Ultra-high Resolution Scanning Electron Microscope

SU8000 Series

SU8040
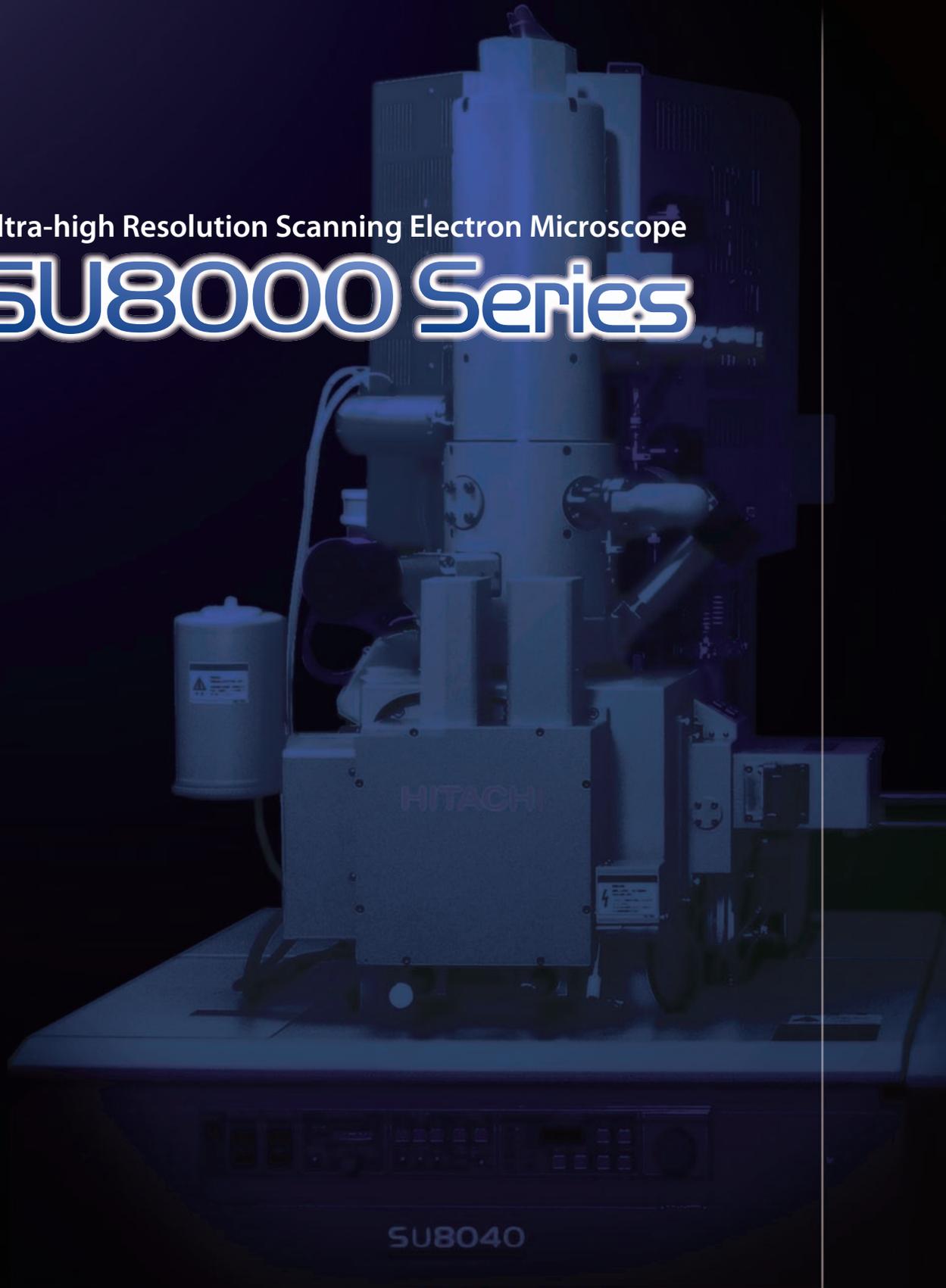
HITACHI

SU8000 Series lineup

Powerful lineup for ultra high resolution microscopy

Nanotechnology fields, such as semiconductors, electronics, catalysis and other functional materials, biotechnology and pharmaceuticals are being researched world-wide as core competencies for next generation cutting-edge technologies. Ultra High Resolution FE-SEM has grown to be an indispensable tool to observe the fine surface structure of materials in a wide range of nanotechnology fields.

Hitachi High-Tech has developed the SU8000 Series to fulfill tomorrow's market needs. The new SU8000 Series has excellent imaging performance throughout the range, and offers a variety of stages, chambers and signal detection systems to meet the wide variety of customer-specific needs for ultra high resolution microscopy.

● SU8020

High performance model with triple detectors

● SU8010

Entry-level model for UHR microscopy with dual detectors

Excellent imaging performance
for a wide range of applications
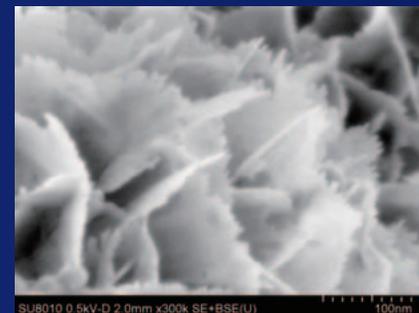
SU8010 0.5kV-D 2.0mm x300k SE+BSE(U)   100nm

Sample : Al electrolytic capacitor
Courtesy of St. Jude Medical, CRMD–U.S.A.

Features of the SU8000 Series

■ Ultra-high resolution imaging, even at ultra low accelerating voltage (SE resolution 1.3 nm at landing voltage 1.0 kV)
■ A wide range of signal detection systems
■ Lineup of four microscopes to meet the wide variety of applications for ultra high resolution microscopy
■ User-friendly GUI, console and wide –format monitor for comfortable operation
■ Wide range of optional accessories to meet customer-specific needs

● SU8040

Top of the SU8000
Series range, with
high performance
Regulus stage [*1]
as standard

● SU8030

Large chamber/
stage model for large,
complex or multi-
samples

※ Image on the FPD(flat panel
display) are simulated.
[*1] Regulus stage : REGULated
Ultra Stable stage
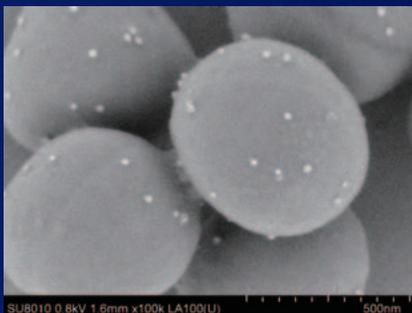
Sample : Staphylococcus aureus (immuno SEM)
Courtesy of Medical Mycology Research Center,
Chiba University   Dr. Masashi Yamaguchi
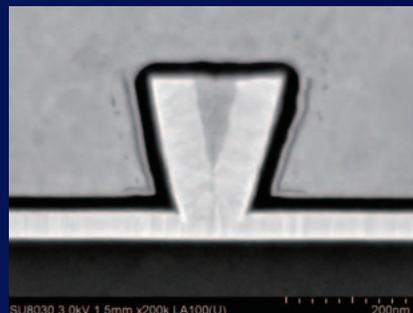
Sample : Hard disc (magnetic head)
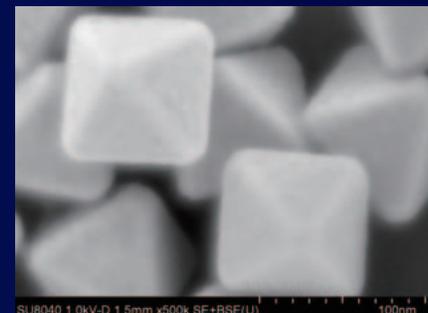
Sample : Single crystal line octahedral gold
nanoparticle Courtesy of Department of Chemistry,
Graduate School of Pure and Applied Sciences,
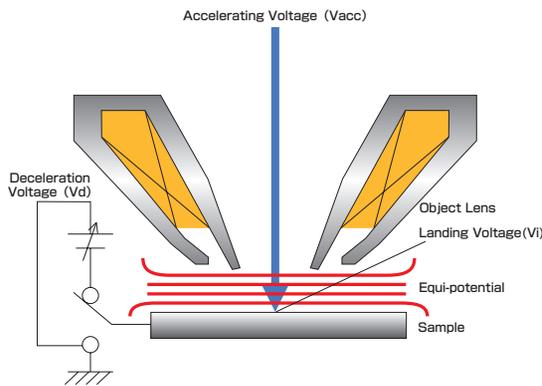University of Tsukuba   Dr. Toshiharu Teranishi

