Scientific / Metrology Instruments

Multi Beam System

Solutions for Innovation

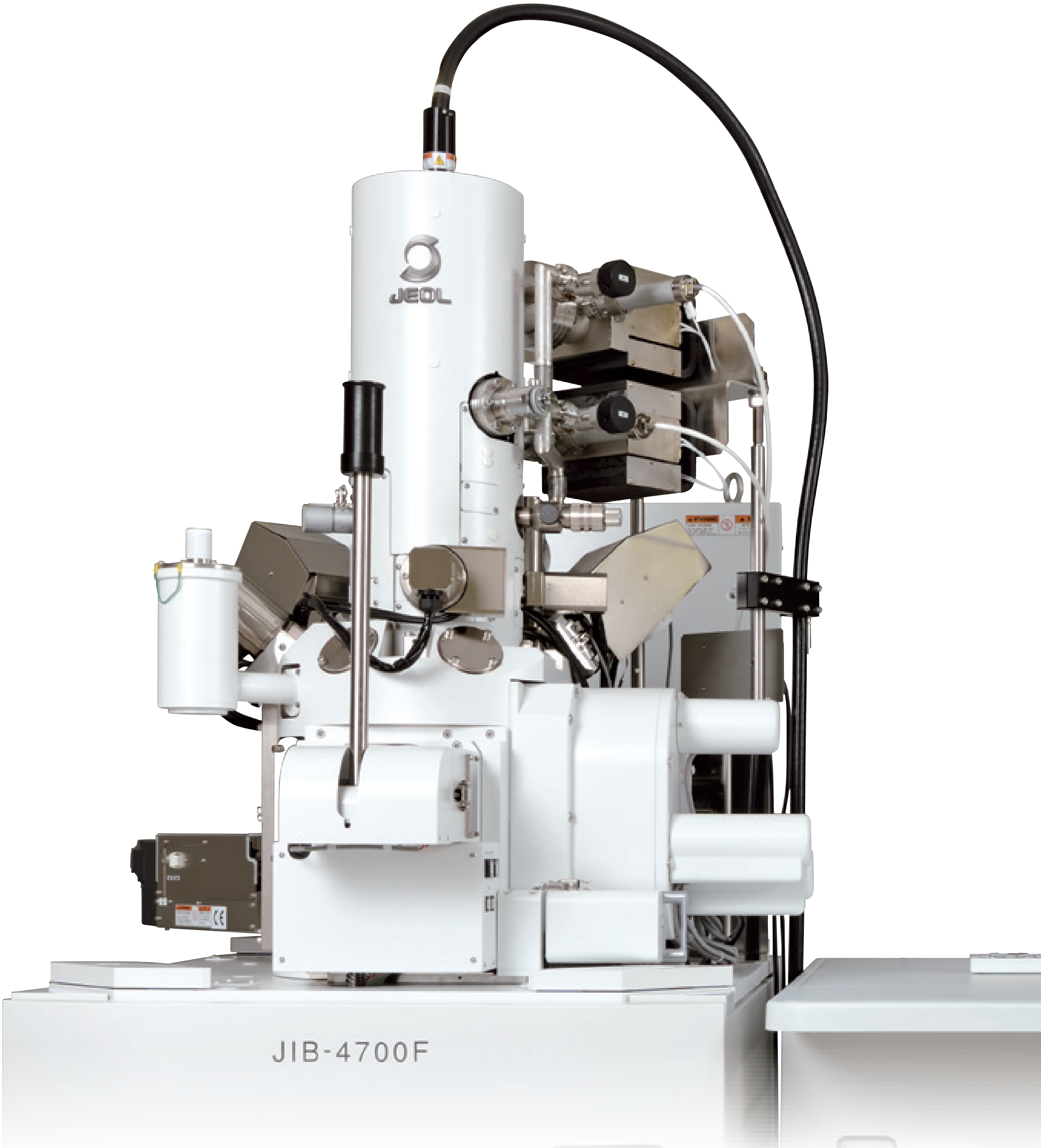
JIB-4700F

JEOL Ltd.

Toward Seamless Observation and

Enabling seamless observation and analysis

Greatly improved SEM imaging by a new optical column.
Further strengthened FIB processing capabilities.
Improved operability with linkage capabilities.



Analysis

SEM : Improved imaging performance by a new optical column

High resolution at low accelerating voltage

Combination of a hybrid conical objective lens and GENTLEBEAM™ achieves high resolution at low accelerating voltage (1.6 nm at 1 kV).

Acquisition of a variety of images

Newly added UED & USD detectors enable acquisition of a variety of SEM images that contain information on properties, chemical compositions and crystal structures.

High resolution at large probe current

Combination of an “in-lens Schottky electron gun” and an aperture angle control lens (ACL) maintains high resolution at large probe current, allowing for fast analysis.

Large depth of focus (LDF) at low magnification

LDF mode for low magnification achieves a large depth of focus on the order of millimeters.

FIB : Further strengthened processing capabilities

Enhanced control system

The vector scan system allows for smooth processing of an arbitrary shape.

Simple 3D observation & analysis is enabled.

Large ion beam current up to 90 nA

High-speed processing of the specimen is enabled.

Linkage with pick-up system

The stage linkage function shares the coordinates linked between instruments.

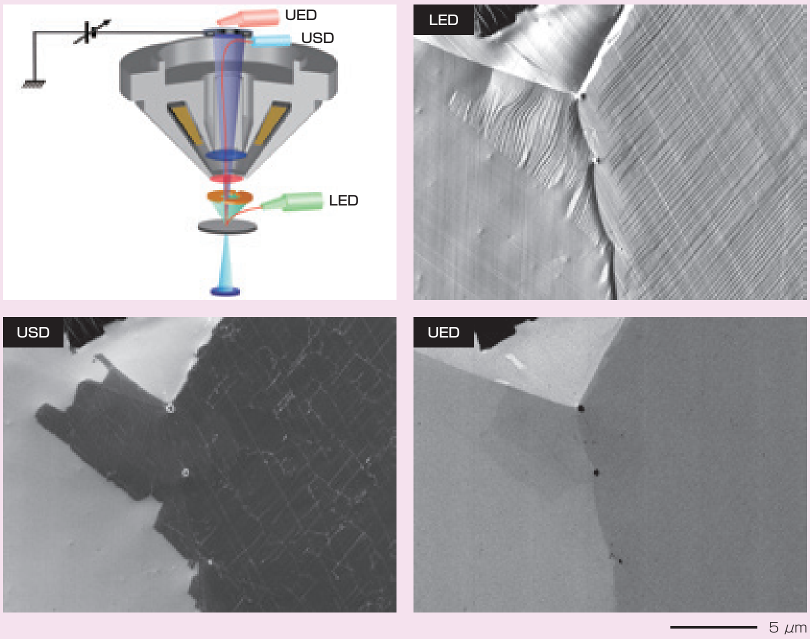
Retraction of a section with an optional pick-up system is smoothly enabled.

Index

Step 1: Determination of observation, processing and analysis positions

SEM observation with multiple detectors

(➡ p.13)



- Position determination assist system

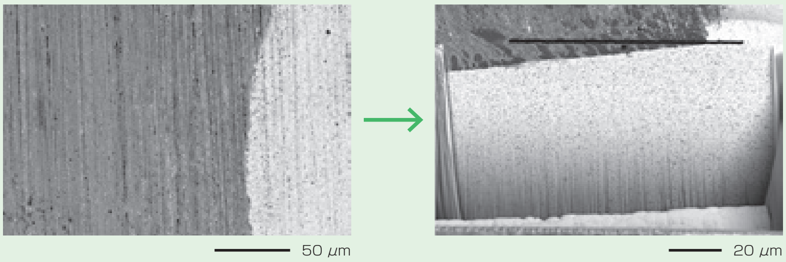
· Stage navigation system
(➡ p. 15)

· Picture overlay
(➡ p. 16)

· Stage linkage
(➡ p. 8)

Step 2A: Cross section milling for observation and analysis (➡ p. 5)

Cross section milling



- Special milling conditions

· Arbitrary shape
→ Vector scan (➡ p. 12)

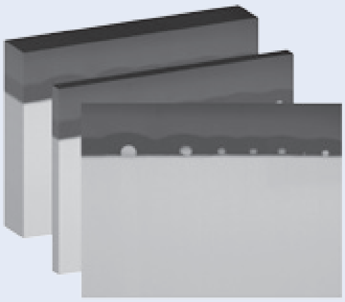
· Heat sensitive / Hydrated specimen
→ Specimen cooling system (➡ p. 6)

· Reactive specimen
→ Air-isolated transfer system

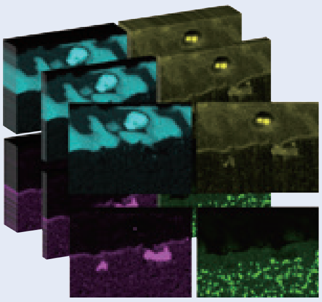
Step 3: Observation and analysis

Observation, analysis and 3D reconstruction of cross sections

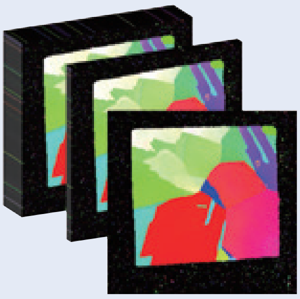
SEM (➡ p. 5、9)



