

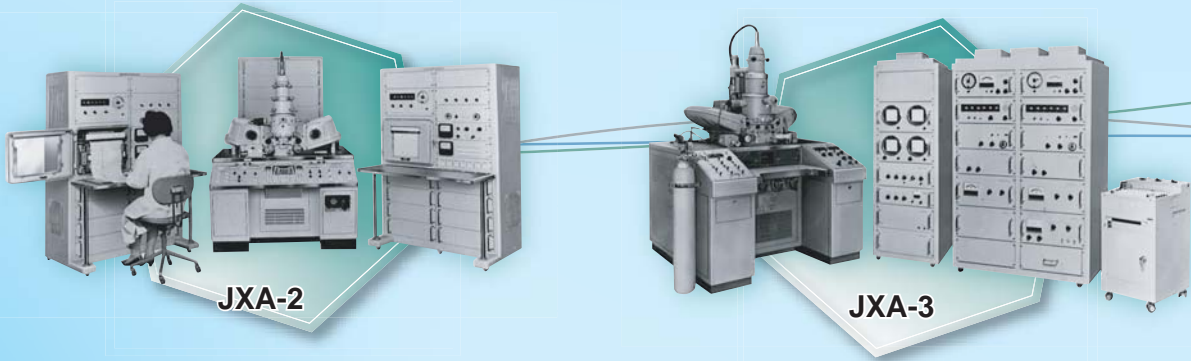
# JXA-8230

Electron Probe Microanalyzer

**JEOL**

*Serving Advanced Technology*

Since  
1961



JXA-2

JXA-3

# New SuperProbe with PC-Based Operating System A Powerful EPMA Analytical Tool for Diverse Applications

JEOL has developed a new EPMA (Electron Probe Microanalyzer), that continues a long history of half a century. The JXA-8230, designed for user-friendly operations, provides for a complete range of applications with a PC-based interface. The high-accuracy and fast speeds offered by the JXA-8230 are a result of its sophisticated EPMA technologies refined over nearly 50 years. The JXA-8230 is a powerful, next-generation, analytical tool for a wide range of applications as an EPMA.

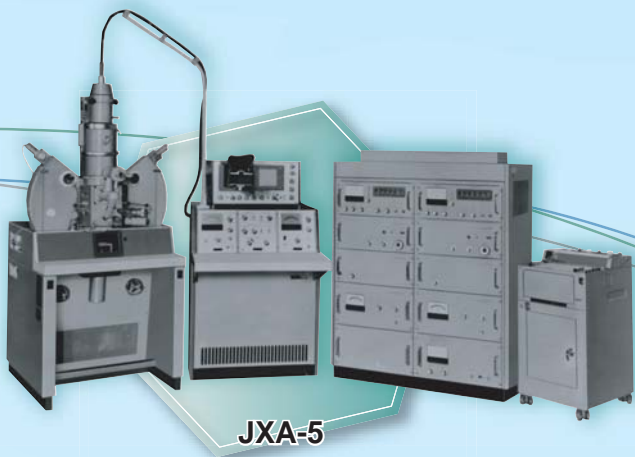


JXA-8230

Since  
2008



JXA-8100  
JXA-8200



# g Environment se Research Needs

EPMA development extending over nearly a  
analyses through a new, simple to use, PC-  
histicated hardware developed from JEOL's  
tool that fully meets all of the requirements of



**FE-EPMA**

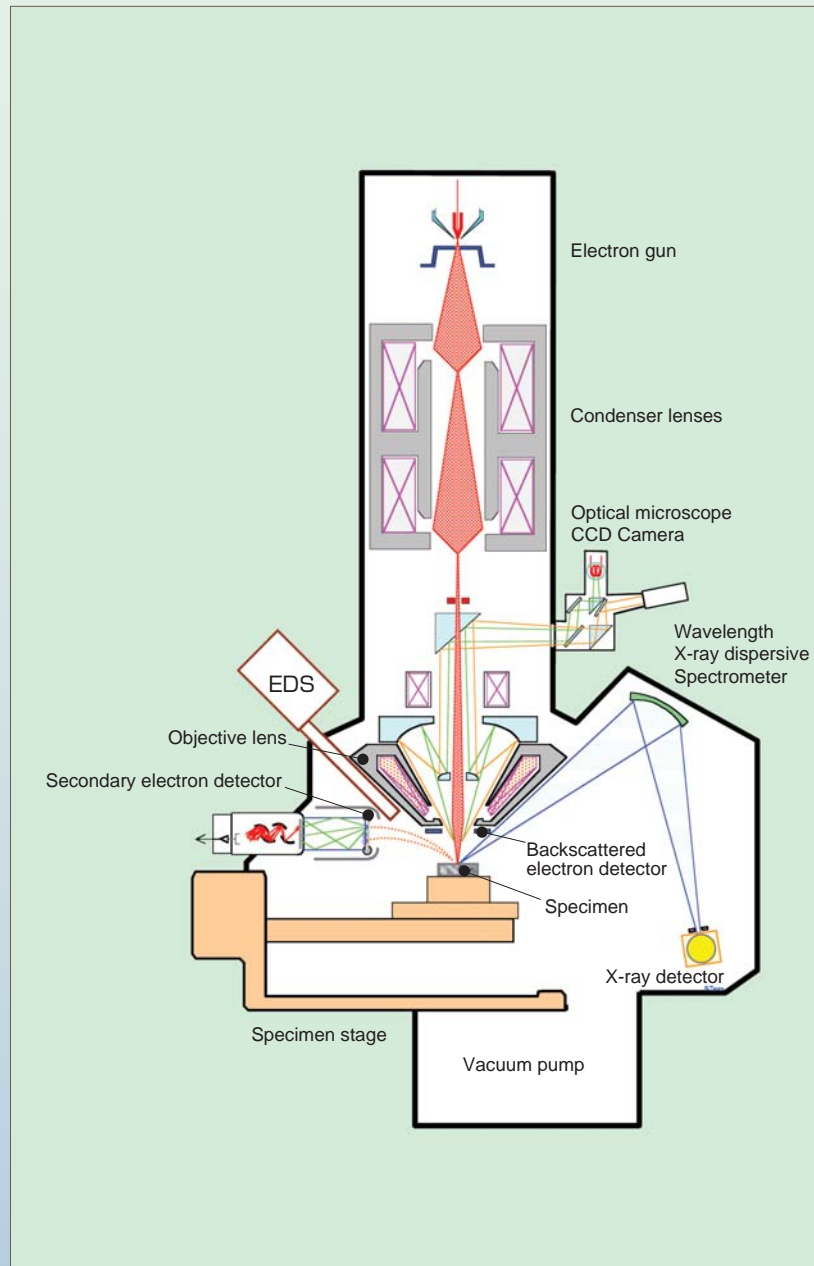
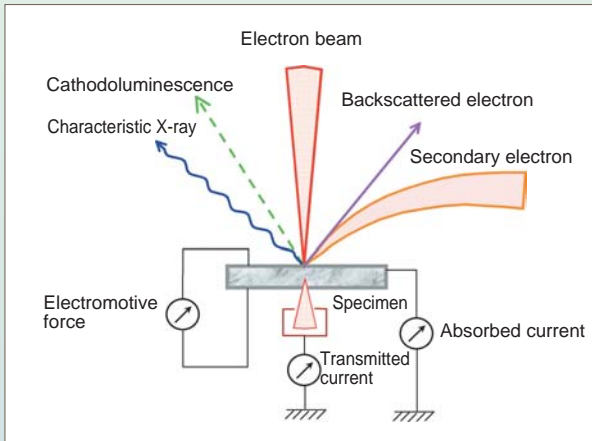
Since  
2003



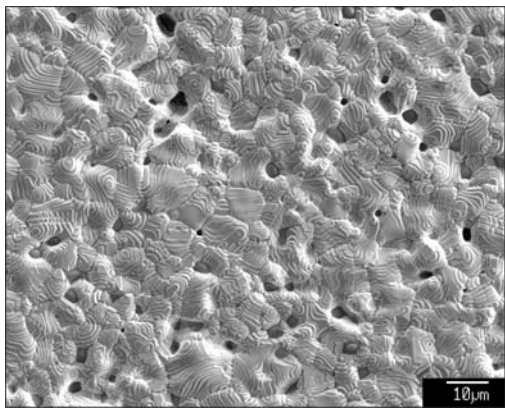
**Tungsten  
/LaB<sub>6</sub> Electron  
Gun**

# Multi-Functional, High-Accuracy EPMA Analyses

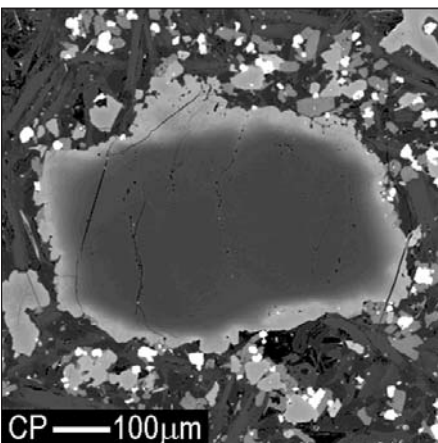
The accelerated electron beam irradiates the specimen to generate characteristic X-rays, secondary electrons, backscattered electrons and a range of other signals. The EPMA detects these signals allowing for imaging of the specimen, performing qualitative and quantitative analyses, and for element mapping in both micro- and macro-size areas.



Secondary electron image (SEI)

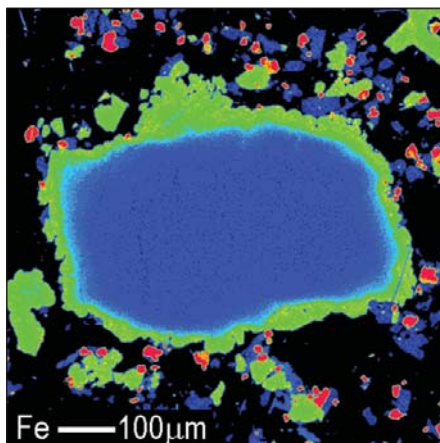


Backscattered electron image (BEI)

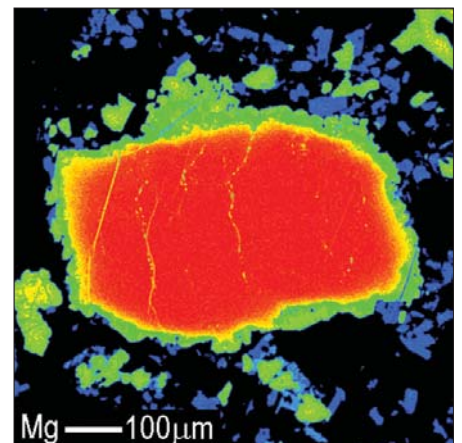


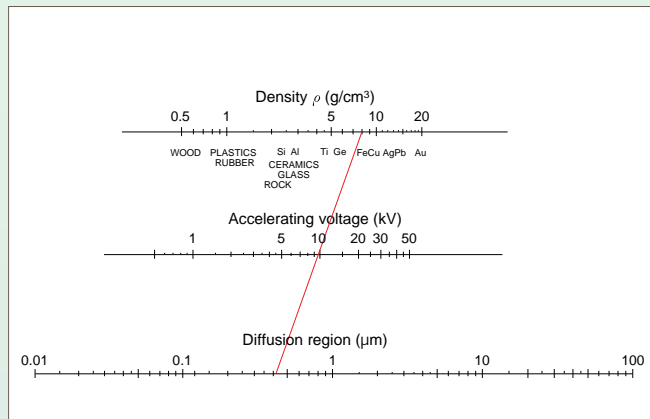
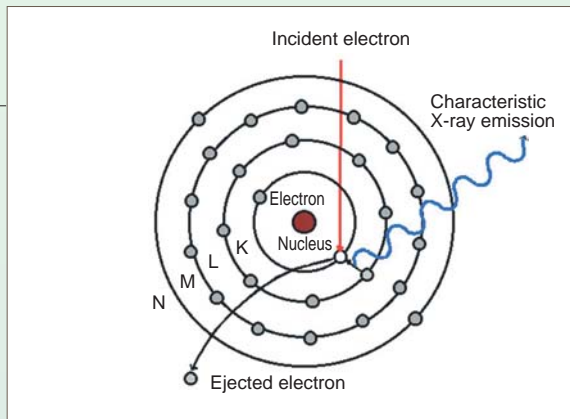
Composition image

Fe-K $\alpha$  color map

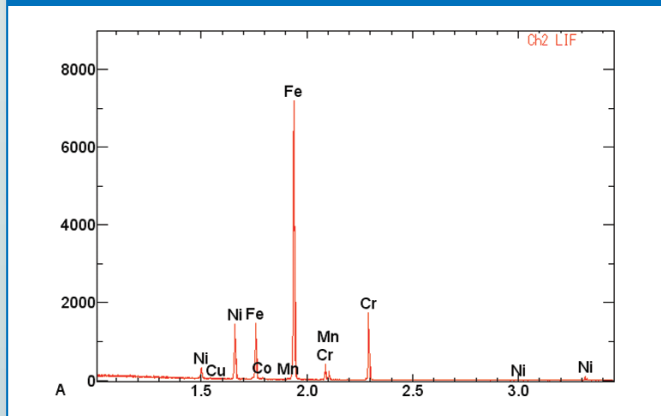


Mg-K $\alpha$  color map

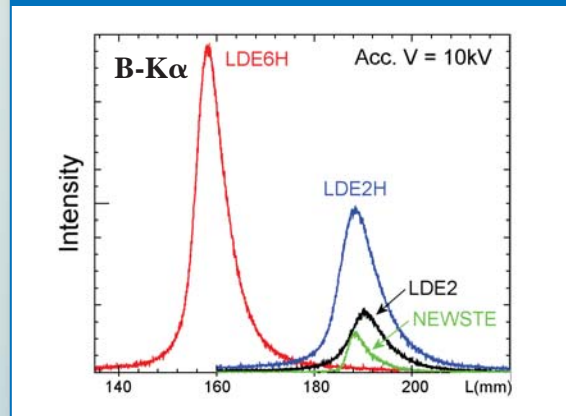




### Automated qualitative analysis



### Light element detection



### Quantitative analysis

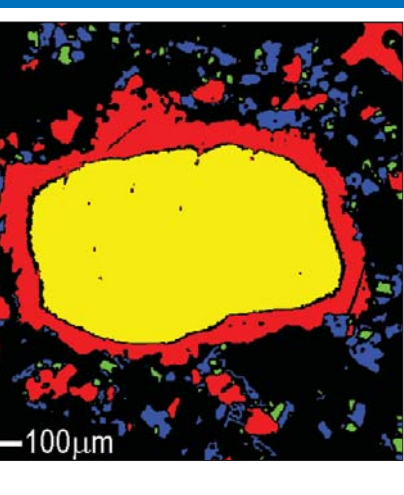
ZAF Metal Element	Mass(%)	Atom(%)	K(%)	ZAF	Z	A	F
Si	0.755	1.4772	0.499	1.4670	0.8921	1.6444	1.0000
Cr	19.709	20.8151	21.341	0.8951	1.0039	1.0058	0.8865
Mn	1.965	1.9647	1.875	1.0159	1.0218	1.0021	0.9921
Fe	66.497	65.3871	63.760	1.0108	1.0024	1.0187	0.9899
Co	0.427	0.3982	0.399	1.0370	1.0224	1.0143	1.0000
Ni	10.646	9.9577	9.919	1.0402	0.9865	1.0545	1.0000
Total	100.000	100.0000	97.794	Iteration = 4		Norm. F = 1.032	