SU8010

SU8010, entry level model for ultra high resolution microscopy

SU8010 has excellent performance as the entry level model in the SU8000 series. The combination of Semi-in-lens type objective lens and cold FE-gun with small energy spread delivers ultra high resolution imaging performance and flexible SE-BSE signal mixing using Hitachi's detector technology for absolute surface information, Z-number contrast and charge suppression.

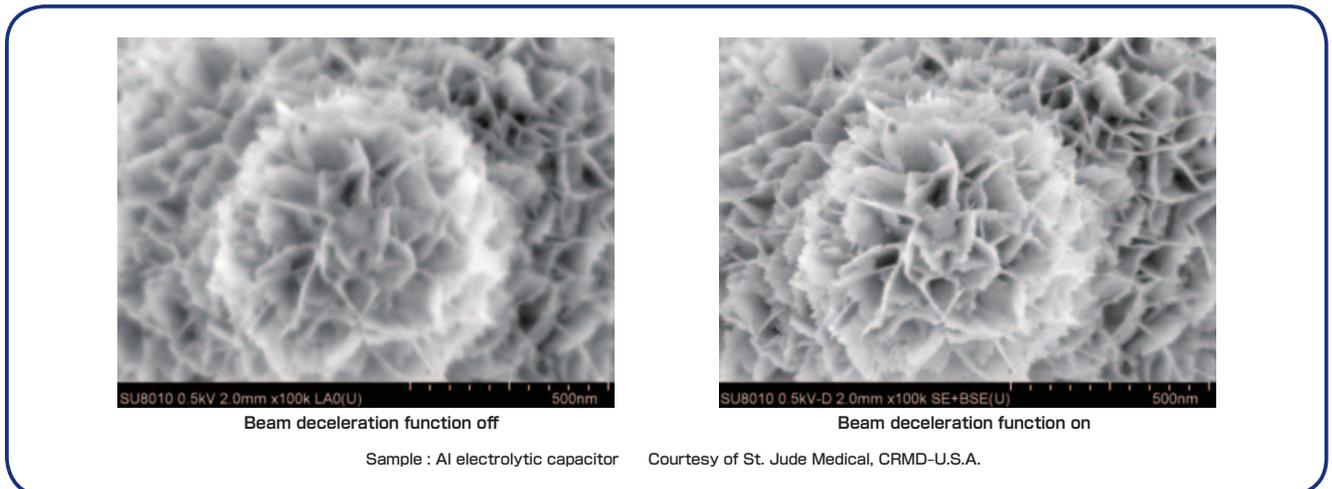### Ultra high resolution imaging (Resolution 1.0nm/15kV)

SU8010 3.0kV 1.5mm x500k SE(U)   100nm

SU8010 15.0kV 3.6mm x800k SE(U)   50.0nm

Sample:Catalyst
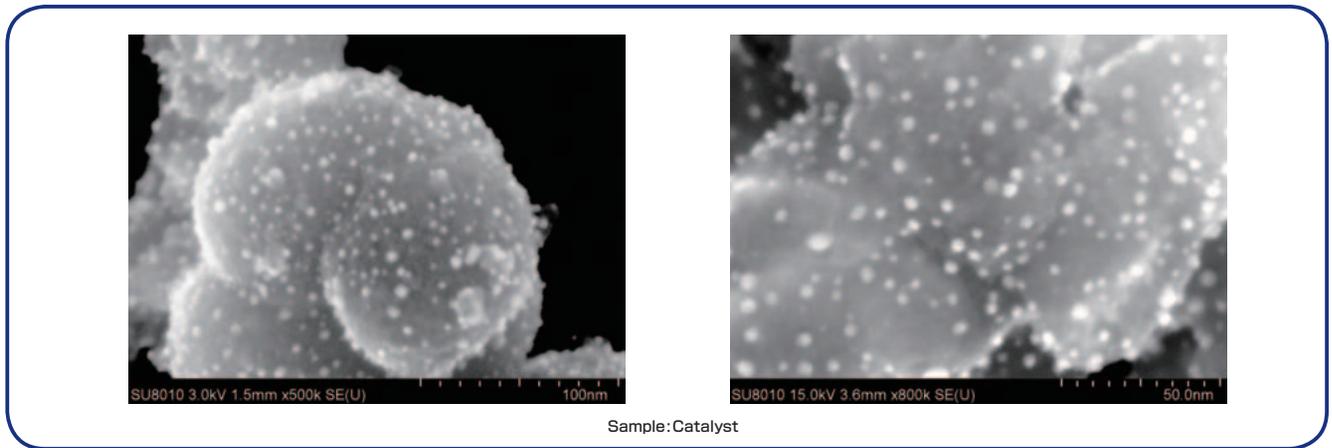
Beam deceleration function as standard (Resolution 1.3nm/1kV)

Accelerating Voltage (Vacc)

Deceleration Voltage (Vd)
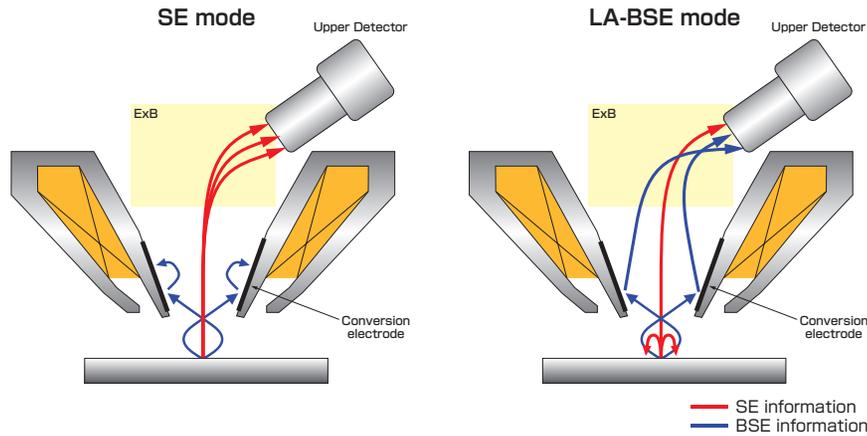
Object Lens

Landing Voltage(Vi)

Equi-potential

Sample

Beam deceleration applies a negative voltage (Beam deceleration voltage : Vd) to the specimen to decelerate the primary electron just before the beam interacts with the specimen. By using beam deceleration, landing voltage can be reduced as low as 100V with low lens aberration. As a result, ultra high resolution imaging of sample surface characteristics can be obtained at ultra low landing voltage.

