# APPLICATION NOTE II

with *COXEM*

SEM (Scanning Electron Microscope) is a high-precision tool designed to observe minute parts of organs and forms. It allows obtaining in-depth focus images of samples in a higher magnification. Recently, the application of SEM is expanding, equipped with various detectors and thanks to its capacity for obtaining complex information of a sample.

COXEM's SEM, which is armed with a wide range of functions and applications, will certainly be the right choice for the entire industry including researchers and scientists.
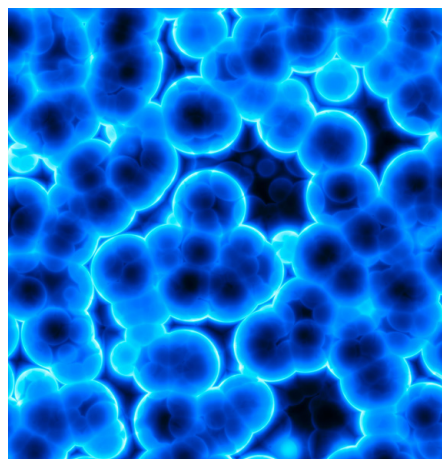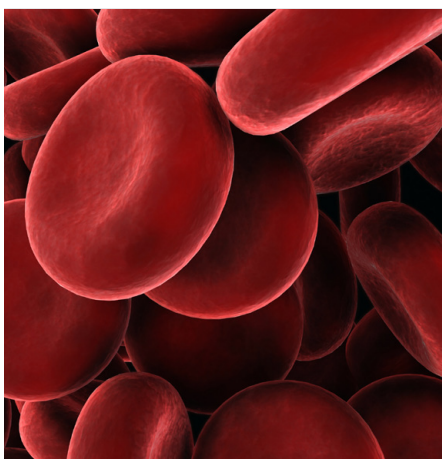
COXEM

Highest Resolution Table Top SEM with Integrated EDS

EM-30AX

COXEM
www.coxem.com

Features

- High Performance EDS System Integrated
- High Quality Images(5 nm resolution)
- Magnification Up To 150,000x
- Easy Navigation with the "Navigation Mode"

- Precise Control with a Joystick and the "Driving Mode"
- Low Energy Consumption
- Intuitive User Interface

Specifications

- **Magnification :** x15 ~ x150,000
- **Acc Voltage :** 1 ~ 30kV (1kV increments)
- **Electron Gun :** Tungsten Filament (W)
- **Detector :** SE Detector
- **EDS :** Oxford : 129eV at Mnk. B(5) ~ Cf(98)
  Bruker : 129eV at Mnk. B(5) ~ Cf(98)

- **Stage :** Auto Stage (X: 35 mm, Y: 35 mm, T: 0 to 45°)
  Manual Stage (Z: 5 to 50 mm)
- **Image Shift :** X, Y, R(Rotation)
- **Operating System :** Microsoft Windows 10
- **Dimension :** 400(W) X 600(L) X 550(H) mm
- **Weight :** 95 kg

1. Effect of Working Distance

INTRODUCTION

Scanning Electron Microscopes (SEM), of which the depth of field is very deep, are more effective when observing an object with big undulations. To increase the depth of field, it is important to extend the Working Distance (WD) between the objective lens and specimen to deepen the depth of field for observation.

Benefits

Users can deepen the depth of field by adjusting WD when observing a specimen whose surface is rough, with some difference in height.

Analysis Solution for:
- Automotive Industries
- Material Industries
- Bioecology
- Sandstone Industries

Availability

'Depth of Field' can be controlled in every product of COXEM.

- EM-30 Series
- CX-200Plus

Operation

'Depth of Field' is adjustable, regardless of the vacuum state; if the distance between the objective lens and specimen increases, the focus area also increases. Another way to increase focus area is to set the electron beam's size small.

<Spring samples>

Depth of Field at WD=50 mm

Depth of Field at WD=9 mm

2. Effect of High Resolution

INTRODUCTION

One of the greatest advantages of SEMs is that they use an electron beam with a short wavelength to ensure observation of an image in a higher magnification. SEM is particularly effective in obtaining a high resolution by adjusting accelerating voltage, working distance (WD), and electron beam's size(so called 'Spot Size').

Benefits

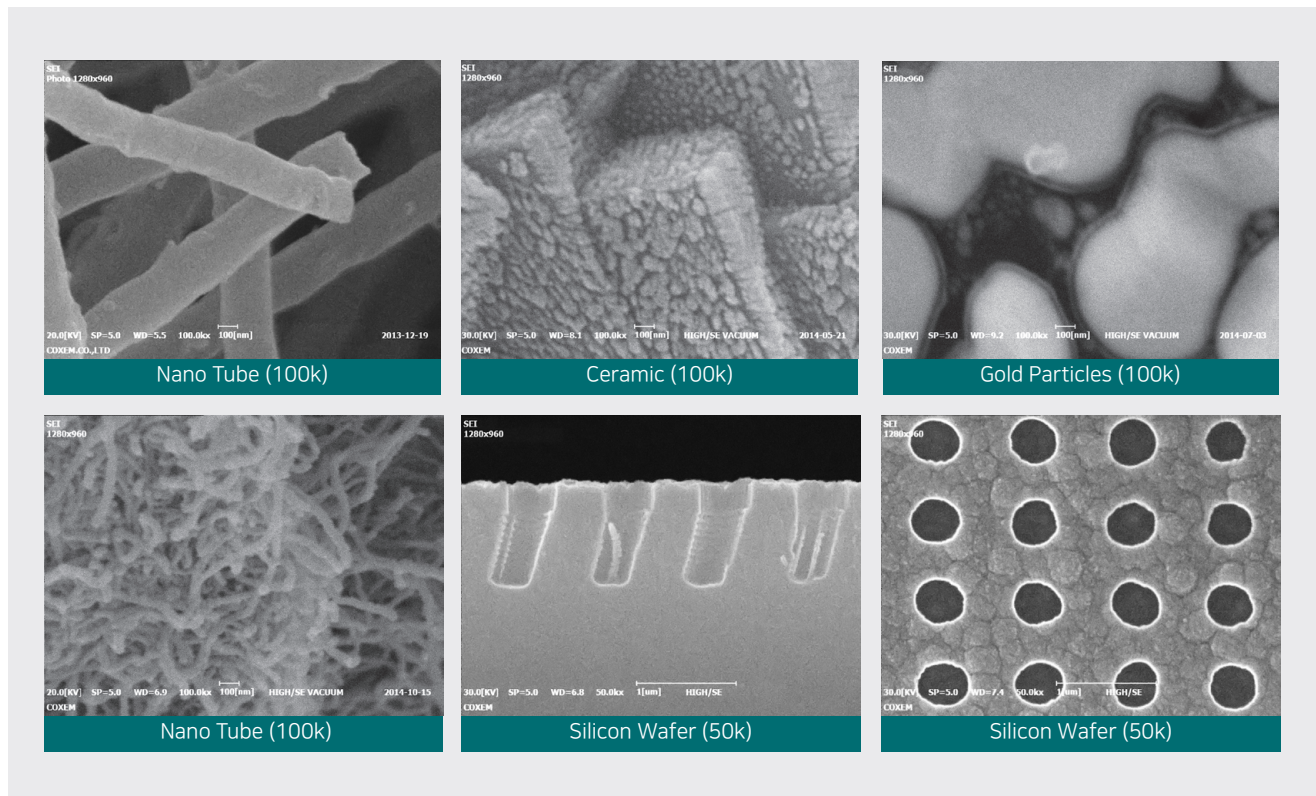A higher resolution is useful when observing minute parts of objects, such as materials or components.

Analysis Solution for:
- Chemistry Industries
- Semiconductors and Electronics Industries
- Material Industries

Availability

- EM-30 Series
- CX-200Plus

Operation

It is possible to obtain a higher resolution image by setting the WD and electron beam's size to be short and small, while setting the accelerating voltage to be high.

Nano Tube (100k)

Ceramic (100k)

Gold Particles (100k)

Nano Tube (100k)

Silicon Wafer (50k)

Silicon Wafer (50k)

3. SE / BSE Detector

INTRODUCTION

SEM allows creating images by collecting different signals. A typical example of this is information on uneven, rough surface gained by SE Detector, as well as elementary information and stereoscopic-like images gained by BSE Detector.

◼ Benefits

These detectors can be used to obtain morphological and topographic images of a sample.

