

Hitachi High-Tech
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Hitachi Ion Milling System

IM4000

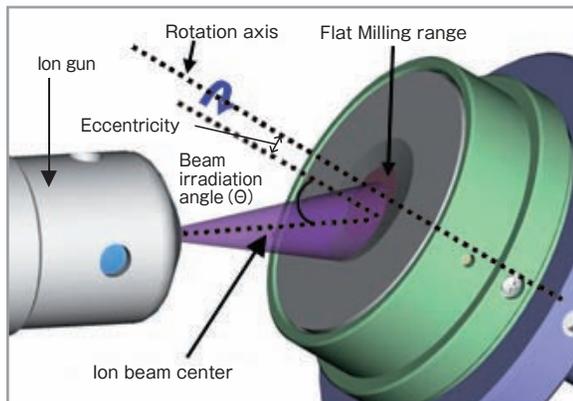
IM4000

Hybrid model : Dual Milling Configuration Available

Flat Milling

Observation via SEM of metallographic microstructures or defects of various materials requires special sample preparation. Traditional mechanical sample preparation via grinding and polishing can result in deformation, flaws, and artifacts that obscure the true structure of the material. Hitachi offers an ion milling system that can eliminate mechanical stress to the sample. The IM4000 can quickly and effectively provide a damage-less flat milling method to enhance mechanically prepared materials.

Processing Principle



Schematic diagram for processing of Flat milling

The ion beam exhibits a Gaussian shaped current density profile. When the ion beam center coincides with the sample rotation center, the center of the sample material is removed at a higher rate than the surrounding area. As the sample rotation and swing center are varied with respect to the ion beam center, a wide-area can be sputtered with increased uniformity.

Major Features and Applications

- Approximately 5 mm in diameter can be ion-milled uniformly
- Eliminate flaws and artifacts from traditional mechanical grinding and polishing techniques
- Diverse range of materials applicable to flat ion milling

Observation of crystal grain boundaries and multi-layer films

Relief ion milling by sputtering perpendicular to the sample surface can enhance topography of composite based materials or crystal orientation for observation.

Interface observation, X-ray analysis, and EBSP* analysis

Flat ion milling at an oblique angle minimizes the dependence between sputtering rate and crystal orientation, yielding reduced surface topography and a flatter sample surface.

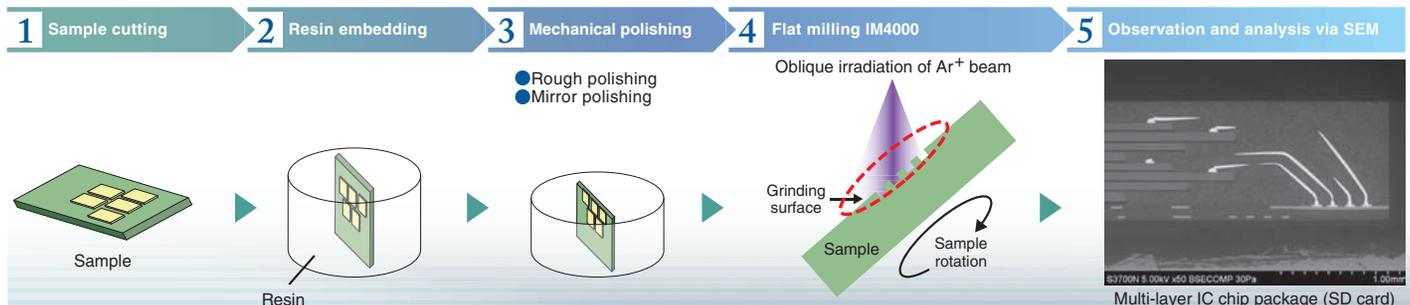
- Allowable sample size up to 50mm in diameter x 25mm height
- Multi-function stage

Multiple rotation speeds and stage oscillation modes provide even greater control to reduce artifacts and sputter flatter surfaces for difficult materials.