Effect of beam deceleration
- High resolution imaging at low landing voltages
- Absolute surface information from the sample
- Less sample damage as a result of the low landing voltages available

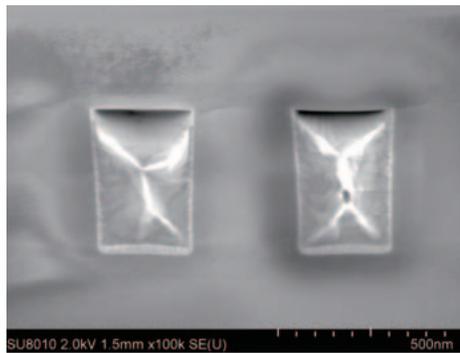SU8010 0.5kV 2.0mm x100k LA0(U)   500nm

Beam deceleration function off

SU8010 0.5kV-D 2.0mm x100k SE+BSE(U)   500nm

Beam deceleration function on

Sample : Al electrolytic capacitor   Courtesy of St. Jude Medical, CRMD–U.S.A.

SE-BSE signal mixing function (Super ExB)

SE mode

Upper Detector

ExB

Conversion electrode

LA-BSE mode

Upper Detector

ExB

Conversion electrode

— SE information
— BSE information

Hitachi High-Tech's unique SE-BSE signal mixing function expands the signal detection capability. By changing the voltage of the signal conversion electrode in the objective lens, the SE-BSE signal ratio can be adjusted to any ratio (100 steps).

In non-conductive samples, low energy secondary electrons commonly show charge up contrast, which does not express, and may hide the correct sample information. By applying the signal mixing function, the secondary electron signal can be selectively or progressively suppressed, to optimize the true image contrast.

SU8010 2.0kV 1.5mm x100k SE(U)　　500nm

SE image (Upper) surface information

SU8010 2.0kV 1.5mm x100k LA25(U)　　500nm
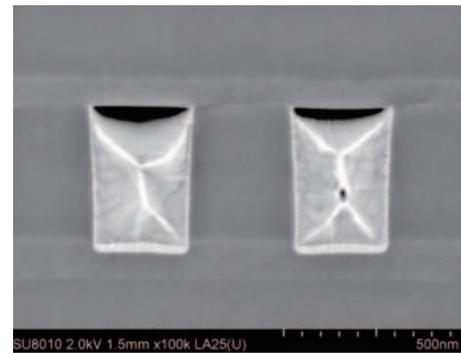
LA-BSE image (Upper) for charge up suppression

Sample : Cu damascene (Cross section)

SU8010

SE Detector		
SE resolution	1.0nm(Vacc 15kV、WD＝4mm) 1.3nm(landing voltage1kV、WD＝1.5mm)
Top detector	—
Upper detector	○
Lower detector	○

Specime Stage			
Stage control		3-axis motor drive stage ＊5-axis motor drive stage(option)
Stage traverse range	X	0～50mm
	Y	0～50mm
	R	360°
	T	-5～70°
	Z	1.5～30mm
Max. sample size		100mm dia. ＊150mm dia.（Option）

SU8020

## SU8020, additional flexibility of signal detection with its stunning triple detector system

With the unique Top detector, additional signal collection is possible. Selective High angle backscattered electrons (HA-BSE) can be detected. The SU8020 offers pure Z-number compositional information using the Top detector, and voltage contrast from the absolute sample surface that has never been possible routinely before. Top, Upper and Lower triple detectors offer optimum signal collection. for many imaging applications.

### Variety of signal detecting system for visualizing absolute surface information
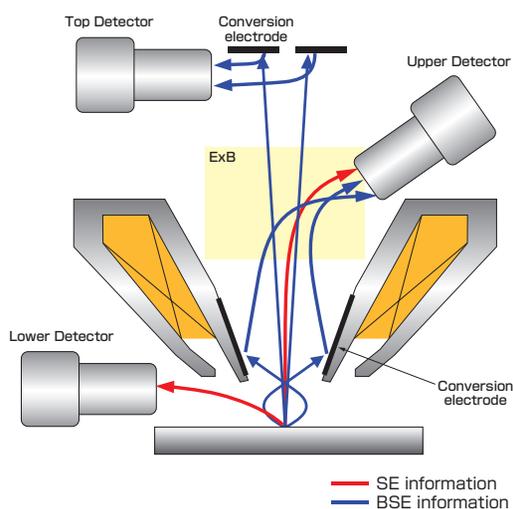
Triple detector system offers a variety of signal collection.
Top detector can detect High angle BSE (HA-BSE), which has pure Z-number contrast with less topographical information. The Upper detector collects either the SE signal for surface topography/voltage contrast, or user-selectable low angle BSE(LA-BSE), for both topographical information and compositional contrast. Both signals can also be mixed. The Lower detector is used for longer working distance SE imaging of surface topography.
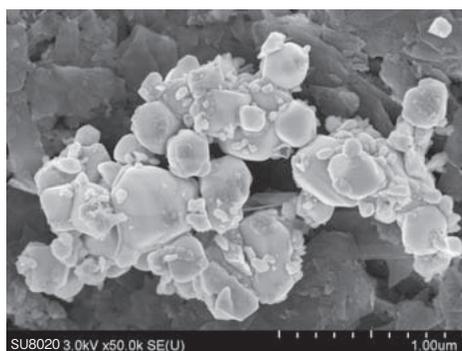
| Signal name	Detector	Signal information
HA-BSE	Top	Compositional/Crystal information
LA-BSE	Upper	Compositional/Topographic information
SE	Upper	Surface information (Including voltage contrast)
Lower	Lower	Topographic contrast
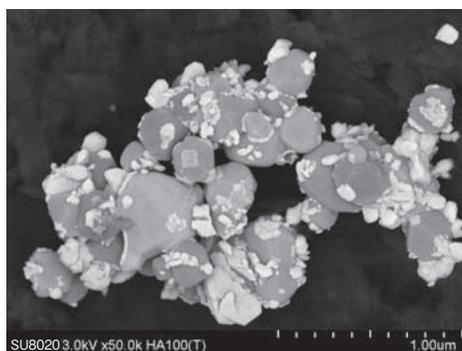
HA-BSE image(Top) : compositional information
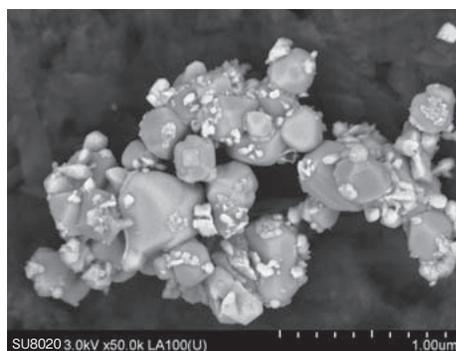
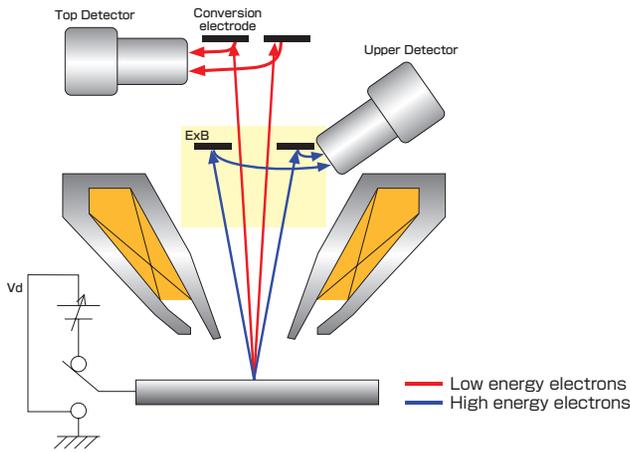LA-BSE image(Upper) : Topographic＋compositional information