Analysis Solution for:
- Automotive Industries
- Material Industries
- Chemistry Industries
- Semiconductors and Electronics Industries
- Smartphones and Display Industries

◼ Availability

All COXEM products are equipped with SE / BSE detectors.
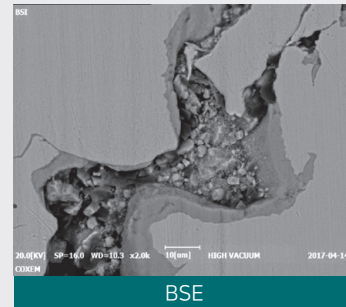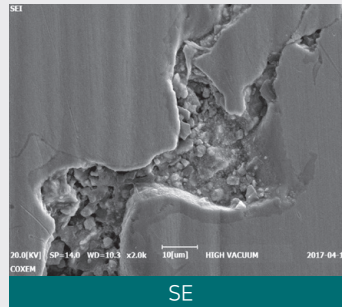
- EM-30 Series(BSE optional)
- CX-200Plus

◼ Operation

For BSE, it is recommended to collect adequate signals by amplifying energy emitted from the sample. Therefore, you must set the size of the 'electron beam' and 'aperture' large enough to receive adequate signals.
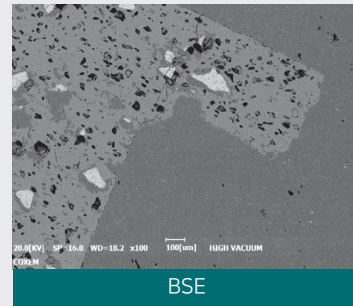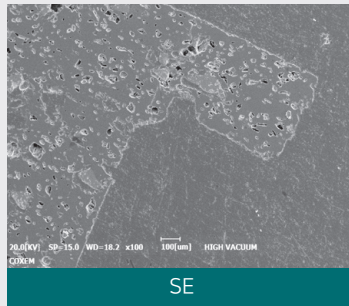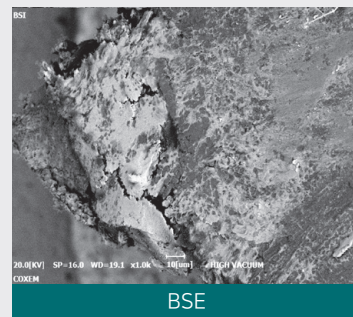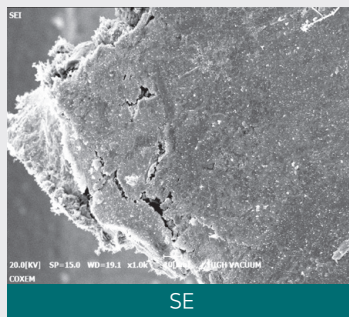
< Mineral >

| BSE-COMP mode | BSE-TOPO mode | SE |

<A crack in an auto part >

| | SE | BSE |

<Ceramic>

SE

BSE

<Alloy>

SE

BSE

<Semi-conductor>

SE

BSE

<Mineral>

SE

BSE
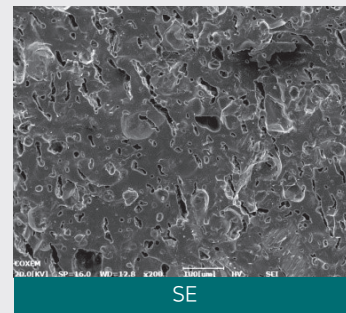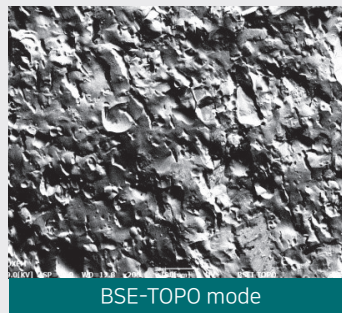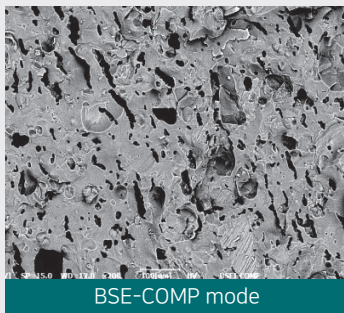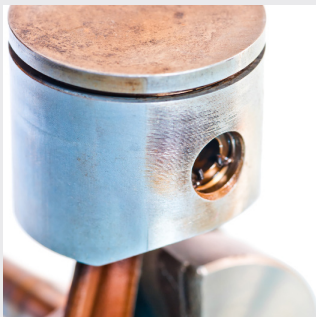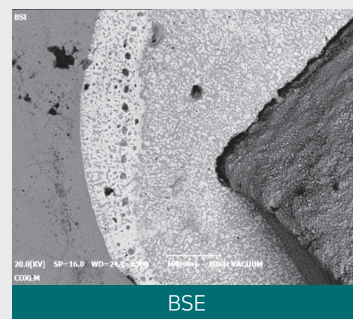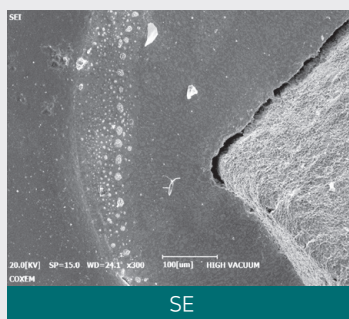
4. SE+BSE Mode

INTRODUCTION

COXEM offers an image merging function to combine SE and BSE images, which allows for observing each and every property of SE and BSE, at a glance.

Benefits

You can obtain SE and BSE images, at the same time.
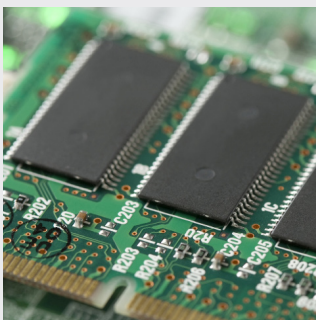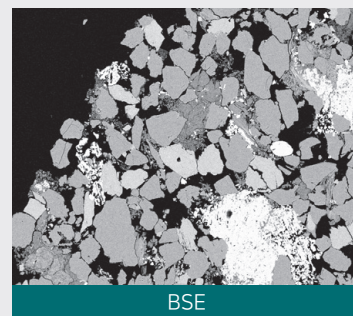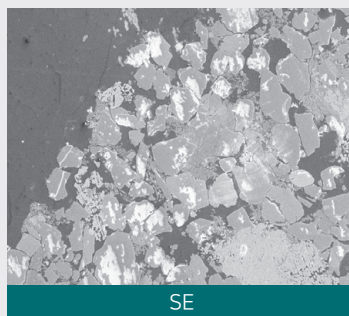
Analysis Solution for:
- Automotive Industries
- Material Industries
- Chemistry Industries
- Semiconductors and Electronics Industries
- Smartphones and Display Industries

Availability

- EM-30 Series
- CX-200Plus

Operation

You can obtain an optimal SE + BSE united image by selecting proper spot sizes for both images.

<Ceramic>

BSE | SE | SE+BSE

<Electronic part>

BSE | SE | SE+BSE

<Spring>

BSE | SE | SE+BSE

<Alloy>

BSE | SE | SE+BSE

5. Low Vacuum Mode

INTRODUCTION

Using the 'Low Vacuum' mode, you can obtain an image of a biological sample or insulation material without a special pretreatment for the specimen.