### BEI LDF mode

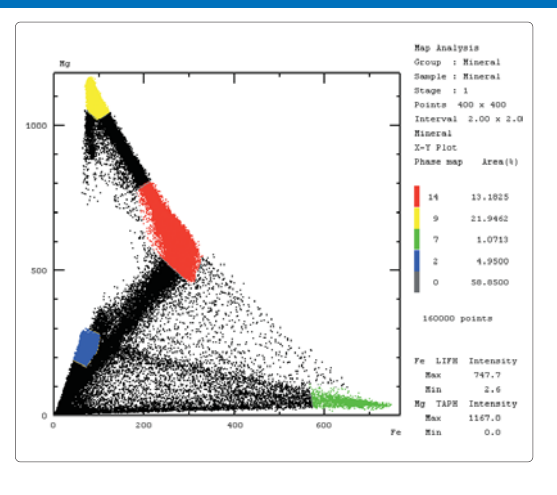


- Multi-mega pixel
- Montage image
- LDF mode

### Phase map

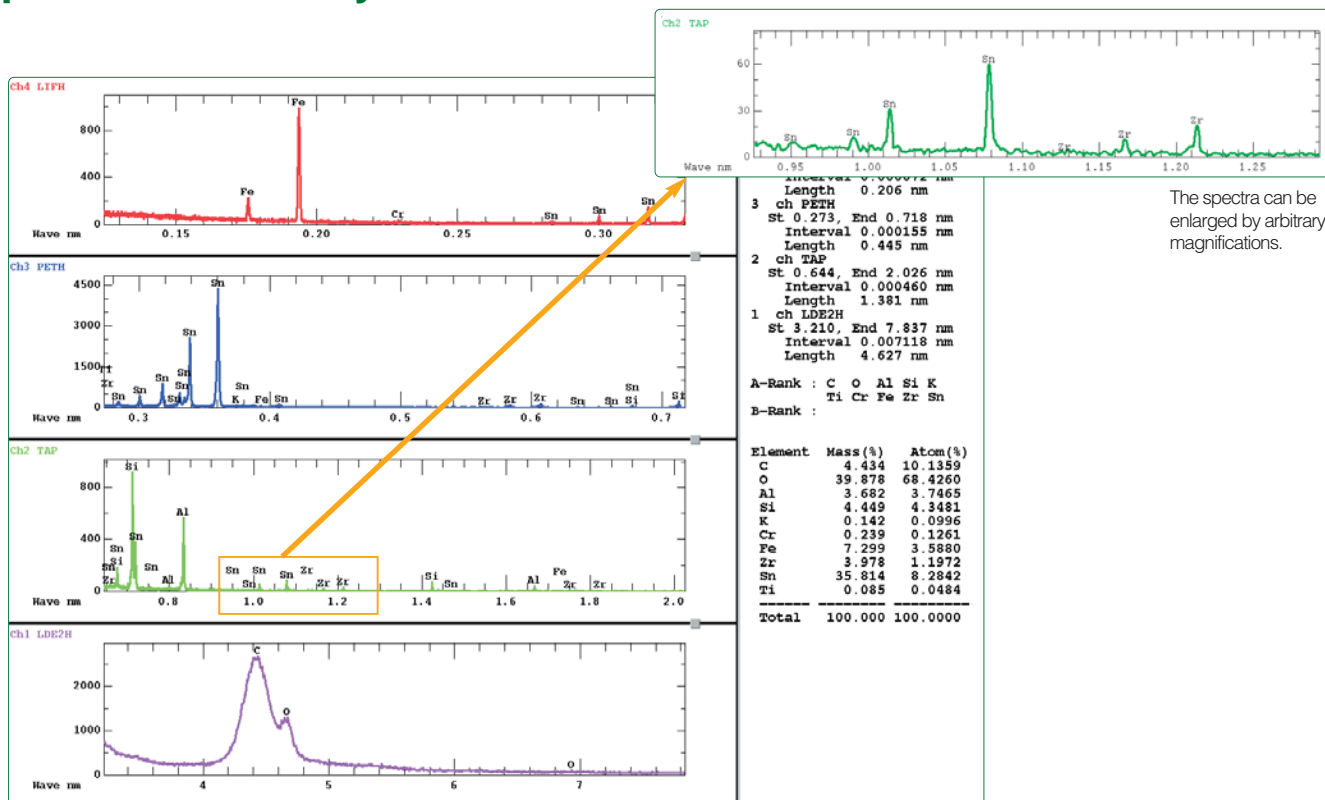


### Phase analysis



# Powerful Analytical Tools

## Automated qualitative analysis and standardless quantitative analysis



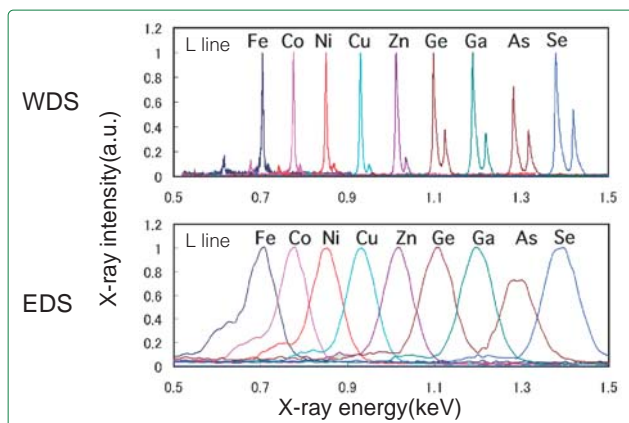
Qualitative analysis results of ceramics.

The results from automated element identification and standardless quantitative are displayed in a single window.

- The use of independent high-speed spectrometers and high-sensitivity analyzing crystals allows for a very fast analysis that can be completed in one minute.
- Elements are identified by the well-respected AI (artificial intelligence) function.
- The results of standardless quantitative analysis are automatically output immediately after the element identification.
- The exclusion mode can exclude elements in the coating; thereby outputting the results of the standardless quantitative analysis absent of these elements.
- The Point & Click Analysis function allows for easy operation, simply by specifying an analysis point on the SEM image.
- The use of a Periodic table enables a user to easily set the analyzing range, simply by specifying the desired elements in the table.
- Extensive analytical tools are available, including: KLM marker, peak ID, and inter-spectrum calculation tools.
- The spectrum analysis function allows for numerical analysis of the spectral shape.
- A WDS spectra database.

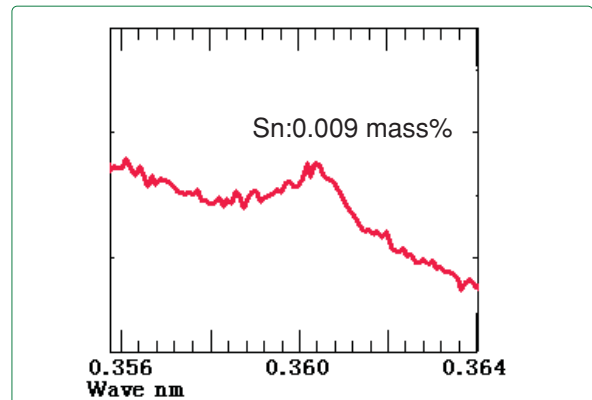
### High wavelength resolution WDS

Figures at the right show X-ray spectra of L line for elements near the transition metals. In the WDS spectra, the individual peaks do not overlap, but in the EDS spectra, the peaks of neighboring elements overlap extensively. In addition, if the K, L, and M lines are very close, the problem of overlapping lines becomes even more complicated.

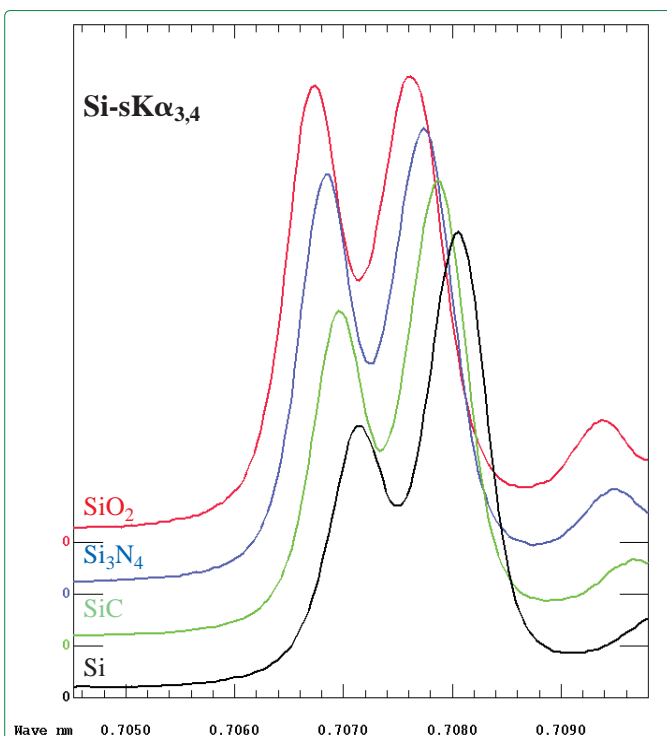


## Trace element detection

Wavelength scans around specific elements enables trace elements to be detected. Since the scan range is set from the Periodic table, the user does not have to look up values in a wavelength table. The figure at right demonstrates that the JXA-8230 can detect very trace concentrations of Sn in stainless steel.



## Support for state analysis



- The 140 mm spectrometer meets the needs for high wavelength-resolution state analysis.
- Users can specify an analyzing crystal and detector slit for high wavelength-resolution.
- The spectrum analysis function distinguishes minute differences in a spectrum.
- The deconvolution function\* allows for quantification of overlapping spectra.

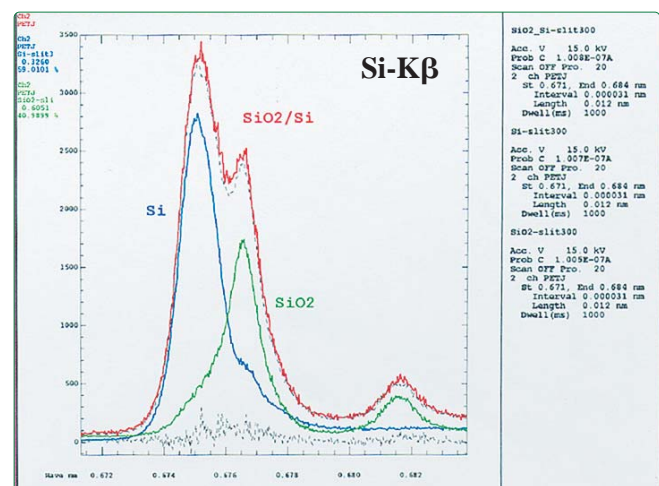
## State analysis

X-ray spectra containing wavelengths reflecting the bonding state of a compound can be measured with very high wavelength resolution, with a spectrometer that has a Rowland circle radius of 140 mm.

Figure at the left shows the Si-sK $\alpha_{3,4}$  line spectra of Si compounds. The difference between the waveforms due to the chemical bonding state difference can be seen.

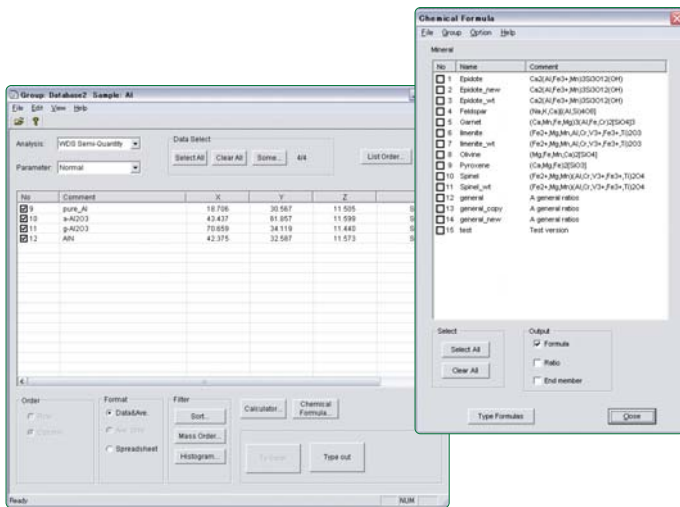
## Spectrum deconvolution\*

Combining digital filtering and least-square fitting, spectrum deconvolution can be applied to overlapping peaks in the WDS qualitative analysis, such as N-K $\alpha$  and Ti-LI. The user can then use the results of the deconvolution as the relative intensities in the quantitative analysis program.



Spectrum deconvolution of SiO<sub>2</sub>/Si system.

# Quantitative analysis



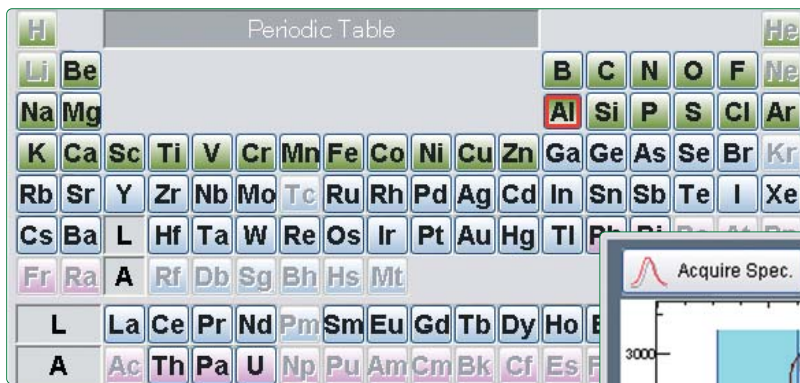
Element	f(chi)	f(rho)	abs-el	1/s-el	r-el	c/k-el	c/k-std
Ca	0.9355	0.0012	0.9689	0.8991	1.0513	1.0806	1.0162
Cr	0.9665	0.0001	0.9874	0.8003	1.0598	1.1939	1.1187
Si	0.7351	0.0015	0.8066	0.9662	1.0163	1.2606	1.0857
Mg	0.6129	0.0067	0.7026	0.9860	1.0011	1.4323	1.1336
Fe	0.5930	0.0000	1.0241	0.5175	1.1096	1.7005	1.7005
Al	0.6432	0.0119	0.7214	0.9478	1.0087	1.4330	1.1086

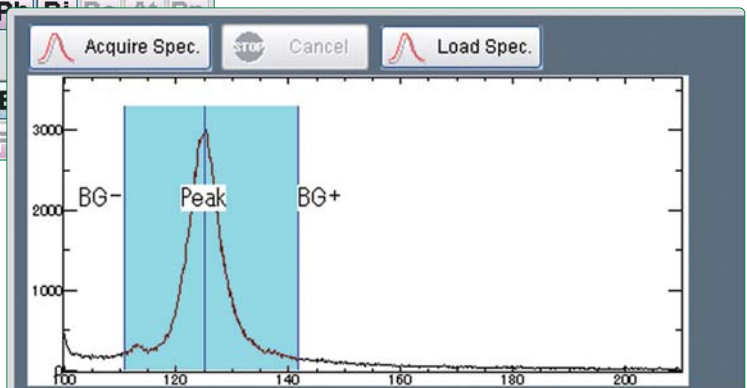
Element	El. mass%	Ox mass%	Norm El%	Norm ox%	At prop	c/k-std	k-value	k-std
Ca	14.18	19.84	14.22	19.90	3.053	1.0162	0.13000	0.40440
Cr	1.76	2.57	1.76	2.58	0.292	1.1187	0.01473	0.02298
Si	24.50	52.41	24.58	52.58	7.528	1.0857	0.19432	0.93311
Mg	12.58	20.86	12.62	20.92	4.465	1.1336	0.08781	0.18396
Fe	0.1420	0.1664	0.1424	0.1669	0.0066	1.7005	0.000835	0.000835
Al	2.03	3.84	2.04	3.85	0.650	1.1086	0.01419	0.17346
O	44.50	-	44.63	-	24.000	-	-	-
Total:	99.69	99.69	100.00	100.00	15.995	-	-	-

Example of analysis result: with Phi-rho-Z ( $\phi(\rho Z)$ ) method (mineral specimen)

- A variety of quantitative-analysis matrix correction methods are available to meet the diverse needs of users.
  - ZAF correction method (metals/oxides)
  - Bence & Albee method
  - Calibration curve method
  - Thin-film quantification method\*
  - $\phi(\rho Z)$  method (XPP & CITZAF)\*
- A summary of the quantitative and standardless-quantitative analytical results is provided in an output format classified by the chemical compound identification function.
- Quantitative analysis corrections can include calculated values for atomic groups such as CO<sub>2</sub>, H<sub>2</sub>O and OH, halogen, and negatively charged ions.
- Each spectrometer uses an independent drive function, crystals that can flip at any position, and can move at very high speeds. This dramatically reduces the waiting time involved with quantitative measurements.
- In addition to the standard peak / background measurement, spectrum area intensity measurements, spectrum interference corrections and quantitative analyses using an on-line deconvolution method are supported.
- Multiple-point quantitative analyses can be easily carried out either along a line or in a grid.
- The results of the analyses can be output to PC applications such as Excel™.
- Detailed data analysis employing the phase analysis program\* can be carried out.
- The use of correction functions guarantees a beam positional reproducibility of 0.08μm during point analysis.



Elements can simply be entered from the Periodic table.

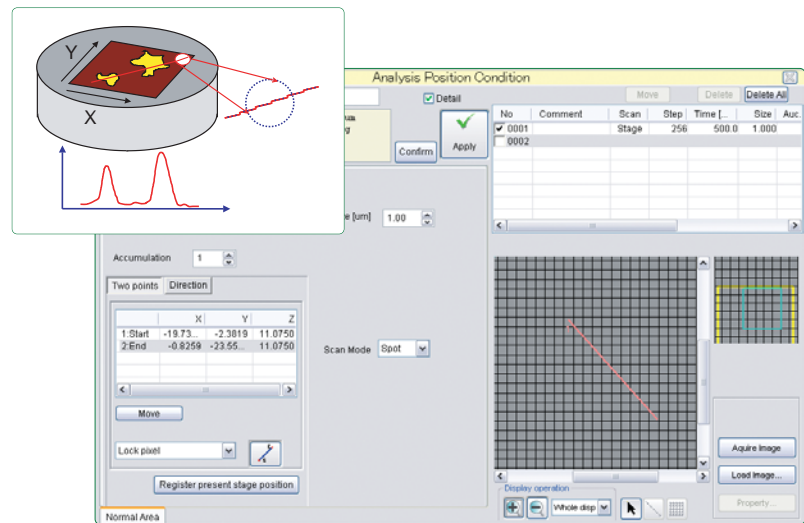


Background position can be entered from the spectrum display.