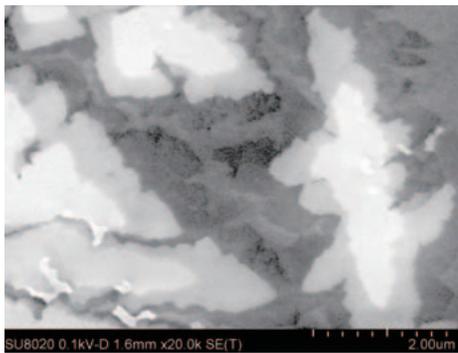SE image (Upper) : surface information
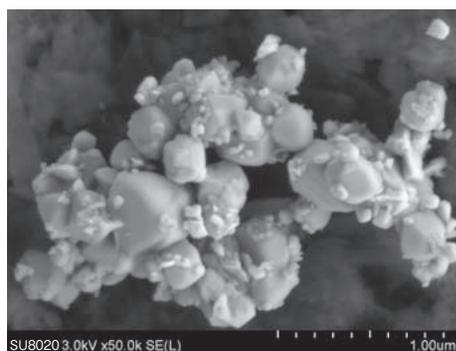
Lower image (Lower) : Topographic information

Sample : Photocatalyst   Courtesy of Nagaoka University of Technology, Faculty of Engineering, Dr. Kazunori Sato

Signal detection with Beam deceleration

Top Detector
Conversion electrode
Upper Detector
ExB
Vd

— Low energy electrons
— High energy electrons

In the beam deceleration mode, it is possible to discriminate between low energy SE's and high energy BSE electrons by selecting either the Top detector or Upper detector in the GUI. Low energy secondary electrons now detected by the Top detector show voltage contrast in deceleration mode. Alternatively, high energy electrons detected by the Upper detector are far less susceptible to charge-up effect. Even if the sample is less conductive, it is possible to observe the sample without charge-up contrast. In addition, fine topographical information can still be obtained as the Upper detector now collects electrons generated at low angle.

SU8020 0.1kV-D 1.6mm x20.0k SE(T)   2.00um

SU8020 0.1kV-D 1.6mm x20.0k SE+BSE(U)   2.00um

SE image(Top) : Surface voltage contrast
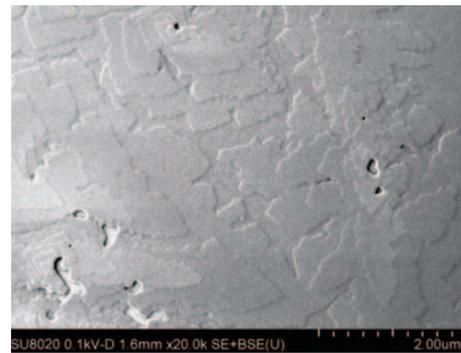
SE + BSE image(Upper) : Topographic information

Sample : Pentacene

SU8020

SE Detector		
SE resolution	1.0nm(Vacc 15kV、WD＝4mm) 1.3nm(landing voltage1kV、WD＝1.5mm)	
Top detector	○	
Upper detector	○	
Lower detector	○	

Specimen Stage		
Stage control		5-axis motor drive stage
Stage traverse range	X	0～50mm
	Y	0～50mm
	R	360°
	T	-5～70°
	Z	1.5～30mm
Max. sample size		100mm dia. ＊150mm dia.（Option）

SU8030

SU8030, with its large chamber & stage for more versatile sample accommodation

SU8030 has a large specimen stage with 110mm traverse range in both of XY direction and a maximum 150mm diameter sample exchange chamber as standard (*200mm diameter option). With the combination of a stunning signal detection system and large chamber/stage, the SU8030 is a highly versatile high resolution instrument.

SU8030, with its large chamber & stage for more versatile sample accommodation.

150mm diameter specimen exchange chamber for large/multi sample observation

SU8030 has a 150mm diameter specimen exchange chamber as standard (200mm option), which is compatible with large/multi sample observation.
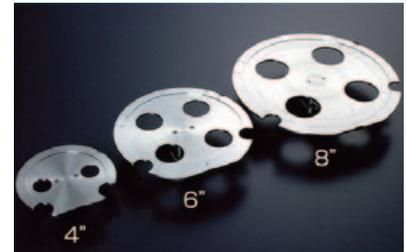
● Stage traverse range 110mm × 110mm
● Whole area observation for 150mm diameter sample
● Maximum 116mm diameter area observation for 200mm diameter sample(*Option)
● Operation assist function for rotation
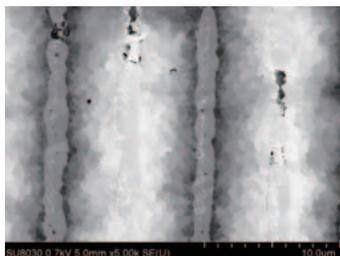● Compatible with variety of large/multi sample holders(*Option)

Standard holder/stub kit
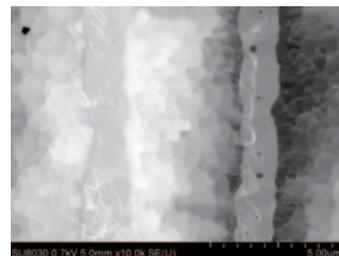(Standard for all SU8000 series)

Cross section holder/stub (*Option)

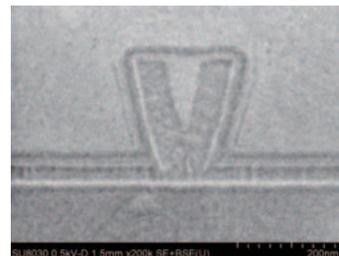
Wafer holder (*Option)

SE image (Upper) ※

SE image (Upper) ※

Sample : Multilayer ceramic condenser

※ Voltage contrast image , with applied voltage by EBIC image observation unit(option)

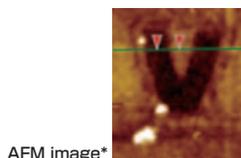HA-BSE image(Top) : compositional information
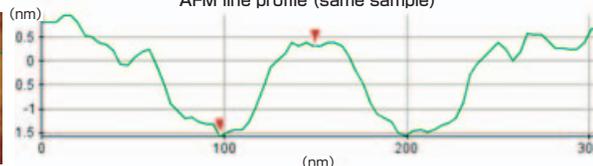

SE + BSE image(Upper) : Topographic information

Sample : Hard disc (magnetic head)

AFM line profile (same sample)

AFM image*

Above : image (Hard disc : SE + BSE image) shows nm level topographic information. Left image taken by AFM shows the difference of elevation in nm level as line profile, which backs up SEM data.
※SU8000 series does not have AFM capability.

