C143-E013A

SHIMADZU
Excellence in Science

Electron Probe Microanalyzer

EPMA-8050G

Debut of the Grand EPMA

Featuring a Cutting-Edge FE Electron Optical System for the Ultimate in Advanced Shimadzu EPMA Analysis Performance

This instrument is equipped with a cutting-edge FE electron optical system, which provides unprecedented spatial resolution under all beam current conditions, from SEM observation conditions up to 1 μA order. Integration with Shimadzu's high-performance X-ray spectrometers achieves the ultimate advance in analysis performance.
Introducing the grand EPMA, the ultimate EMPA system.


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EPMA-8050G
ELECTRON PROBE MICROANALYZER


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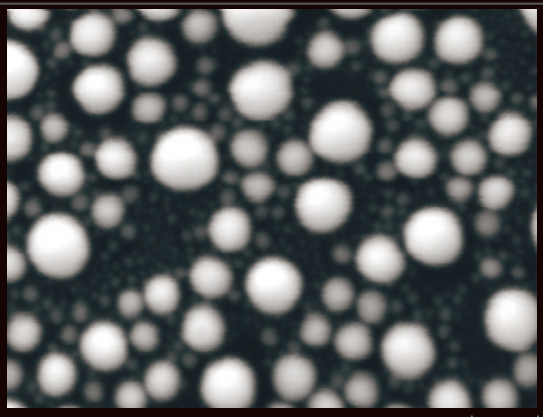
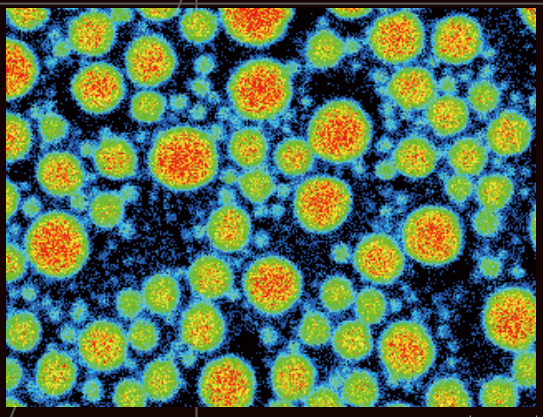
Ultra-High-Resolution Mapping

A mapping analysis of Sn balls on carbon was performed at a magnification of 30,000×. Even Sn particles a mere 50 nm in diameter, visible in the SE image (left), can be confirmed precisely in the X-ray image (right).



SE 500nm



Sn 500nm

The Benefits of Cutting-Edge Technology

Unprecedented Spatial Resolution

The secondary-electron image resolution of 3 nm (30 kV accelerating voltage) is the highest level for an EPMA system.
This is the ultimate secondary-electron image resolution under analysis conditions. (With an accelerating voltage of 10 kV, 20 nm at 10 nA / 50 nm at 100 nA / 150 nm at 1 μA)

Large Beam Current Enabling Ultra-High-Sensitivity Analysis

This system achieves a maximum beam current of 3.0 μA (30 kV accelerating voltage). There is no need to replace the objective aperture across the entire beam current range.

Up to Five High-Performance 4-Inch X-Ray Spectrometers Can be Mounted

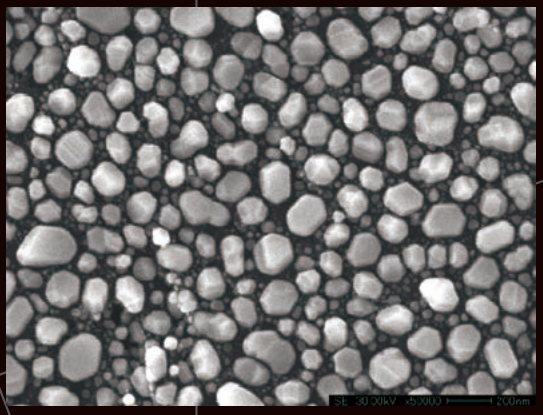
The 52.5° X-ray take-off angle is in a class by itself.
The 4-inch Rowland circle radius provides both high sensitivity and high resolution.
The system can accommodate up to five X-ray spectrometers of the same type.

Simple and Easy-to-Understand Operations for All Analyses

Advanced operability ensures that all operations can be performed with just a mouse.
The user interface is designed for ease of use.
Easy mode analysis automates all processes up to generating reports.

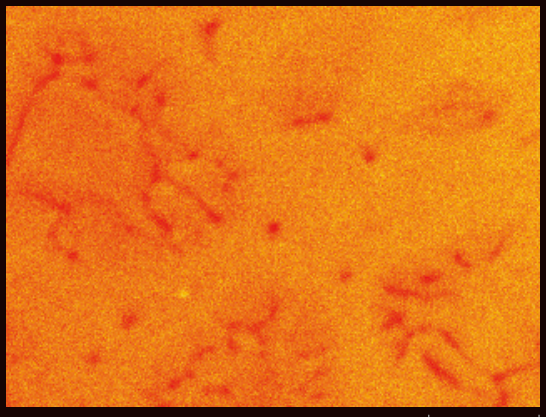
Highest Secondary-Electron Image Resolution of 3 nm

This is a sample observation of gold particle deposition on carbon. A maximum resolution of 3 nm (at 30 kV) is achieved. The beam is focused even at a comparatively large beam current, so a smooth, high-resolution SEM image is easily obtained.

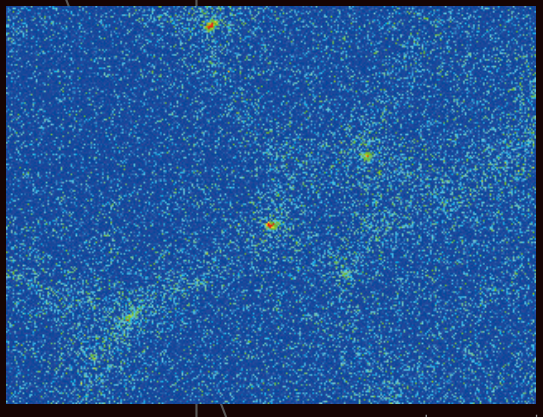


Ultra-High-Sensitivity Mapping

A mapping analysis of stainless steel was performed with a beam current of 1 μA at a magnification of 5,000x (Left). The distribution of phases with slightly different Cr concentrations is precisely captured (Right). The system succeeds in visualizing a distribution of Mn content under 0.1 %.



Cr 5μm



Mn 5μm

Advanced Technology Enabling Ultra-High-Sensitivity Analyses of Minute Areas

1 High-Brightness Schottky Emitter

A high output Schottky emitter with a larger tip diameter than ordinarily used in SEMs is adopted for the FE electron gun. A stable electron beam is obtained that while bright has the large current indispensable for high-sensitivity analysis.