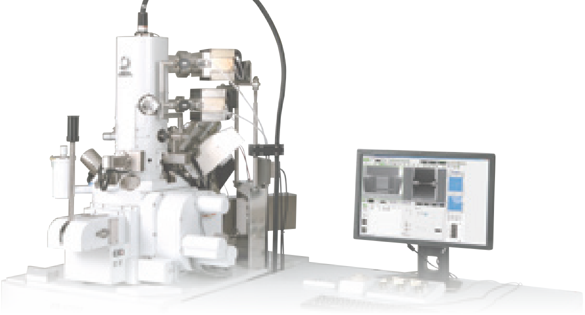
EDS (➡ p. 9)



EBSD (➡ p. 9)



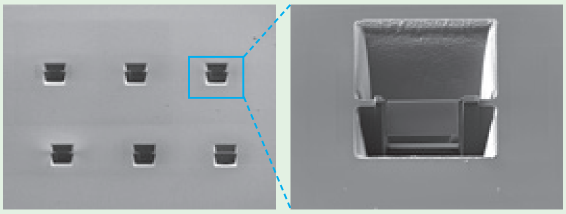
Images



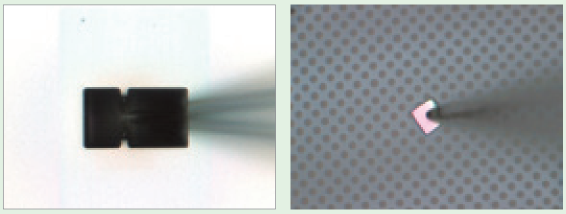
Step 2B: TEM lamella preparation (➡ p. 7)

Pick-up method (high throughput)

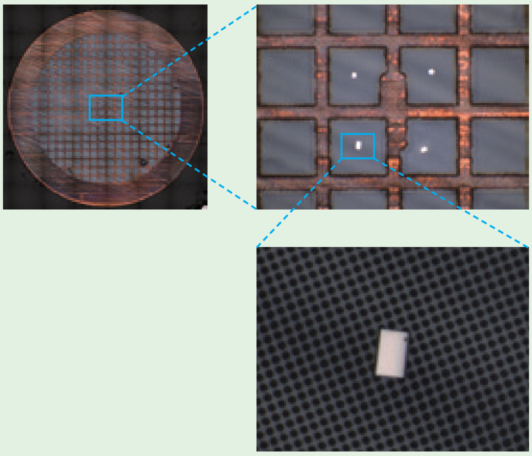
- FIB processing



- Pick-up

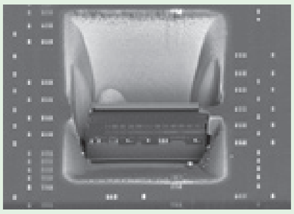


Stage linkage (➡ p. 8)

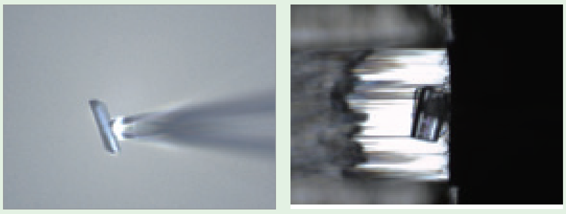


Bulk pick-up method (high quality)

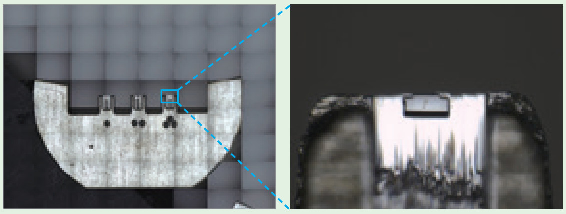
- FIB processing



- Pick-up



Stage linkage (➡ p. 8)



- FIB additional processing

Multiple specimen observation

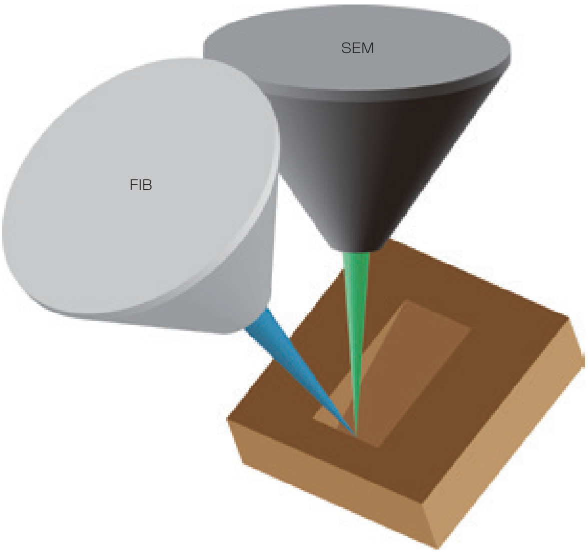
Additional thinning

TEM

Versatile solutions offered by FIB-SEM

Cross section milling

The JIB-4700F Multi Beam System allows for seamless operations from protective-film preparation, specimen milling to cross section observation and analysis.

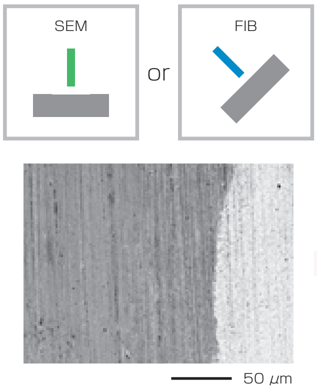


Capabilities offered by SEM and FIB (beams)

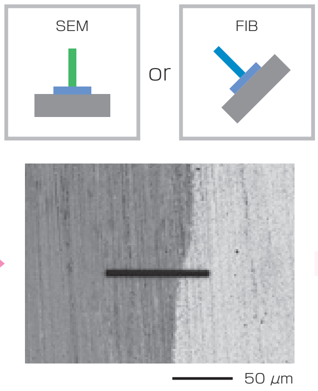
● SEM	● FIB
Observation	Observation
Protective-film preparation (deposition)	Protective-film preparation (deposition)
EBSD & EDS analysis *	Milling

Process of preparation and observation of cross sectional specimen using FIB-SEM

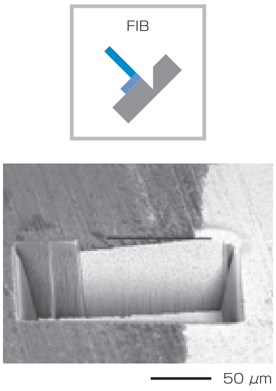
- Determine the position of processing and observation.



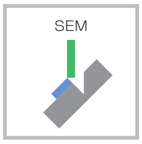
- Prepare a protective film.

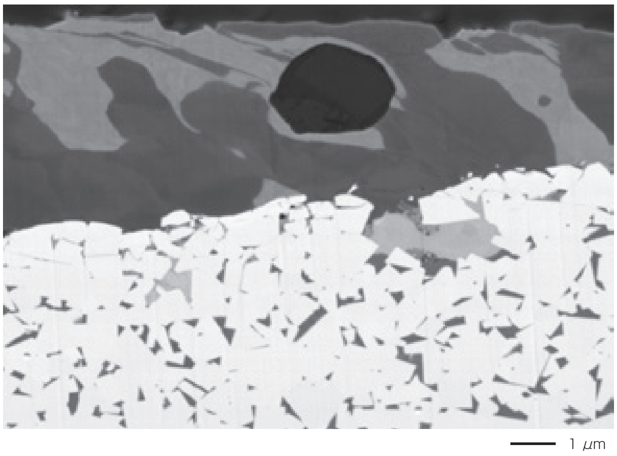


- Mill the cross section.



- Observe the cross section.





Cross section of a carbide drill
Accelerating voltage : 5 kV
Detector : BED

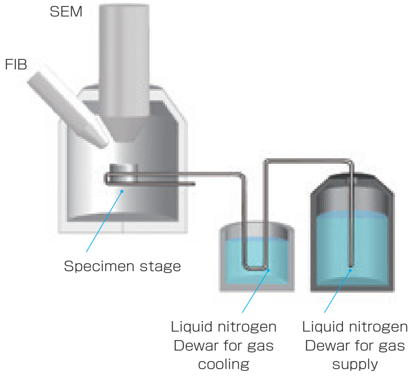
* is optional.

Specimen cooling system *

The cooling stage is suitable for specimens which may deform during processing (specimens like low-melting metal, macro-molecule material). The cryo-system is effective for hydrated specimens (biological specimens, foods, medicines, etc.).

Processing and observation of a heat-sensitive specimen using the cooling stage

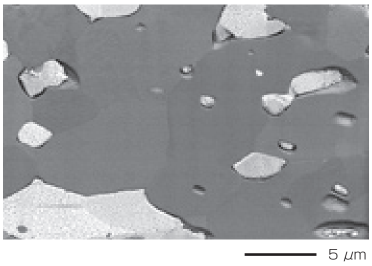
Specimen: Low melting-point alloy, macro-moleculer material, etc.