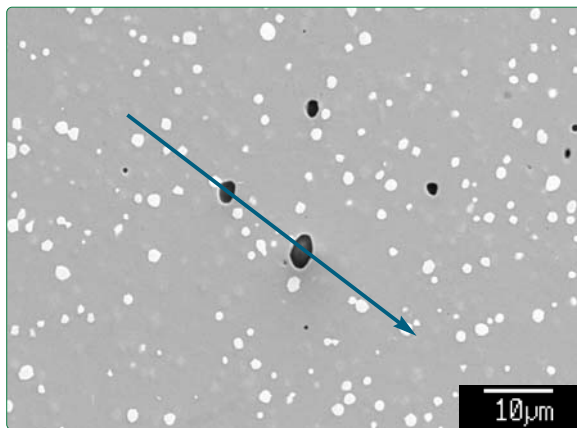


## Line analysis

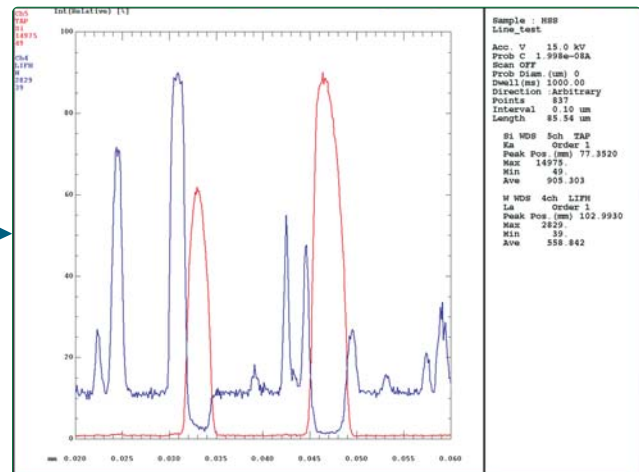
- Line analyses can be carried out using either a stage scan or a beam scan.
- The lines can be run in an arbitrary direction on the stage in minimum steps of 0.02  $\mu\text{m}$ .
- In a manner similar to that of the qualitative analysis program, various data analysis and display functions, such as displaying intensity values and quantitative values, can be made by using the mouse pointer on the line profile.



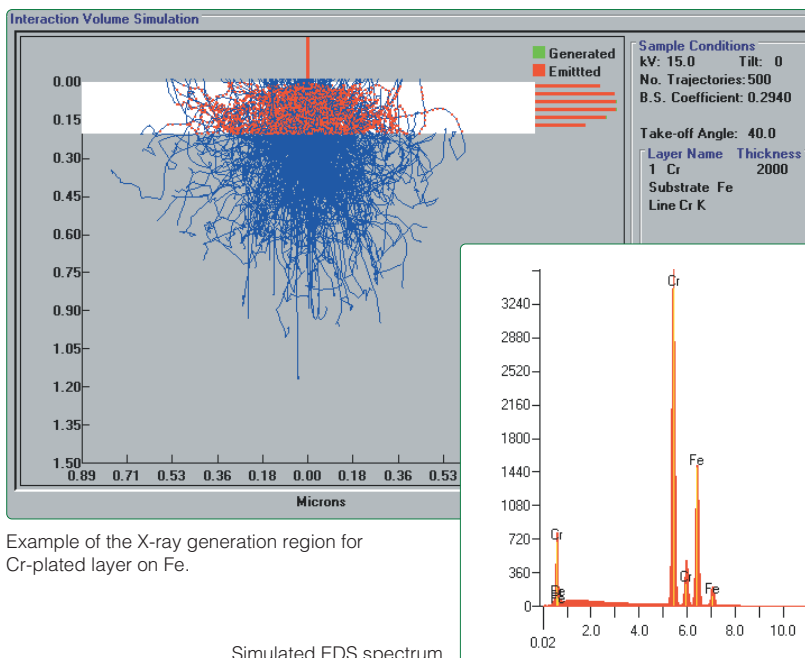
The stage drives in any direction on the sample for line analysis.



Example of oblique-direction stage line analysis of high-speed steel.



## Electron Flight Simulator (EFS)\*



Example of the X-ray generation region for Cr-plated layer on Fe.

Simulated EDS spectrum.

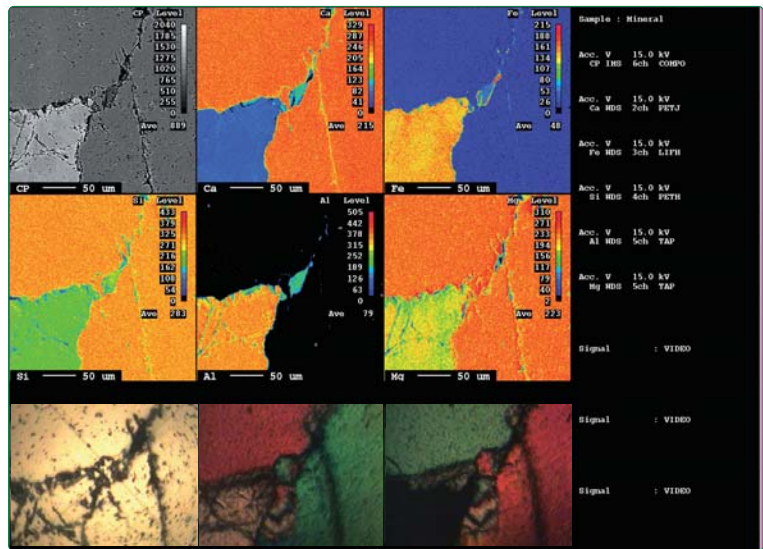
The Electron Flight Simulator is Monte Carlo simulation program for EPMA or SEM. This simulation program displays the trajectories of electrons in the specimen and models the X-ray generation function, backscattered electron intensity and EDS spectrum to be obtained.

This program is useful for checking the penetration region of the incident electron beam before analysis.

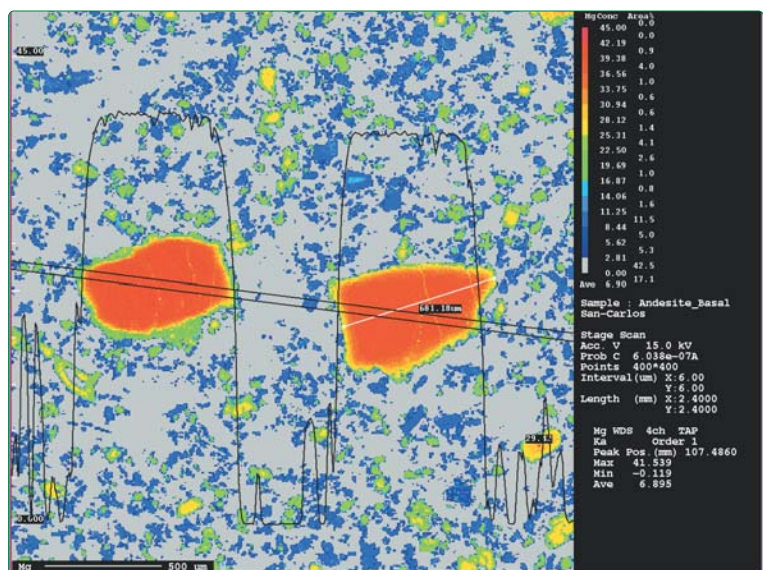
## Area analysis

- Maps can be acquired of areas that range from micro to macro in size. The largest being 90 mm square.
- The micro-step stage drive mode allows for steps intervals of as small as 0.02 μm, making extremely accurate stage mapping possible.
- It is possible to simultaneously acquire multiple data sets, including up to 5 elements analyzed by WDS, EDS active map\*, and 2 image signals.
- Measurement of curved specimens is supported by various methods: guide net map, random surface map program\* and tracing OM auto focus\*.
- The analytical area can be any polygonal shape, in addition to simple rectangles.
- Image drift correction by means of Probe Tracking.
- Numerous data processing functions are provided.
- The color display screen can be subdivided to allow for up to 25 images display simultaneously.
- It is possible to rotate and display images at any angles.
- Color level can be changed (linear/arbitrary intervals)
- Functions for point analysis, line analysis in arbitrary direction and length measurement, are provided.
- Inter-map calculation functions are provided (addition, subtraction, division, superposition of element color map on the electron image, masking function).
- Combination map
- Contour-line display, bird's-eye view, etc.

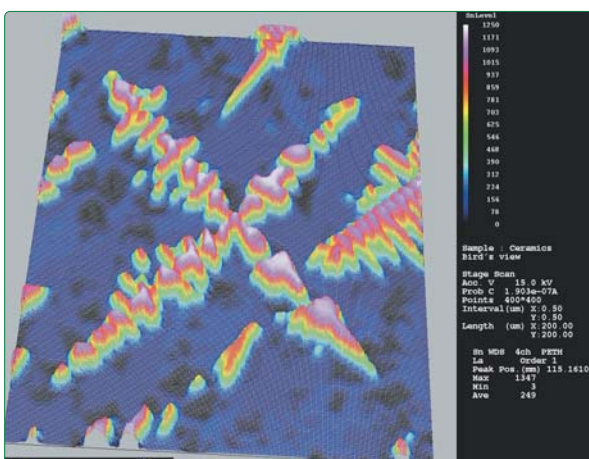
\* Simultaneous acquisition of all spectra



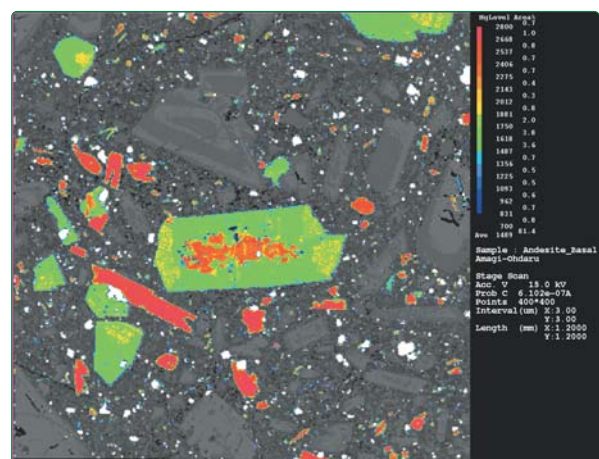
Color map display (simultaneous display of electron image, OM image and X-ray map)



Point analysis, arbitrary-direction line analysis and length measurement functions

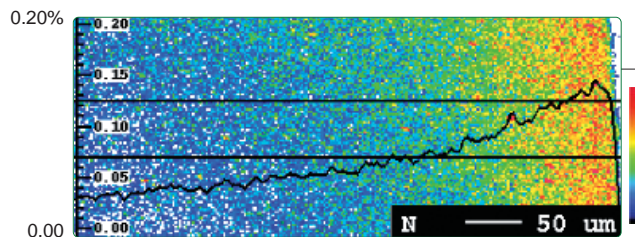


Bird's-eye view



Superposition of color map on electron image

\*optional

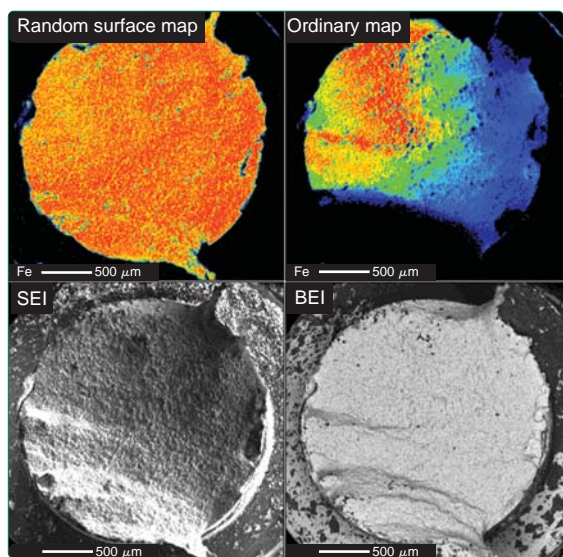
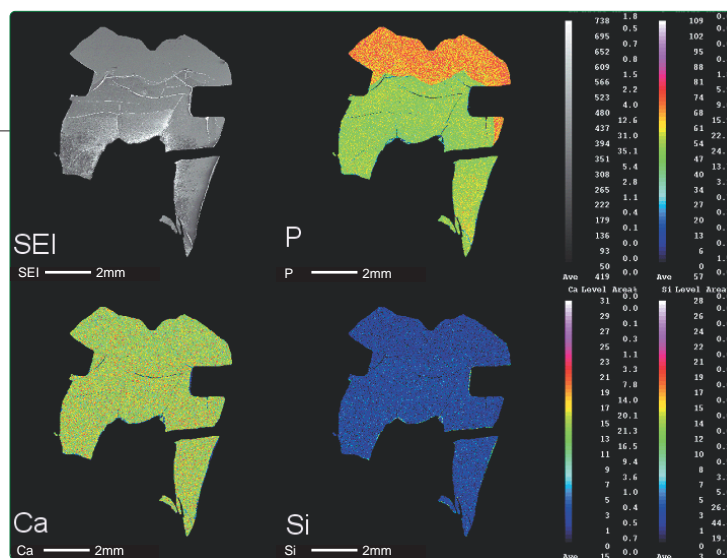


## Trace element map

Figure at the left shows that in a steel, variation in the nitrogen concentration of 0.15% or less can be analyzed. This is due to the use of a superb electron optic system that produces a stable electron probe at both small and large currents, and high-sensitivity analyzing crystals.

## Arbitrary shape map

This mapping method allows for scans of user-specified arbitrary shapes. This method is particularly useful for a resin-embedded specimen, enabling the user to acquire a map from only the area of interest, without irradiating the resin with the electron beam. Figure at the right shows the analytical results from a tooth cross section. Only the region of interest was analyzed.

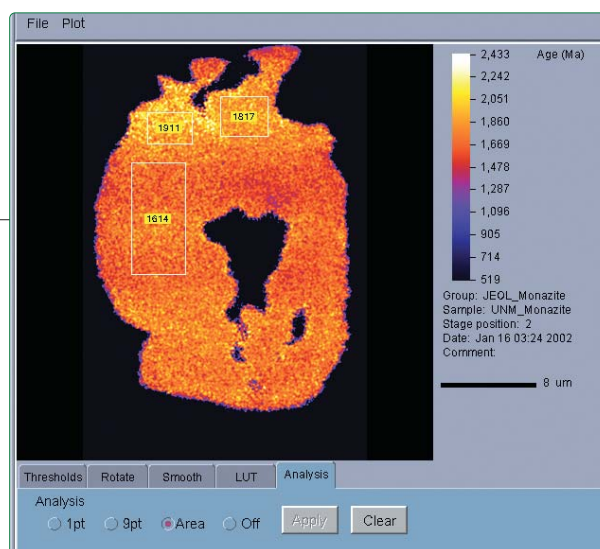


## Random surface map\*

To enhance the Guide-Net Map method, a new program was developed for uneven specimens. It constructs a pseudo curved-surface using arbitrary positions entered by the user from the irregular-shaped surface, then follows that surface to acquire the map. Figure at the left shows the analytical results of a fractured surface from a screw. Using the random surface map program, an accurate distribution of Fe can be obtained.

## MonaziteAge —the age dating software

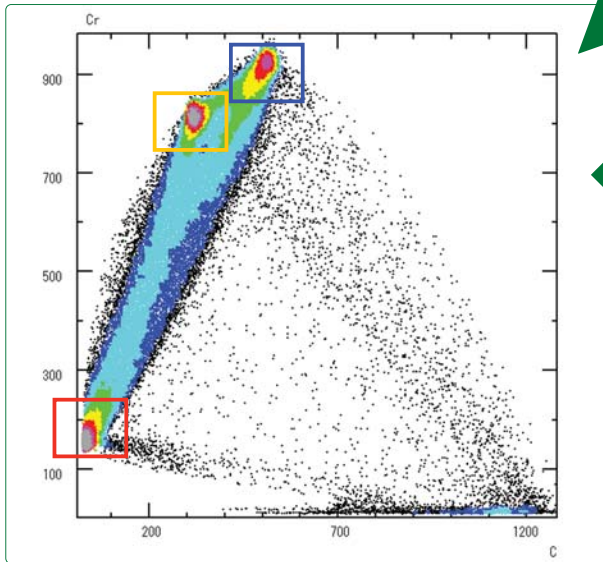
The MonaziteAge software estimates the age of a mineral, such as monazite or zircon, using the quantitative analyses of Th, U, and Pb. Monazite is a ubiquitous accessory mineral, therefore it can be used to date clastic, igneous and metamorphic rocks. The calculation method is based on the CHIME<sup>1)</sup> (Chemical Th-U-total Pb Isochron Method) approach. The age of the mineral, or a sub-region, is determined using a regression isochron line of the Th-U-Pb data. Additionally, age maps can be created using Th, U, and Pb map data or quantitative data.



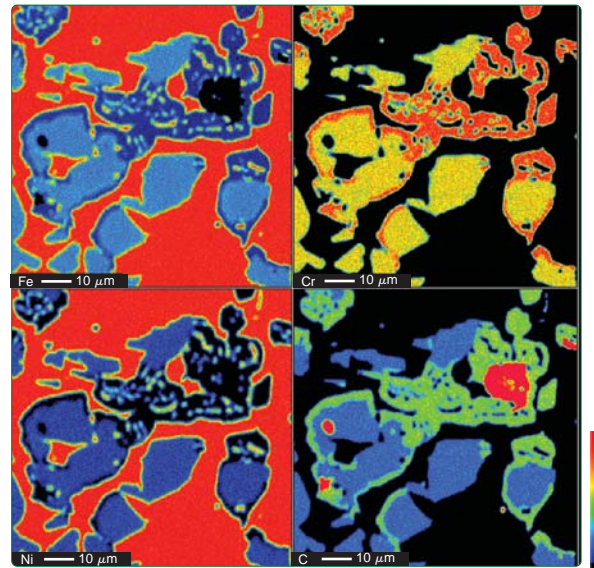
1) Suzuki, K., Adachi, M. and Tanaka, T. (1991); Sediment. Geol., 75, 141-147.