2 Special EPMA Electron Optical System

The electron optical system has a proprietary configuration and control method (Japan Patent No. 4595778). The condenser lens is set as close as possible to the electron gun. Crossover is formed not with the condenser lens but with an iris lens, with the objective aperture arranged at the same position. While this is a simple lens configuration, a large current can be obtained. At the same time, the angular aperture can be optimally configured under all current conditions, minimizing the electron beam diameter. Naturally, there is no need to replace the objective aperture.

3 Ultra-High-Vacuum Evacuation System

A two-stage differential evacuation system has been adopted, partitioned at the orifices between the electron gun chamber, intermediate chamber, and analysis chamber. Minimizing the orifice between the intermediate chamber and analysis chamber limits the flow of gas to the intermediate chamber. The electron gun chamber is always maintained at an ultra-high-vacuum level, stabilizing emitter operation.

4 X-Ray Spectrometers with High Sensitivity

The system can be equipped with up to five 4-inch X-ray spectrometers, which provide both high sensitivity and high resolution.
The 52.5° X-ray take-off angle enhances the spatial resolution of the X-ray signal, while enabling high-sensitivity analysis with minimal X-ray absorption by the sample.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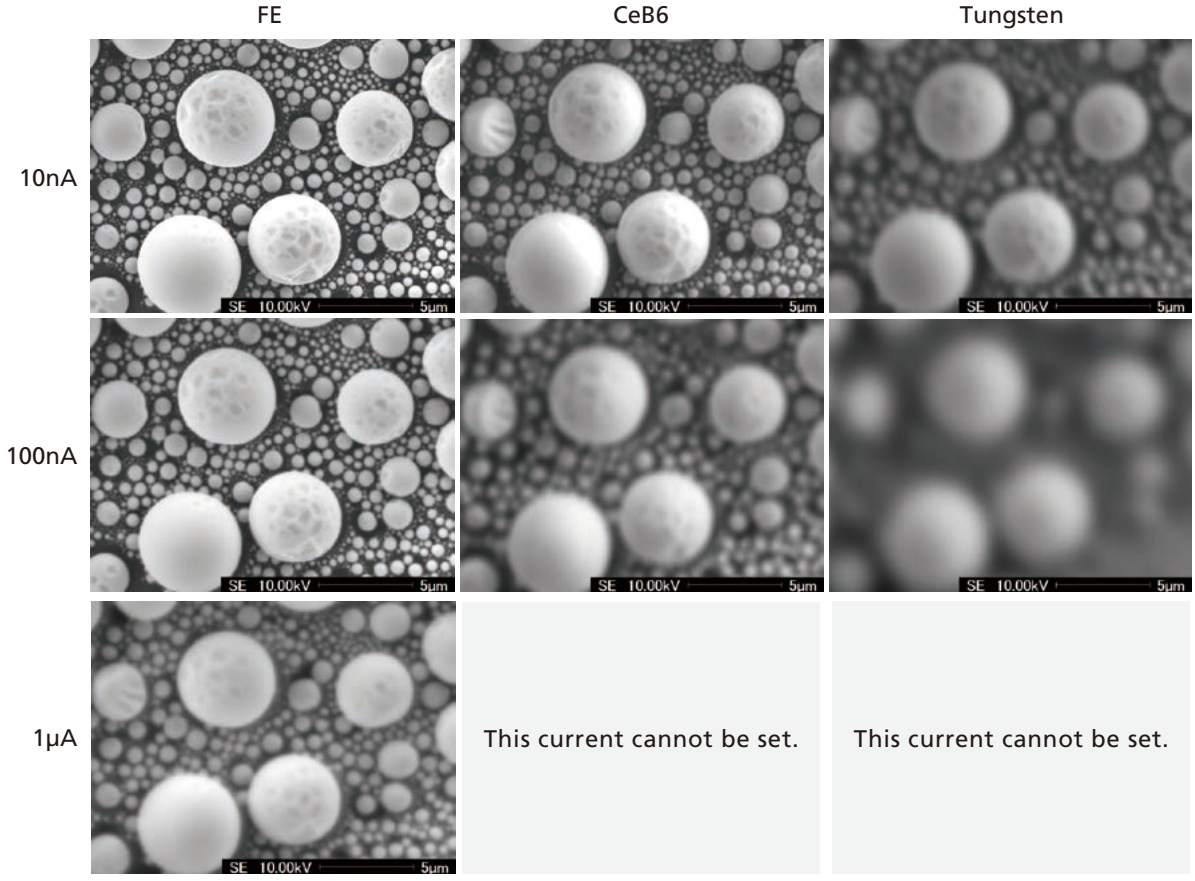
Unprecedented Spatial Resolution

The system offers the ultimate in secondary-electron image resolution under the beam current conditions used for analysis. (With a 10 kV accelerating voltage, 20 nm at 10 nA / 50 nm at 100 nA / 150 nm at 1 μA). The results are very clear in comparison to a conventional electron gun (CeB6, tungsten).
The same resolution image can be obtained with a dramatically larger beam current than with a conventional electron gun, so extremely high-sensitivity X-ray analysis can be performed.
A further point of interest is SEM imaging with a 1 μA beam current. Only the EPMA-8050G provides a beam current of at least 1 μA, and moreover, finely focuses the beam to this point.



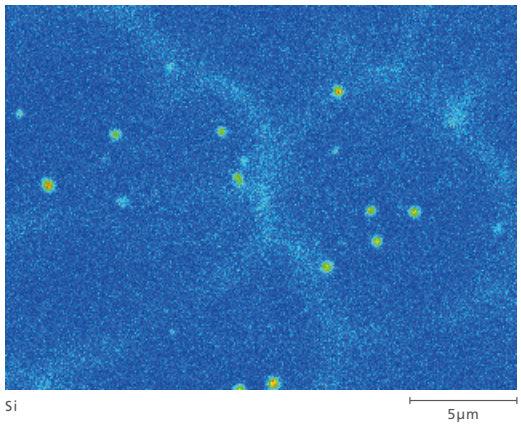
Comparison of Electron Gun Beam Characteristics (10 kV accelerating voltage)

Large Beam Current Enabling Ultra-High-Sensitivity Analysis

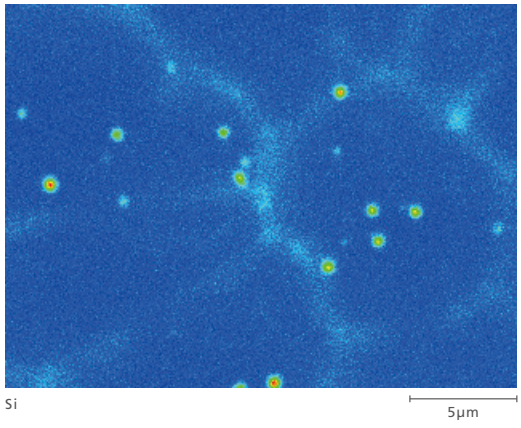
In SEM and EPMA with the FE type, the uniquely large beam current (up to 3 μA with a 30 kV accelerating voltage) dramatically enhances the detection sensitivity for ultra trace elements. This enables ultra-trace component imaging in element mapping.
In addition, there is no need to replace the objective aperture across the entire beam current range, so the analysis process can be fully automated, with no concerns about axis offset.
These three images show the results* of a mapping analysis of approx. 1 % Si in stainless steel, using different beam currents. The roughness decreases as the beam current increases, enabling the areas containing Si to be precisely identified.