Schematic of cooling stage

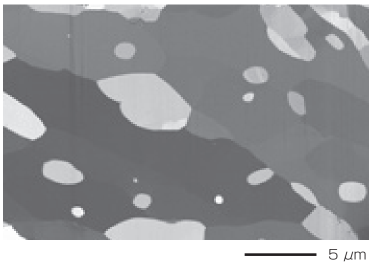
Application examples

When lead solder is FIB-processed at room temperature, voids are generated at an interface between the solder and tin, thus inducing the missing of lead. But in the figures below, low-temperature FIB processing provides the interface with no void.



Accelerating voltage : 5 kV
Temperature : 25 ℃

Backscattered electron image of a milled face at room temperature



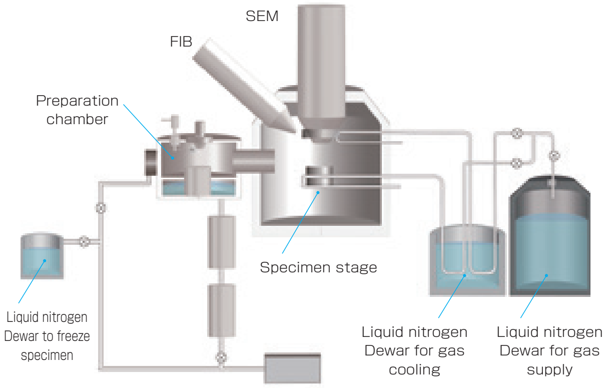
Accelerating voltage : 5 kV
Temperature : -100 ℃

Backscattered electron image of a cross section at -100 ℃

Processing and observation of a hydrated specimen using the cryo-system

Specimen: Specimen with large water or fat content (biological specimen, food, medicine, etc.)

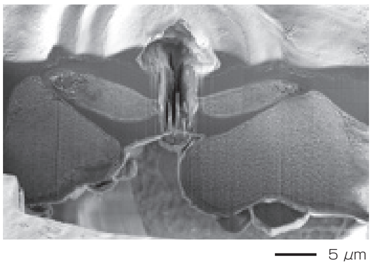
1. Cool a specimen (to freeze) with Liquid nitrogen Dewar.
2. Transfer to a preparation chamber, then apply fracturing and coating.
3. Process and observe using the Multi Beam System.



Schematic of cryo-system

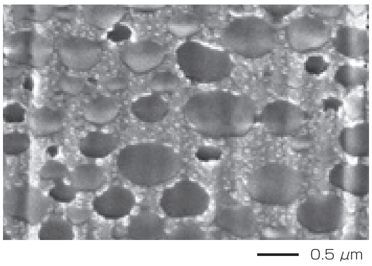
Application examples

The cryo-system enables observation and cross-sectional milling of a frozen specimen.



Accelerating voltage : 5 kV
Temperature : -130 ℃

Secondary electron image of a cross section of stoma of leaf



Accelerating voltage : 5 kV
Temperature : -130 ℃

Secondary electron image of a cross section of macro-molecular emulsion

* is optional.

TEM lamella preparation

The stage linkage function, which links the JIB-4700F to the pick-up system, allows for smooth thin-film preparation.

- Stage linkage function *
  This function shortens a time to search the target object even when the stage moves between different instruments.
- Pick-up system *
  A specimen with a size of the micrometer order is displayed on the monitor via an optical zoom microscope. Operations with a mouse / touch panel allow the operator to smoothly transfer the specimen to a grid mesh for TEM observation.

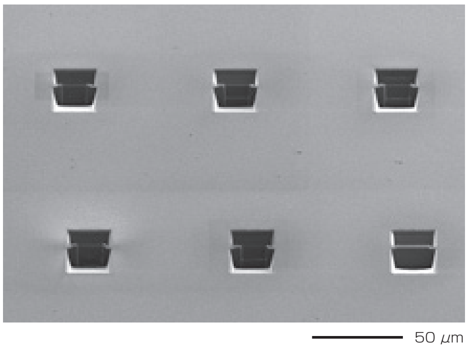
Methods depending on requirements

Two methods are available; pick-up method and bulk pick-up method. Both methods have different advantages, thus enabling you to use a better one depending on your requirements.

Pick-up method – High throughput –

In Pick-up method, a thin film specimen prepared by FIB is mounted on a grid mesh for TEM observation with a pick-up system. Multiple thin film specimens can be mounted on the grid mesh for TEM observation. Another advantage is that adhering is not needed and specimen pick-up is made in a short time, thus effective for observation of many thin film specimens.

● JIB-4700F



① Cutting a thin film specimen.

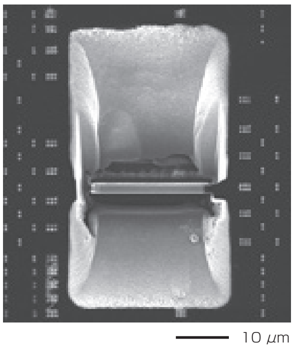
Stage linkage →

You can immediately recall the specimen position.

Bulk pick-up method – High quality –

In Bulk pick-up method, a thick block specimen prepared by FIB is mounted on a grid with an ex-situ pick-up system. Then, thin film processing is made again by FIB. This method enables you to perform various processing, including thin film preparation of a magnetic material, re-processing after TEM observation, thin film preparation from a different direction (from bottom of specimen, etc.), and cross-sectional or planar milling.

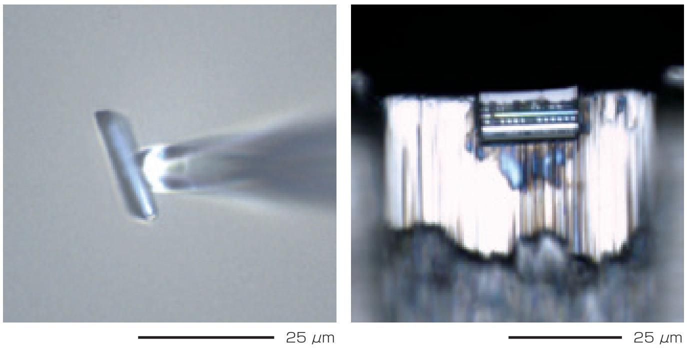
● JIB-4700F



① Cutting a block specimen.

Stage linkage →

● Pick-up system

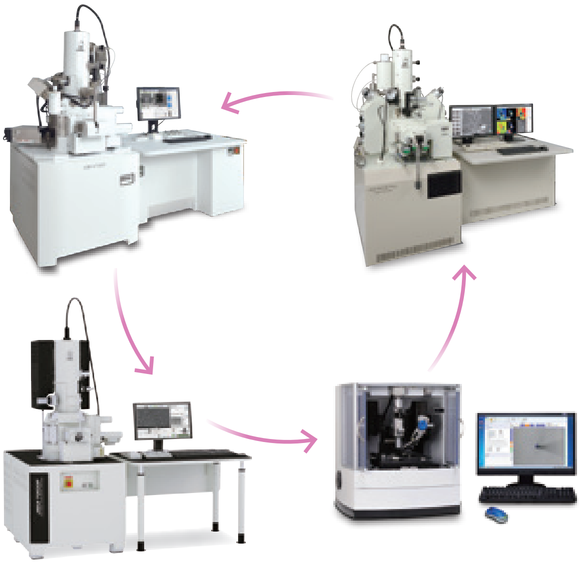


② Replacing a block specimen.

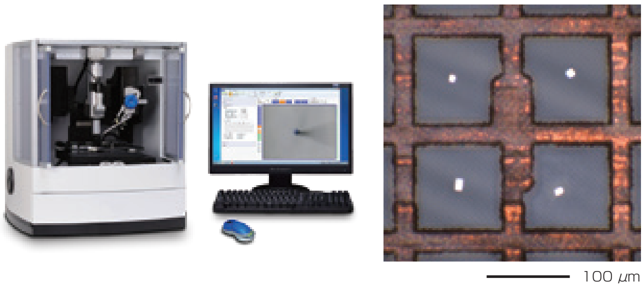
* is optional.

Stage linkage function

This function enables the linkage of stage-coordinate information between the JIB-4700F and the other instruments.
You can immediately approach the object found by the JIB-4700F with the atmosphere pick-up system (IB-62010AXP). Reverse steps can also be made.
Using the function, this information linkage with a JEOL SEM or EPMA is also possible.

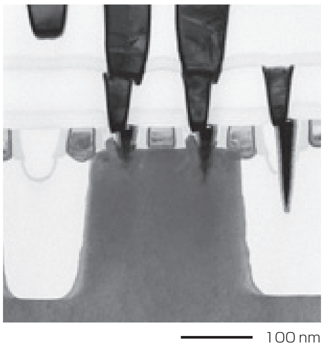


● Pick-up system



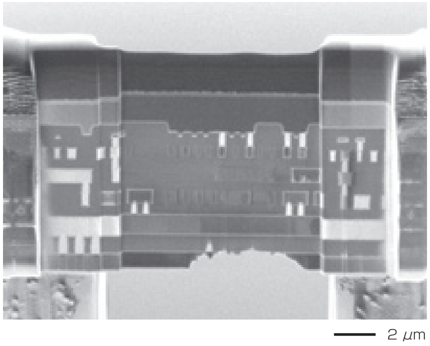
② Replacing a thin film specimen.