Large stage with 5 axis motor drive as standard

User Interface of stage

- ■ **X-Y basic control**
  With a trackball, or joystick(*Option)
- ■ **Stage history function**
  The stage history function allows the operator to automatically save the stage position each time an image is captured. The saved positions can be recalled and used on subsequent sample runs. This function improves throughput and repeatability from sample to sample.
- ■ **Computer eucentric tilt and rotation**
  The sample field of view will automatically remain in focus and centered within the field of view when the stage is tilted or rotated.
- ■ **Continuous focus with Z axis movement**
  The focus of the image is automatically maintained as the stage Z axis is moved.
- ■ **X-Y step function**
  The step function will move the stage in the X or Y direction by a predetermined user-defined distance with the click of the mouse. This function is advantageous for observation and counting of repeated patterns/structures.
- ■ **Graphic display of stage position**
  An interactive graphical interface of the stage and objective lens helps the user know the position of the sample in relation to the objective lens.
- ■ **Virtual joystick**
  The stage can be moved with the mouse by controlling the on-screen virtual joystick.
- ■ **Image navigation**
  The image navigation function can utilize imported color optical images, schematics or diagrams or captured low magnification SEM image to traverse the sample under investigation. A single click on the reference image will drive the sample to the chosen location.
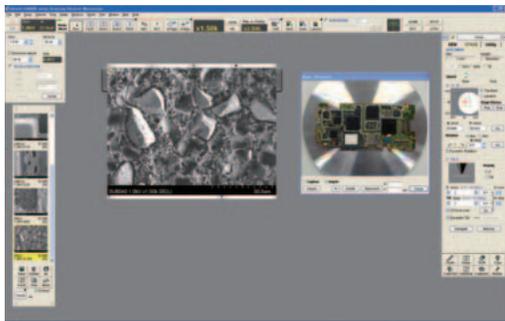
Image navigation function
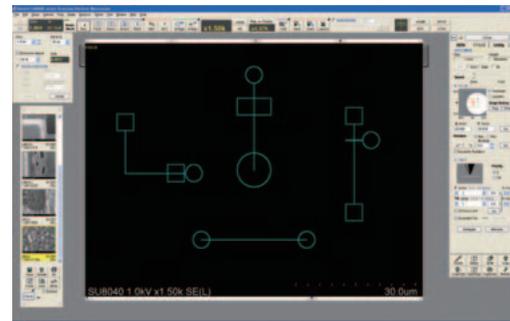
Virtual joystick function

SU8030

SE Detector	SE resolution	1.0nm(Vacc 15kV、WD＝4mm) 1.3nm(landing voltage1kV、WD＝1.5mm)
	Top detector	○
	Upper detector	○
	Lower detector	○

Specime Stage	Stage control		5-axis motor drive stage
	Stage traverse range	X	0 ～ 110mm
		Y	0 ～ 110mm
		R	360°
		T	-5 ～ 70°
		Z	1.5 ～ 40mm
	Max. sample size		150mm dia. ＊200mm dia.（Option）

SU8040

SU8040, top of the SU8000 Series range, with high performance Regulus stage*1 as standard

(*1 REGULated Ultra Stable stage)

The SU8040 has the high performance Regulus stage as standard. By improving the drivetrain from the motor, the high precision stage motion has been developed for ultra-smooth motion, extending the microscope's capability for high throughput observation even at the highest magnifications.

Newly developed Regulus stage for high magnification microscopy needs

FE-SEM has grown to be an indispensable tool for the semiconductor and cutting-edge nanotechnology materials industries. These types of sample often have nm scale structures requiring ultra high magnifications. Applications such as these demand that the sample stage motion traverses smoothly and with precision during observation to assist the user's task at ultra high magnifications.

To meet the needs of ultra high resolution microscopy, Hitachi has developed a new stage called Regulus. The smooth operation of the Regulus stage helps to achieve high throughput observation contributing to operator ease of use.
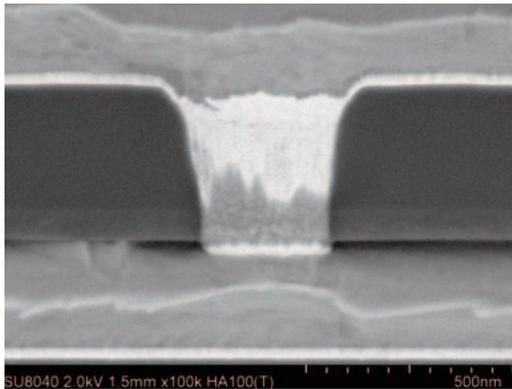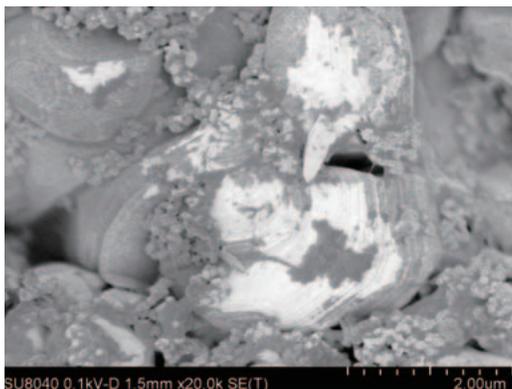

HA-BSE image(Top) : compositional information
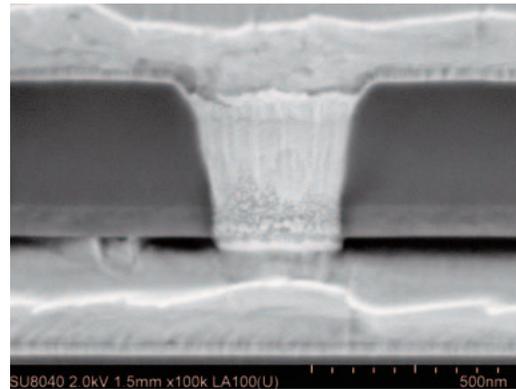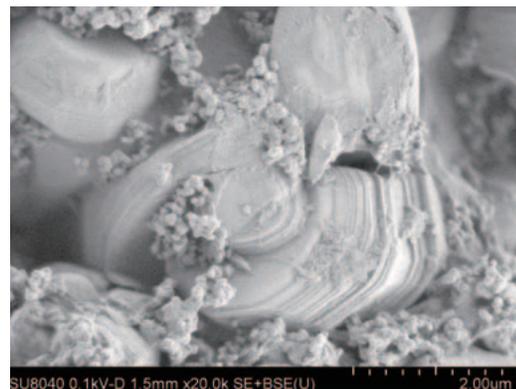

LA-BSE image(Upper) : Topographic + compositional information

Sample : Cu damascene (Cross section)

SE image(Top) : Surface voltage contrast

SE + BSE image(Upper) : Topographic information

Sample : Li ion battery (Surface of negative electrode)

New cell counting software assists in locating, and following the field of interest (*Option for SU8040)

Utilizing the excellent performance of the Regulus stage, optional cell counting software is available(*Option for SU8040).
Combination of the high performance Regulus stage providing smooth stage motion, and excellent SEM performance even at high speed TV scan mode will offer high reliability cell counting.
By recognizing the repeated pattern of DRAM/SRAM products, the new cell counting assist software helps to locate the target field of view.