* In all of the measurements, the accelerating voltage was 10 kV and the sampling interval was 50 msec. The measurements required approx. 1 hour.

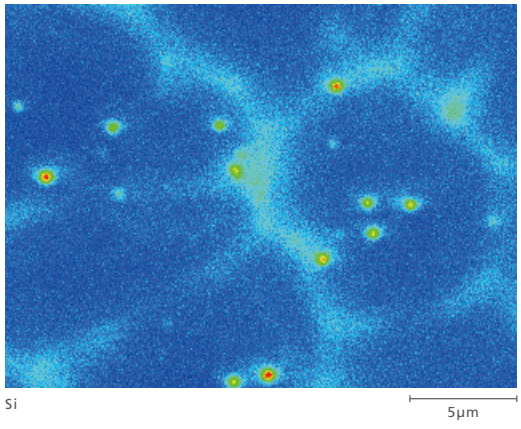
100nA



500nA

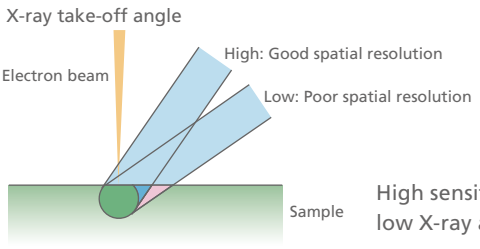


1.5μA

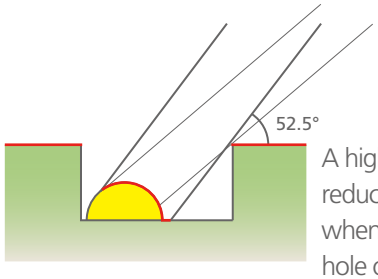


Up to Five High Performance 4-Inch X-Ray Spectrometers Can be Mounted

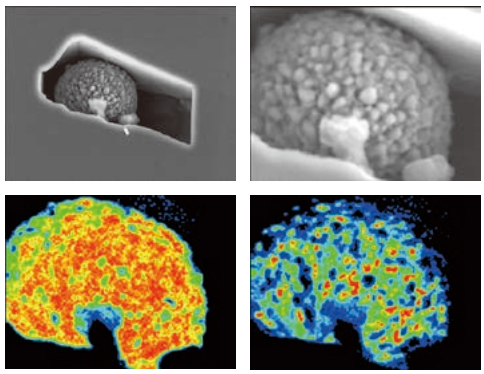
Maintains the 52.5° X-ray take-off angle that is fundamental to analytical performance.



High sensitivity caused by low X-ray absorption

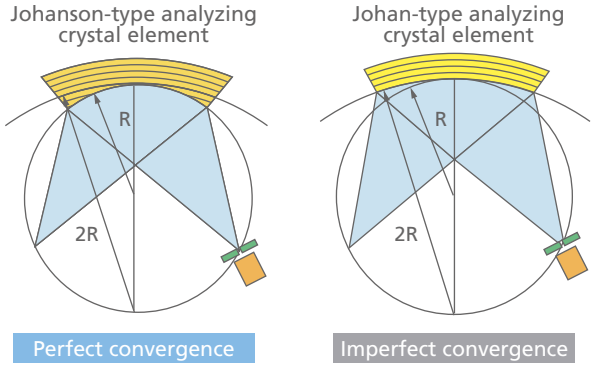


A high X-ray take-off angle reduces the absorption effect when the bottom of a deep hole or the foreign matter in a hole is analyzed for examples.



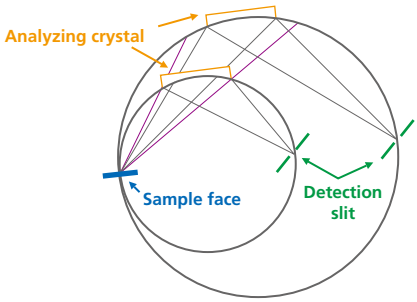
Analysis data for foreign matter in a pit. Bottom-left is the distribution of iron (Fe); bottom-right is the distribution of titanium (Ti). The high take-off angle used by the EPMA-8050G ensures highly accurate analysis of rough samples.

Johanson-type analyzing crystal achieves perfect convergence.



Shimadzu applied its unique crystal manufacturing expertise to offer analyzing crystals that deliver both high sensitivity and high resolution. The Johanson-type analyzing crystal achieves perfect convergence with no aberration.

EPMA-8050G accommodates up to five 4-inch spectrometers that offer both high sensitivity and high resolution.



The Rowland circle radius in the X-ray spectrometer is an important factor affecting an EPMA's analytical performance. Increasing the radius of the Rowland circle by one inch reduces the detection sensitivity by more than 30%. Shimadzu EPMA instruments accommodate up to five 4-inch spectrometers to cover the entire spectral range.

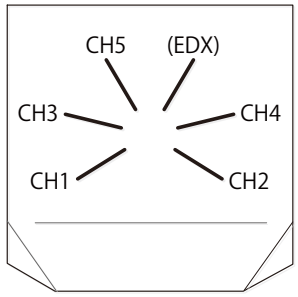
Spectrometer Configuration

Elements analyzed by each crystal and recommended spectrometer configuration

When multiple spectrometer channels are equipped, the optimal spectrometer element for the target must be selected from a large number of spectrometer elements.
Shimadzu's EPMA is designed to maintain optimal performance without replacing the objective aperture or otherwise changing the instrument parameters. The same philosophy was applied to the X-ray spectrometer, so that maximum sensitivity and optimal resolution are assured without the need to select the Rowland circle radius or replace the slit during analysis.