● Transmission electron microscope



③ TEM observation

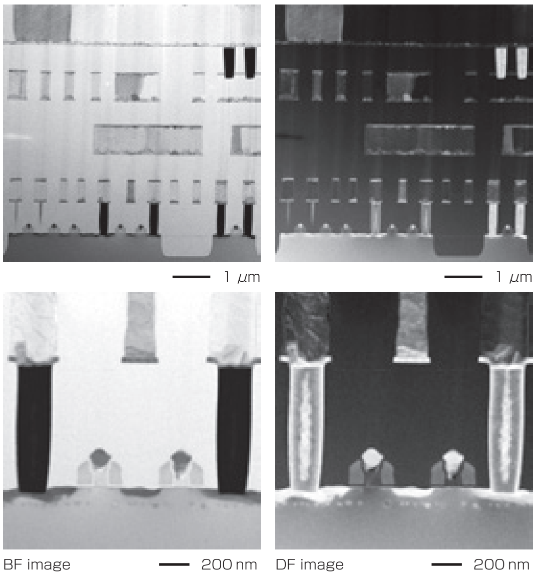
● JIB-4700F



③ Thinning a block specimen.

If you use a shuttle retainer* and a special holder*, smooth replacement of a specimen for a JEOL TEM can be made. (→p17)

● Transmission electron microscope



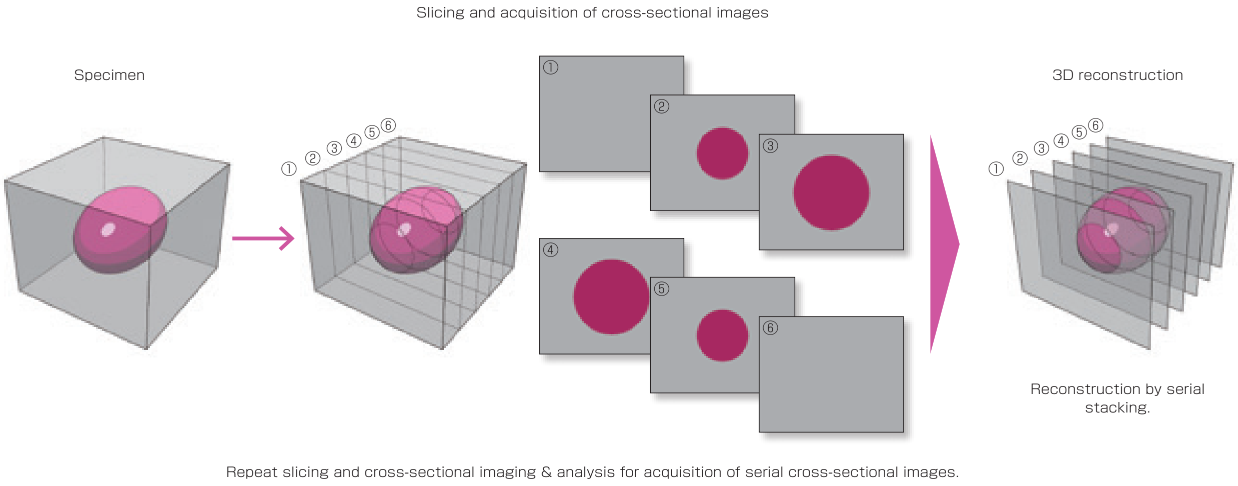
④ TEM observation

* is optional.

3D observation and analysis

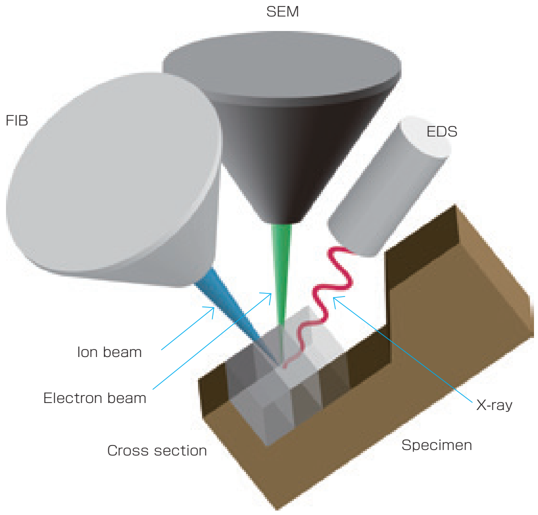
The Slice and View system (standard component of the JIB-4700F) enables automatic repetition of processing, observation and analysis. After the repeated steps, a 3D reconstructed image is acquired by the 3D-reconstruction software (IB-67020STKV)* from the serially-acquired data. In addition to SEM images, 3D reconstruction of elemental distribution and crystal orientation is possible.

Principle of 3D measurement



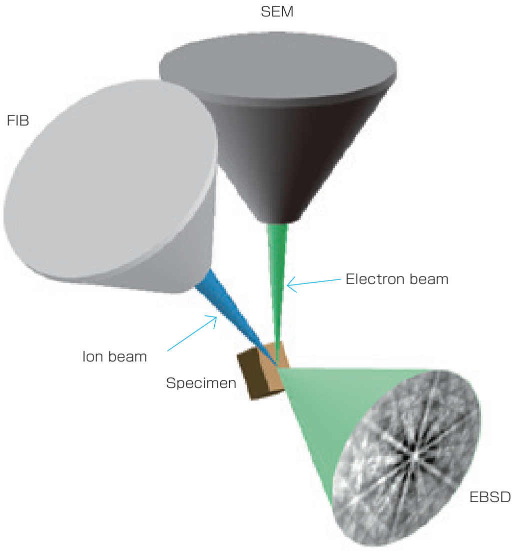
● 3D-EDS*

3D-EDS enables automatic serial steps of both FIB milling with an incident ion beam normal to the specimen surface and EDS analysis using a SEM probe.



● 3D-EBSD*

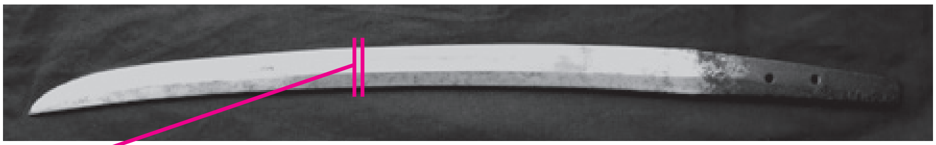
An EBSD detector, which is optimally placed, enables processing and analysis with no stage movement. This feature provides high positional accuracy of data acquisition with a shortened time.



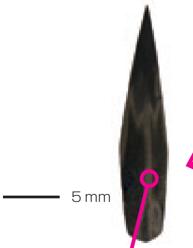
* is optional.

Application examples of 3D imaging and elemental analysis (3D-EDS)

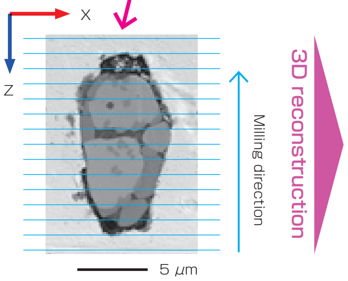
3D measurement (imaging and analysis) of non-metallic inclusions in a Japanese sword (made in 16th century)



Specimen courtesy: Masahiro Kitada, Professor Emeritus, Tokyo University of the Arts

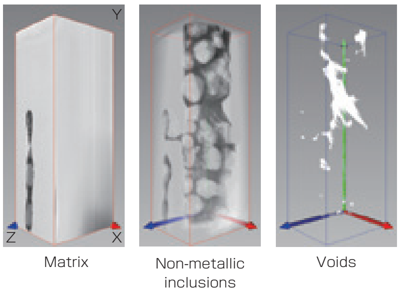


Whole image of a cross section of Japanese sword

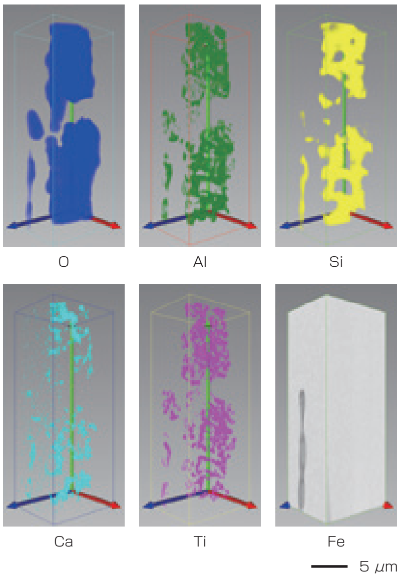


Backscattered electron image of non-metallic inclusions

3D-reconstructed image (backscattered electron image)



3D-reconstructed EDS map (phase map)

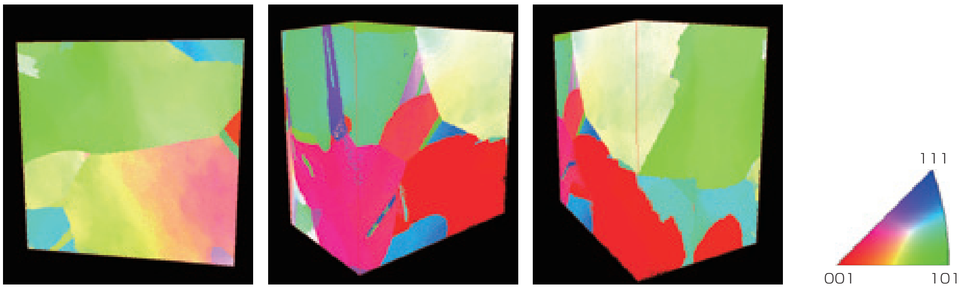


3D-reconstructed backscattered electron images reveal that voids exist at the non-metallic inclusions.
3D elemental mapping shows that the inclusions are vitreous and consist of various elements.