Workflow

① Recognize the cell shape
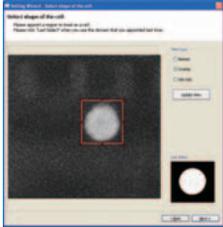
② Input the counting number for number of cells
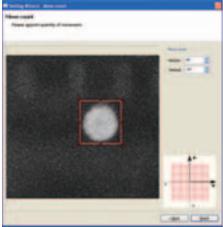
③ Select the cell pattern

④ Start the cell counting routine
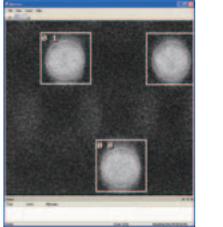
Example of cell counting application (DRAM, TV scan) Magnification 200kx

(0,5)
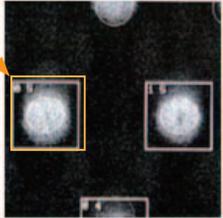
(0,7)
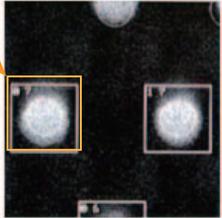
Merit of Cell counting assist software
① Eliminating the tedious and time consuming task of manual counting
② Eliminating human error
③ Higher throughput

SU8040

SE Detector	SE resolution	1.0nm(Vacc 15kV、WD＝4mm) 1.3nm(landing voltage1kV、WD＝1.5mm)
	Top detector	○
	Upper detector	○
	Lower detector	○

Specime Stage	Stage control		5-axis motor drive stage(Regulus stage) (repeatability ±0.5μm)
	Stage traverse range	X	0 ～ 110mm
		Y	0 ～ 80mm
		R	360°
		T	-5 ～ 70°
		Z	1.5 ～ 40mm
	Max. sample size		150mm dia.

Ultra-high Resolution Scanning Electron Microscope

■ BF/DF STEM function (Option)

Observation of sample using transmitted electrons

Upper Detector

DF-STEM image(Lower)

SE image(Upper)

Sample

DF-STEM
Conversion electrode

DF-STEM
information

BF-STEM
Aperture

BF-STEM
Detector

Lower Detector

DF-STEM
information

Sample

DF-STEM
Conversion electrode

BF-STEM
Aperture

BF-STEM
Detector

BF-STEM image(TE)
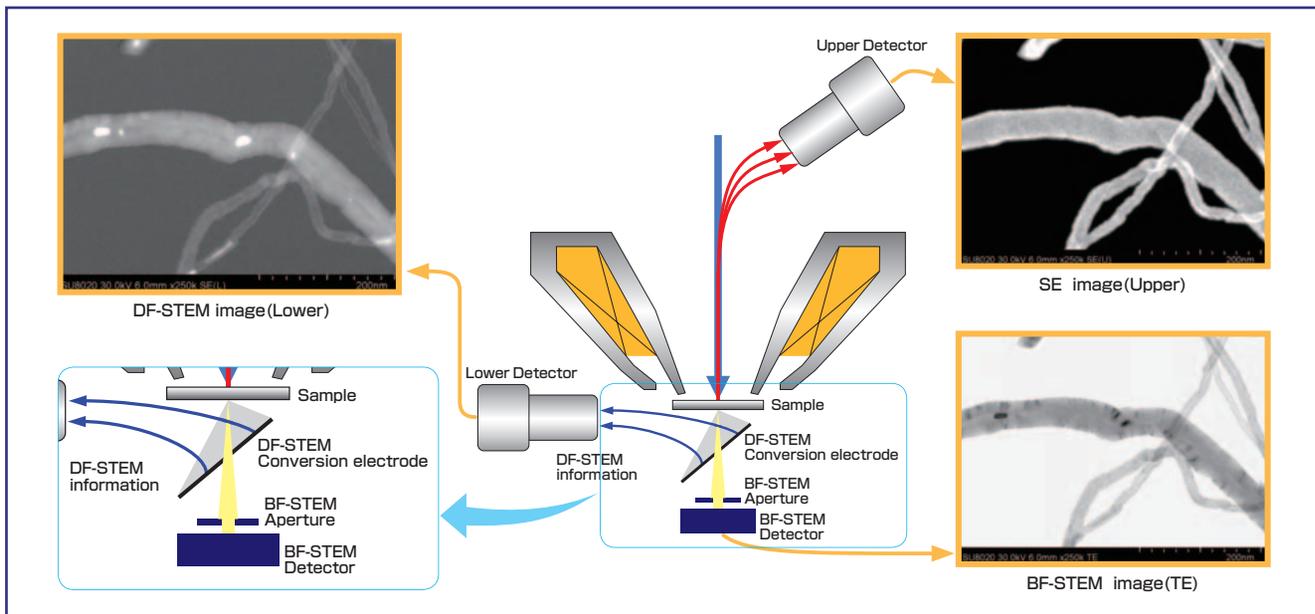
In the SU8000 series, BF/DF-STEM detection is available for imaging thin specimens and grid-mounted samples, forming an image from the transmitted electrons.

In addition to SE imaging for surface topography observation, both Bright Field(BF)-STEM (electron absorption) and Dark Field(DF)-STEM Z-number contrast (atomic number contrast) imaging can be applied using the optional sample holders and detectors.

In BF-STEM observation, it is possible to obtain high contrast images even of light element materials, such as organic samples, as a result of the application of accelerating voltages up to 30kV.

Furthermore, by utilising the optional BF-STEM apertures it is also possible to obtain higher contrast imaging by controlling the detection angle.

In DF-STEM imaging the detection angle is varied by changing the hole size of the DF-STEM holder to optimize the Z (atomic number) contrast.

■ ZigZag capture (Option) and stitch software (Option)

The ZigZag capture software helps to obtain successive images by moving the stage automatically. By stitching the images taken by the ZigZag capture software, it is possible to obtain an ultra low magnification image or large area image at high pixel resolution.
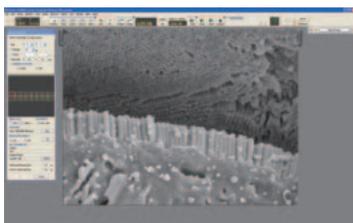
ZigZag capture software operation screen

■ **Maximum number of captured images number (X, Y)**
Maximum 200 images(* The number depends on the free space of destination drive.)

■ **Selective capture range setting**
● (X,Y) image number setting
   Input the X-Y image number and specify the range.
● Starting point, end point setting
   Input the starting point and end point for the images. The image number is automatically calculated.

■ **Auto Vacc off**
The acceleration voltage is automatically turned off when the end point is reached and all necessary images have been taken and automatically saved.

$5\mu m$
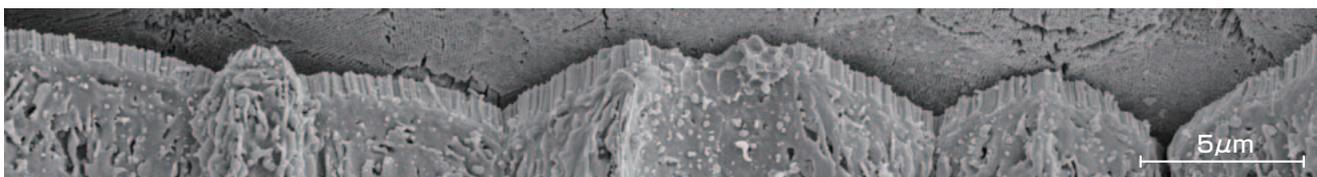
Sample : Small-intestinal villus (Rat) (each image is taken at 20kx magnification, 2 x 8 images)

■ EBIC image observation unit (Option, Not available for SU8040)

EBIC image(Electron Beam Induce Current Image) is widely used to identify semiconductor P/N junctions, or breakdown failure.

When the electron beam lands on the semiconductor P/N junction, an electron/hole pair is induced and electric current is passed through an external circuit. EBIC image is obtained by amplifying the electric current.