	Qualitative analysis	Quantitative analysis	Mapping/line analysis	State analysis
X-ray spectrometer providing good sensitivity and resolution (Shimadzu EPMA)	Supported	Supported	Supported	Supported
	* Only the Shimadzu EPMA spectrometer, which offers both good sensitivity and resolution, achieves optimal analysis conditions in all analysis modes.			
X-ray spectrometer emphasizing good sensitivity	Supported to an extent Peaks can overlap, causing incorrect evaluation.	Supported	Supported	Not supported More difficult to capture changes in wavelength.
X-ray spectrometer emphasizing good resolution	Supported to an extent	Not supported More difficult to reproduce peak intensity.	Not supported Greater sample surface effects; more difficult to maintain stable peak intensity over long periods.	Supported to an extent Difficult to detect small peaks.

Spectrometer Arrangement Diagram



Types of Crystals

Crystal name	2d value (nm)	Detector	Comments
LiF	0.401	Kr-EXA	*
PET	0.874	Kr-EXA	*
ADP	1.064	Kr-EXA	
RAP	2.612	FPC	*
PbST	10.02	FPC	*
LSA55	Approx. 5.5	FPC	For high-sensitivity analysis of O, F
LSA70	Approx. 7	FPC	For high-sensitivity analysis of O
LSA80	Approx. 8	FPC	For high-sensitivity analysis of N
LSA120	Approx. 12	FPC	For high-sensitivity analysis of C
LSA200	Approx. 20	FPC	For high-sensitivity analysis of B
LSA300	Approx. 30	FPC	For high-sensitivity analysis of Be

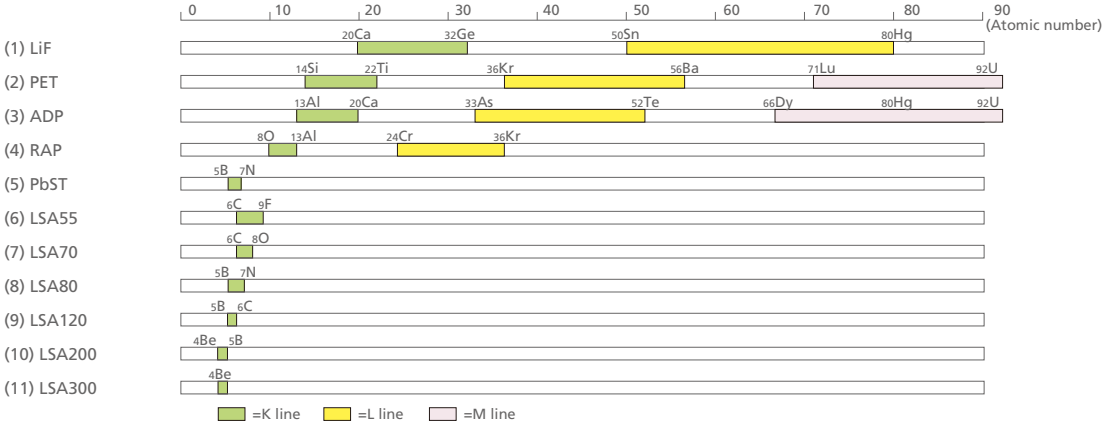
Combinations of analyzing crystal marked * support analysis from 5B to 92U.

Examples of Analyzing Crystal Combinations

Spectrometer No.		2 CH specification	3 CH specification	4 CH specification	5 CH specification	
					Mainly heavy elements	Mainly light elements
1CH	Main	RAP			RAP	RAP
	Sub	PbST	RAP	RAP	LSA120	LSA120
2CH	Main		PbST	LSA120	PbST	PbST
	Sub			PbST	LSA70	LSA70
3CH	Main	LiF		LSA70	LiF	LiF
	Sub	PET	LiF	LiF	PET	PET
4CH	Main		PET	PET	LiF	LiF
	Sub		LiF	LiF	ADP	ADP
5CH	Main		ADP	ADP	LiF	LSA120
	Sub				PET	LSA200

* No analyzing crystal combination is subject to sample stage drive range restrictions, option restrictions, or other restrictions.

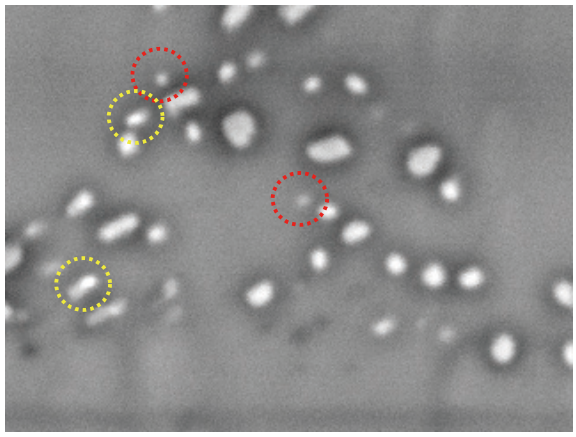
Spectral Range of Analyzing Crystals

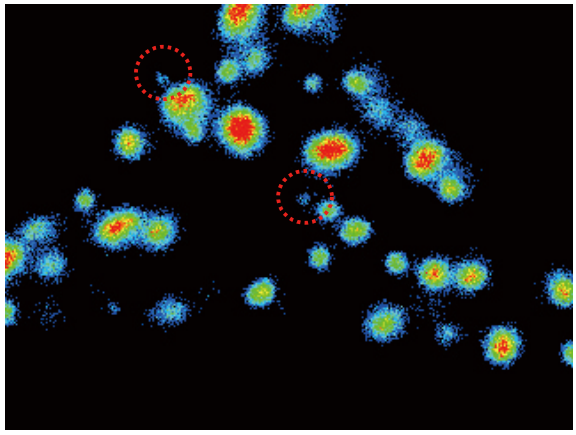


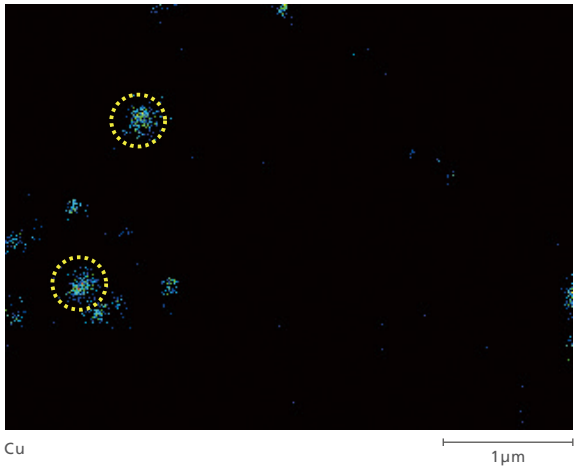
Applications

Distribution of Ag and Cu in Lead-Free Solder

This data is from a mapping analysis of areas in lead-free solder containing a large amount of Ag. (Accelerating voltage: 10 kV; beam current: 20 nA) The shape of the particles in the Ag X-ray image agrees well with the shape of the particles in the BSE image (COMPO). It is evident that the particles with a diameter of about 0.1 µm, indicated by the red dashed lines, are also Ag particles. In addition, the existence of Cu-containing particles can also be confirmed, as shown by the yellow dashed lines.