Benefits

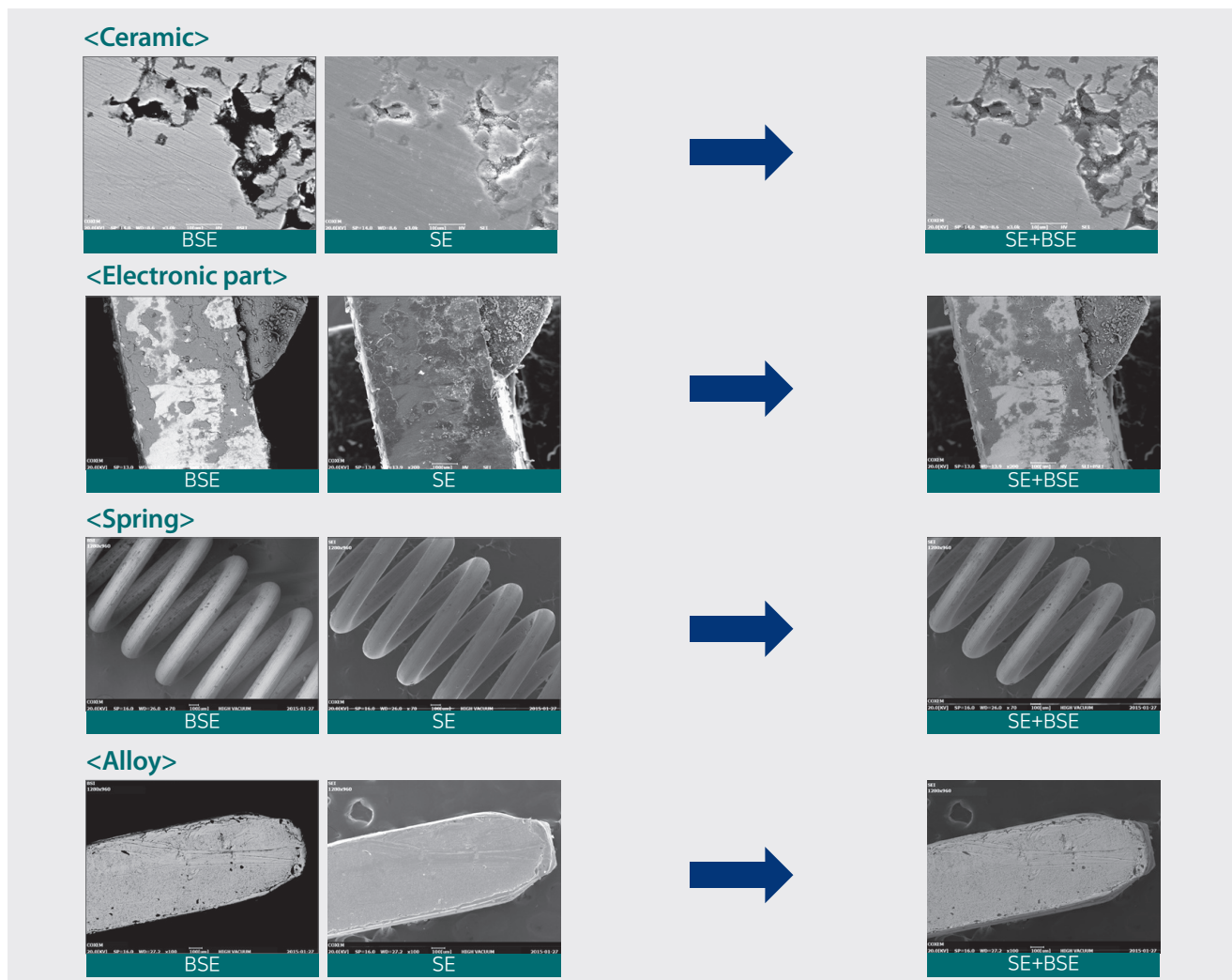Useful for samples including biological samples that cannot be pretreated for coating.

Analysis Solution for:
- Automotive Industries
- Material Industries
- Chemistry Industries
- Semiconductors and Electronics Industries
- Bioecology
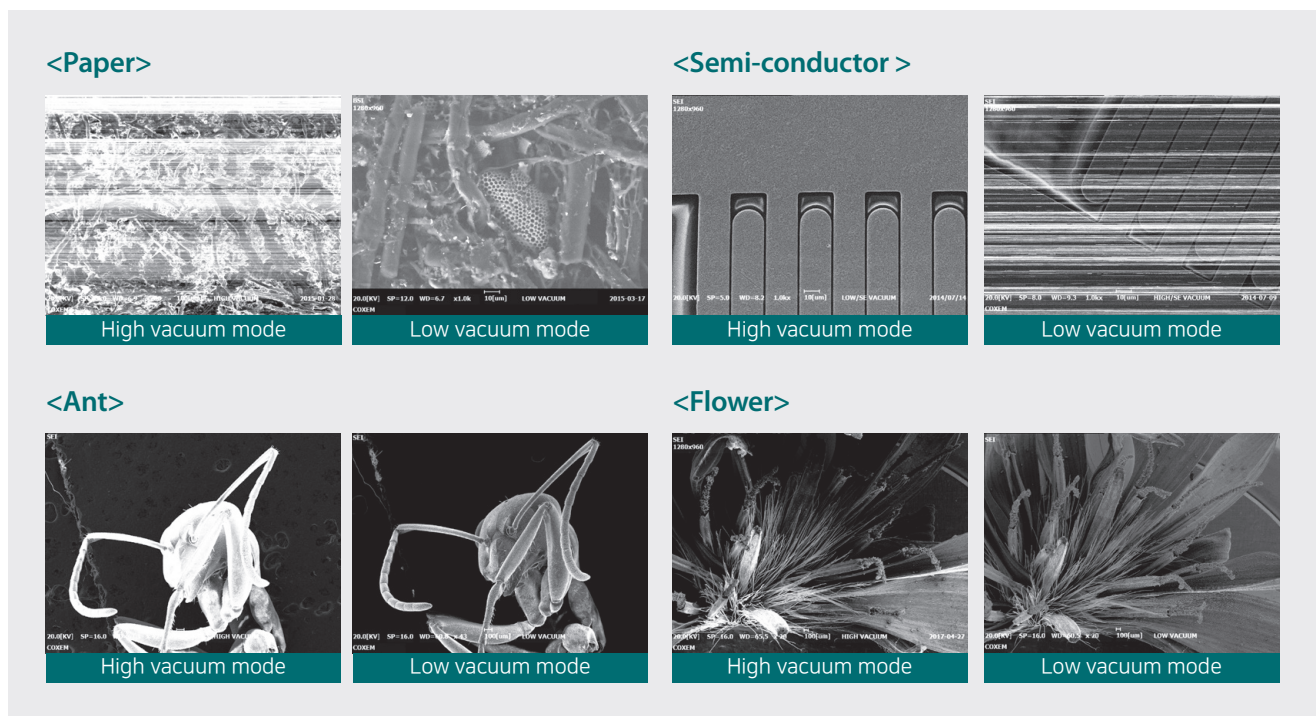
Availability

'Low Vacuum' mode is available as an option.

- CX-200Plus (LV optional)

Operation

Without a pretreatment process, you can analyze a nonconductor sample.

<Paper>

High vacuum mode

Low vacuum mode

<Semi-conductor >

High vacuum mode

Low vacuum mode

<Ant>

High vacuum mode

Low vacuum mode

<Flower>

High vacuum mode

Low vacuum mode

6. Effect of Accelerating Voltage

INTRODUCTION

SEM enables observing an image with the accelating voltage (acc.voltage) adjusted from 1kV to 30kV. The lower acc.voltage is convenient for two occasions: when there is concern that the sample might be damaged by electron beams and when the user wishes to observe certain points of the surface.

Benefits

To avoid any damage to the sample by the electron beam's heat, bring down the Acc. Voltage, by considering the nature of the sample, especially for polymer or metal samples - sensitive to heat.

Analysis Solution for:
- Automotive Industries
- Material Industries
- Chemistry Industries
- Semiconductors and Electronics Industries

Availability

Acc.voltage setting is available in all products of COXEM.
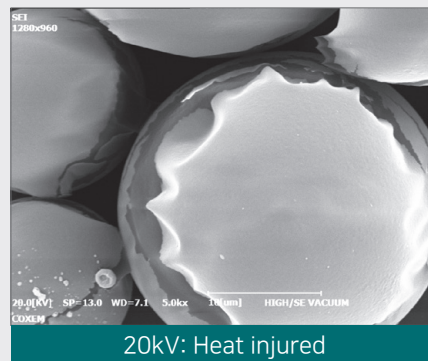
- EM-30 Series
- CX-200Plus
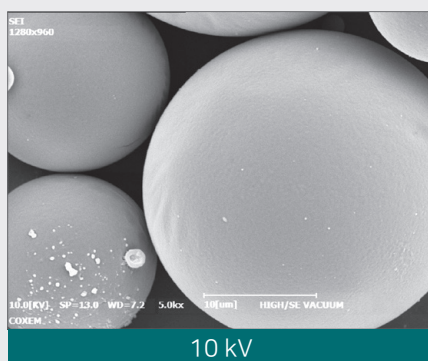
Operation

The 'Interaction volume' for the sample may vary depending on the voltage, so users can obtain the surface information more effectively by lowering the voltage to reduce the 'Interaction volume.' This is also true when the sample is likely to be damaged by electron beams.