*EBSP: Electron Back Scattering Pattern

Sample Preparation Flow: Pre-processing procedure of a typical sample

Flat milling

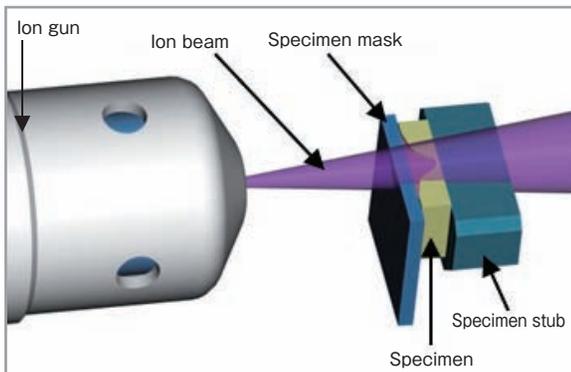




Cross-section Milling

High quality preparation of structures below the sample surface for SEM observation is common method often reserved for focused ion beam systems. Other alternatives for preparing cross-sections rely on mechanical or cleaving methods which often distort or induce damage. The Hitachi IM4000 Ion Milling System utilizes a broad, low-energy Ar⁺ ion beam milling method to produce wider undistorted cross-sections without applying mechanical stress to the sample.

Processing Principle



Schematic diagram for processing of Cross-section milling

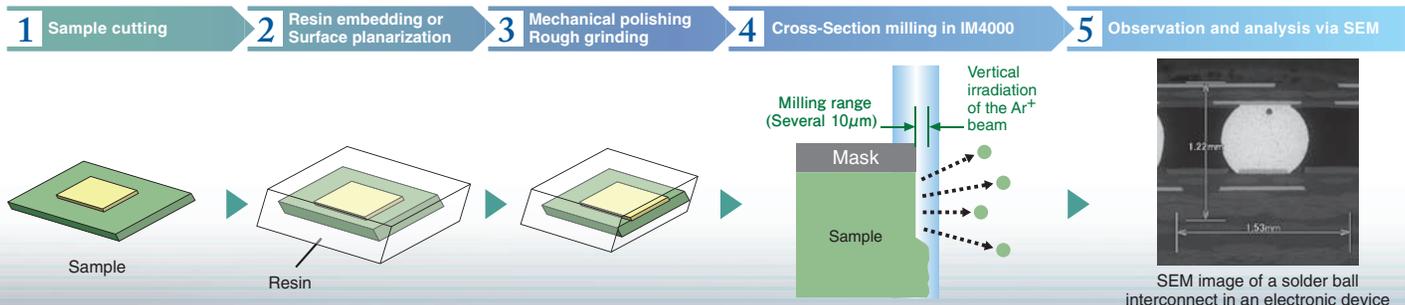
A mask is placed directly on top of the sample, which is not only used for protecting the top surface but also provides a sharp edge to create a damage-less flat cross-section face by sputtering away material that is exposed beyond the masked edge.

Major Features and Applications

- High quality damage-less cross-section for the analysis of structures below the surface
- Sample examples: Electronic components such as IC chips, PCB, IC cards, LED (analysis of layers, interconnects, cracks, voids), metals (EBSD grain structure, EDS elemental analysis, coatings), polymers, papers, ceramics and glasses, pharmaceutical drugs, powders etc.
- Removable sample stage unit for bench top optical alignment of sample and for site specific ion milling (see explanation below)
- Samples with maximum dimensions of 20mm wide x 12mm square x 7mm thick can be milled.
- Sample stub compatibility eliminates the need to change mounts between mechanical polishing,* ion milling, and SEM observation (Hitachi models)

*Maruto polisher (option)

Cross-section milling

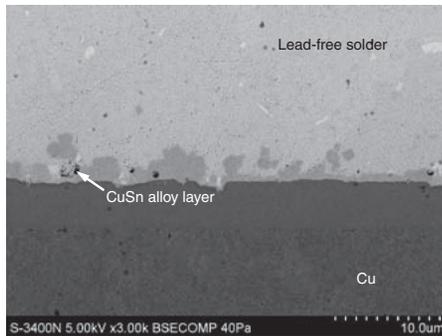


IM4000

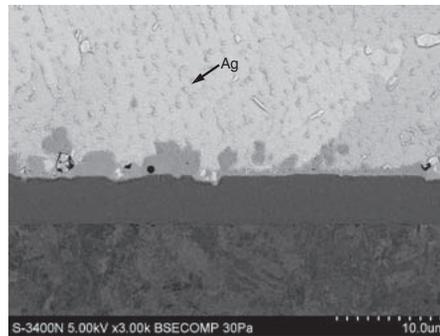
Example Application Data (Flat Milling)

Grinding flaws and smearing from mechanical polishing can easily be removed by the IM4000. The metal and alloy interfaces are now clearly visible, including enhanced contrast via ion milling after only five minutes.