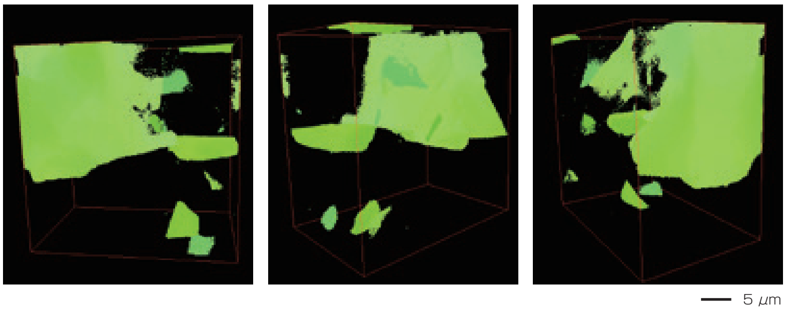
Application examples of 3D crystal-orientation analysis (3D-EBSD)

Crystal-orientation analysis of copper

3D-reconstructed EBSD map of inverse pole images



3D-reconstructed EBSD map of inverse pole images in which extraction is made near [101]



Basic performance supporting high throughput

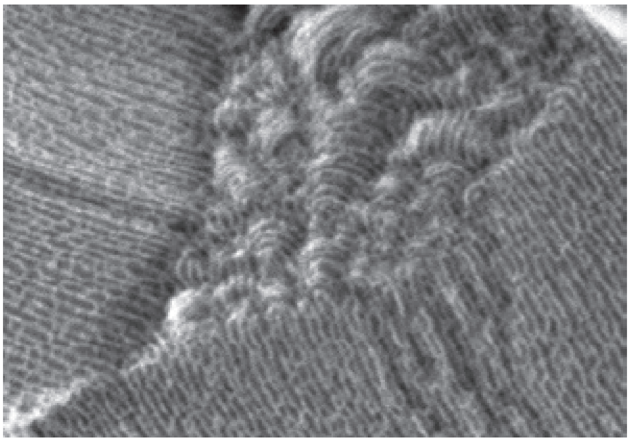
SEM

High power optics

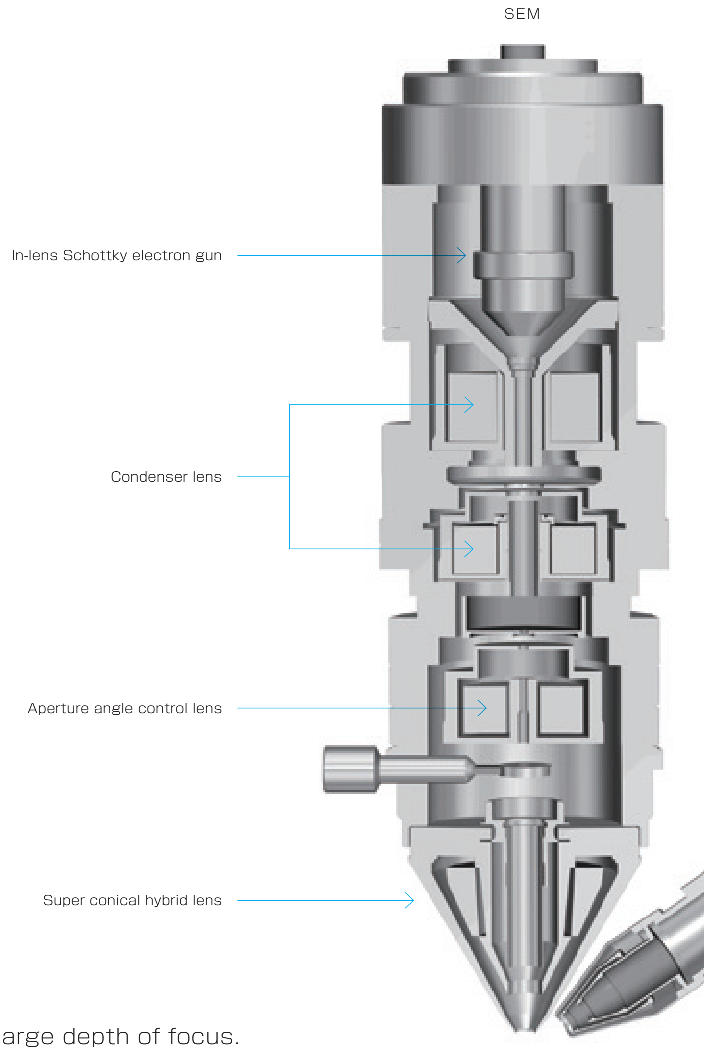
The combination of an in-lens Schottky electron gun and an optimally controlled new condenser lens produces a large probe current up to 300 nA at 30 kV accelerating voltage. Furthermore, at a very low accelerating voltage of 5 kV, a superbly large probe current of 20 nA or more, is achieved.

Super conical hybrid lens

In addition to a hybrid lens that combines the static-magnetic and static-electric fields, a newly-developed compact lens is incorporated to achieve FIB processing at a shorter working distance. A superbly high resolution of 1.6 nm (at 1 kV) is achieved, thus offering sufficiently high performance as a high resolution SEM.

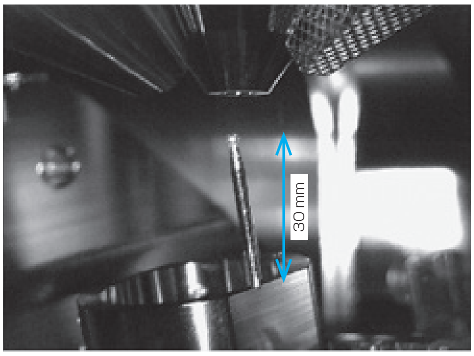


Specimen : Mesoporous silica
Accelerating voltage : 0.5 kV
Detector : UED
Specimen courtesy : Professor Shunai Che, Shanghai Jiao Tong University, China

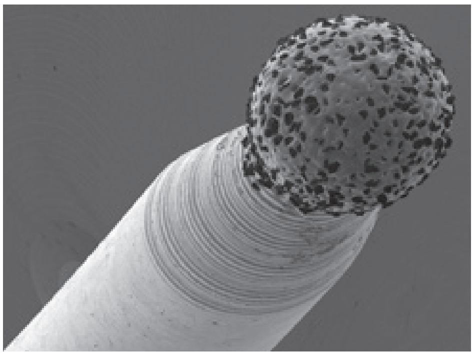


LDF (large depth of focus) mode

LDF mode for low magnification enables SEM observation at a large depth of focus.



CCD image in specimen chamber



Secondary electron image

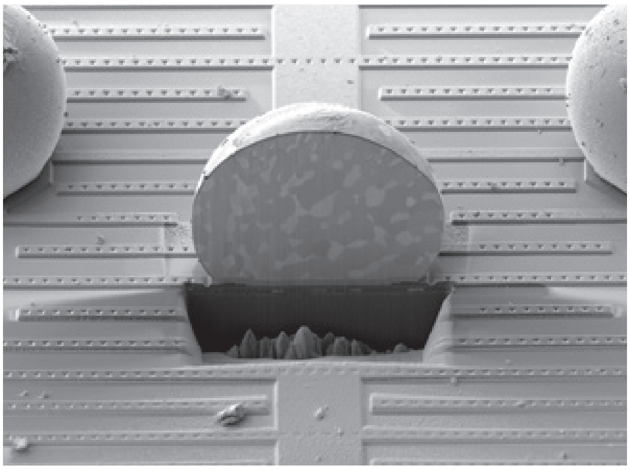
Specimen : Grinding bit
Accelerating voltage : 1 kV
Detector : LED

FIB

Large current FIB column

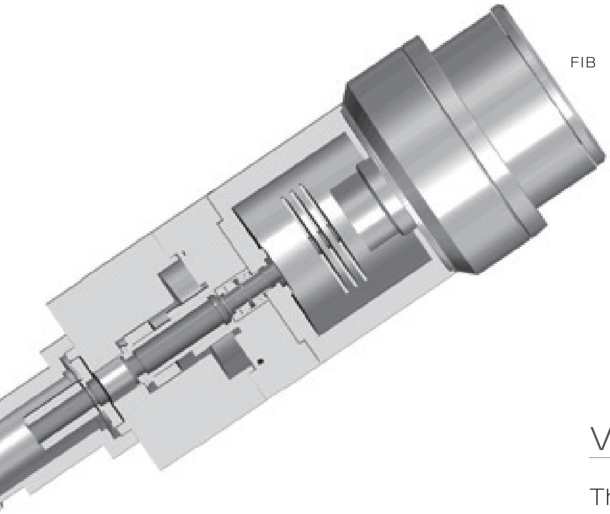
The FIB column enables processing with a large-current Ga ion beam (up to 90 nA). This large-current processing is particularly effective for a large-area observation and analysis.