## Phase analysis\*

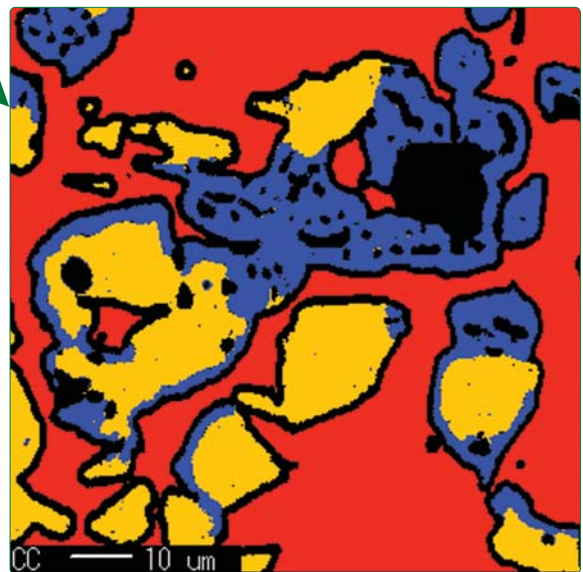
Binary and ternary scattered diagrams can be created from the data obtained from area analyses as well as data from line, quantitative and qualitative analyses. From these scatter diagrams, the correlation between the elements and the connection between each correlation are analyzed. For area analysis data, each cluster in the scatter diagram is differentiated by color, allowing for the creation of a phase map displaying the distribution of each phase.



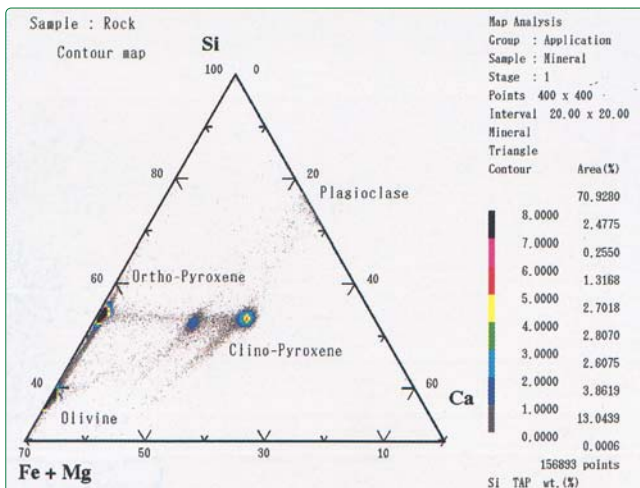
Scatter diagram showing the X-ray intensity of C and Cr at each pixel in the acquired maps. Three clusters are color-coded as red, orange and blue.



Element map of carbides in steel.



Phase map created when the scatter diagram was color-coded.

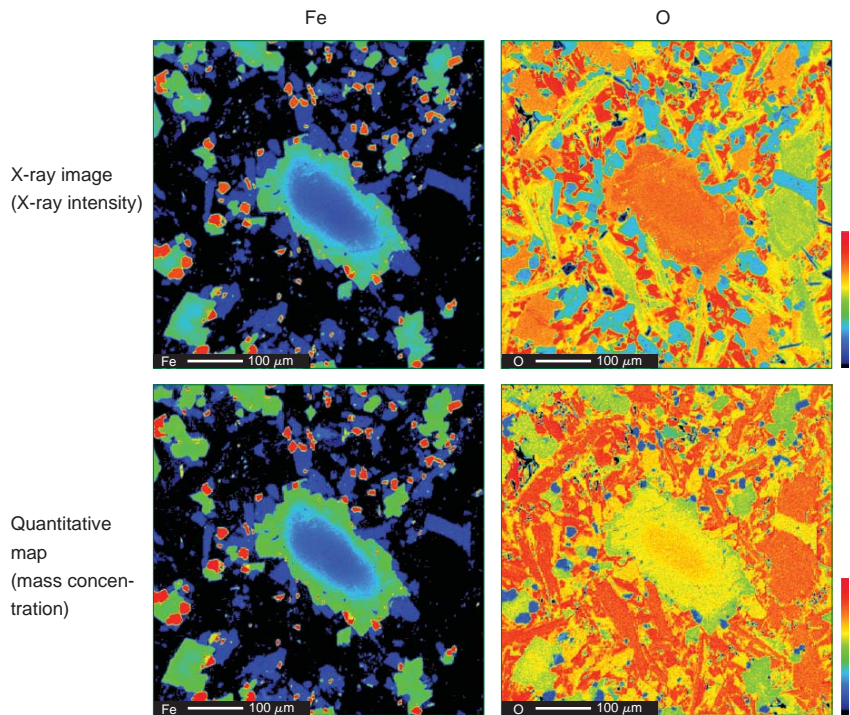


## Scatter diagrams

The user can choose not only a single element, but also a combination of multiple elements for each axis on the diagram. Figure at the left is a ternary scatter diagram obtained from an area analysis of a garnet peridotite in which clusters of Fe+Mg, Si and Ca are color-coded. In addition, the densities of the plotted points are contoured with different color levels.

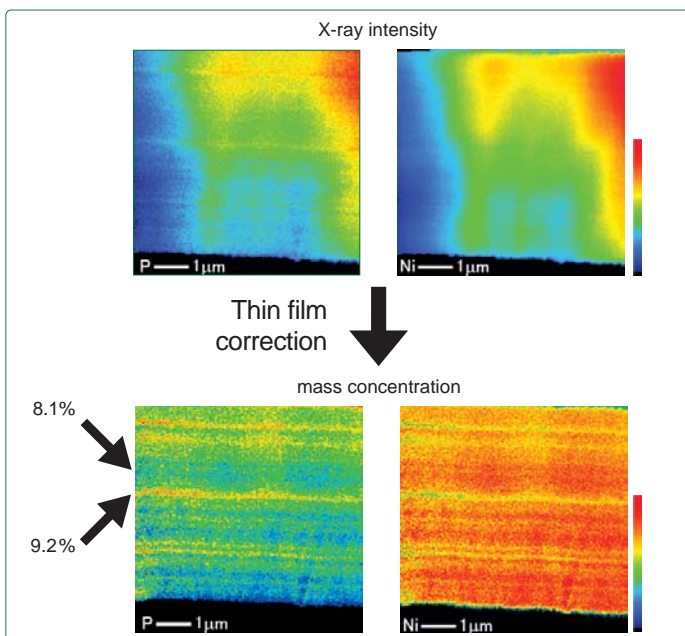
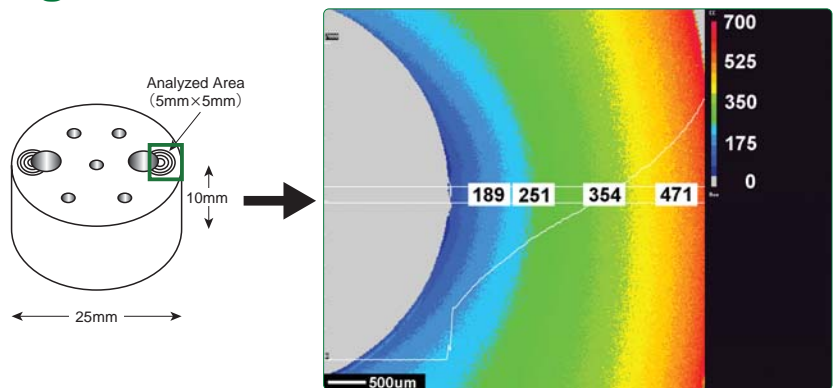
## Quantitative map\*

Matrix corrections are performed on each pixel of the map using either ZAF or the  $\phi(\rho Z)$  method to convert the X-ray intensities into quantitative values. Since the matrix corrections are performed on each point, even light elements, which are easily affected by absorption, can be mapped to provide their true concentration distribution. Figures at the right compare quantitative element maps with the original X-ray intensity maps from a basalt specimen. For a heavy element like Fe, the differences between the distribution of X-ray intensities and the mass concentrations are not large. However, for a light element like O, the matrix correction calculations enable the acquisition of a quantitative map that is significantly different from its corresponding X-ray intensity map.



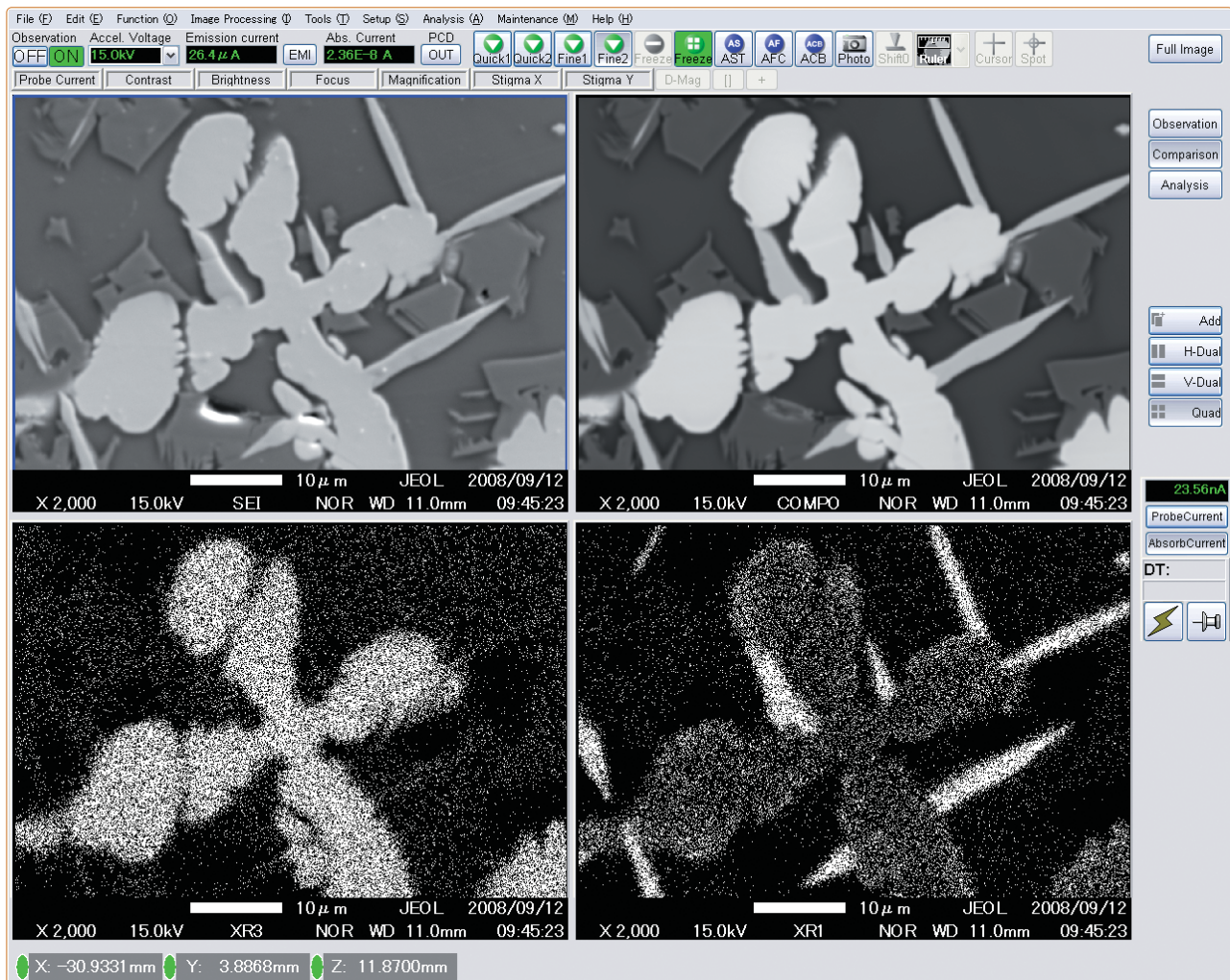
## Thin film analysis program\*

This program allows for quantitative analyses of thin films on a bulk specimen. It is intended for films thin enough to be penetrated by the electron beam and corrects for the effects of the film thickness and the substrate composition. The program also works within the quantitative mapping program in which each pixel is matrix corrected. A map of the film thickness can be obtained by assuming a density for the thin film. Figure at right shows the measured thickness of an electroplated Cr-layer. The thicknesses are shown in nm.



Very high spatial-resolution can be obtained by using a TEM thin film specimen in the EPMA. However, the measured intensities will be affected by any changes in the film's thickness. Using the thin film analysis program, the effect of the variability within the film thickness can be corrected. Figures at the left are the X-ray intensity and corrected concentration maps showing the variation in the abundance of Ni and P in an analyzed plated layer. A concentration difference of 1% is visible within a 0.1 μm area.

# Simultaneous Observation of Up to Four Live Images



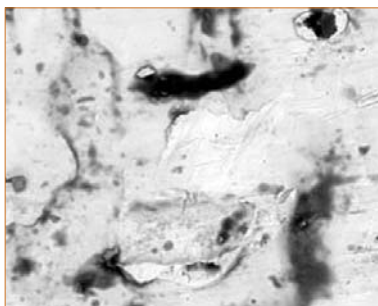
## Simultaneous observation and acquisition of live images

Up to four live images, such as SEI, BEI and X-ray images, can be simultaneously observed. If the OM image is also displayed, field searching can be done while referencing a total of five images at the same time.

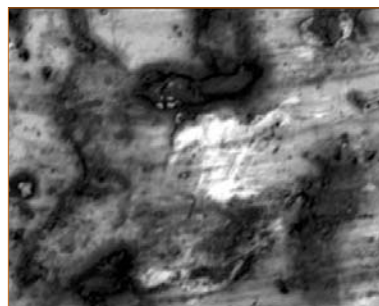
In addition, multiple signal images can be acquired simultaneously during an analysis, enabling the SEI and BEI to be captured within the same WDS analytical sequence. A resolution of up to 5,120 × 3,840 pixels is obtainable on the scanned images. These electron and WDS X-ray images can also be combined together in a real-time display.

## Excellent column control

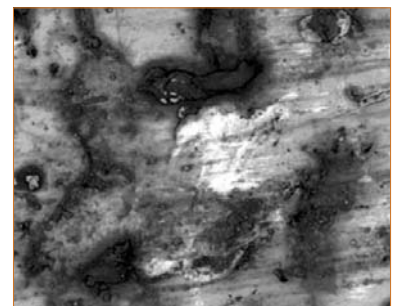
The sophisticated program optimally corrects the electron optical parameters for each accelerating voltage, facilitating the focusing and astigmatism correction even with the variations of accelerating voltages.



First 15kV  
Specimen: metal-discolored part ×1,000



When the accelerating voltage is changed to 5 kV:

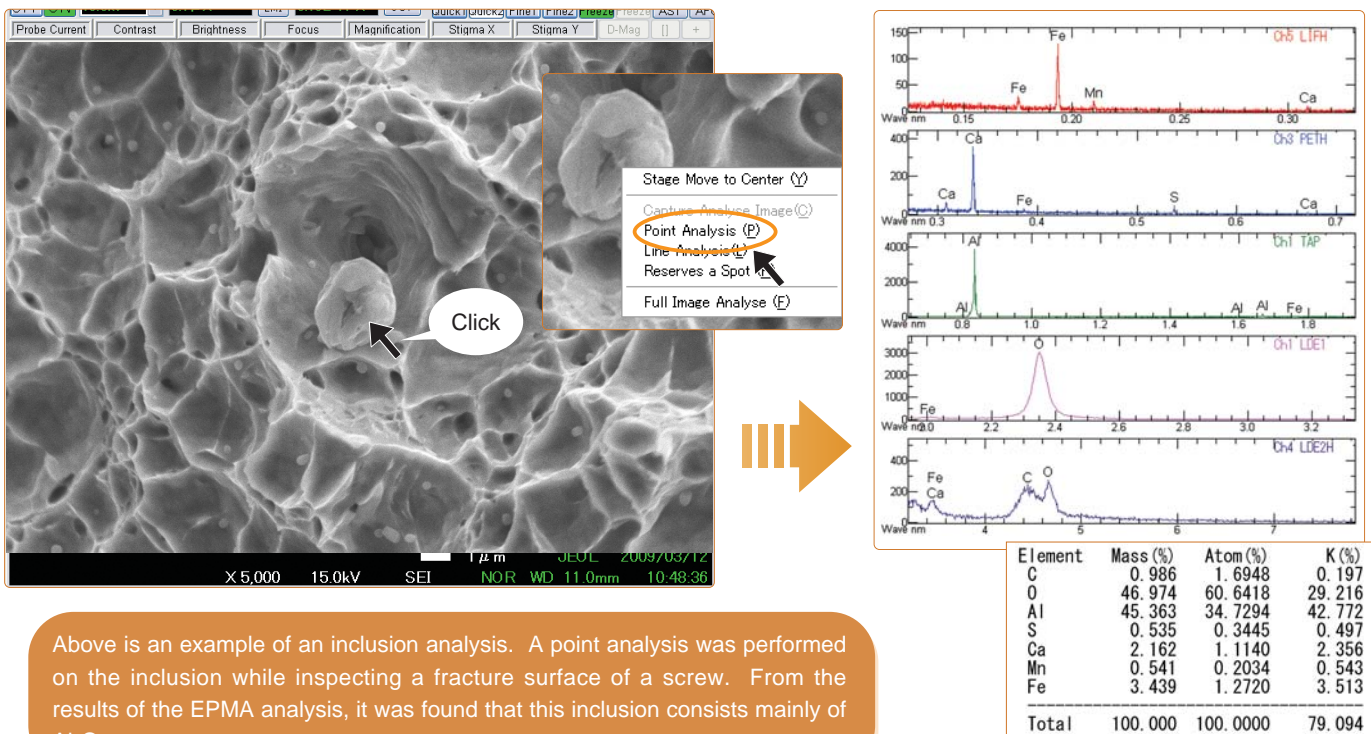


Fine adjustment after changing the accelerating voltage to 5 kV:

# Simple Operation of EPMA Analysis

## “Point & Click” function

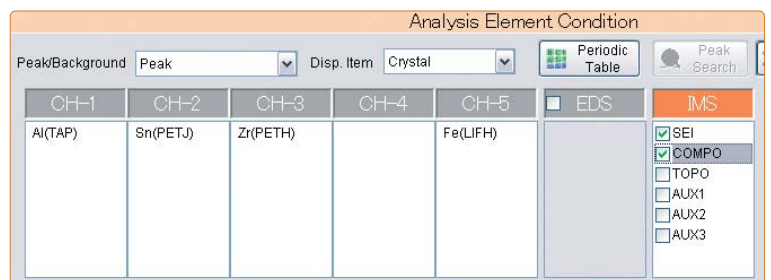
The Point & Click function dramatically reduces the operational steps after an analytical point has been identified. Simply by selecting the point on the SEI or BEI, a qualitative or quantitative analysis with the EPMA (WDS) can be started without opening any of the analytical condition windows, enabling the analysis to be quickly obtained.