Sample : Lead-free Solder



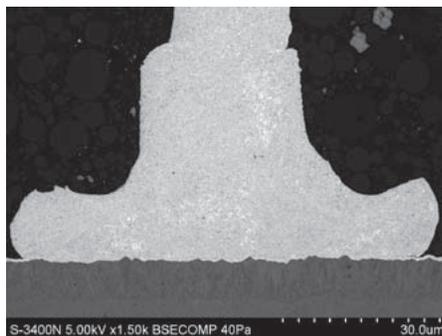
After Mechanical Polishing



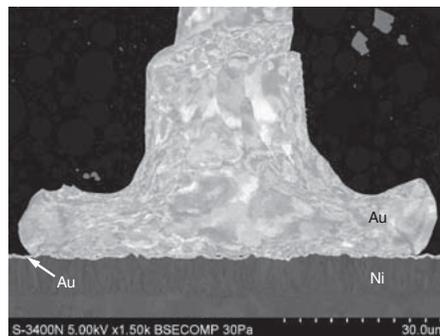
After Ion Milling

The IM4000 in conjunction with sample preparation allows for higher quality results. Channeling contrast, not normally evident after mechanical grinding, is easily observed after ion-milling.

Sample : Au Bonding Part



After Mechanical Grinding

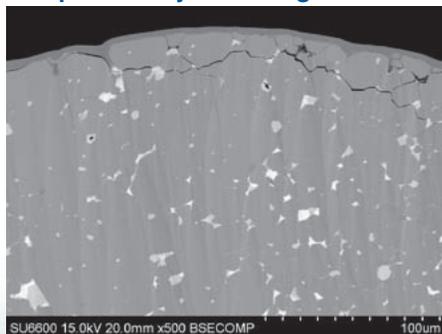


After Ion Milling

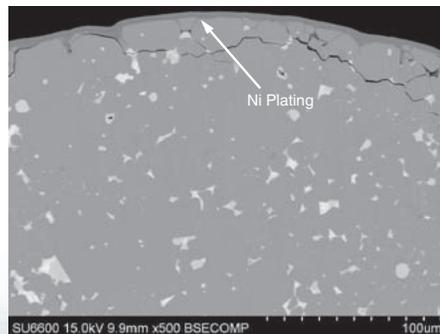
Example Application data (Cross-section milling & Flat milling)

Mechanical polishing induces oxidation and cracking along grain boundaries in Neodymium magnets, making it unsuitable as a final step in cross section sample preparation. Cross section ion milling can polish large areas without inducing mechanical damage, but material differences may cause "curtaining" on the polished surface. A final Flat ion mill step removes the curtaining artifacts, providing a smooth surface.

Sample : Neodymium magnet



Cross-section Milling only

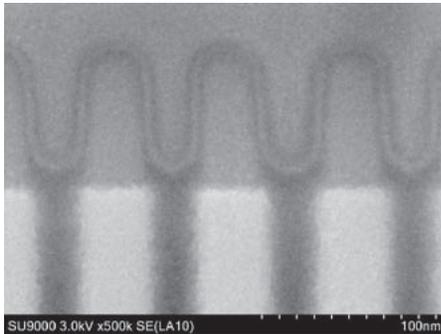


Additional Flat Milling after Cross-section Milling

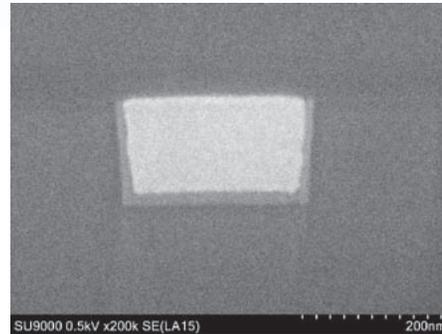
Example Application Data (Cross-section Milling)

Composite based materials in electronic components are susceptible to physical stress induced by traditional cross-section techniques. Ion milling with the IM4000 yields a touch less, more precise cross-section solution.