\<Image of an alien metal substance\>

5 kV

30 kV

\<Polymer\>

10 kV

20kV: Heat injured
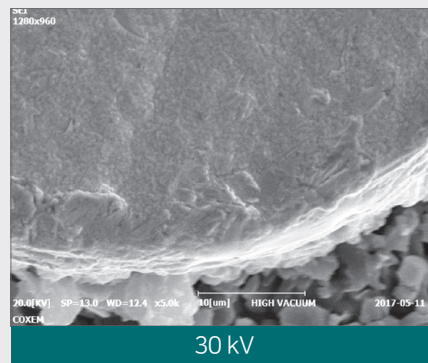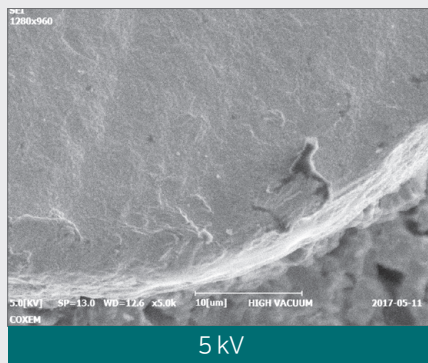
7. Effect of Tilt Angle

INTRODUCTION

In most cases, an analysis may be proceeded without any information about the shape of the sample. In such a case, one of the most commonly made errors is analyzing the sample by observing it simply from above to obtain fragmentary information.

Benefits

By tilting the sample stage, it is possible to observe the sample in different types of images from different angles.

Analysis Solution for:
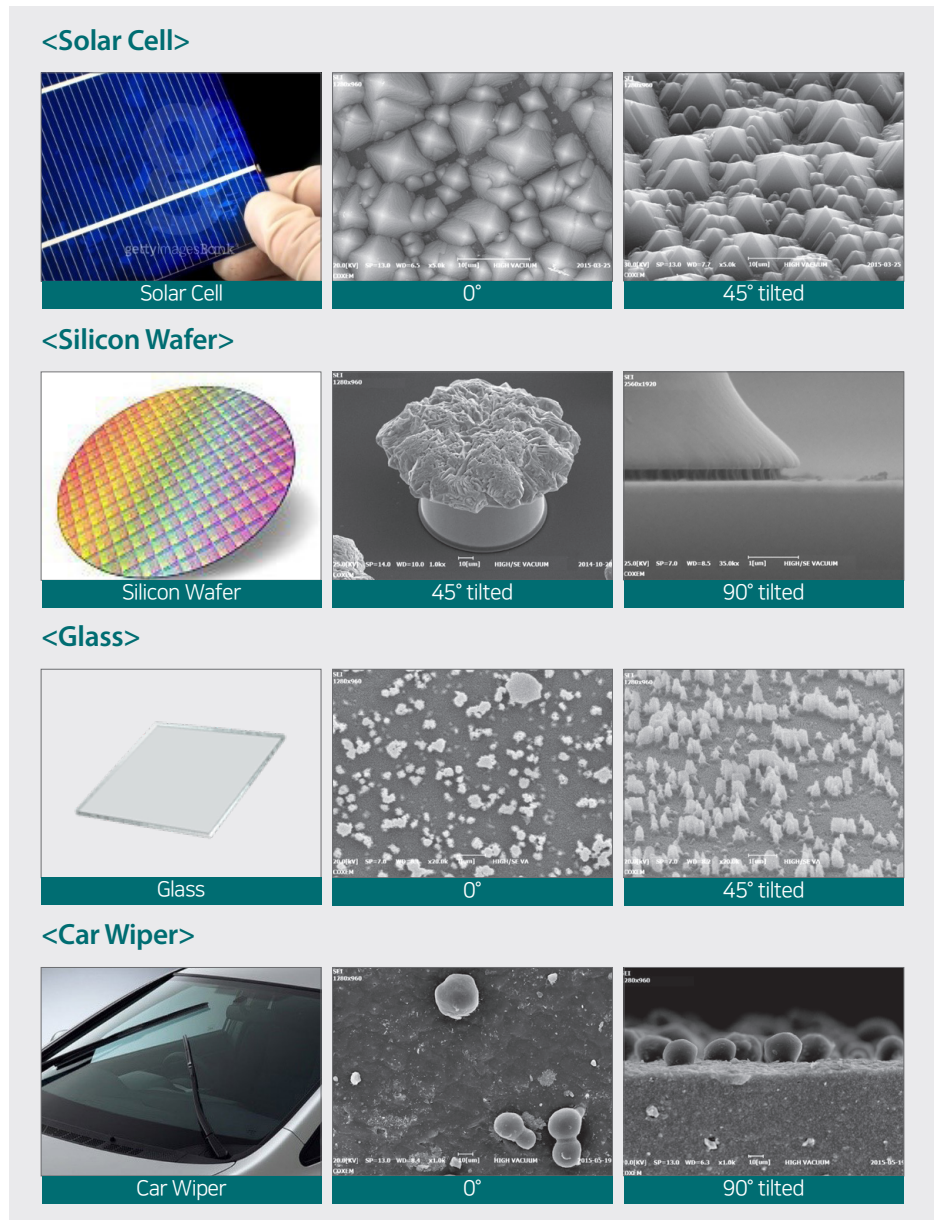Used in many applications.

Availability

You can observe the sample by tilting the sample stage for all COXEM products.

- EM-30 Series
- CX-200Plus

Operation

To identify an accurate shape of the specimen, apply tilt effects in multiple angles.

<Solar Cell>

| Solar Cell | 0° | 45° tilted |

<Silicon Wafer>

| Silicon Wafer | 45° tilted | 90° tilted |

<Glass>

| Glass | 0° | 45° tilted |

<Car Wiper>

| Car Wiper | 0° | 90° tilted |

Cost-Effective Normal SEM Solution

CX-200Plus

COXEM

www.coxem.com

Features

- Magnification Up To 300,000x
- Full Auto Stage (X, Y, R, T, Z Axis)
- Panorama Shot

- Click & Move Stage Control
- Auto Functions : Filament, Focus, Contrast, Brightness
- Higher Image Pixel : 5120 X3840 Pixel

Specifications

- **Magnification :** x15 ~ x300,000
- **Acc Voltage :** 1 ~ 30 kV (1kV increments)
- **Electron Gun** : Tungsten Filament (W)
- **Detector :** SE (standard)
           BSE, EDS (optional)
- **Image Shift :** X, Y, R (Rotation)

- **Stage :** Auto Stage
  (X: 40 mm,Y: 40 mm,T: -20° to 90°, R: 360°, Z: 5 to 60 mm)
- **Operating System :** Microsoft Windows 10
- **Dimensions :** 800(W) x 900(L) x 1500(H) mm
- **Weight :** 400 Kg

8. Effect of Sample Preparation

INTRODUCTION

For SEM, it is not necessary to prepare a special preparation for the sample, and there are only few limitations for samples, which make it highly useful. However, it is better to, identify the sample's conductivity or contamination before processing a pretreatment to obtain a higher-quality image of the sample.

1) Effect of Coating

SEM is designed to detect and analyze signals to obtain different types of images generated by electrons – being projected at an extremely fast speed - colliding with the sample. In this process, if an excessive portion of electrons remain on the specimen, there will be a 'Charging effect' which has a negative effect on the image. To prevent such an effect, you must use an 'Ion sputter coater' to cover the sample's surface with a thin conductive layer.

Ion Sputter Coater (SPT-20)

<Paper>
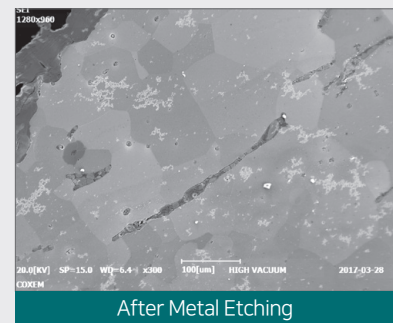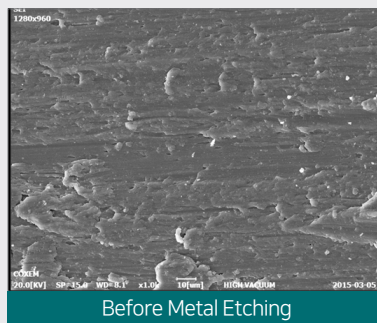
Before coating	After coating
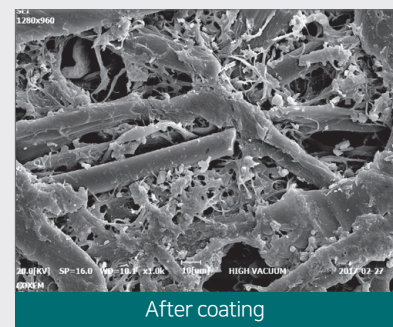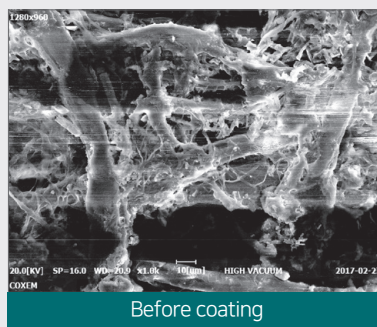
2) Chemical Etching Effect

To observe a fine structure of a specimen, it is required to use chemical etching.

