)	0.25 ~ 4 nm • mm (13)	
TEM HD DIFF	6 ~ 90 nm • mm (13)	6 ~ 90 nm • mm (13)	
TEM HR DIFF	30 cm (1)	30 cm (1)	(option EM-AD40)
ECP rocking angle	±2.5° ~ ±15° (11)	±2.5° ~ ±15° (11)	(option EM-ASID40)
STEM micro DIFF	0.2 ~ 3 nm • mm (13)	0.25 ~ 4 nm • mm (13)	(option EM-ASID40)
Max. CBD angle	15 mrad (2 nmφ)	20 mrad (6 nmφ)	
Acceptance angle	16°	16°	
Beam tilt angle	±3° (X, Y)	±3° (X, Y)	
Specimen Chamber			
Number of specimens/load	2	2	
Tilt angle	±15°	±45°	
Specimen movement	8 mm (X) 2 mm (Y) 0.5 mm (Z) (+0.2 ~ −0.3)	8 mm (X) 2 mm (Y) 0.5 mm (Z) (+0.2 ~ −0.3)	
EDS			
Horizontal (0°)	———	19.5 mm/0.079 str	(option LINK UTW)
	———	20.5 mm/0.023 str	(option TN UTW)
High angle (65°)	31 mm/0.031 str	31 mm/0.031 str	(option LINK)
	32 mm/0.029 str	32 mm/0.029 str	(option TN)
ELS			(option EM-ASEA40)
Guaranteed resolution	2 eV	2 ev	
Working range	0 ~ 10 kV	0 ~ 10 kV	

Specifications subject to change without notice.

● Dimensions and weight (mm & kg)

	Height	Width	Depth	Weight
Main console	3,150	2,240	3,565	4,300
Power supply	1,750	570	800	500
Rotary pumps (2 sets)	310	250×2	500	33×2
Air compressor (option)	800	380φ		45

● Installation Layout



Installation Requirements

● Environment

Floor space:	Min. 5,000W × 7,000D (mm)
Ceiling height:	Min. 3,200 mm
Entrance:	Min. 1,600W × 2,000H (mm)
Temperature:	15°C to 20°C
Humidity	Less than 60%
Floor vibration:	1μm(2Hz), 2μm(3 ~ 9Hz), 3μm(10Hz ~)
Stray magnetic field:	0.3 μT (3 mG), fluctuation less than 0.1 μT (1 mG)
● Power	3-phase, 200 V, 20 kVA (60 A) (including ASID40, ASEA40, CP10, DSC10 or DSC20) Tolerable fluctuation ± 10%
● Ground terminal	One, Less than 100 Ω
● Water	
Flow rate:	10ℓ/min.
Pressure:	0.2 to 0.5 MPa (2 to 5 kg/cm²)
Temperature:	15°C to 20°C
Faucet:	One, ISO 1/2″, female One, natural drain, I.D. more than 25 mm

JEOL

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