Sample : NAND Flash Memory

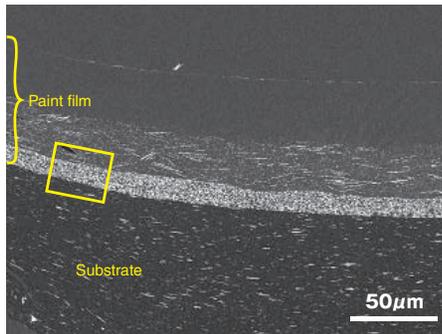


Sample : Copper Interconnect

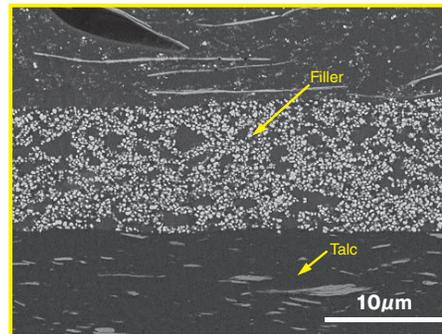


Even heat sensitive specimens such as easy to change or shrink shapes are possible to be cross sectioned by using low accelerating voltage. This makes it easier to be treated even for both fillers or talcs having deformation hardness and the structure or orientation of fillers can be clearly observed.

Sample : Bumper Paint Film



Entire image

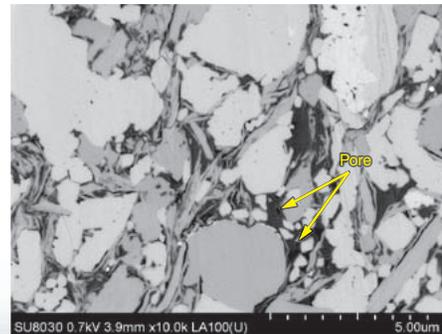
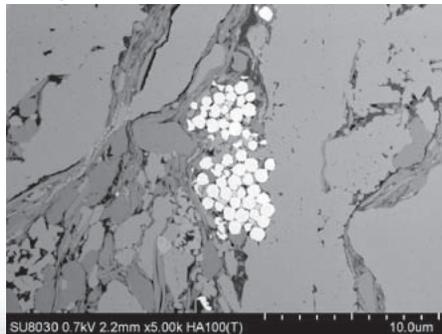


Backscattered electron image
SEM: S-3400N

Expanded image

Micro porosity and compositional differences are key indicators for successful characterization of shale oil and gas reservoirs. Broad ion cross section milling produces smooth and clean surfaces for accurate morphological information and chemical composition.

Sample : Shale



Specimen courtesy of Energy & Geoscience Institute, USA

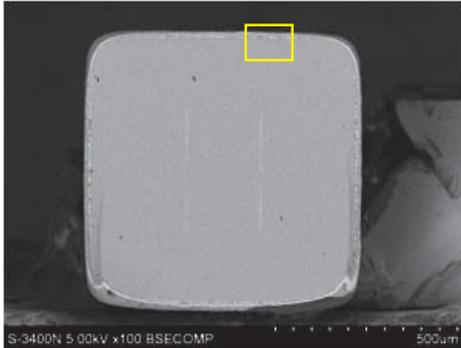
IM4000

Higher Throughput : Improved milling efficiency

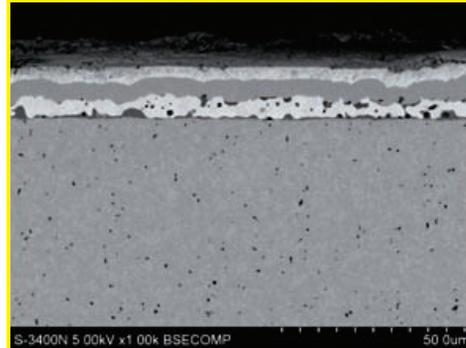
The all new ion gun reduces mill times and maximizes throughput compared to previous models (Max. milling rate : 300µm/h for Si – 66% reduction in processing time)

Revolutionary Hitachi ion technology incorporated into the IM4000 can now process a ceramic capacitor in only 3 hours.