Cross-sectional SEM images of a large-area solder bump



Secondary electron image
Accelerating voltage : 5.0 kV, Detector : LED

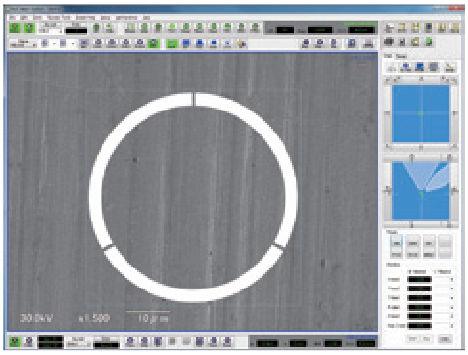
Backscattered electron image
Accelerating voltage : 5.0 kV, Detector : UED



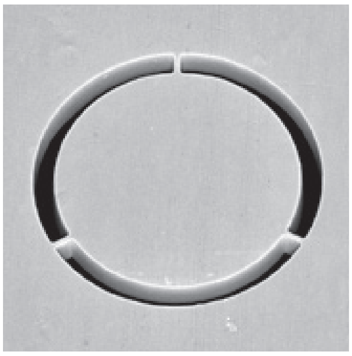
Vector scan system

The vector scan system allows for smooth, efficient processing of an arbitrary shape. The system can load a bitmap image for FIB processing.

Preparation and observation of an annular through-hole made for metal foil



Setting of bitmap processing



Accelerating voltage : 5.0 kV
Detector : UED

Signal detection system to acquire a wide range

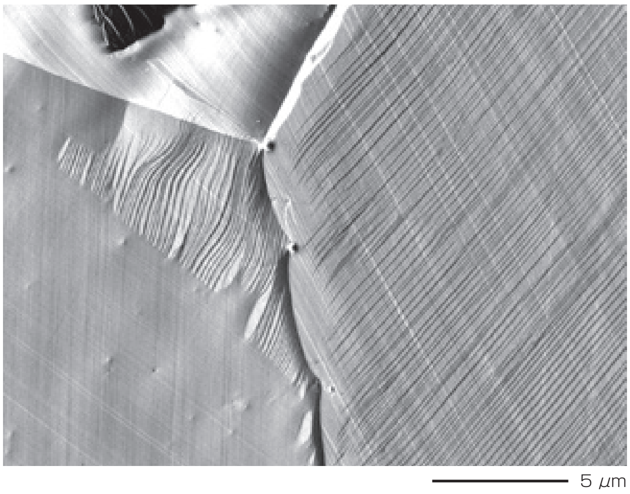
The JIB-4700F accommodates multiple detectors including a new in-lens detector, thus allowing for efficient acquisition of various signals generated from a specimen. Selecting an optimum detector depending on your requirements makes it possible to observe sharp images of various specimens.

Application examples of LED/USD/UED

Figures show three SEM images of a monolayer graphene grown on Ni, acquired simultaneously with three detectors. The USD (upper secondary electron detector) clearly reveals the existence of the monolayer graphene.

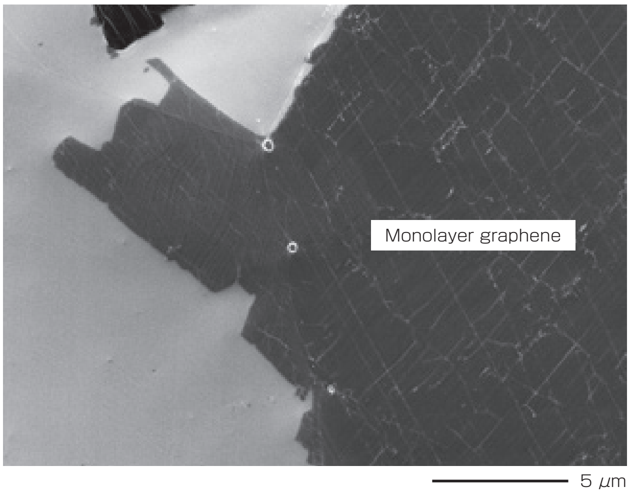
Accelerating voltage : 1.5 kV
WD : 3 mm
Specimen courtesy : Professor Yoshikazu Homma,
Tokyo University of Science

LED



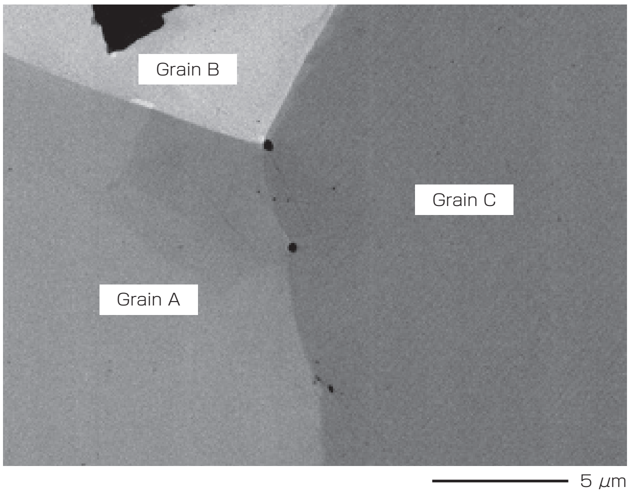
Topographical information on the specimen is captured at a short WD (working distance). The coincident WD is suitable for secondary electron imaging of an FIB-prepared cross section.

USD*



Low-energy secondary electrons can mainly be detected. These electrons are very sensitive to the surface state. USD enables observation of the difference of the top-surface state.

UED

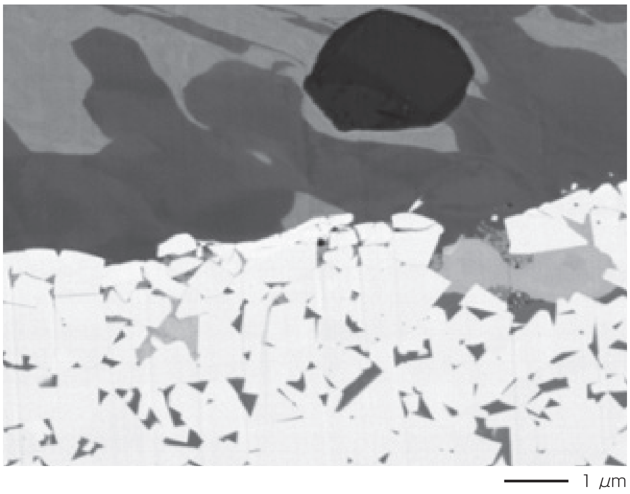


An energy filter is placed at the front of the detector, so as to preferentially acquire a variety of information. You can observe a backscattered electron compositional image at low accelerating voltages.

* is optional.

# of information

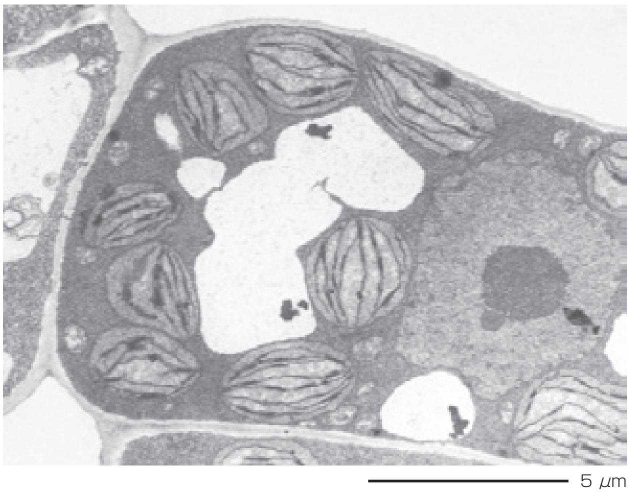
BED*



The detector is placed just above the specimen for detecting backscattered electrons with high efficiency. This detector is suitable for compositional observation of an FIB-milled face.