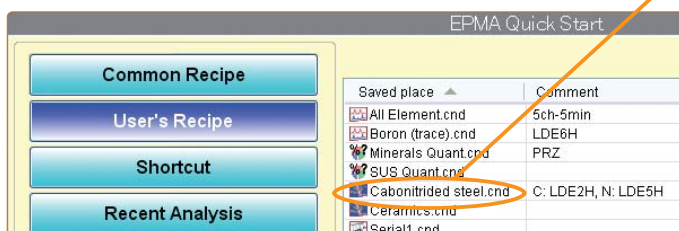
Above is an example of an inclusion analysis. A point analysis was performed on the inclusion while inspecting a fracture surface of a screw. From the results of the EPMA analysis, it was found that this inclusion consists mainly of Al<sub>2</sub>O<sub>3</sub>.

## “User's recipe” function

The user recipe function facilitates repeated measurements of the same combination of elements. User's recipes can save and recall frequently used sets of analytical conditions. The saved analytical conditions can be recalled from the EPMA Quick Start window. Setting an analysis point then starts the analysis using the preset analytical conditions.



Analyzing element conditions for area analysis

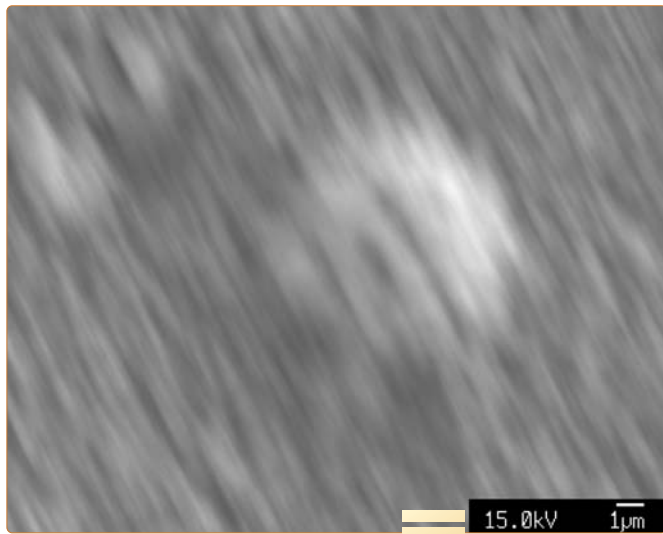


EPMA Quick Start window (default display)

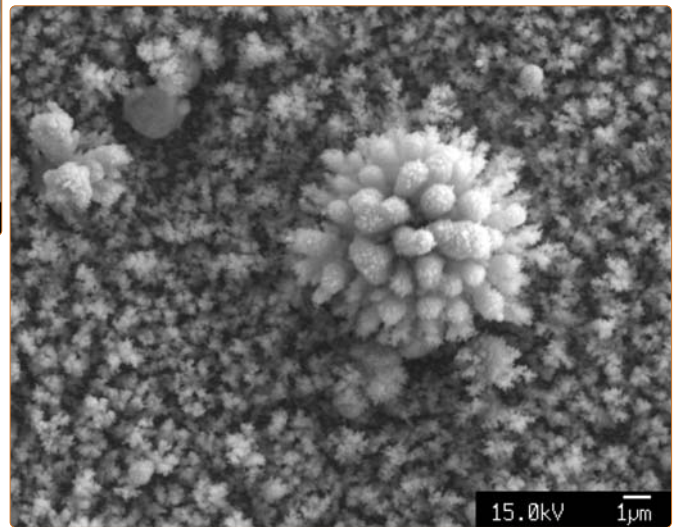
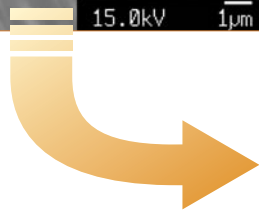


Data icon display

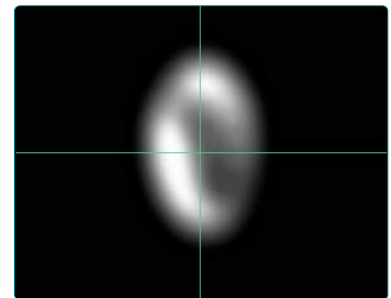
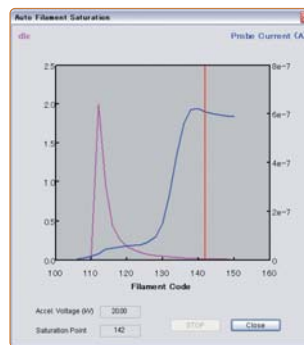
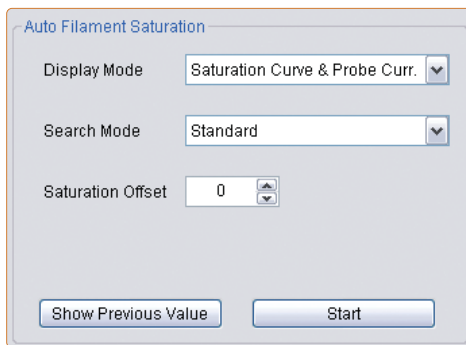
# Various Automated Features



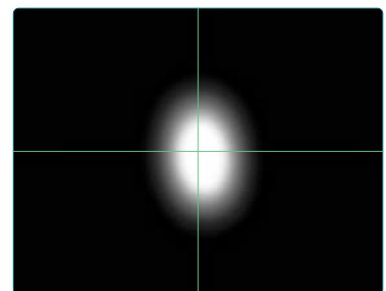
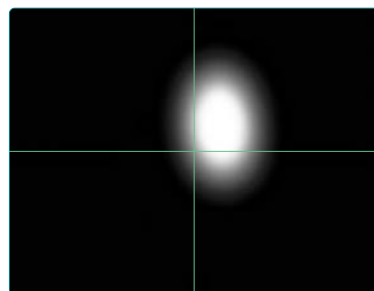
Automated focusing,  
astigmatism correction, and  
contrast / brightness adjustment



## Automated filament saturation



## Automated gun alignment

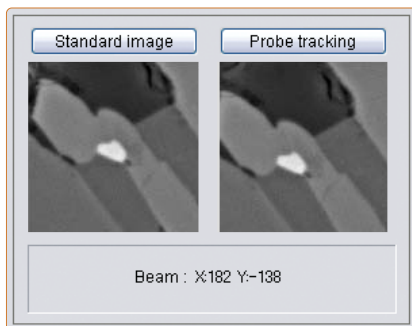




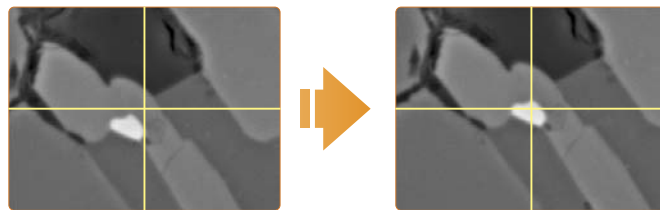
## Probe tracking function

The probe tracking function (provided as standard) can correct for an image shift resulting from specimen drift during a high-magnification area analysis. This function is also helpful when doing point analyses on multiple particles, since the electron probe (beam) will target points more accurately with the additional correction from the probe tracking function.

The probe tracking function calculates the amount of offset between a standard image (left side of frame) and the reference image acquired during the analysis (right side of frame). The function then shifts the beam position to match the standard image.

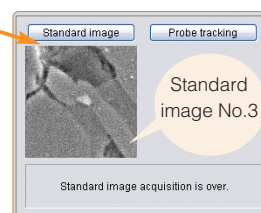
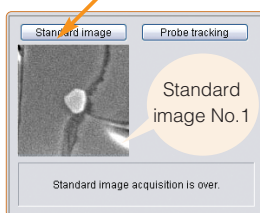


Probe tracking monitor



Probe tracking being executed

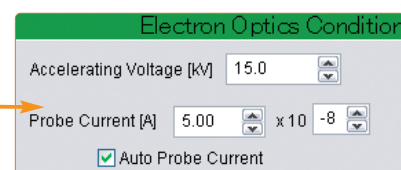
No	Comment	Scan	X	Y	Z
✓ 0001	Particle_1	Stage	26.0321	-24.5383	11.7665
✓ 0002	Particle_2	Stage	24.1507	-25.0061	11.7580
✓ 0003	Particle_3	Stage	23.6814	-25.1038	11.7580



## Automated serial analysis

The serial analysis program consists of an independent batch recipe allowing a user to easily run a series of different kinds of analyses, using different accelerating voltages and different probe currents, all in an automated fashion. The serial analysis recipe can be easily edited to change the analytical conditions for any of the listed tasks.

Index...	Analysis kind	Accelerati...	Analysis...	Comment
✓ 001	Qualitative Analysis	20.0	003	5ch-5min
✓ 002	Map Analysis	15.0	001	Ceramics
✓ 003	Line Analysis	15.0	003	Carbonitrided
✓ 004	Quantitative Analysis	15.0	010	Minerals



# Sophisticated GUI

## Various analysis menus in a plane

A redesigned GUI for the analysis monitor screen provides a wealth of information, while eliminating the overlapping, frequently used windows, such as the analysis setup window, Periodic table, and OM monitor. The displays of the various analysis menus, supporting tools, and monitors are selectable at anytime using both icons and tabs, providing efficient operations.

### Area analysis simplified setting window

The screenshot displays the JEOL software interface with the following components:

- Menu Bar:** Edit, View, Analysis, Monitor, Tool, Maintenance, Help.
- Toolbar:** Quick, Qual, Line, Map, Quant, Std, Off/On, Start, Stop, Monitor, Data, Serial, Periodic, Search, PHA, Std Mng, OM Mon, SPC, P-TRKG.
- Project Information:** Project Name: Solder, Path: C:\EpmaData\JEOL.
- Map Analysis Panel:** Recipe Name: Pb-free Solder, Total Time: 01:41, buttons for Acquire, Add to Serial Anal., Save Recipe, Read Now.
- Electron Optics Condition:** Accelerating Voltage [kV]: 15.0, Probe Current [A]: 2.00 x 10<sup>-8</sup>.
- Analysis Position Condition:** Scan range: 50.000 x 50.000 um, Analysis time: 01:41:08, buttons for Read, Confirm, Apply.
- Analysis Element Condition:** Table with columns CH-1 to CH-5 and EDS/IMS. Elements listed include Sn(PETJ), Cu(LIFH), Ag(PETH).
- OM Monitor Panel:** Live image of a sample with a crosshair, buttons for Setup, OM control, Volume: 120.
- Analysis Job List:** Table with columns No, Kind, Comment, State.
- Analysis Job Information:** Job ID, Start time, Elapsed, Job state.

### OM monitor

### EPMA explorer (data management tool)

Selecting an icon from the EPMA explorer automatically starts the data processing software. The EPMA explorer also supports a drag-and-drop display for each data type.

The EPMA explorer displays a grid of analysis data visualizations with the following parameters and values:

Sn	Level	Area%	Cu	Level	Area%
414	0.7	303	0.0	1856	0.1
107	7.4	1007	0.0	1857	0.0
301	32.1	209	0.7	1857	0.0
349	19.8	200	1.9	1857	0.0
315	45.3	221	1.3	1857	0.0
280	19.8	132	1.9	1857	0.0
283	4.1	117	4.4	1857	0.0
217	1.3	88	4.4	1857	0.0
184	0.0	46	1.7	1857	0.0
182	0.0	1	0.2	1857	0.0
338	0.0	38	0.0	1857	0.0
163	0.0	1857	0.0	1857	0.0
116	11.4	1259	10.9	1857	0.0
140	3.1	1462	6.8	1857	0.0
93	0.0	1080	74.9	1857	0.0
79	19.9	881	4.5	1857	0.0
23	20.1	464	2.3	1857	0.0
0	0.0	285	2.4	1857	0.0
46	0.0	1116	0.4	1857	0.0

Area analysis data processing software

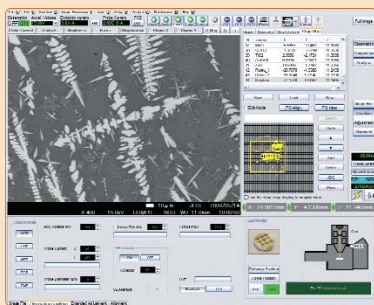
Since the basic analytical conditions can be set in the simplified setting window shown on the left page, the user does not need to open or switch between many different windows. For a more detailed view of the analytical conditions, one can use the detailed setting windows shown below. Even when this window is used, optimally labeled displays (Periodic table, peak search monitor, etc.) allows for a smooth setup of each condition.

**Quantitative analysis detailed setting window for analysis element conditions**

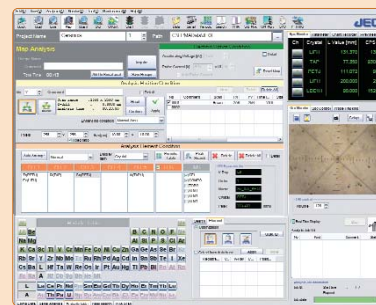
The screenshot displays the JEOL software interface. The main window is titled 'Analysis Element Condition' and is divided into several sections:

- Top Section:** Includes a menu bar (File, View, Analysis, Monitor, Tool, Maintenance, Help) and a toolbar with icons for various functions like Quick, Qual, Line, Map, Quant, Std, Off/On, Start, Stop, Monitor, Data, Serial, Periodic, Search, PHA, Std Mng, OM Mon, SPC, and P-TRKG. Below this, the 'Project Name' is 'Minerals' and the 'Path' is 'C:\EpmData\JEOL'.
- Analysis Element Condition Table:** A table with columns for channels (CH-1 to CH-5) and a 'CAL' column. The 'CAL' column contains the value '0'. To the right, there are 'WDS parameter' settings for X-Ray (La), Order (1), Name (Nd\_La\_2ch), Crystal (LIF), and Peak (164.846 [mm]).
- Element Selection:** A section for selecting the element 'Nd' (Neodymium). It shows 'X-Ray: La', 'Order: 1', 'Name: Nd\_La\_2ch', and 'Add in the data base'. Below this are 'Channel' (2) and 'Crystal' (LIF) settings. The 'Fixed time mode' section includes 'Fixed Time method', 'Peak' (10.0), 'Upper' (1.500), 'Lower' (2.500), and 'Back' (5.0) settings.
- Acquire Spec. Graph:** A graph showing a spectrum with a peak at 164.846. The peak is labeled 'Peak' and is flanked by 'BG-' and 'BG+' regions. The y-axis ranges from 0 to 450, and the x-axis ranges from 155 to 175.
- Periodic Table:** A standard periodic table is shown at the bottom left, with the element 'Nd' highlighted in blue. A callout bubble points to it with the text 'Periodic table (for element selection)'. To the right of the table is a 'Search Element' section with 'Optimization' and 'Select from data base' options.
- Spectrometer Control Monitor:** Located on the right side, it shows a 3D model of the spectrometer and various control parameters. A callout bubble points to it with the text 'Spectrometer control monitor'. The monitor displays 'Ch: TAP', 'Crystal: L', 'Value: 171.97', 'PETJ', 'PETH: 220', 'LDE2H: 220', 'LIFH: 14', and '992'. Below the model, there are 'Control' and 'Movement' settings, including 'Rate/Step' (0.005) and 'Move position' (77.545).
- Real Time Display:** At the bottom right, there is a 'Real Time Display' section with a 'Stop' button and an 'Analysis Job List' table. The 'Analysis Job Information' section shows 'Job ID', 'Start time', 'Elapsed', and 'Job state'.

Two monitor screens (for observation and analysis) of the JXA-8230 provide seamless operations. The newly designed GUI enables smooth operations from image observation and analysis to data analysis and management.