Sample : Ceramic capacitor Processing time : 3hours



Entire image



Expanded image

Removable Sample Stage Unit

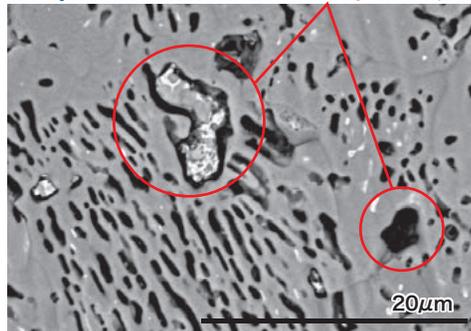
- Easy bench top design for positioning of the sample and mask adjustment
- Repeat milling can be performed without stage re-alignment
- Dedicated optical scope included allows for precise site specific cross-section milling



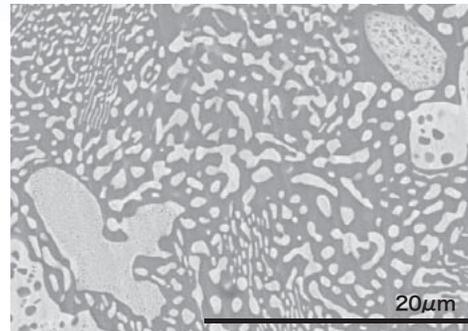
Cooling Unit

Thermal deformation for temperature sensitive materials can occur by heat generated from the ion beam irradiation during ion milling. To reduce and dissipate heat during ion milling, a cooling unit is available for the IM4000.

Sample: Lead Solder



Ion Milling without Sample Cooling



Backscattered electron image
SEM: TM3000

Milling with Sample Cooling

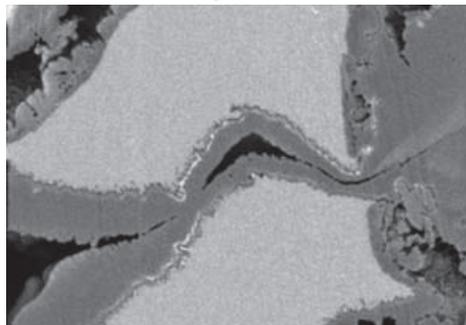
Options

Air Protection Holder Unit

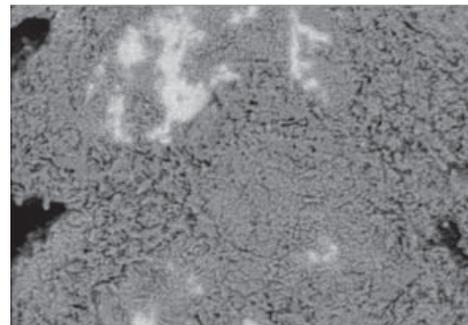
Some reactive materials exhibit drastic changes in chemical and/or physical state when exposed to ambient conditions. The Hitachi IM4000 with the optional Air Protection Holder allows ion milling without any exposure to the atmosphere. The air protection system incorporates a vacuum enclosure that is sealed in situ, allowing safe and easy specimen transfer to the SEM* within an inert or vacuum environment.

*Compatible with Hitachi FE-SEM with Air Protection Specimen Exchange Chamber.

Sample: Li Ion Negative Electrode



(a) Milling with Air Protection Holder



(b) Milled sample exposed to air for 10 min.

Backscattered electron image
SEM: SU-70

(a) The negative electrode structure shown is well preserved.

(b) The sample is deformed by air exposure (deformed by reaction with water moisture).

Sample Observation during Ion Milling

The IM4000 has an observation port, for in-situ specimen observation. In addition, when using the stereoscopic microscope (option: Binocular type or Tri-eye type) for sample observation during ion milling, the processing surface can be observed up to 100 times magnification. Automated observation is also available by CCD camera* (option) mounted on a Tri-eye type optical microscope.