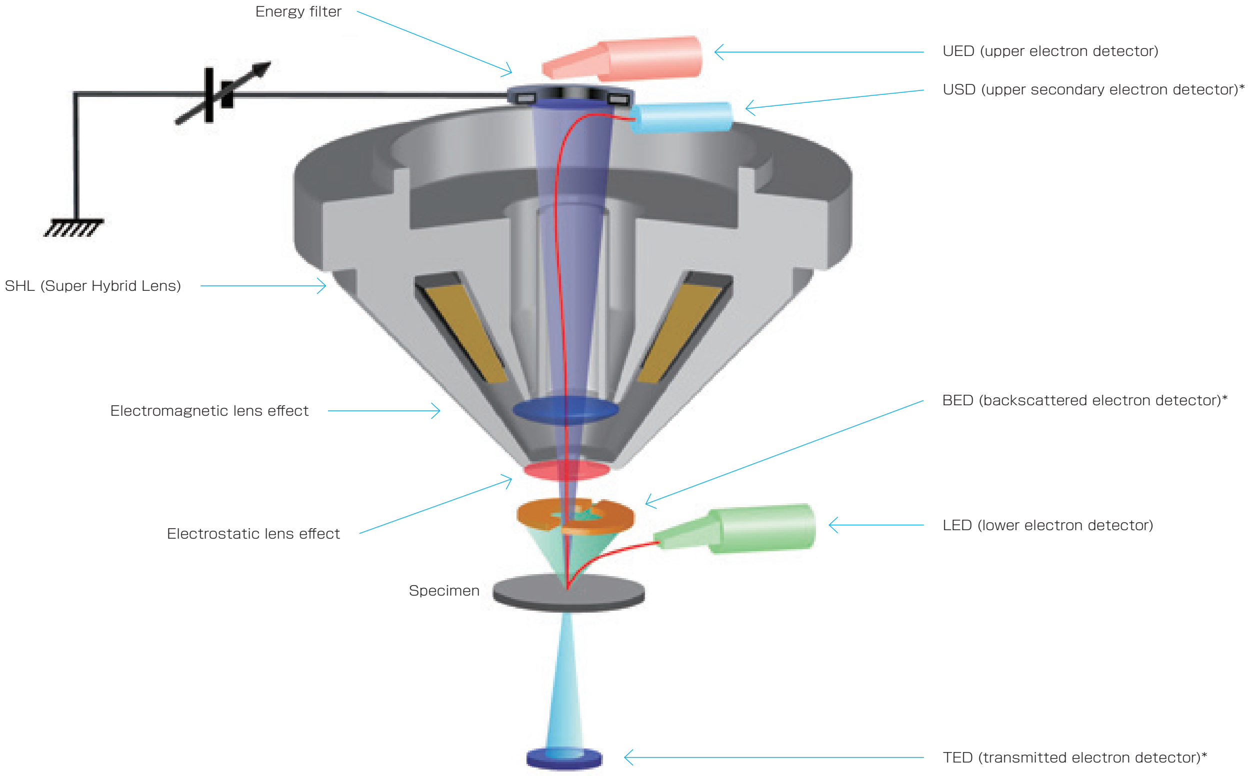
Specimen : Cross section of carbide drill
Accelerating voltage : 5 kV
WD : 8.5 mm

TED*



Preparing a thin film specimen enables observation of a transmission electron image. The use of an STEM holder allows for repetition of additional processing and cross-sectional observation, thus enabling a high-quality thin film to be obtained.

Specimen : Spinach leaf
Accelerating voltage : 30 kV
WD : 3.0 mm

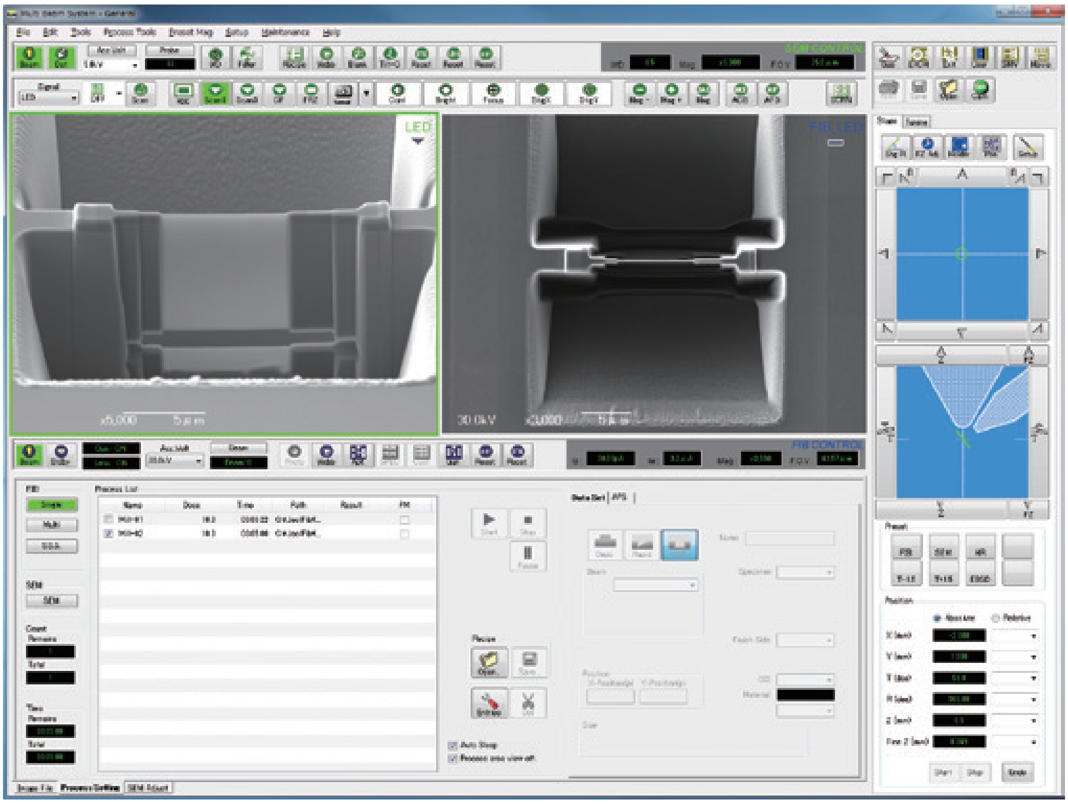


* is optional.

Experimental results smoothly obtained

GUI for intuitive operations

A graphical user interface (GUI), designed with a concept on simultaneous smooth operations for both SEM and FIB, can maximally exploit the performance of the both functions. Different colors are used for the function buttons of SEM and FIB, allowing for the operator to easily find what operations to perform.
The display mode can be switched as required: Quad display, Dual display and Single display.

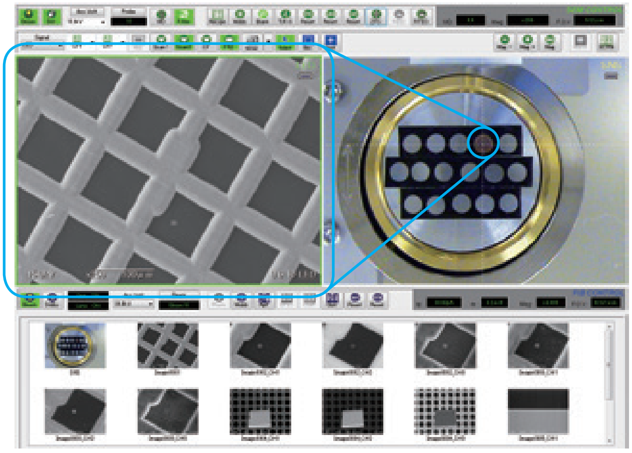


Operation panel

The operation panel is linked with GUI so that axis alignment and focus adjustment are available for both SEM and FIB.

Stage navigation system *

The operator can search the observation area by taking the color photo of the whole specimen holder. When you double-click on the target area on the photo, the stage moves to this target position.

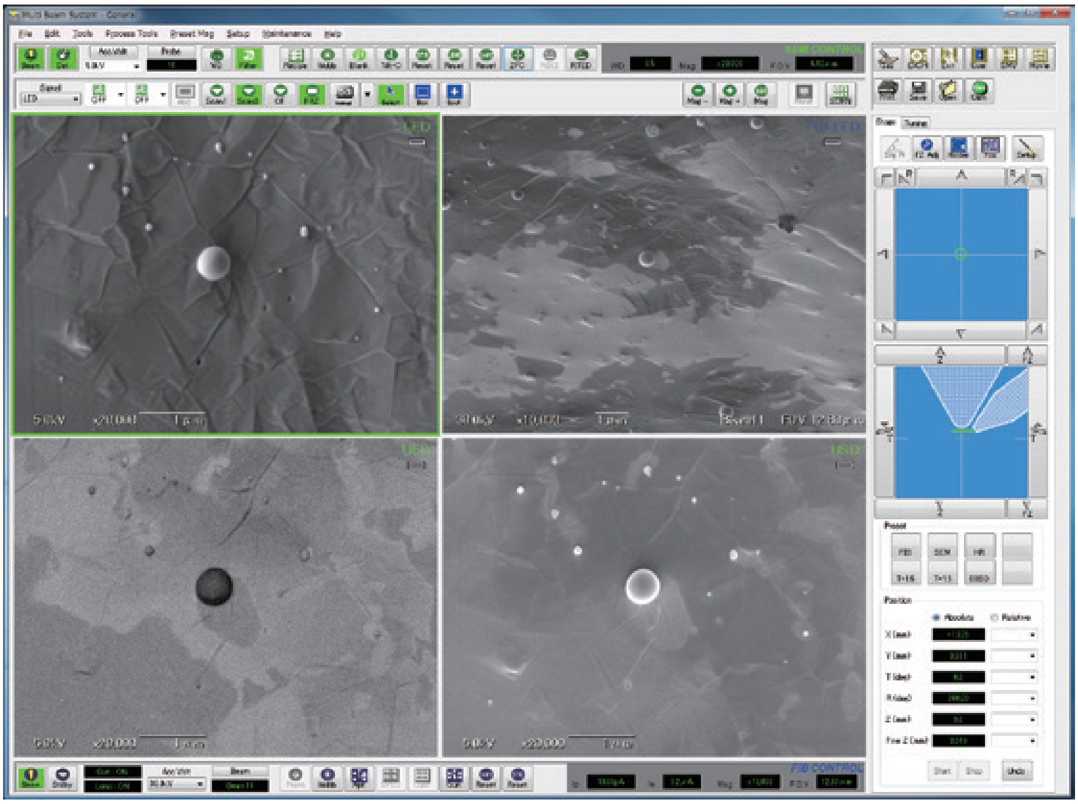


* is optional.