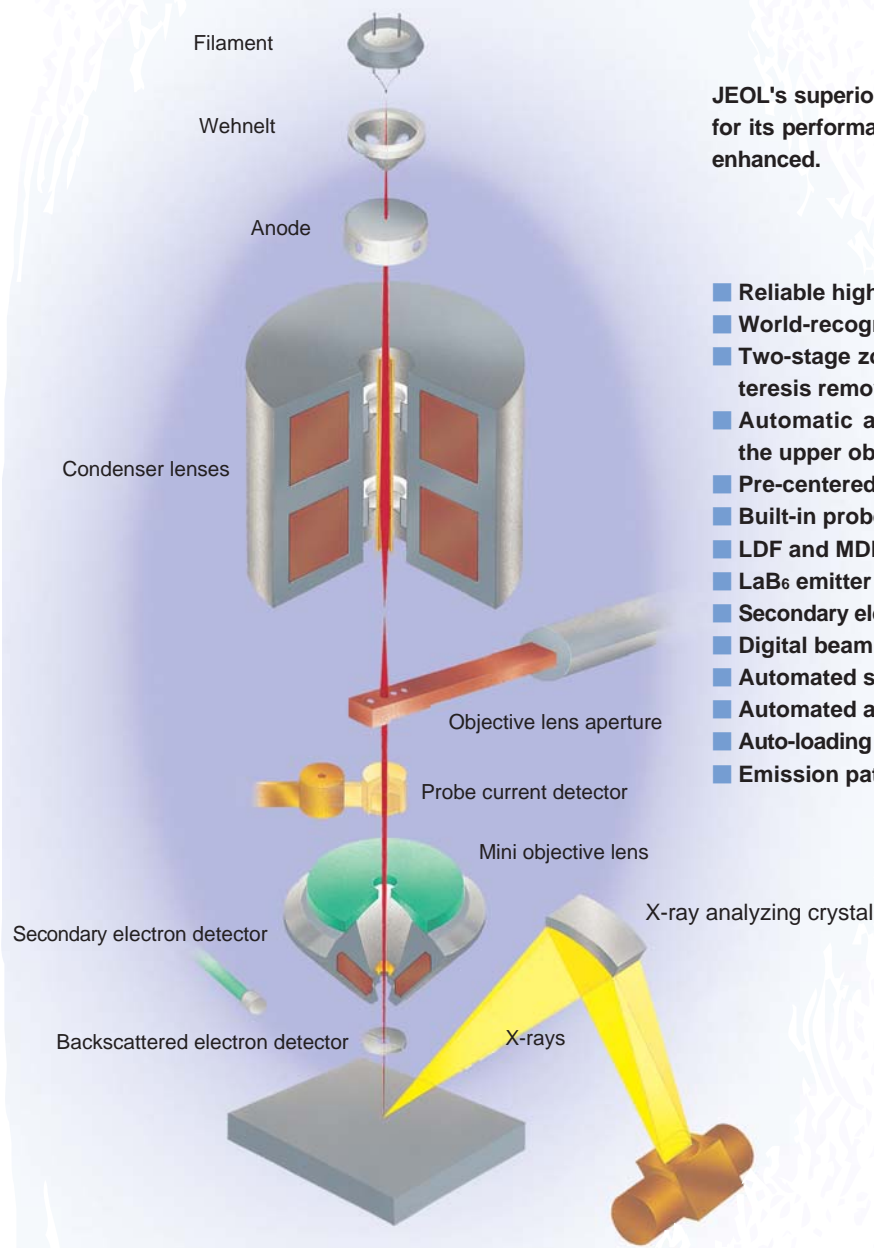


Observation monitor screen



Analysis monitor screen

# JEOL's Tradition – Electron Optical System

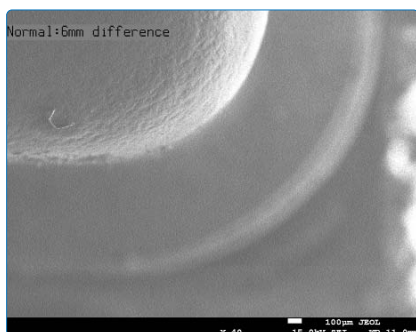


JEOL's superior electron optic system, well respected for its performance and ease of use, has been further enhanced.

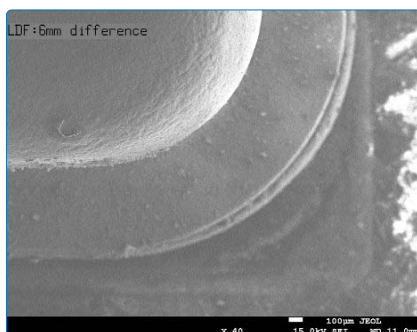
- Reliable high-stability electron gun
- World-recognized mini objective lens for EPMA
- Two-stage zoom condenser lens with built-in hysteresis removal function
- Automatic aperture-angle control method using the upper objective aperture
- Pre-centered filament system
- Built-in probe current detector
- LDF and MDF modes
- LaB<sub>6</sub> emitter (optional)
- Secondary electron resolution: 5 nm (LaB<sub>6</sub>), 6 nm (W)
- Digital beam stabilizer
- Automated saturation (filament heating)
- Automated alignment
- Auto-loading of optimized gun alignment parameters
- Emission pattern monitor, etc.

## Large depth of focusing mode (LDF) / Maximum depth of focusing mode (MDF)

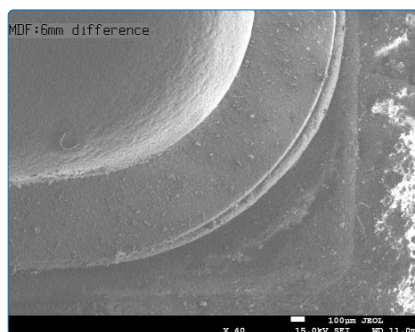
EDS analyses and imaging of specimens with uneven surfaces can be performed using the LDF mode with a focal depth of 2 mm and a low magnification of 100×. Using the MDF mode, surfaces with height differences of as great as 6 mm can be kept continuously in focus.



Normal mode



LDF mode



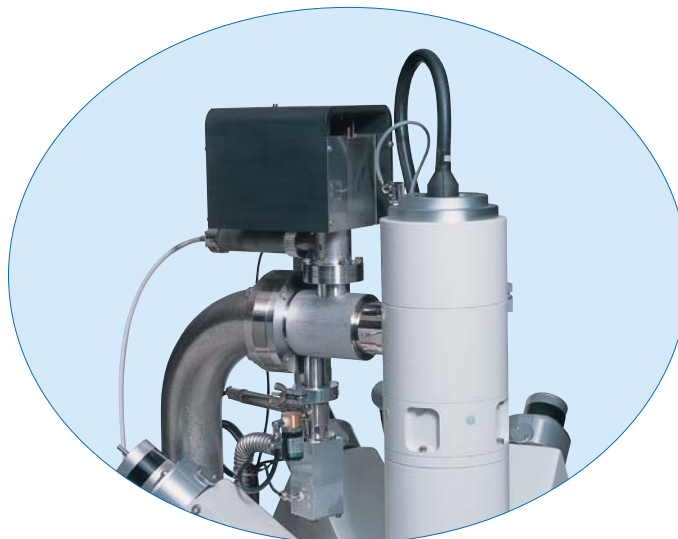
MDF mode

Specimen : electronic device

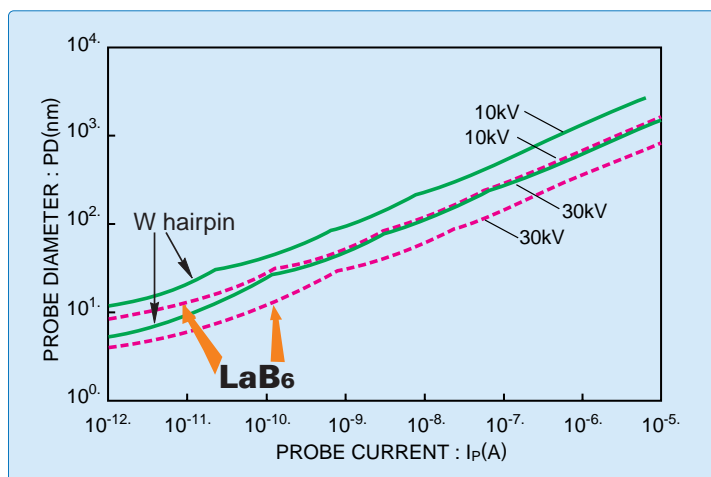
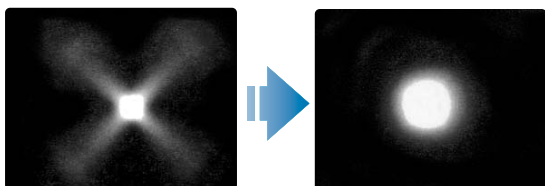
## LaB<sub>6</sub> electron gun\*

The field-proven, high-brightness, LaB<sub>6</sub> electron gun comes into its own when analyzing features in the submicron range.

- Single-crystal, long-life, LaB<sub>6</sub> tips have an established reputation.
- It achieves a high probe current and small probe diameter even at a low accelerating voltage.
- It enhances the measurements of submicron areas and for trace elements under a range of analytical conditions.
- Accurate, stable saturation-point setting using the emission-pattern monitor function.
- Achieves a clean, high vacuum through the use of an ion pump.
- JEOL's LaB<sub>6</sub> system does not require baking out. High vacuum conditions can be obtained very rapidly.



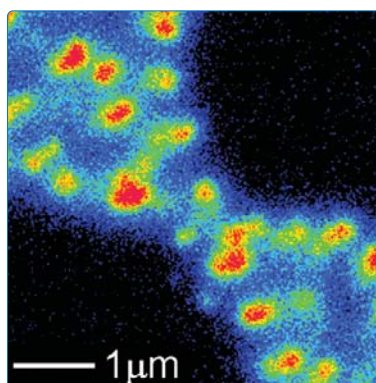
Using an emission pattern, one can set an accurate filament saturation point. Example below left shows an unsaturated emission pattern that has not yet converged to spot. The example at below right shows an emission pattern at the saturation point. The high-brightness electron gun will only perform at its full potential at this saturated condition.



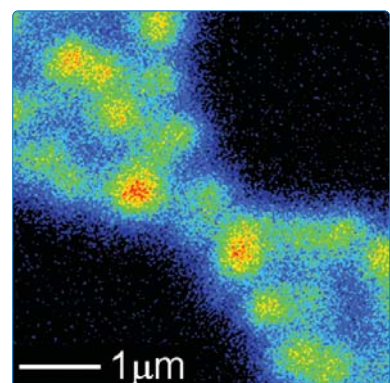
Comparison of LaB<sub>6</sub> electron gun and tungsten (W) hairpin electron gun (Probe current vs. minimum probe diameter)

## Area analysis with higher spatial resolution

By using a LaB<sub>6</sub> electron gun, it is possible to analyze trace element segregations at grain boundaries with high spatial resolution.



Ag mapping using LaB<sub>6</sub> electron gun (Specimen : solder)



Ag mapping using W electron gun

\*optional

# The World of X-ray Analysis – High Sensitivity and High

The installation ports for the individual spectrometers (WDS, EDS) are shown.

# High Resolution with an Impressive Lineup of Accessories

JEOL's X-ray spectrometers, the core of the EPMA, solve many analytical needs. A wide range of spectrometers, including a high-resolution type, a high X-ray intensity type, and a four-crystal type, can meet a variety of research requirements. Also, a range of analytical crystals are available that cover the Periodic table from Be to U. To analyze very light elements, sophisticated synthetic superlattice analyzing crystals are available. These crystals have intensities an order of a magnitude higher than conventional ones. The crystals can be changed at any position, and even when the analyzing crystals are being driven, the electron beam will not shift due to JEOL's unique electron optic system.

## X-ray spectrometers

X-ray spectrometer	Model name	Abbr.	Number of crystals	Crystal exchange	Features
XCE-type X-ray Spectrometer	XM-86010	XCE	2	At any position	High resolution in wavelength
L-type X-ray Spectrometer	XM-26050L	L	2	At any position	Trace element overlaps for geology
H-type X-ray Spectrometer	XM-86030	H	2	90% of full range	High X-ray intensity
XCE-type Four Crystal Spectrometer	XM-86040	FCS	4	90% of full range	Four different crystals can be mounted. B to U can be analyzed

## Analytical ranges of crystals

K  $\alpha$ ,  $\beta$

L  $\alpha$ ,  $\beta$

M  $\alpha$ ,  $\beta$ ,  $\gamma$

	2d (nm)	6 C	14 Si	22 Ti	30 Zn	38 Sr	46 Pd	54 Xe	62 Sm	70 Yb	78 Pt	86 Rn
TAP	2.576	8O	15P	24Cr	41Nb	46Pd	79Au					
TAPH	2.576	9F	13Al	24Cr	35Br	47Ag	70Yb					
PET	0.8742	13Al	25Mn	36Kr	65Tb	70Yb						
PETL	0.8742	14Si	24Cr	36Kr	62Sm	71Lu						
PETH	0.8742	14Si	22Ti	37Rb	56Ba	72Hf						
LIF	0.4027	19K	37Rb	48Cd								
LIFL	0.4027	20Ca	35Br	50Sn	87Fr							
LIFH	0.4027	20Ca	31Ga	50Sn	79Au							

## List of crystals for the detection of very light elements

In 1986, JEOL developed the first practical-use artificial superlattice analyzing crystals for EPMA in the world. Since then, continual improvements have been made to these crystals, leading to high-sensitivity synthetic multi-layered analyzing crystals. These advancements, plus high-reliability pulse height analyzing system, and high-reproducibility spectrometers have made the JEOL WDS the leading tool for light-element analyses. The LDE1 and LDE2 analyzing crystals have wide analytical ranges and versatility. The LDE5H achieves very high X-ray intensities for N, 30 times higher than the STE crystal. The LDE6H is very effective for analyzing trace concentrations of B and C.

	2d (nm)	Be	B	C	N	O	F
STE	Approx.10		○	○	○	○	
LDE1	Approx.6			△	◎	◎	◎
LDE2	Approx.10		◎	◎	◎	○	
LDEB	Approx.14.5	◎	○				
LDE1H	Approx.6			△	◎	◎	
LDE2H	Approx.10		◎	◎			
LDE3H	Approx.20	◎	○				
LDE5H	Approx.8			◎	◎		
LDE6H	Approx.12		◎	◎			

◎ best  
◎ better  
○ good  
△ possible

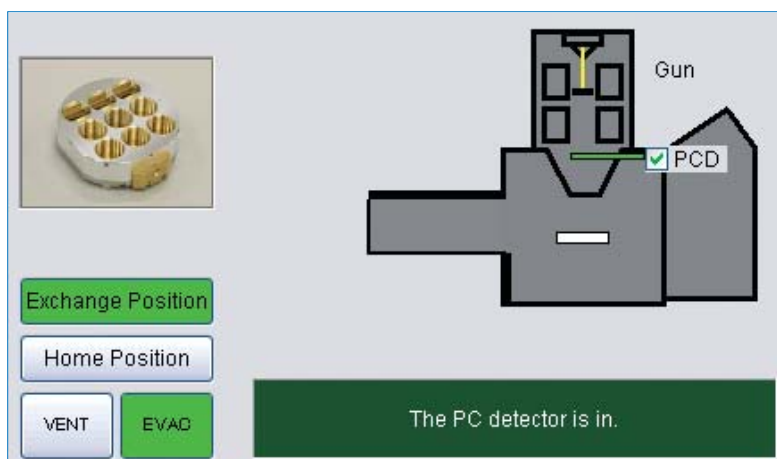
# Specimen Stages with High Speed and High Reproducibility

- Loadable specimen size of up to 100 × 100 × 50 mm.
- Maximum drive speed: 15 mm/s (X,Y).
- Specimen stage allows for a measurement area of up to 90 × 90 mm with high speed and high accuracy.
- Z-axis movement of up to 7.5 mm is possible.
- Minimum step size of 0.02 μm supports line analyses in any arbitrary direction.
- Silent direct-drive movement is employed.
- Tilt-rotation specimen holder simplifies the analysis of cross-sectioned specimens prepared by FIB.
- Specimen exchange rod can be folded down for a safer work environment.
- The stage control can be visually operated using the specimen navigator\* software.



The vacuum in the pre-evacuation chamber is always monitored.

The location of the specimen (pre-evacuation chamber or specimen chamber) is automatically displayed on GUI.





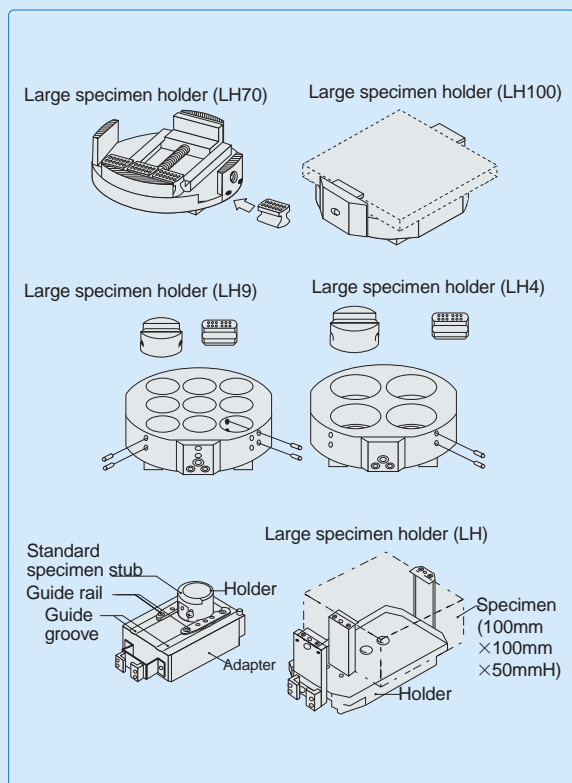
## Standard specimen holder

The standard specimen holder carries 13 standard specimens (Mg, Al, Si, Ti, Cr, Fe, Ni, Cu, Zr, Mo, Cd, W, Au), ZrO<sub>2</sub> for probe position observation, and a Faraday cup.