*CCD camera and monitor are provided by customer.

Zoom Stereo Microscope (Tri-eye type)



Major specification

Item	Description	
	Flat Milling	Cross-section Milling
Gas used	Ar (argon) gas	
Accelerating voltage	0 to 6kV	
Maximum milling rate (Material : Si)	Approx. 20 μ m/h*1 (spot) Approx. 2 μ m/h*2 (flat)	Approx. 300 μ m/h*3
Maximum sample size	ϕ 50x25(H)mm	20(W)x12(D)x7(H)mm
Sample moving range	X 0 to +5mm	X \pm 7mm, Y 0 to +3mm
Rotation speed	1r/min, 25r/min	-
Swing angle	\pm 60° \pm 90°	\pm 15° \pm 30° \pm 40°
Tilt	0~90°	-
Gas flow rate control system	Mass flow controller	
Evacuation system	Turbo-molecular pump (33L/s) + Rotary Pump (135L/min at 50Hz, 162L/min at 60Hz)	
Dimension	616(W)x705(D)x312(H)mm	
Weight	Main unit 48kg + Rotary pump 28kg	
Optional Accessories	Optical microscope for viewing the specimen during milling	
IM4000 with cooling unit		
Cooling unit	Mask surface temperature: -30°C*4	
Options		
Zoom stereo microscope unit	Binocular type, Tri-eye type (for CCD)	
Air protection specimen holder	Applicable for the use with S-4800, SU-70, SU6600 and SU8000 series microscopes. Note: SEM requires Air Protection Specimen Exchange Chamber	

*1: Illuminating angle : 0° Eccentric value : 0mm *2: Illuminating angle : 60° Eccentric value : 4mm

*3: Si protrudes 100 μ m from the mask edge. *4: Attainable temperature at the surface of mask within 30 minutes after the cooling starts.

Installation Requirements

Item	Description
Room Temperature	15 to 30°C
Humidity	45 to 85% without moisture condensation
Power supply*5	AC100V (\pm 10%), 50/60Hz, 1.25kVA
Grounding	100 Ω or less

Products prepared by customer

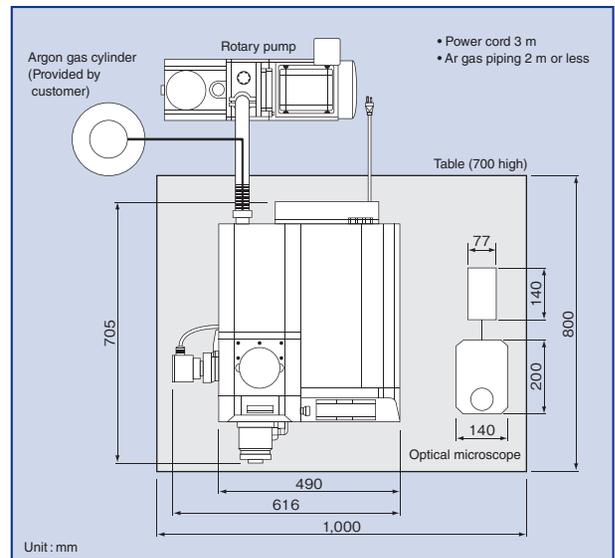
Item	Description
Ar gas	99.99% purity
Ar gas pressure	0.03 to 0.05MPa
Ar gas tubing*6	1/8-inch SUS piping (1/8 Swagelok-compatible), Pressure regulator
Oxygen content meter*7	19% oxygen concentration
Recommended table	1000(W)x800(D)x700(H)mm or more, Min. weight tolerance : 70kg (Minimum strength when installing only IM4000 on the desk)

*5: IM4000 is equipped with a power cord with 3-Pin plug or with M6 crimp contact terminal.

*6: Tubing connects Ar gas supply (Ar gas cylinder) to the equipment. Pressure gauge regulator required.

*7: Adequate ventilation and air quality measurements are required.

System layout



Notice: Follow the instruction manual for proper operation.

Specifications in this catalog are subject to change with or without notice, as Hitachi High-Technologies Corporation continues to develop the latest technologies and products for our customers.

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