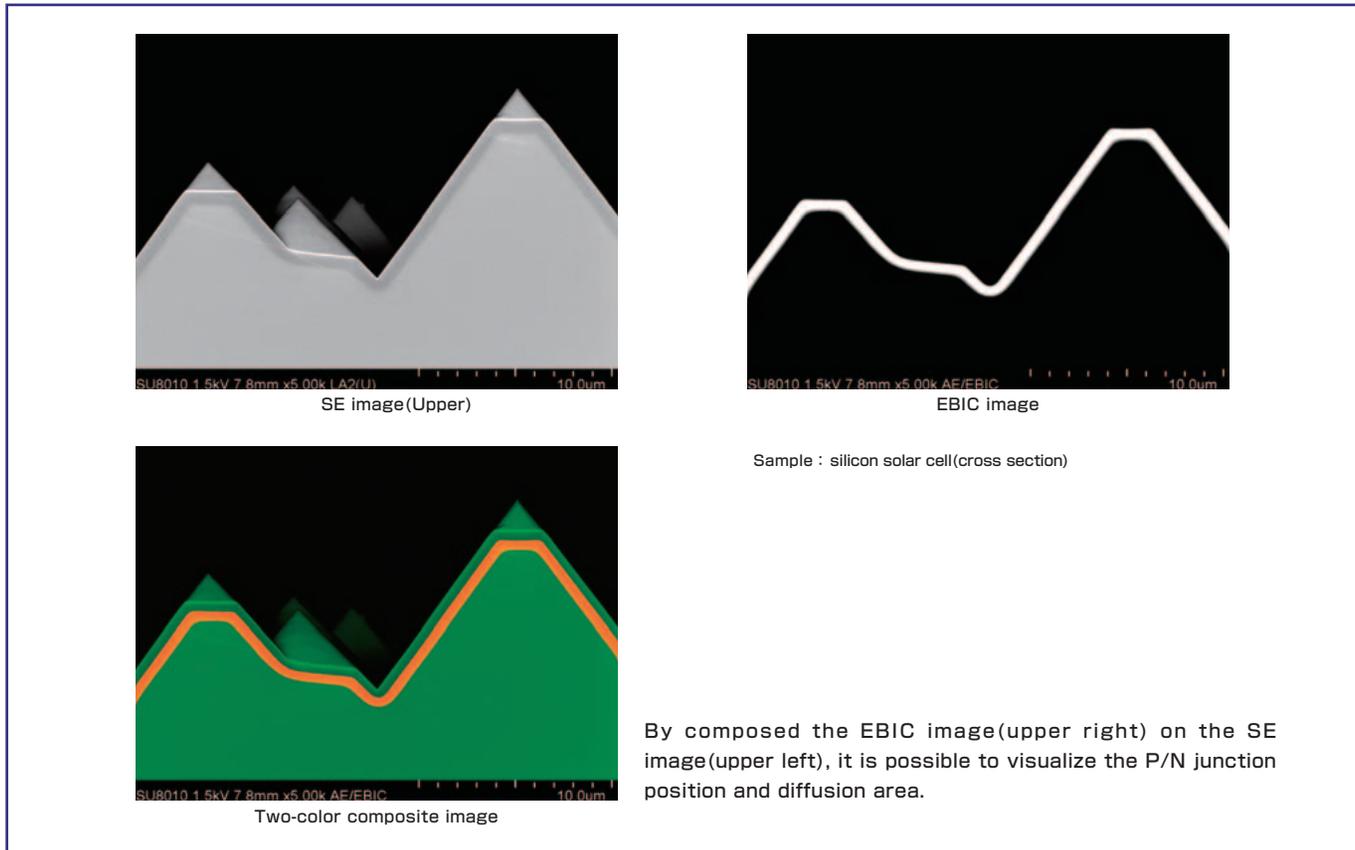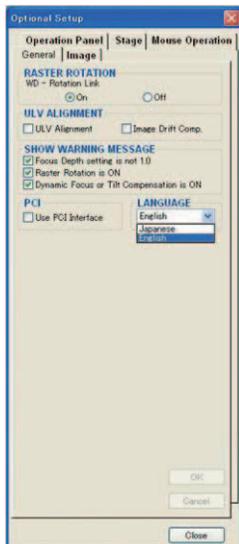### EBIC application of silicon solar cell

SE image(Upper)

EBIC image

Sample : silicon solar cell(cross section)

Two-color composite image

By composed the EBIC image(upper right) on the SE image(upper left), it is possible to visualize the P/N junction position and diffusion area.

■ CD-Measurement (Option)

CD-measurement utilises software that can measure the specified width, or angle on the SEM image. Selectable manual measurement and auto measurement is available for various purposes.

The CD-measurement algorithm is based on the Hitachi CD-SEM that has a very good reputation in the market. By using a standard sample (Optional microscale) for calibration, high accuracy CD-measurement can be realized.

Sample : Si line and space pattern
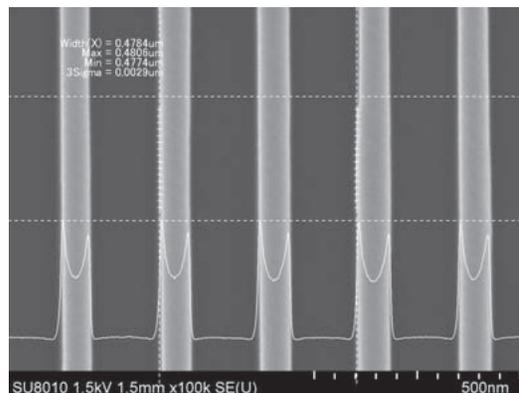
- ● Width/separation/pitch auto-measurement (horizontal/vertical direction)
- ● Width + pitch simutaneous auto-measurement. (horizontal/vertical direction)
- ● Width manual measurement (horizontal/vertical/diagonal direction simultaneously)
- ● Angle manual measurement
- ● Enlargement window for a cursor selected area
- ● Measurement data is displayed on the image (recordable) + file output (text file or Microsoft Excel compatible)

	SU8010	SU8020	SU8030	SU8040
Secondary Electron Image Resolution	1.0 nm (Vacc 15 kV, WD=4 mm)[1] 1.3 nm (landing voltage 1kV, WD=1.5 mm)[1]			

| Mag. | Low mag mode | 20-2,000 × (Magnifi cation on Photo)[2]
60-25,000 × (Magnifi cation on display)[3] | | | |
| | High mag mode | 100-800,000 × (Magnifi cation on Photo)[2]
300-2,000,000 × (Magnifi cation on display)[3] | | | |

Electron Optics	Electron gun	Cold cathode field emission source
	Accelerating voltage	0.5 kV to 30 kV(Standard mode)
	Landing voltage	0.1 kV to 2.0 kV(Deceleration mode)
	Lens system	3-stage electromagnetic lens reduction system
	Objective lens aperture	Objective aperture(Heating type), 4 openings selectable from outside of vacuum, finely adjustable.
	Stigmator coil	Octopole electromagnetic system (X,Y)
	Scanning coil	2-stage electromagnetic deflection

Specime Stage	Stage Control	3-axis motor drive 5-axis motor drive[4]	5-axis motor drive		5-axis motor drive (Regulus Stage)
	Traverse range X	0〜50mm	0〜110mm		0〜110mm
	Y	0〜50mm	0〜110mm		0〜110mm
	R	360°			0〜80mm
	T	-5〜70°			
	Z	1.5〜30mm	1.5〜40mm		
	Max. sample size	100 mm dia. (Maximum)	150 mm dia. (Maximum)		
		150 mm dia.[4]	200 mm dia.[4]		—
	Stage repeatability	—	—	—	less than ± 0.5 μm

| Electrical Image Shift | ± 12μm (WD=8 mm) |

Detector	Secondary electron detector	Lower/Upper	Lower/Upper/Top
		SE/BSE Signal Mixing Function (Upper detector)	
	Backscattered Electron Detector	Semiconductor type BSED[4]
		YAG BSED[4]
	Transmission Electron Detector	STEM detector (for BF-STEM)[4]
		BF-STEM aperture[4]
		DF-STEM holder[4]
	Other	Energy dispersive X-ray spectrometer[4]
		Faraday cup[4]
		Cathodoluminescence detector[4]
		EBIC image observation unit[4] —