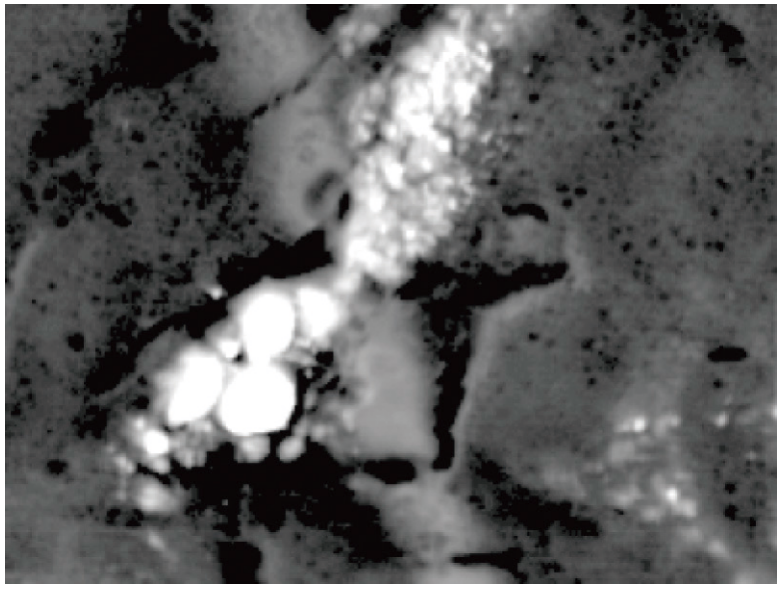


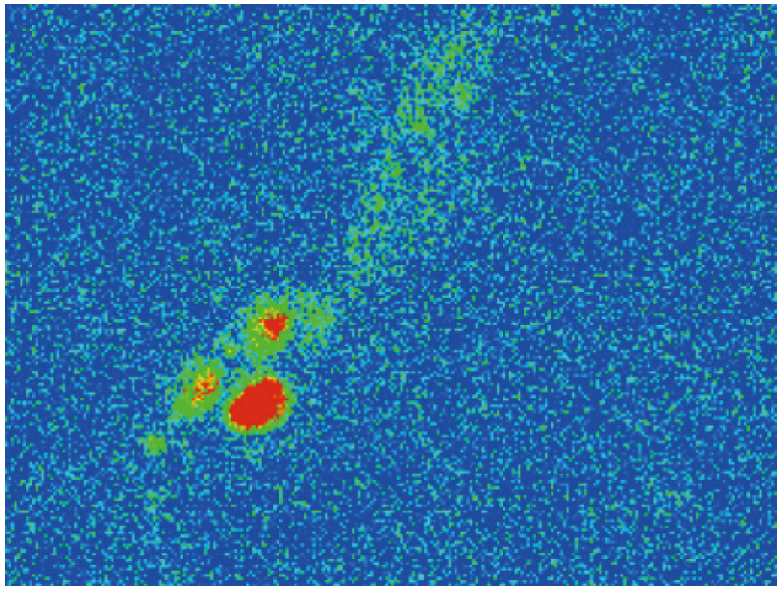




Metallic Elements in Biological Tissues (DDS)

This EPMA element imaging data shows the existence of platinum (Pt), a component (platinum complex) of the anticancer drug carboplatin, delivered (by a DDS) into the tissue of a head and neck tumor in a mouse.
By binding with DNA strands, the genetic substance inside the cancer cells, the carboplatin prevents cell division (DNA replication), destroying the cells. The element imaging clearly shows the manner in which the anticancer drug is delivered within the cancer cells.