<Metal>

Before Metal Etching	After Metal Etching

3) Polishing

A polishing process can be applied to any sample whose surface is not smooth - such as a semi-conductor chip section or a grain boundary in metal – for accurate observation.

Solder Ball Molding	Rock Molding
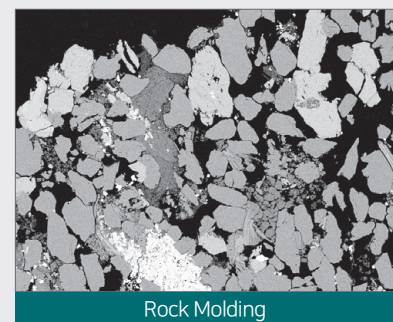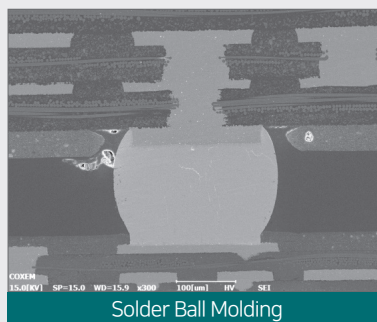
9. Application of Coolstage

INTRODUCTION

A biological sample requires various chemical treatments including dehydration and fixing. To reduce this complex sample preparation process, you can use a Coolstage function which rapidly lowers the temperature of the sample stage to instantly freeze the sample against any damage to it.

Benefits

Useful for a sample containing moisture.

Analysis Solution for:
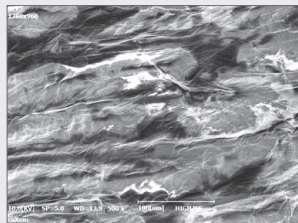- Bioecology

Availability

Coolstage can be mounted in all COXEM equipment.

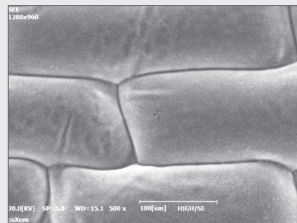- EM-30 Series (Coolstage optional)
- CX-200Plus (Coolstage optional)

Operation

With Coolstage, you can observe a sample with moisture by freezing it up to 25 degrees below zero, against any damage to its structure, without a special pretreatment.
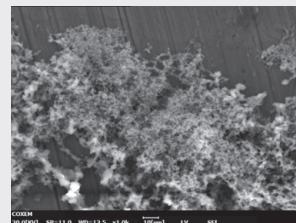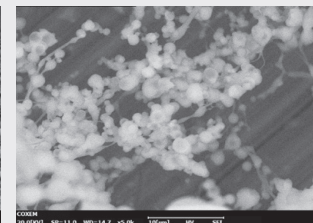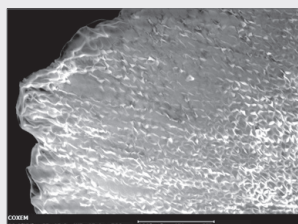
<Onion Cell>

without Coolstage

with Coolstage

<Yogurt>

without Coolstage
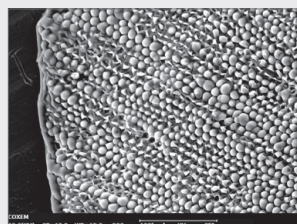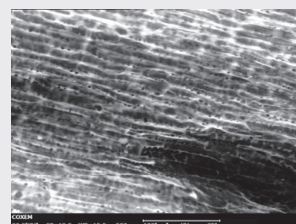

with Coolstage

<Flower(1)>

without Coolstage

with Coolstage

<Flower(2)>
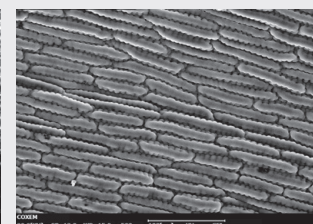

without Coolstage

with Coolstage

10. Application of Panorama Shot

INTRODUCTION

'Panorama Shot' function (so called MxN) is designed to repeatedly shoot multiple images. This function allows observing the entire image at a glance.

■ Benefits

This function is optimized for analyzing large areas such as a semiconductor surface, minerals and other metals.

Analysis Solution for:
- Semiconductors and Electronics Industries
- Material Industries
- Sandstone Industries

■ Availability

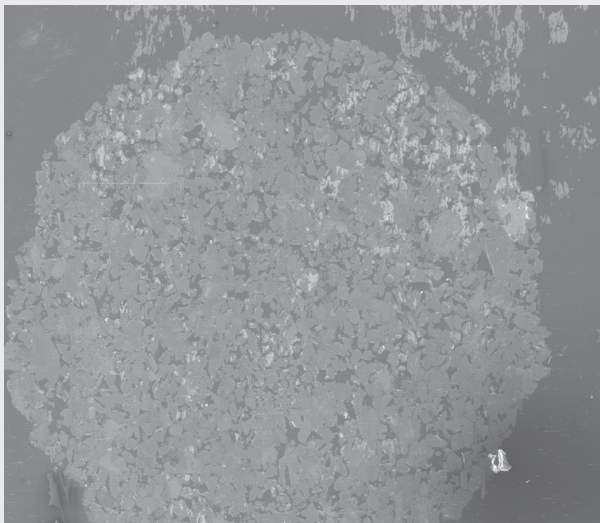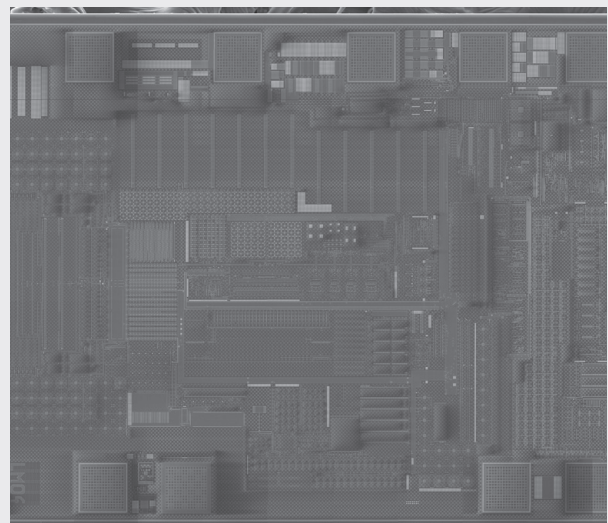MxN function can be used in COXEM's console-type SEM.

- EM-30 Series
- CX-200Plus

■ Operation

An image can be generated automatically, by selecting a desired area and mode. After analysis, it is also possible to move or reshoot a particular cell image for observation.

Mineral (x1,000 - an image from 72 combined pieces)

Semiconductor surface (x1,000 - an image from 1,440 combined pieces)

11. Application of 3D Topography Software

INTRODUCTION

Using 3D imaging software, users can obtain reconstructed 3D SEM images fast and easy. Advanced functions such as image colorization, enhancement and surface metrology including roughness are also available.