Applicable to various types of specimens

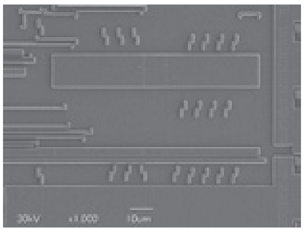
Simultaneous Quad display

Images acquired with multiple detectors can be displayed at the same time. Single scan enables simultaneous acquisition of images by different detectors, thus features of the specimen are surely captured.

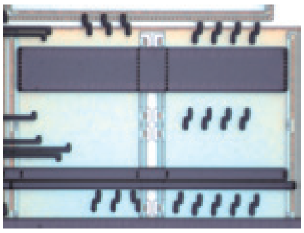


Picture overlay software

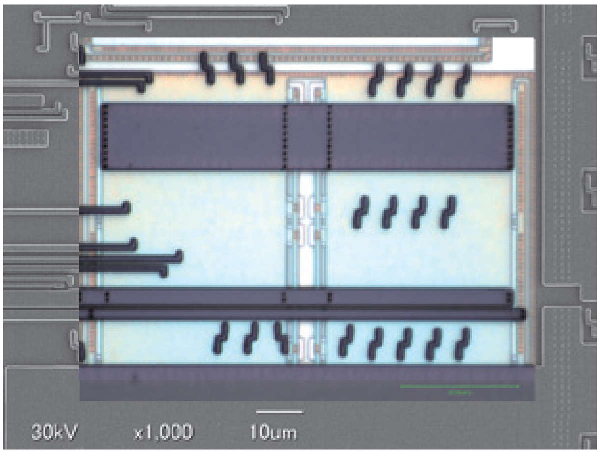
This software enables an image acquired with the other observation instrument (optical microscope, etc.) to be overlaid on an SEM or FIB image. This feature is suitable for determining a processing position on a specimen which is difficult to view by SEM or FIB.



FIB image



Optical microscope image



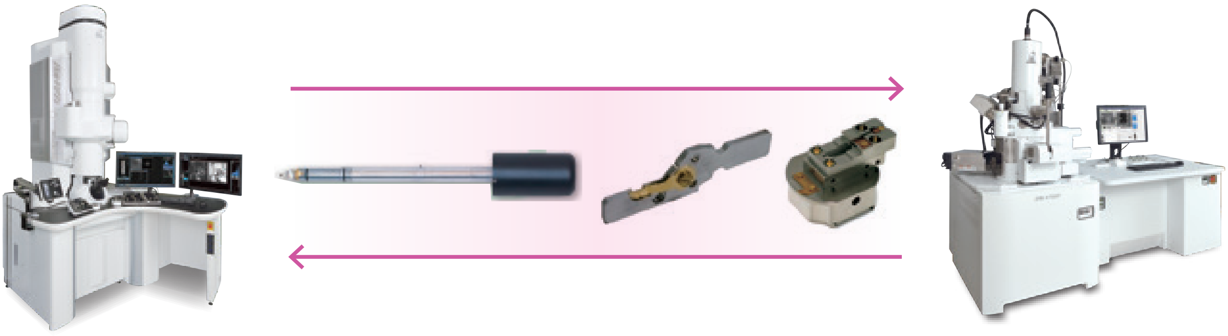
Experimental results smoothly obtained

Atmosphere pick-up system : IB-62020AXPE *

The system is used to pick up a TEM thin film specimen prepared by FIB and to transfer the specimen to a grid mesh for TEM observation.
A high-operability, Micro Support's AxisProFC is optimized for an FIB-milled specimen and also, simple and fast mounting of the FIB-milled specimen is enabled.

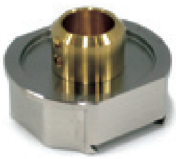
Shuttle retainer & Shuttle retainer holder *

By the use of the Shuttle Retainer, specimen transfer from a JIB-4700F holder to a TEM holder can be made easily. By directly mounting the specimen on the Shuttle Retainer Holder, it is possible to perform observation and processing with the JIB-4700F. In addition, mounting the specimen on a TEM holder allows for TEM observation.

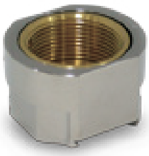


Specimen holders

Extensive holders are available, which are applicable to different types of specimens and various measurements.



12.5 mm standard holder



32 mm standard holder

STEM holder *

Shuttle retainer holder *

One touch holder *

Grid holder *

3D-EBSD holder *

2-inch bulk holder *

* is optional.

Specifications

SEM	
Accelerating voltage	0.1 to 30.0 kV
Image resolution	Optimum WD (working distance) : 1.2 nm (15 kV with GB mode) : 1.6 nm (1 kV with GB mode) FIB coincident WD : 3.0 nm (2 kV)
Magnification	×20 to 1,000,000
Probe current	1 pA to 300 nA
Detector	Lower Electron Detector (LED), Upper Electron Detector (UED)

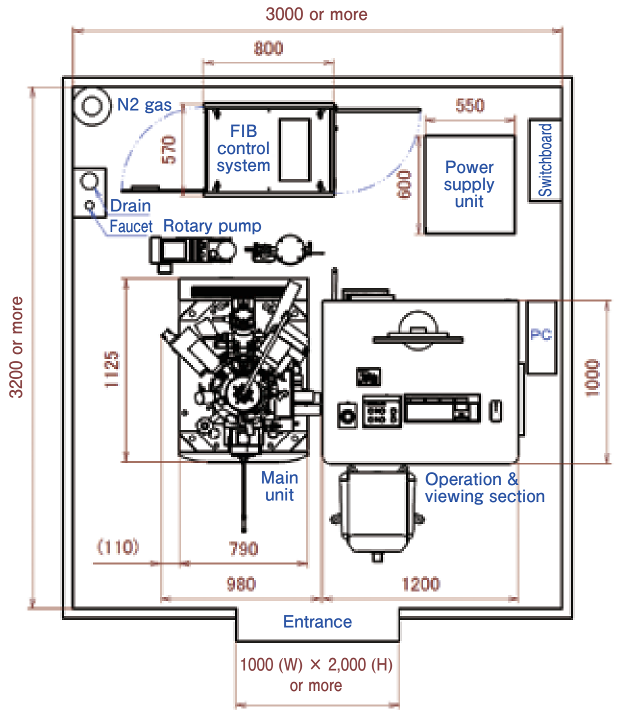
FIB	
Accelerating voltage	1.0 to 30.0 kV
Image resolution	FIB coincident WD : 4.0 nm (30 kV)
Magnification	×100 (×50) to 300,000 Note: Magnification indicated in parenthesis is obtained at 15 kV.
Probe current	1 pA to 90 nA (13 steps)
Processing shapes by milling	Rectangle, Line, Spot, Circle, BMP

Main Optional Accessories		
Detector	Transmitted Electron Detector (TED)	Gas Injection System 2 (GIS2) *The first one is a standard, and the second one and later are optional. *To use the system, the Gas Cartridge is required.
	Backscattered Electron Detector (BED)	Gas Material Cartridge (C, Pt, W)
	Upper Secondary Electron Detector (UED)	Atmosphere Pick-Up System
Energy Dispersive X-ray Spectrometer (EDS)		3D-Reconstruction Software
Electron Backscatter Diffraction System (EBSD)		Transfer Vessel
Stage Navigation System (SNS)		Cooling Stage (Liquid nitrogen type or Peltier type)
IR Chamber Camera		Cryo-system

Installation Requirements	
Power supply	Single phase 200 V ±10% 50/60 Hz 6 kVA
Grounding terminal	100 Ω or less ×1
Dry nitrogen gas	0.45 to 0.55 MPa
Cooling water	Flow rate : 0.5 L/min, Pressure : 0.1 to 0.25 MPa, Temperature : 20℃ ± 5℃
Footprint	3,000 mm (W) × 3,200 mm (D) or more
Ceiling height	2,700 mm or more
Entrance	1,000 mm (W) × 2,000 mm (H) or more

* Specifications subject to change without notice.

Installation room example



Room dimensions : 3,000 mm × 3,200 mm × 2,700 mm or more

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