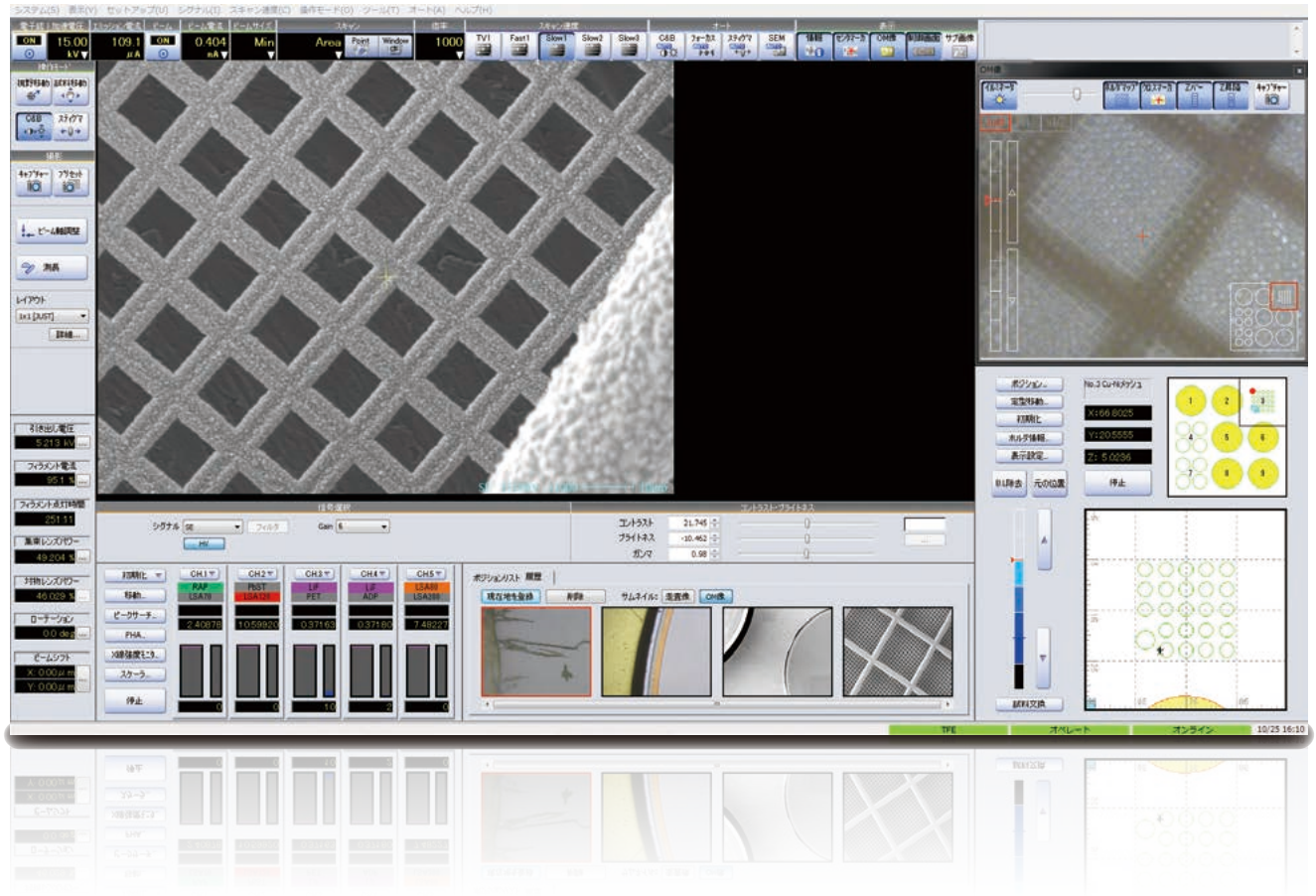




Simple and Easy-to-Understand Operations for All Analyses

This system is equipped with a number of new functions to enable simple and easy-to-understand operations. These include advanced operational performance, with all operations controlled using just a mouse, as well as an easy-to-understand user interface and a built-in easy analysis mode. While easy enough for even novices to use, it also supports sophisticated analysis by experienced users.

- Easy operations for everything from sample mounting to report generation
- Even novices can easily perform everything from sample searching to SEM imaging
- Unprecedented operability dramatically heightens operational efficiency prior to the start of the analysis
- The user interface has been designed in a visual, easy-to-understand format
- Equipped with an easy analysis mode that automates all processes up to generating reports



1 First, on the App store or on the Google Play store, please search for "XAR" then download the application.

XAR

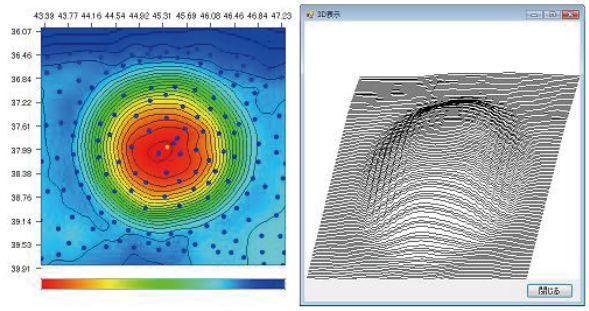
2 When the application is launched, AR information will be retrieved from the QR code.

<Notification concerning communication fee>
The use of the "xAR" application is free. However, the application download and packet communication fees for browsing content are customer charges.

3 Hold your smartphone over the image above.

Trace Mapping Analysis

Trace functions can be added to standard mapping analysis. For samples with surface irregularities or inclination, when the height changes as a function of the X-Y position, the sample's Z axis height can be corrected, enabling high-accuracy mapping analysis in which reductions in signal intensity are minimized. This feature is achieved by minutely controlling the stage's Z axis coordinates during the analysis, based on height data obtained beforehand from multiple points. The trace surface found from the configured height data can be confirmed via contour lines and 3D displays.



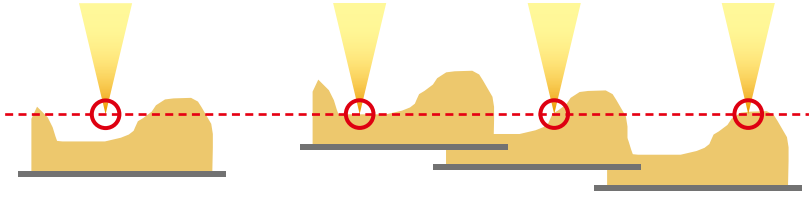
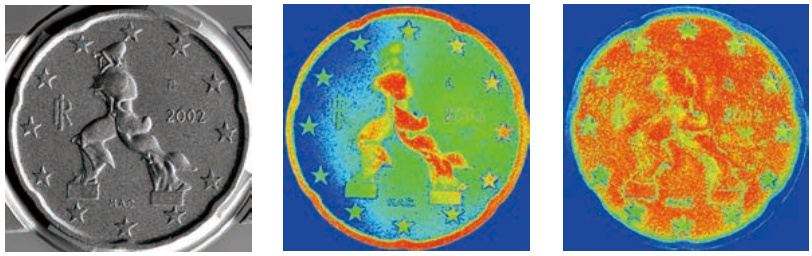


Illustration of the Basic Principle

● Mapping Analysis Results

Example of a sample 20 cent coin: Cu mapping

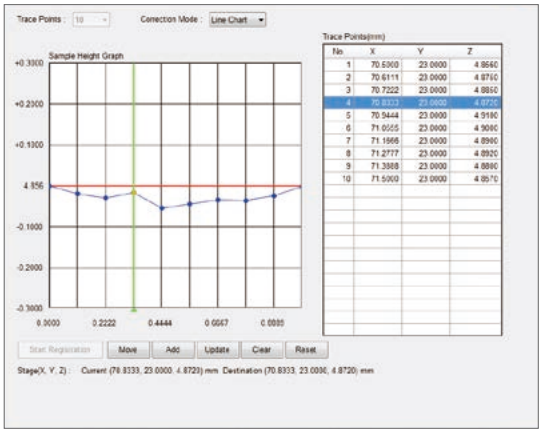


Topographical image | No trace applied | Trace applied

A more correct elemental distribution is obtained by using the trace.
*The trace is centered on the figure and periphery. The stars and the border are not targeted.

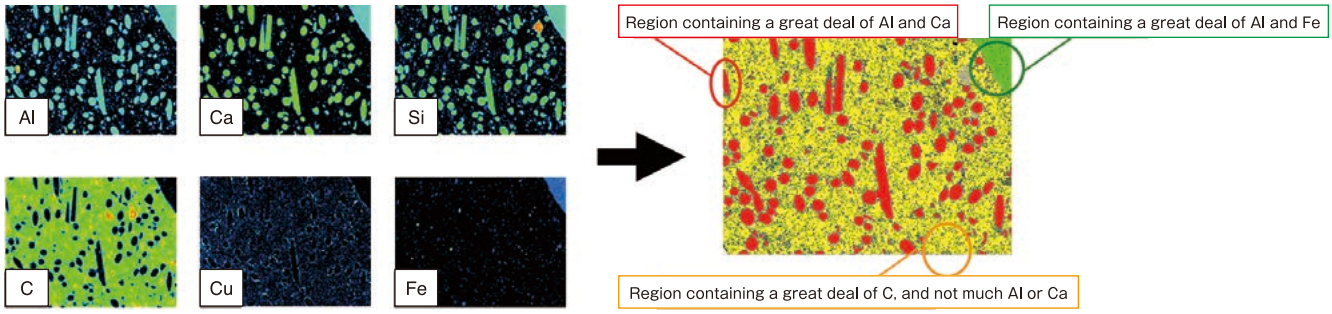
Trace Line Analysis

As with trace mapping analysis, trace functions can be added to a standard line analysis.