It can hold a 32 mm dia. × 25 mm specimen.



## Specimen holder



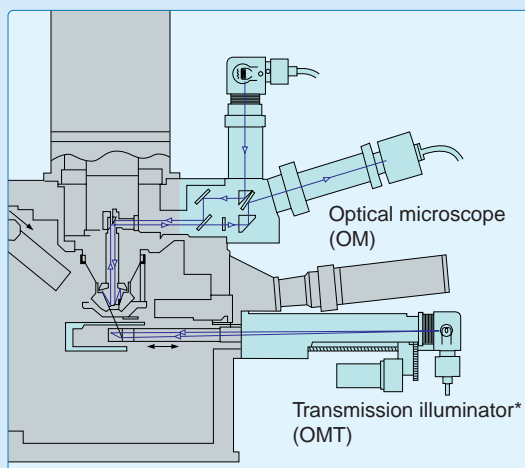
## Optical microscope (OM)

The use of a TV camera (CCD) for OM images provides the operational ease of the electron images, because the OM image is displayed on the PC monitor. Looking down the OM eyepiece is no longer required. Focusing is aided by displaying the OM's focusing cross marker on the digital OM image. In addition, the SE and OM images can be observed simultaneously, simplifying greatly the search for a specific location. OM images can be saved as digital images and displayed along with the electron images and X-ray color maps.



## Transmission illuminator (OMT)\*

This device is optionally available for observing thin sections of rock specimens. Insertion and retraction of the OM condenser lens and 360° rotation of the polarizer are motor driven. When the polarizer is used with the OM's analyzer, the OM can be used as a polarizing microscope.



# WD/ED Combined System

## WD/ED combined analysis

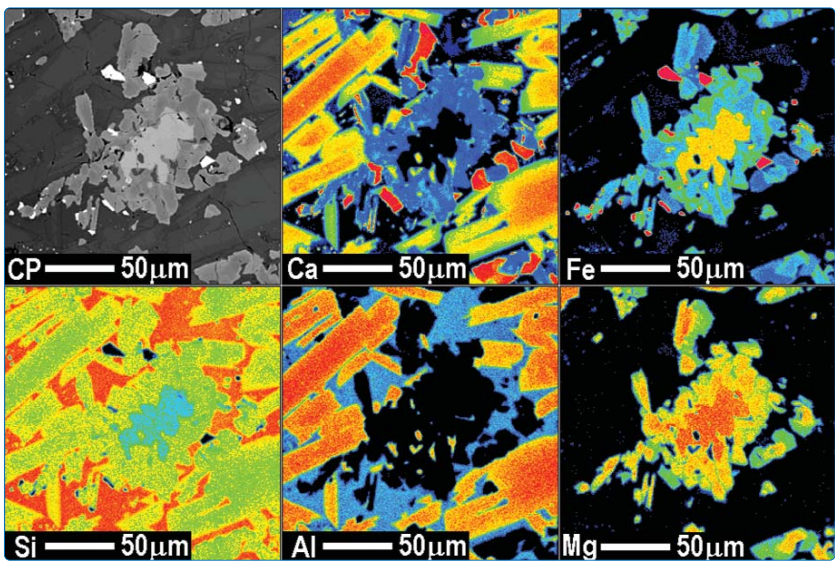
JEOL's WDS and EDS have been further enhanced achieving a much easier-to-use WD/ED combined system. WDS is essential for trace-element analyses, whereas the EDS system is very well respected in JEOL's analytical SEMs. Thus, the combination of WDS and EDS exploits the strengths of both systems for wide-ranging stage mapping and efficient data acquisition in quantitative analyses.

### WDS

- Analysis using up to five channels
- Trace-element analysis with large probe currents ( $10^{-9}$  to  $10^{-5}$  A)
- High-accuracy qualitative and quantitative analyses
- State analysis with superior wavelength resolution
- High-sensitivity detection for light elements

### EDS

- Simultaneous analysis of multiple elements
- Probe condition for X-ray analysis same as for SEM-image observation ( $10^{-12}$  to  $10^{-8}$  A)
- Rapid analyses
- Minimum specimen damage



Backscattered electron image of basalt and its WD/ED combined color map (Top: WDS, bottom: EDS)

WD/ED combined quantitative analysis result of stainless-steel

ZAF Metal								
Element	Mass (%)	Atom (%)	K (%)	K-row (%)	ZAF	Z	A	F
Si	0.675	1.3233	0.370	0.370	1.8229	0.9008	2.0240	0.9998 WD
Cu	0.062	0.0534	0.055	0.055	1.1157	1.0301	1.0831	1.0000 WD
Co	0.294	0.2748	0.281	0.281	1.0480	1.0203	1.0273	0.9999 WD
Mo	0.076	0.0434	0.059	0.059	1.2770	1.0789	1.1863	0.9977 WD
Cr	19.345	20.4792	21.894	21.894	0.8836	1.0055	1.0102	0.8698 ED
Mn	2.421	2.4260	2.491	3.216	0.9720	0.9733	1.0079	0.9908 ED
Fe	66.809	65.8503	65.285	65.285	1.0233	1.0016	1.0338	0.9882 ED
Ni	10.185	9.5498	9.354	9.354	1.0888	0.9828	1.1079	1.0000 ED
<b>Total</b>	<b>99.867</b>	<b>100.0000</b>	<b>99.790</b>	<b>100.515</b>	<b>Iteration = 4</b>			

In the JXA-8230, a silicon-drift detector (SDD) can be selected as an EDS detector. The SDD does not require cooling by liquid nitrogen, enabling element mapping with higher energy resolution. Conventional EDS, which uses liquid nitrogen, is also available. All JEOL EDS systems support WD/ED combination analysis.



Dry SD (SDD)

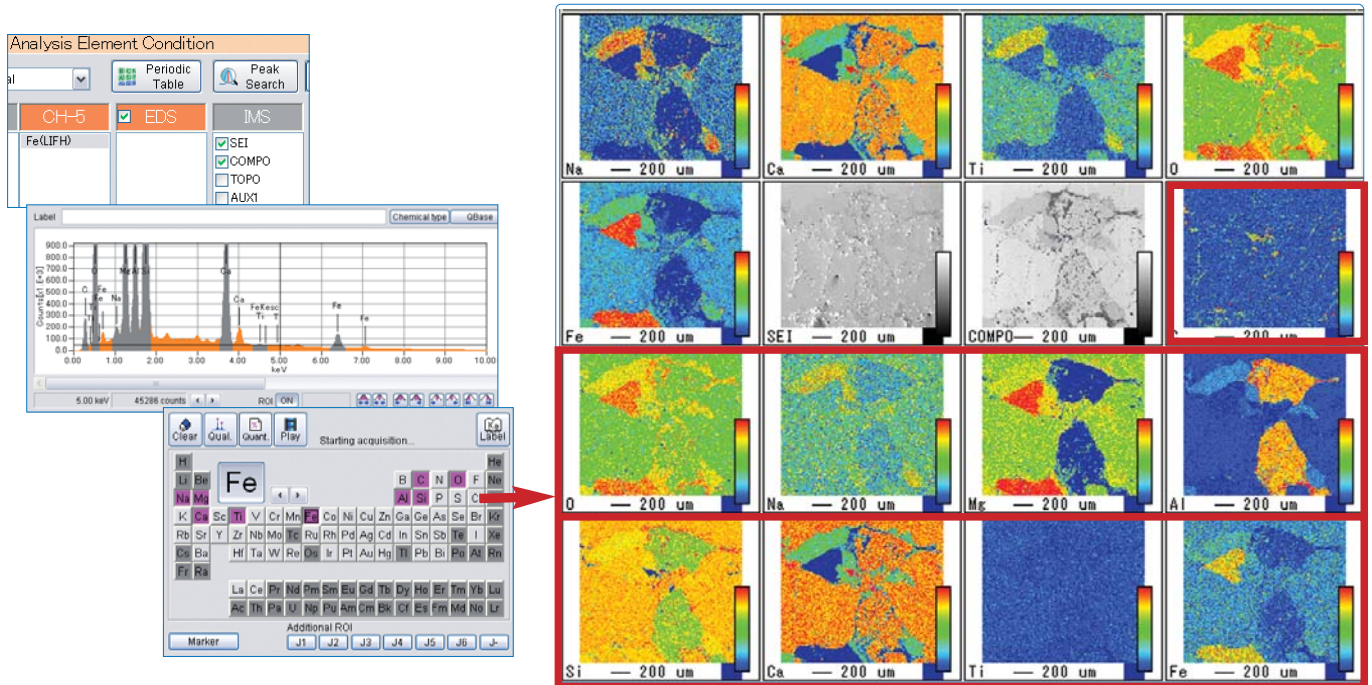


Mini Cup EDS

## EDS active map function possible in WD/ED combined analysis

The JEOL EDS employs the active mapping method that acquires complete spectra at each measurement point. In WD/ED combined line and area analyses, one does not need to specify the elements to be measured with EDS. For example, in area analysis the EDS element maps are sequentially constructed, based on real-time automatic element identification. Even after the mapping is finished, EDS maps for user-selected elements can be added.

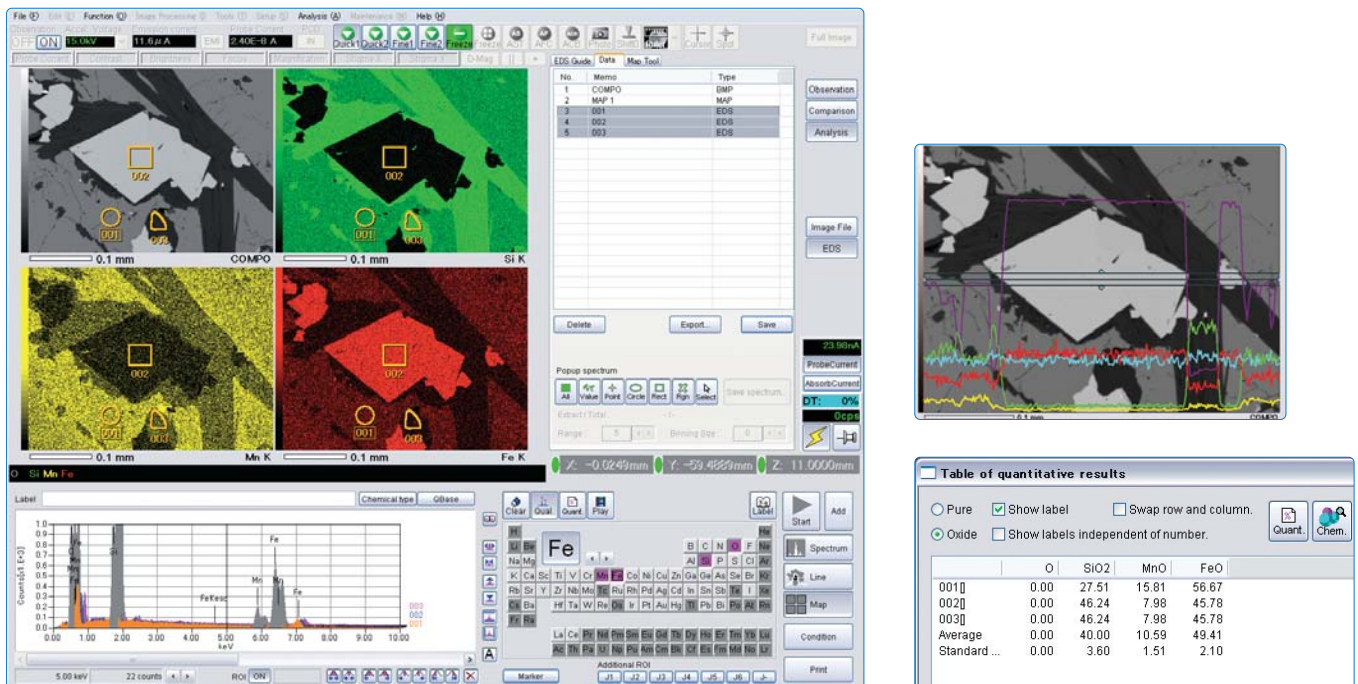
Area analysis real-time monitor



Simply by checking in the check box of EDS, EDS spectra are acquired from all measured points. Automatically identified elements from the spectra are displayed on the monitor screen in real-time.

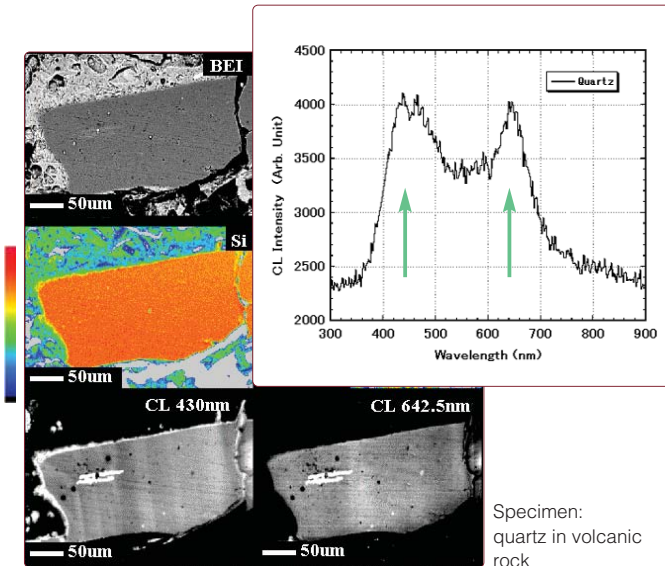
## Extensive analytical functions for EDS

The JXA-8230 also provides various EDS analyses such as line analysis, area analysis and quantitative mapping.



# Cathodoluminescence System\*

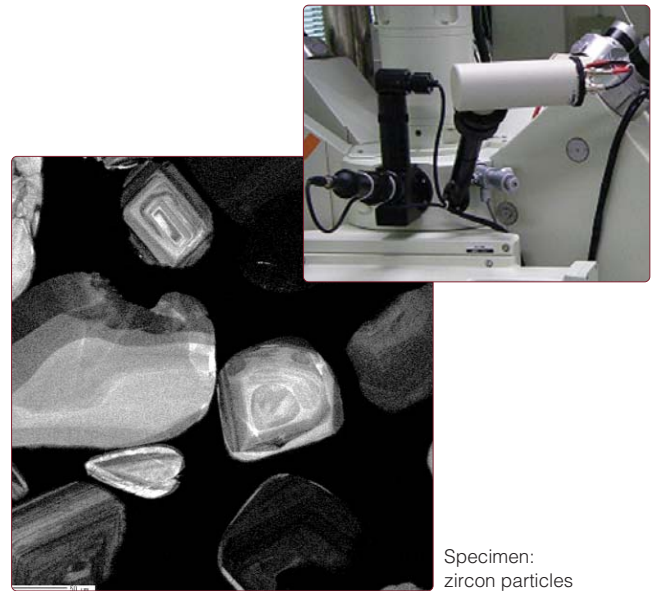
Irradiating a specimen with an electron beam may generate cathodoluminescence. Analyzing the cathodoluminescence enables one to, for example, determine minute concentration differences of 1 ppm or less, or obtain information on crystal defects.



Specimen:  
quartz in volcanic  
rock

MCL

CL spectrometer of monochromatic type attached to OM port. Used for materials analysis.



Specimen:  
zircon particles

Panchromatic CL

CL detector of panchromatic type. Used for geological mineral screening.

## Optional Attachments\* & Optional Programs

### LaB<sub>6</sub> Electron Gun XM-20110LBG

Ensures higher secondary electron image (SEI) quality with the same resolution, or higher resolution with the same image quality, than with a tungsten (W) electron gun in secondary image observation. In X-ray analysis it emits a probe current several times higher with the same probe diameter, than with the W electron gun. It offers advantages for micro-area analysis.

### Smart Stage Controller

Used for aligning the specimen-surface to the focus point of the optical microscope (OM) automatically. The tracing mode is not provided.

### Tracing OM Auto Focus

Used for aligning the specimen-surface to the focus point of the Optical Microscope (OM) automatically. For line analysis or area analysis, using the tracing mode, a specimen with a slightly rough surface can be automatically analyzed continuously with this device.

### Specimen Navigator

Software for controlling the specimen stage by clicking an image on the specimen holder, which appeared on the monitor screen.

### Large Specimen Holder [LH] XM-81320 (LH)

Maximum specimen size : 100 mm × 100mm × 50 mm (H)

### Large Specimen Holder [LH100] XM-86LH100

Maximum specimen size : 100 mm × 100 mm × 10 mm (H)

### Large Specimen Holder [LH100T] XM-86LH100T

Maximum specimen size : 100 mm × 100 mm × 20 mm (H)

### Large Specimen Holder [LH4] XM-86LH4

Maximum specimen size : 36 mm (dia.) × 20 mm (H)  
Loadable specimens : Up to 4  
Four specimen cylinders (for specimens up to 33 mm (dia.) × 15 mm (H)) provided.