Benefits

Reinforce the surface information to obtain an image.
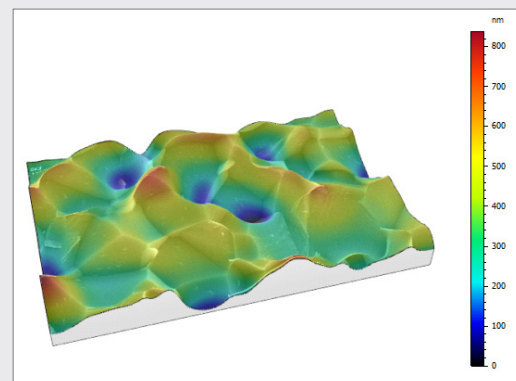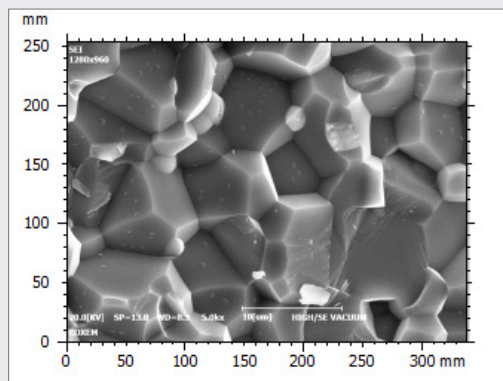
Analysis Solution for:
- Material Industries
- Chemistry Industries

Availability

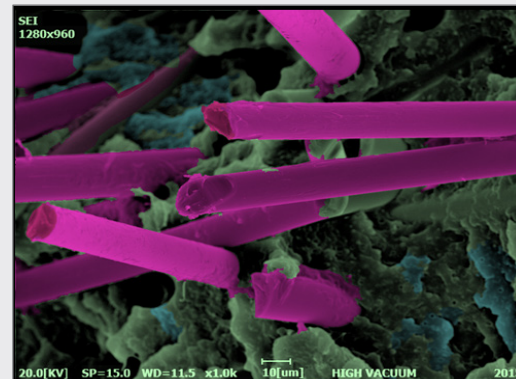Installation of the program is possible in all COXEM systems.

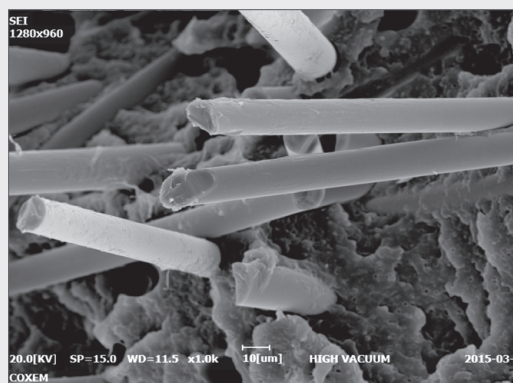- EM-30 Series (optional)
- CX-200Plus (optional)

Operation

< 3D reconstruction of SEM image>

<Polymer>

<Colorization of SEM image>

12. Application of Scanning Transmission Electron Microscopy (STEM)

INTRODUCTION

STEM is designed to project electron beams generated by an electron gun onto a sample and extract electrons transmitted to create an image from them. This system is generally used to observe cells, structures or Nano construction.

1) Bright Field Mode

BF (Bright Field) images show a two-dimensional structure synchronized on the sample's surface with signals transmitted, while a detector placed on the beam axis catching the electrons transmitted. This tool is useful especially when observing the information about the form and structure of 'bulk samples.'

2) Dark Field Mode

DF (Dark Field) images are created without receiving the central beam and with a donut-shape detector installed in 'spawn areas' with sharp angles. This is useful when it is difficult to observe the structure in detail or when analyzing the structure of a defect.

3) STEM with EDS Mode

You can use a STEM Holder that does not affect a light elements analysis for more accurate observation of light elements.

▉ Benefits

COXEM's STEM solution allows a large-area observation, which was limitedly possible with STEM-in-TEM, under a relatively low magnification.

Analysis Solution for:
- Bioecology

▉ Operation

Check the image with COXEM's special sample holder.
'Low Vacuum' mode is useful in minimizing any damage to the sample.

Large Intestine

Colorectal Cancer

Asbestos(1)

Asbestos(2)

Neuron(1)

Neuron(2)
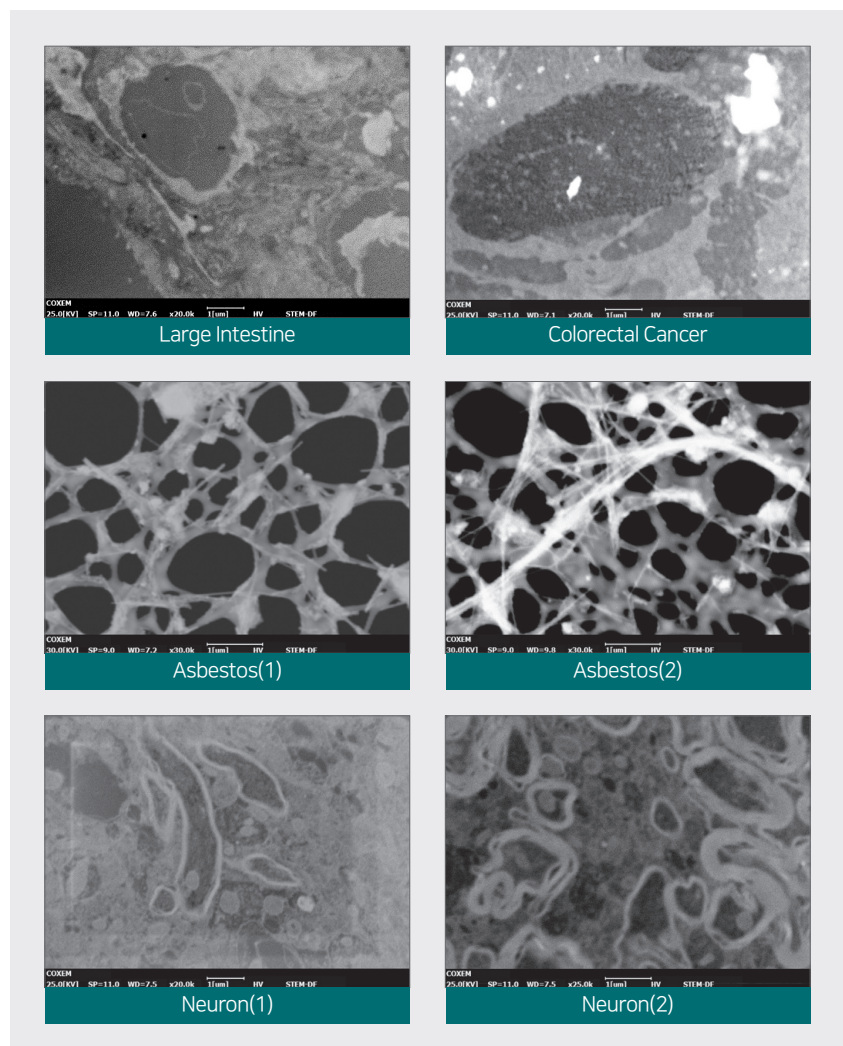
13. Application of EDS

INTRODUCTION

By collecting and detecting 'Characteristic X-rays' generated by deviating electrons from electron beams using an energy dispersive spectroscopy, it is possible to make both a quantitative and qualitative analysis to determine constituent elements of the sample, including identification, concentration, and distribution.

EDS Analyzer

An image showing the deviation of electrons from E-Beam
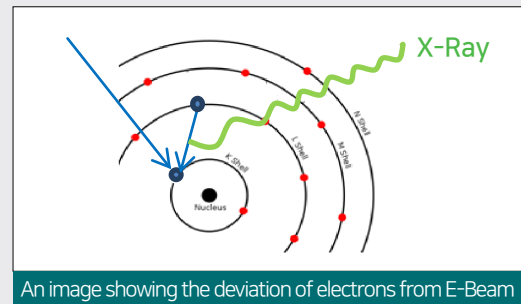
1) Point Analysis

A quick analysis result can be obtained by designating a section, dot and other desired areas.

▮ Benefits

EDS allows convenient obtainment of both quantitative and qualitative values.

Analysis Solution for:
- Material Industries
- Chemistry Industries
- Semiconductors and Electronics Industries
- Sandstone Industries
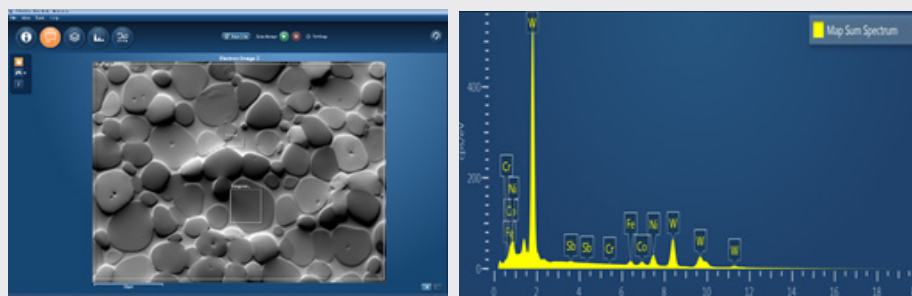- Automotive Industries

▮ Availability

Can be mounted in every COXEM system.

- EM-30 Series (EDS optional)
- CX-200Plus (EDS optional)
* EM-30AX has EDS integrated.