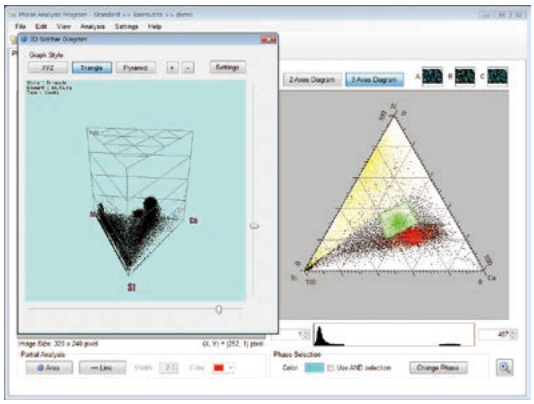
Phase Analysis Program

A scatter diagram is created with the 2D or 3D correlations obtained from mapping data for each element. Regions featuring a particular relationship between elements are displayed in different colors.
In addition, multiple scatter diagrams can be displayed simultaneously, enabling the observation of correlations between multiple elements.

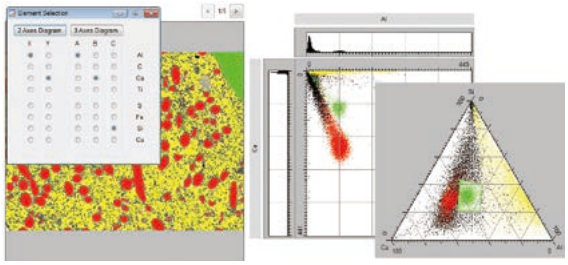


Features

By creating a 3D image of the scatter diagrams, it is possible to observe the correlation from a variety of observation points.

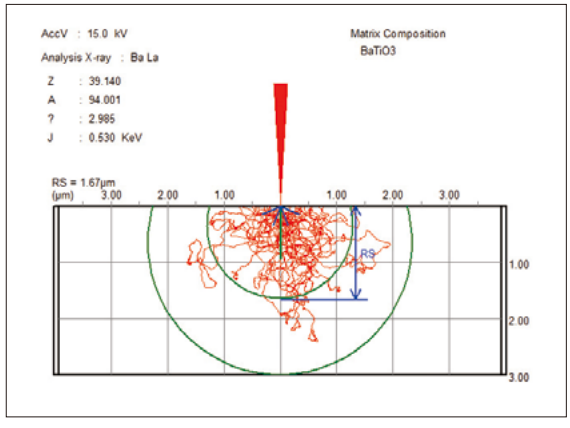


Multiple correlations can be analyzed while switching between elements and scatter diagrams.



Electron Beam Penetration Domain

It is possible to simulate the analysis depth and width of the irradiating electron beam penetrated from the surface of the sample. The X-ray penetration domain can be calculated by using either the electron range method, with which the electron beam diffusion size and the analysis domain are found, or the Monte Carlo method, which follows individual electron trajectories to obtain the total electron trajectory (penetration domain).



Other Options

EPMA Spectra Collection

This qualitative spectral data collection consists of actual measurements of 76 elements including metallic compounds and standard compound samples. When difficult determinations are needed in qualitative analyses of samples containing complicated elements and trace elements, results can be confirmed through comparison with actual spectral peaks.

External PC Software

This software enables the same type of data processing on an external PC as on the EPMA host PC. By connecting with the host PC over a network, not only can you review acquired data in the host PC, but you can also download the data for analysis or upload analyzed data to the host PC.

Air Compressor

The EPMA-8050G uses separate compressed air sources to drive the air valves and air dampers. This quiet air compressor is available for both.

Cooling Water Circulation Unit

The excellent cooling water circulation unit used to cool the electron optical system in the EPMA-8050G is a low-vibration, stable-temperature model.

Ion Pump Backup Power Supply

In the event that the system is shut down by an unexpected power outage, or the system must be shut down completely due to a power outage from facility maintenance, the internal battery can continue to run the ion pump for several days. This maintains the ultra-high-vacuum in the electron gun chamber.

Special Accessories (By Separate Arrangement)

- Transmitted Polarization Observation System
- Sample Rotation Stage Kit
- Sample Holders
- Large Specimen Stage (L Stage)
- Cathodoluminescence Spectrometer
- X-Ray Generation Indicator Lamp
- Interface (for energy dispersive X-ray spectrometer)
- Emergency Machinery Stop Button

Specifications

Electron Optical System		
Electron Source		Schottky emitter
Secondary-Electron Image Resolution		3 nm (30 kV accelerating voltage)
Analysis Conditions for Secondary-Electron Image Resolution		(10 kV accelerating voltage) 20 nm (10 nA beam current) / 50 nm (100 nA beam current) / 150 nm (1 μA beam current)
Accelerating Voltage		0.5 kV to 30 kV (in 0.1 kV increments. At 5 kV or less, can be set in 10 V units.)
Beam Current		0.2 nA to 3 μA (30 kV accelerating voltage)
Beam Current Stability		±0.3 %/h (Beam current: 50 nA, accelerating voltage: 10 kV)
Magnification		40× to 400,000×
Maximum Pixel Size for Saved Images		5,120 × 3,840
Back-Scattered Electron Detector		4-block, semiconductor detector
Objective Aperture		Selection not required
Observation Optical System		
Resolution		1 μm (for observation with the naked eye)
Field of View		Approx. 600 μm dia. (for observation with the naked eye), approx. 480 μm × 360 μm (on a computer screen)
Subject Depth		4 μm
Sample Stage System		
Maximum Sample Dimension		100 mm × 100 mm × 50 mm^t
Maximum Sample Weight		2kg
Maximum Stage Drive Range		X,Y : 90mm Z : 7mm
Minimum Feed Distance		X,Y : 0.02μm Z : 0.1μm
Maximum Stage Drive Speed		X,Y : 15mm/sec Z : 1mm/sec
X-Ray Spectrometer System		
Analyte Elements Range		$_4$Be〜$_{92}$U
Number of X-Ray Spectrometers		2 to 5 channels
X-Ray Take-Off Angle		52.5°
Rowland Circle Radius		4 inch (101.6 mm)
Evacuation System		
Vacuum Level	Analysis Chamber	1.0 × 10^{-3} Pa max.; Electron Gun Chamber
	Chamber	3.5 × 10-7 Pa max.
Evacuation Pump	Turbomolecular pumps	One unit for main evacuation; one unit for preliminary evacuation
	Rotary pumps	One unit for main evacuation; one unit for preliminary evacuation
	Ion pumps	Two units for the electron gun chamber; one unit for the intermediate chamber
Vacuum Detection		Penning gauge, Pirani gauge, and ion gauge
Automated Functions		Automatic evacuation (main chamber evacuation, shut-down, sample loading chamber evacuation), safety operations via error detection
Computer System		
PC		PC/AT compatible; main memory 8 GB or more; HDD 1 TB or more
Display		23-inch touch panel LCD (Full HD, 1,920 pixels × 1,080 pixels), two monitors
OS		Windows 7
Analysis Software		
Analysis Mode		Qualitative analysis, mapping analysis, quantitative analysis, calibration curve analysis, state analysis, line analysis
Automated Analysis		Auto sequence analysis, easy mode analysis
Operation Support		Data browser, report function, instrument monitor
Management Functions		Environment set-up program
Observation Software		
Control Functions		Electron optical system control, observation system control, sample stage control, X-ray spectrometer control, evacuation system control
Automated functions		Auto focus, auto stigma, auto contrast/brightness, filament automatic saturation, automatic beam current settings