Evacuation system	Auto evacuation	Pneumatic valve system
	Ultimate vacuum	Electron gun chamber 〜 10^{-7}Pa
		Specimen chamber 〜10^{-4}Pa
	Vacuum pumps	Ion pump 60 l/s x 1、20 l/s x2
		Magnetic bearing type turbo molecular pump, 300 l/s x 1
		Oil rotary pump 135 l/min at 50Hz (162 l/min at 60Hz) x 1
	Vacuum gauges	Penning gauge x1, Pirani gauge x2
	Anti-contamination	Anti-contamination trap

Display unit	PC/OS	PC/AT compatible, OS : Windows® [5]
	External device connection port	USB interface
		Network interface (Ethernet)[4]
	Monitor	24.1" type or the equivalent LCD (display screen image : 1,920 × 1,200)
		Chamberscope[4]
	Image display modes	Full screen display (1280 × 960)
		Reduced display (640 × 480)
		Reduced display for adjustment (320 × 240)
		2-image simultaneous display (640 × 480, × 2)
	Scanning speeds	TV scan (640 × 480 pixel display, 25/30 frames/s)[6]
		Fast scan (full screen display, 6.25/7.5 frames/s)[6]
		Slow scan (full screen display, 1/4/20/40/80 s/frame)
		(640 × 480 pixel display, 0.5/2/10/20/40 s/frame)
	Image data saving	640 × 480pixels、1,280 × 960pixels、2,560 × 1,920pixels、5,120 × 3,840pixels
	Image data printout	Free layout print function provided

| Protective functions | Protection against power, water and vacuum failures |

	SU8010	SU8020	SU8030	SU8040
Optional software	CD-measurement *4			
	CD-measurement function for SEM Data Manager (for external PC) *4			
	Hi-Mouse (single keyboard, single mouse) *4			
	RS-232C Communication interface *4			
	DBC interface *4			
	Zigzag Capture *4 & Stitch *4			
	—			cell count assist software *4

	SU8010	SU8020	SU8030	SU8040
Optional holders	Wafer holder (2", 3", 4", 5", 6") *4			
	—	Wafer holder (8") *4		—
	various types of specimen stubs and cross section holders *4			

Other optional items	Microscale(standard sample for magnification calibration) *4
	Joystick unit *4

Utility Requirement		
	Temperature	15 ～ 25℃
	Humidity	less than 60% (RH) (non-condensing)
	Power (Main unit)	AC100V ± 10% , 4kVA (Crimp contact for M5)
	Power (W-5020Td *4)	AC100V ± 10% , 2kVA (Crimp contact for M6) *4
	Grounding	100 Ω or less
	Cooling water	Dedicated cooling water circulation system *4
	Compressed air *7	350 to 500 kPa (Rc1/4taper internal thread) *4
	N2 purge *7	30 to 50 kPa (Rc1/4taper internal thread) *4
	Optional items	Scroll type dry pump(switching from oil rotary pump) *4
		Battery backup unit for Ion Pump *4
		N2 gas leak port *4
		Auto-Transformer (for 115 ～ 240V power supply) *4

Dimension & Weight **8				
	Main unit	840(W)×970(D)×1,680(H)、593kg	840(W)×970(D)×1,720(H)、661kg	840(W)×970(D)×1,720(H)、667kg
	Display unit	1,000(W) × 1,010(D) × 1,200(H)、205kg		
	Oil rotary pump	530(W) × 240(D) × 240(H)、28kg		
	Air compressor	420(W) × 210(D) × 520(H)、16kg		
	Weight	200(W) × 180(D) × 160(H)、40kg		
	W-5020Td *4	400(W) × 450(D) × 670(H)、73kg		

*1 Based on the gap (point to point) method by using Hitachi standard sample for resolution measurement
*2 at 127 mm × 95 mm (4" × 5" Picture size)
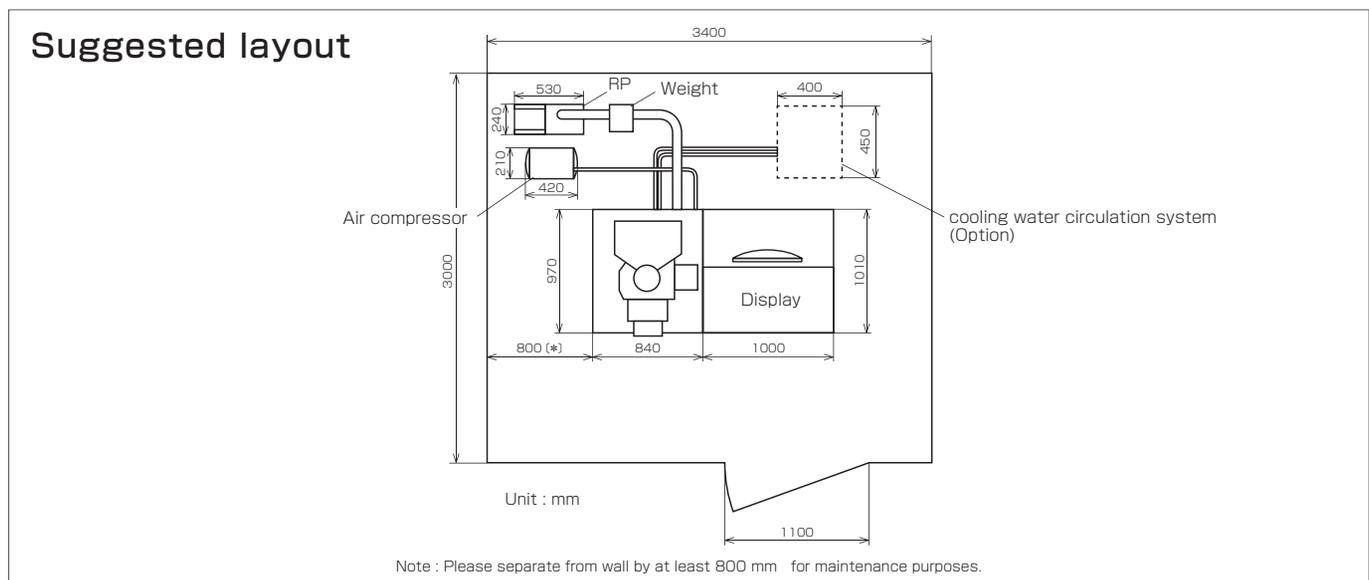*3 at 345 mm × 259 mm (1,280 × 960 pixels)
*4 option
*5 Windows XP Professional is a registered trademark of U.S. Microsoft Corp. in U.S.A. and other countries.
*6 50Hz/60Hz
*7 In case of connection from the installation site facilities.
*8 Weight does not include options
※ For disposal of this product, please contact your nearest sales representative.

Suggested layout

Unit : mm

Note : Please separate from wall by at least 800 mm for maintenance purposes.

Bringing the frontier to the forefront.

◎ **Hitachi High-Technologies Corporation**