▮ Operation

Making the sample as flat as possible may help obtain accurate values.

< An image showing particular points in an analyzed metal sample >

2) Mapping Analysis

If the sample consists of multiple elements, it is useful in representing the components in different colors to identify the distribution of each element.

▌Benefits

It provides images of elemental distributions in a sample without requiring quantitative point analysis.

Analysis Solution for:
- Material Industries
- Semiconductors and Electronics Industries
- Sandstone Industries

▌Operation

Mapping allows obtaining the information, by offsetting the 'Peak overlap' and the 'background.'

< An image showing the comparison of Map, TruMap ('Peak Overlap' offset), QuantMap (a quantitative map),and PhaseMap (a phase map) >
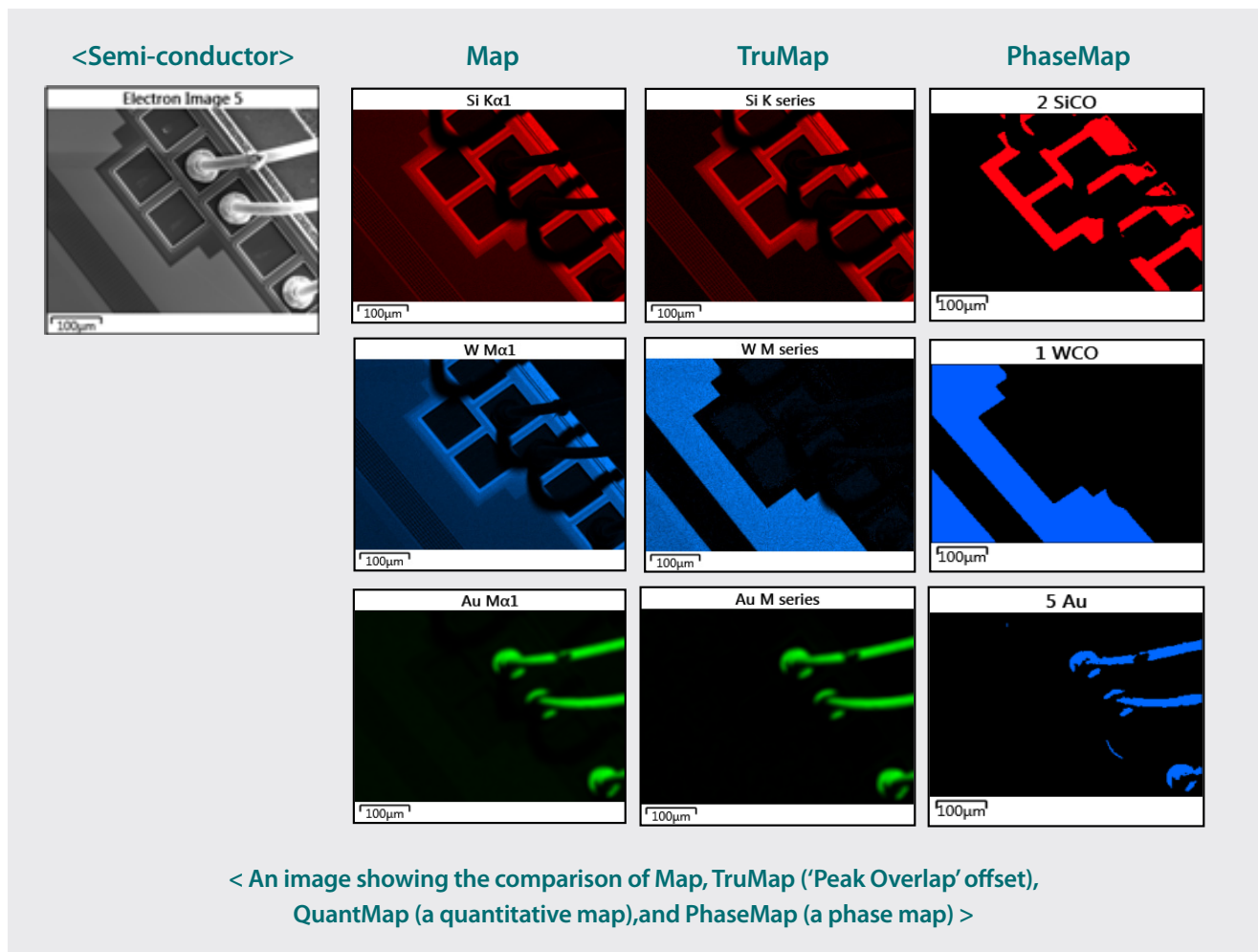
3) Large Area Mapping

This function is designed to implement a high-resolution 'Elemental composition image' and EDS mapping for a large selected area.

▉ Benefits

Useful when identifying the distribution of all the components of a sample.

Analysis Solution for:
- Material Industries
- Sandstone Industries

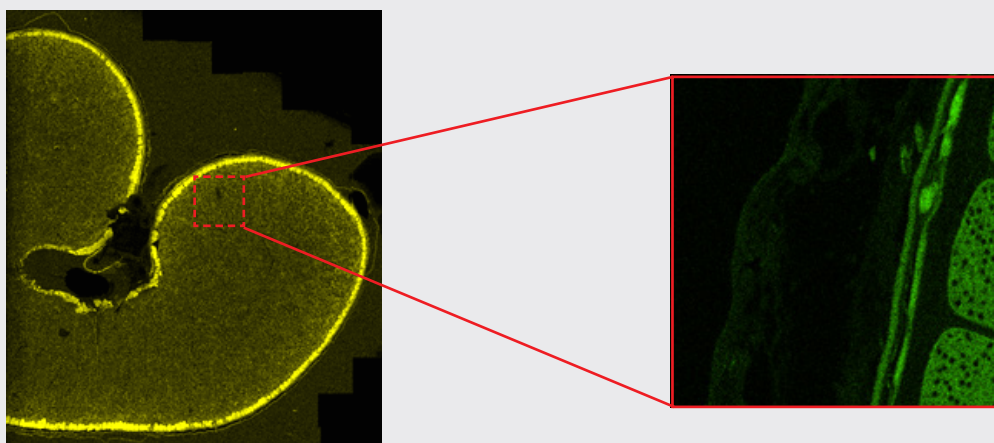## ▉ Operation

Each field can be observed in 'Zoom in' mode.

< An image mapping all components of an alloy sample >

< An image mapping all the wheat grains >
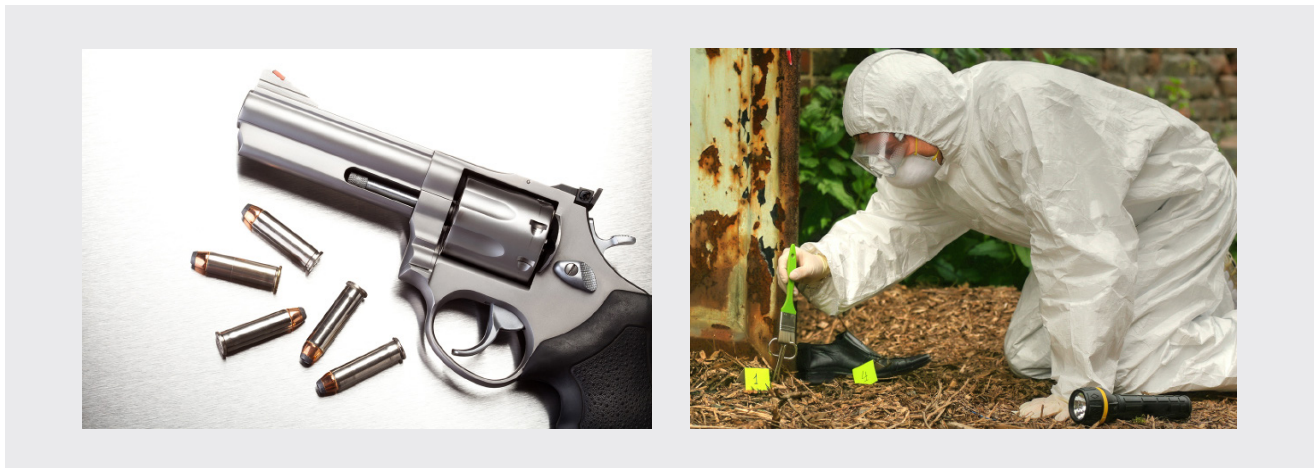
4) Gun Shot Residue (GSR) Analysis

This is an analysis method designed to detect remnants generated during a gun shot. The user can conduct the analysis by setting the conditions to analyze all the 42 detectable elements. This method is generally used in a Forensics application such as CSI (Crime Scene Investigation)

■ Benefits

Useful for forensic science.