Installation Requirements

Ambient Conditions

- Temperature 18 °C to 28 °C
  (Provide an air conditioning system to control temperature fluctuation within ±1 °C.)
- Humidity 30%RH to 60%RH
- Heat Generation Rate When used with natural cooling water discharged: Approx. 3 kW
  When used with cooling water circulation unit: Approx. 6 kW (including heat generated by that unit)

Installation Room

- Floor Area 3 m × 4 m min.
- Door Width: 1.25 m min., height: 1.8 m min.

Power Requirements

- Analyzer Single phase 200 V AC ±10%, 30 A, 50/60 Hz, 1 circuit
- PC Single phase 100 V AC ±10%, 15 A, 50/60 Hz, 1 circuit

Grounding Resistance

- 100 Ω max.

Cooling Water

(2 systems required)

- Water Supply Water pressure: 0.12 MPa to 0.18 MPa
  Water temperature: 20 °C to 25 °C
  Flow rate: 3.5 L/min min. (for DP)
  and 0.7 L/min min. (for objective lens)
  Faucet outer diameter: 11 mm (2 faucets required)
- **Water Drainage** Natural drainage (same height as floor)

Gas

- PR Gas Mixture of 90% Ar (Argon) and 10% CH_4 (methane)
  Pressure: 1 kPa to 3 kPa
  Flow rate: 10 mL/min to 14 mL/min
  Connection port: Connect a gas cylinder filled to the following specifications.
  Gas filling pressure: 15 MPa max.
  Cylinder port : W22 - 14 right-handed male screw
- Compressed Air Prepare the following compressed air sources for driving the air valves and air dampers. (Two systems)
  Pressure: 0.45 MPa to 0.6 MPa; connection port: Rc 1/4
- Dry Nitrogen Gas (EPMA-1720H only. Recommended for purging electron gun when using CeB_6.)
  Pressure : 0.08 MPa to 0.1 MPa
  Connection port: Joint for tube with 6 mm diameter

Vibration and Stray Magnetic Fields

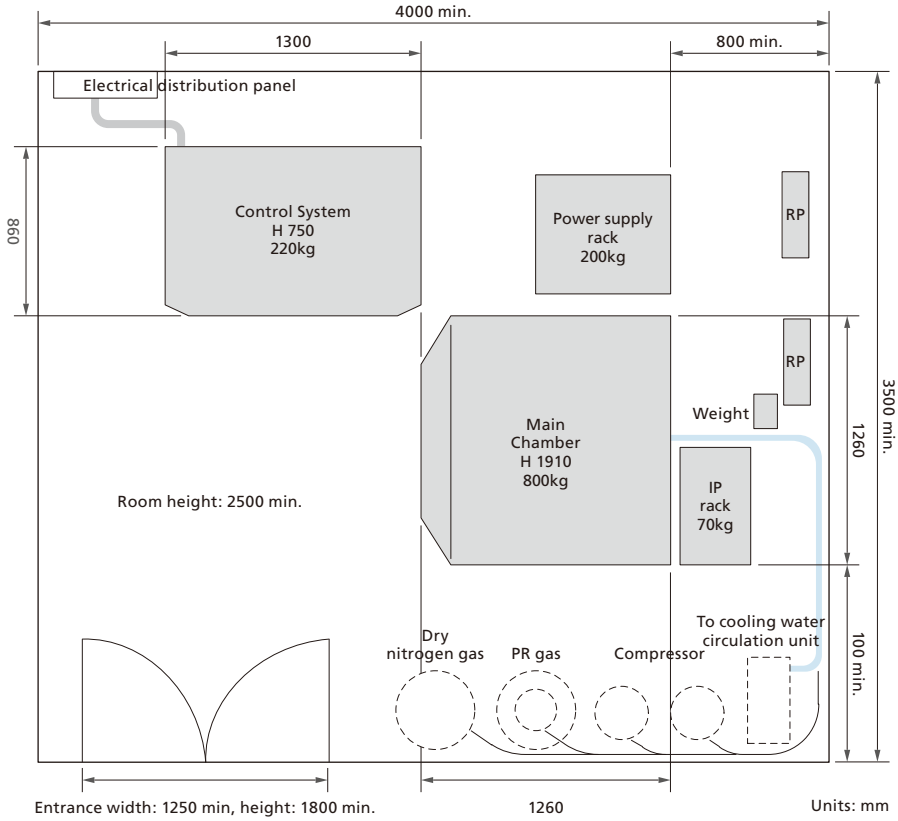
Indicated in the Pre-Installation Requirements. For more information, contact your Shimadzu representative.

Laws and Regulations

To prevent X-ray radiation accidents, safety regulations and standards for devices equipped with X-ray generators have been established in each country. Observe the laws and regulations for X-ray generators that are applicable in the country where the product is used. For notifications on installation and safety controls, follow the necessary procedures in compliance with the laws and regulations applicable in the country where the product is used.

(1) Rated output: 30 kV, 0.2 mA max.
(2) External (surface) exposure rate: 1 μSv/h max.

Layout Example



Note) Parts shown in broken lines are not included in the standard configuration.

EPMA-8050G

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