### Large Specimen Holder [LH9] XM-86LH9

Maximum specimen size : 25.5 mm (dia.) × 20 mm (H).  
Loadable specimens : Up to 9.  
Nine specimen cylinders (for specimens up to 22 mm (dia.) × 15mm (H) ) provided.

### Large Specimen Holder [LH70] XM-86LH70

Maximum specimen size : 70 mm × 100 mm × 10 mm (H)

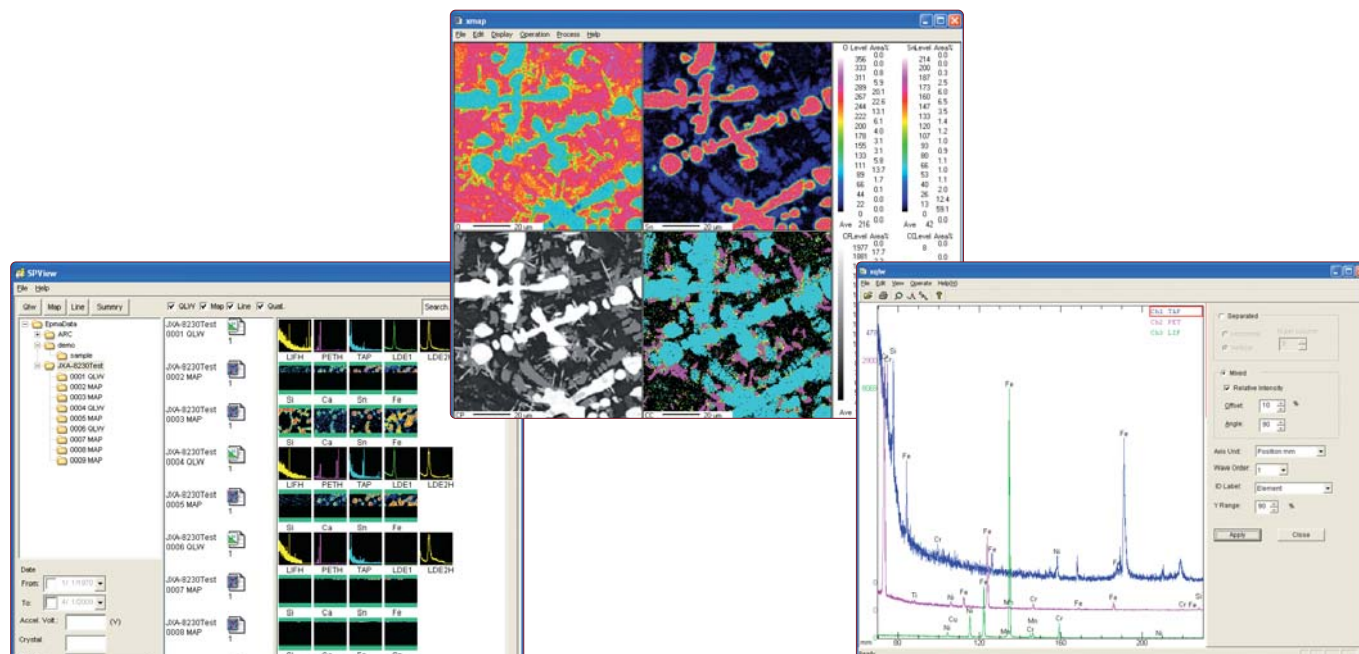
Vise-type specimen holding method used

### Large Specimen Holder [LH44] XM-86LH44

Two 40mm (dia.) × 20 mm (H) (maximum) specimens and two 25.5 mm (dia.) × 20 mm (H) (maximum) specimens can be held simultaneously.  
Two cylinders for maximum 37 mm (dia.) × 15 mm (H) specimen and two cylinders for maximum 22 mm (dia.) × 15 mm (H) specimen provided

# SPView\*-Editing of Analysis Data on Your PC

SPView is a program to process EPMA analysis data on your PC. SPView enables versatile editing of your data, even though the PC is separated from the main console of your EPMA. Using this program, you can carry out printing, reporting, presentation preparation, etc., by changing color levels for area analysis data or by enlarging/reducing spectrum.



## Large Specimen Holder [LH30] XM-86LH30

Thirty 10 mm (dia.) × 20 mm (H) (maximum) specimens and one standard specimen can be held simultaneously.

## Standard Specimen Mount XM-86LHS

Used for specimen holders.  
Up to twelve standard specimens can be held simultaneously.  
Maximum specimen size : 3 mm (dia.) × 12mm (H)

## Tilt and Rotation Holder XM-81450 (TRH)

This holder can tilt a 25.5 mm × 15 mm (H) (maximum) specimen by up to 20° toward the right side as viewed from the front of the column (toward the direction for the SE detector) and rotate 360° (to any angle in horizontal plane, endless).

## Liquid Nitrogen Trap XM-11550

Used to reduce the specimen-surface contamination induced by electron beam irradiation. It is especially effective for analysis of minute amount of carbon.  
Operating time after liquid nitrogen filling :  
Approximately 10 h

## Low Magnification Optical Microscope 733-OML2

Wide-field, low-magnification optical microscope can be used simultaneously with the standard OM.  
Magnification : × 30  
Field of view : 6 mm diameter  
Image orientation : Reversed

## Transmission Illuminator XM-26710OMT

This unit consists of a transmitted illumination source and a specimen holder. Used for observing a thin specimen or LCD panel using an optical microscope through transmitted light.

## Color Printer

Used for outputting the analysis results of color map, qualitative spectra, line analysis and quantitative analysis.

## EPMA Data Viewer XM-17630EDV

Using this program, you can carry out various editing on your own PC by changing color levels for area analysis data or by enlarging/reducing spectrum (SPView).

## Electron Flight Simulator XM-87660 (EFS)

This is a program for simulating the traces of electrons inside a specimen by the Monte Carlo method, which runs under MS-Windows XP. The traces of electrons inside a specimen and the position from which X-rays were generated and EDS spectra are displayed graphically.  
Film specimens with up to five layers can be analyzed simultaneously.

## SMileView SM-35080 (SMV)

Software for easily processing a SEM image beginning with selecting an image from the SEM image list saved in the same folder on the PC to print it. It runs under MS-Windows95/98/Me/NT/2000/XP. This is useful to process the image data of EPMA using the secondary PC for data processing or individual PC.  
Applicable image format: BMP, JPEG, TIFF, WMF.

## Spectrum Deconvolution Program XM-27410DCMS

Overlapping spectra such as N-K $\alpha$  and Ti-LI in WDS analysis are deconvolved by a combination of the digital-filter method and the least-squares method. Deconvolved spectra can be utilized for correcting calculation as a relative intensity in the quantitative analysis program.

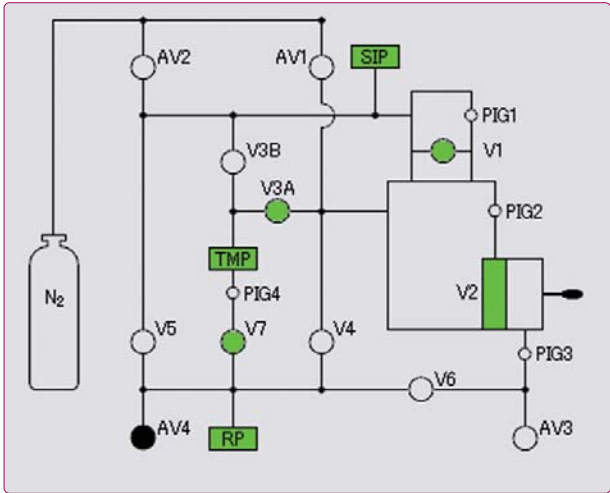
# Stable and Clean Vacuum

The JXA-8230 obtains a stable and clean vacuum by a turbo-molecular pump (TMP). The vacuum system always monitors the vacuum status of the instrument.

In addition, its TMP and modified power supplies for the instrument dramatically reduce power consumption, one-half smaller compared with that for conventional instruments.



JXA-8230



**Phi-Rho-Z Quantitative Analysis Program  
XM-27450PRZ**

This program, based on a correction equation developed by Dr. John Armstrong in California Institute of Technology, improves the correction accuracy, especially for light elements.

**Phase Analysis Program  
XM-27530PHASE**

This program can create binary or ternary scatter diagrams, phase maps etc. from the data of area analysis, line analysis, qualitative analysis or quantitative analysis, and can be used for analyzing the correlation among constituent elements and the relationship among correlation. Up to 63 phases can be displayed.

**Panchromatic cathodoluminescence system  
(PCL)**

This is a cathodoluminescence (CL) detector of panchromatic type, which supports beam scan at low magnifications. CL can be observed and measured at X-ray analysis positions. Although acquisition of CL spectral cannot be done, this system enables high-speed analysis at low magnifications. This is used for geological mineral screening.

**Quantitative Map Program  
XM-27590QTMAP**

This program can create a concentration map and chemical composition map, by applying quantitative correction to the map data obtained with a WDS.

**Random Surface Map Program  
XM-27570RSMAP**

This is a program for area analysis with stage scan, even when the specimen has complicate surface irregularities. The measurement results can be processed in the same manner as the ordinary area analysis data.

**EBSD Analysis System  
(EBSD)**

It is a device which analyzes the crystal azimuth on the sample by projecting diffraction image (Electron Backscatter Diffraction : EBSD) by a real scattering when the electron beam irradiates a crystalline sample to a fluorescent board and processing the taking image with the camera. The application to the azimuth of the material of crystal of the aggregate structure of the rolled material and the grain boundary analysis, etc. can be expected.

**Thin Film Analysis Program  
XM-27470THIN**

This is a function-extension program that can obtain the composition ratios and film thicknesses of each thin film from the Quantitative Analysis Program and Area Analysis Processing Program. Using the backscattered electron intensity, this program takes account of the effects of the substrate layer on the X-ray generation function, enabling the analysis of a relatively thick film up to approximately 1 μm in thickness.

**Monochromatic cathodoluminescence system  
(MCL)**

This is a cathodoluminescence (CL) spectrometer of monochromatic type, which is incorporated in the JXA-8230/8530F and uses an optical microscope (OM) for analysis. CL can be observed and measured at X-ray analysis positions. Acquisition of CL spectra is made using a PC system. This is used for various fields of semiconductors, geology and ceramics, etc.

**EBSD Specimen Tilt Holder  
(STEB)**

When the EBSD analysis system is used, it is a necessary special holder. The sample can be installed in 70° in the inclination corner by fixing.

## Principal specifications

Detectable element range	WDS : (Be) <sup>*1</sup> /B to U, EDS : B to U
Detectable X-ray range	Detectable wavelength range with WDS : 0.087 to 9.3nm Detectable energy range with EDS : 20keV
Number of spectrometers	WDS: Up to 5 selectable, EDS: 1
Maximum specimen size	100mm × 100mm × 50mm (H)
Accelerating voltage	0.2 to 30kV (0.1kV steps)
Probe current range	10 <sup>-12</sup> to 10 <sup>-5</sup> A
Probe current stability	±0.05%/h, ±0.3%/12h (W)
Secondary electron image resolution	6nm (W) , 5nm (LaB <sub>6</sub> ) <sup>*2</sup> (W.D. 11mm, 30kV)
Scanning magnification	×40 to ×300,000 (W. D. 11mm)
Scanning image resolution	Maximum 5,120 × 3,840
Color display	For EPMA analysis : LCD 1,280 × 1,024 For SEM operation and EDS analysis : LCD 1,280 × 1,024

\*1: With optional analyzing crystal for Be analysis

\*2: LaB<sub>6</sub>: optional

## Installation requirements

### Power

Base unit	Single phase 200 V, 50/60 Hz, 4 kVA Allowable input-voltage fluctuation ± 10% (Ground : One, 100 Ω or less)
Computer	AC100 V, 50/60 Hz, 15 A or more

### Cooling water

Faucet	One, ISO7/1 Rc3/8 (R3/8 on hose end)
Flow rate	3.0 to 3.5 lit/min
Pressure	0.1 to 0.25 MPa (gauge)
Temperature	20 ± 5 °C
Drain	1 or more (Drain to accommodate 2 OD 10 mm hoses) *Water chiller (option) recommended

### Dry N<sub>2</sub>gas

To be purchased by user.

Pressure	0.4 to 0.5 MPa (gauge)
Gas outlet	ISO7/1 Rc1/4 (female)

### PR gas

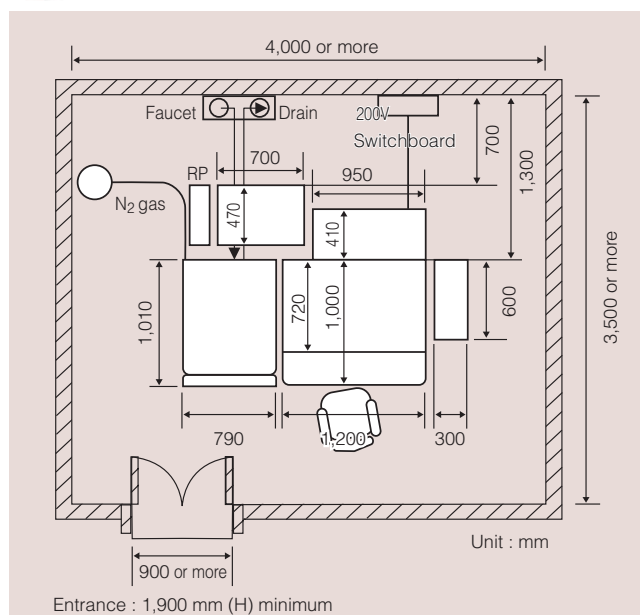
To be purchased by user.

	Ar 90%, CH <sub>4</sub> 10%
Connection	ISO7/1 Rc1/4 (internal thread)

### Installation room

Room temperature	20 ± 5 °C (fluctuation : ± 1 °C recommended)
Humidity	60 % or less (no condensation)
Stray magnetic field	0.3 μT(p-p) or less (50/60 Hz) 0.1 μT(p-p) or less, vibration of DC magnetic field
Floor vibration	3 μm (p-p) or less (at 6Hz or higher)
Floor space	4,000 mm (W) × 3,500 mm (D)
Entrance	900 mm (W) × 1,900 mm (H) minimum

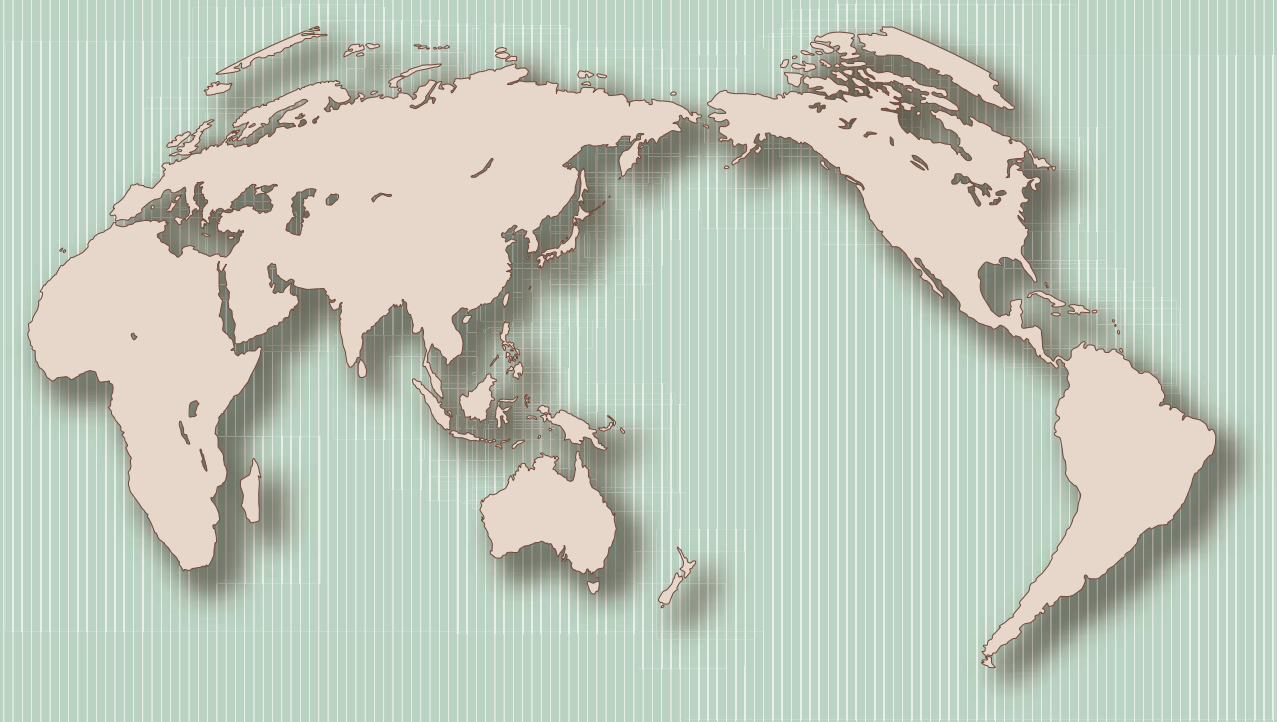
## Installation layout



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# ***SUPER PROBE***



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