Analysis Solution for:
- Scientific Investigation Industries

\<Cheminstry\>

Element	Wt %		σ
Barium	46.5	████████	1.61
Oxygen	21.5	███	1.26
Aluminum	12.1	██	0.652
Antimony	12.1	██	0.816
Lead	5.3	█	2.45
Sulfur	2.4	█	0.344

\<Morphology\>

Area(μm^2)	181.17
Aspect Ratio	1.07
Breadth(μm)	15.61
Direction(˚)	142.03
ECD(μm)	15.19
Length(μm)	16.68
Perimeter(μm)	63.31
Shape	1.76

5) Multi Layer Analysis

Identify the thickness of a specimen composed of multiple layers by using just an X-ray, without a special pretreatment.

◼ Benefits

Analysis Solution for:
-Material Industries
-Semiconductors and Electronics Industries

< An image showing the layers of a semiconductor sample >
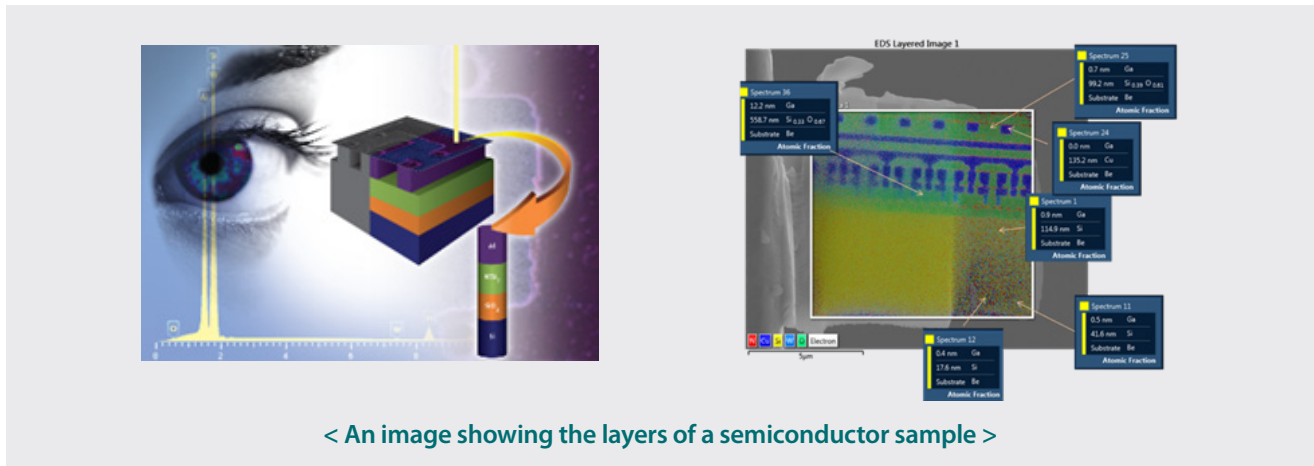
6) Mineral Map Analysis

For a mineral sample with multiple components, you can observe the distribution of each component with a mapping analysis.

◼ Benefits

Analysis Solution for:
- Sandstone Industries

< A mapping image for a mineral sample >

Perfect Table Top SEM for General Purpose

EM-30

COXEM

Features

- High Quality Images (5 nm resolution)
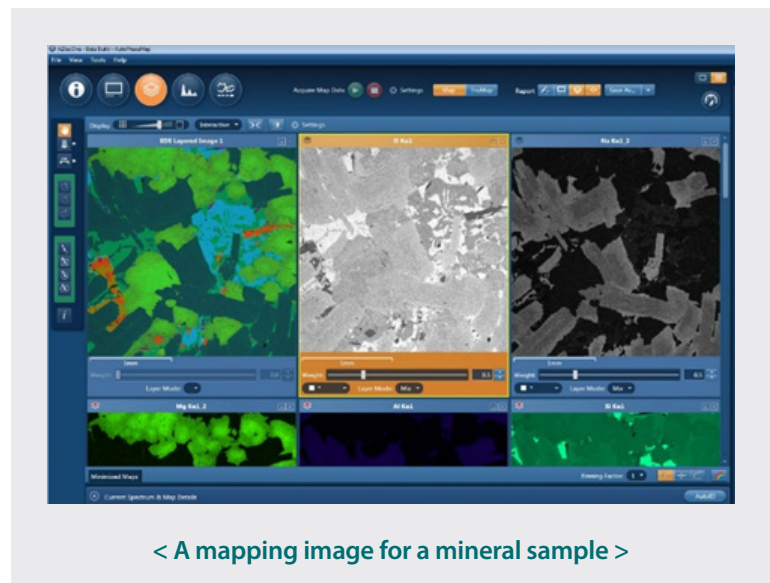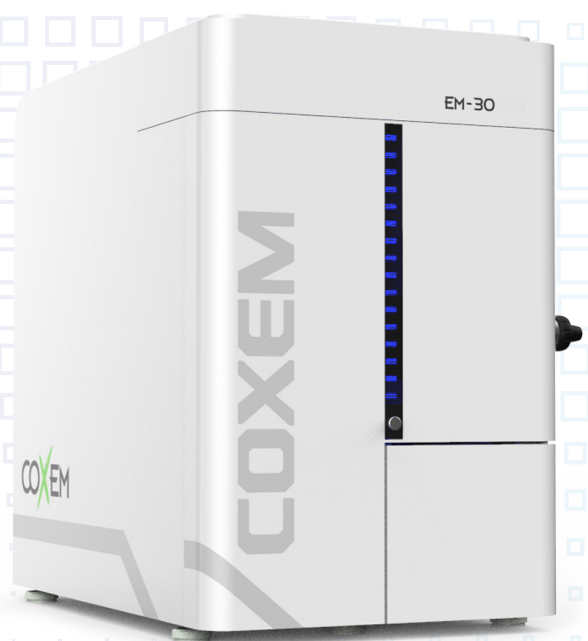- Magnification Up To 150,000x
- Easy Navigation with the "Navigation Mode"

- Precise Control with a Joystick and the "Driving Mode"
- Easy operation (Auto focus, Contrast, Brightness)
- Low Energy Consumption
- Intuitive User Interface

Specifications

- **Magnification :** x15 ~ x150,000
- **Acc Voltage :** 1-30 kV (1kV increments)
- **Electron Gun :** Tungsten Filament (W)
- **Detector :** SE Detector
- **Image Shift :** X, Y, R(Rotation)

- **Stage :** Auto Stage (X: 35 mm, Y: 35 mm, T: 0-45°)
          Manual Stage (Z: 5 to 50 mm)
- **Operating System :** Microsoft Windows 10
- **Dimensions :** 400(W) x 600(L) x 550(H) mm
- **Weight :** 85 Kg

Specifications

Items / Model	EM-30	EM-30AX	CX-200Plus
Resolution SE	5.0 nm at 30 kV		3.0 nm at 30 kV
Magnification	x15 ~ x150,000		x15 ~ x300,000
Accelerating Voltage	1 ~ 30 kV		
Vacuum Mode	High Vacuum		
	-		Low Vacuum (Optional)
EDS	Integrated (Optional)	Integrated (Standard)	External (Optional)
Maximum Specimen Size	60 mm in diameter		160 mm in diameter
Stage	3-Axes Motorized		5-Axes (Motorized)
X	0~35 mm		0~40 mm
Y	0~35 mm		0~60 mm
T	0~45°		-20~90°
Z	5~50 mm (Manual)		5~60 mm
R	360°　(Raster)		360°
Observation Area	40 mm in diameter		110 mm in diameter
Maximum Height	45 mm		55 mm
Electron Gun	Pre-centered Cartridge		
Source	Tungsten		
Detector	SE		SE
	BSE(Optional)		BSE
Control	Mouse		Mouse
	Keyboard		Keyboard
	Joystick		Joystick
Auto Image Adjustment	Auto Focus		
	Auto Brightness & Contrast		
	Auto Filament		
	Auto Start		
Special Features	Multiple Sample Holder		
	Panorama Shot		
	Dual Display(SE/BSE)		
	Signal Mixing(SE+BSE)		
	Line Profile		
	Image Processing		
	Measuring tool		
	Remote Access		
	Navigation View		CCD Camera
Options	EDS	-	EDS
	BSED		Low Vacuum
	Cool Stage		Cool Stage

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