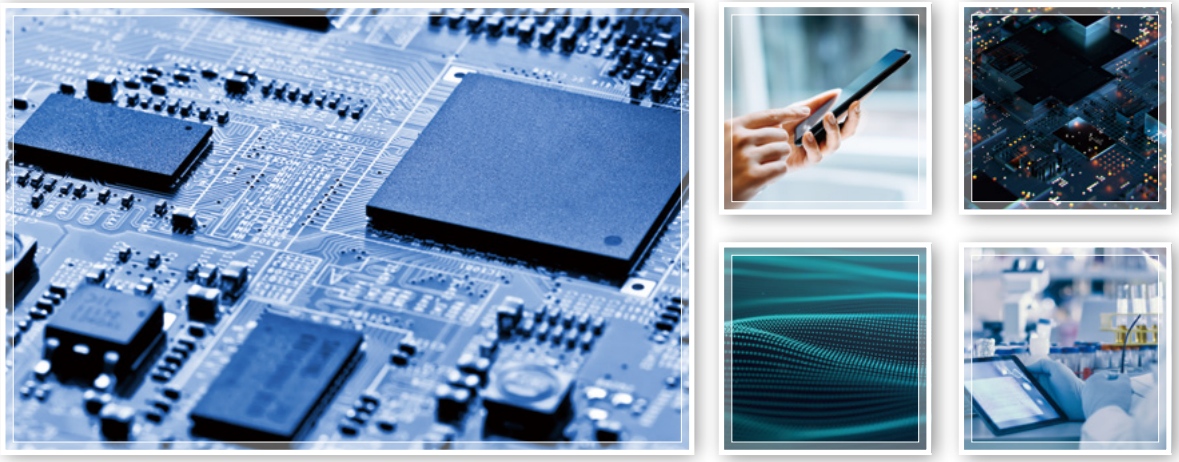
C10G-E093

SHIMADZU
Excellence in Science

Support for Product Evaluation to Quality Control of Electronic Components

Instruments for Analyzing / Evaluating Electronic Devices



Shimadzu Analytical and Measuring Instruments Used in Electrical/Electronic Fields

Electronic devices and semiconductor technologies support a variety of industries and add comfort to our lives.
Shimadzu develops and manufactures a wide range of instruments to help manufacturers conduct quality control of electronic devices and comply with regulations and directives.
This catalog introduces equipment and related applications, such as observation of minute parts, elemental analysis, evaluation of optical properties, measurement of hazardous substances, and evaluation of mechanical properties.

Evaluation Parameters, Measurement Instruments, and Application Examples for Electrical/Electronic Products

Testing/Evaluation Parameter	Testing/Evaluation Parameter (Details)	Instrument	Application Examples
Observation and Analysis / Evaluation	Micro-area observation and elemental analysis	Electron probe microanalyzer (EPMA)	Submicron contaminant analysis Elemental analysis of intermetallic compounds, such as solder joints for mounted devices
	Elemental analysis and chemical state analysis	X-ray photoelectron spectrometer (XPS)	Composition/bond state analysis of a sample's surface and metal surface discoloration analysis
	Micro-area observation	Scanning probe microscope (SPM) and atomic force microscope (AFM)	3D measurement and physical property measurement of nano-regions Observation of micro-shapes on sample surfaces, LCD panel alignment films, or ITO membranes
	Non-destructive observation of interior structures	X-ray fluoroscopy and CT system	Observation of joints on mounted circuit boards (BGA joints, etc.) Observation of internal structures in electrical/electronic components and failure analysis Non-destructive 3D measurement of plastic connectors and other molded parts
	Elemental analysis and contaminant analysis	Infrared microscope	Identification of organic compounds and analysis of contaminants on electronic components
Evaluation of Optical Properties	Evaluation of film thickness	Fourier transform infrared (FTIR) spectrophotometer	Quantitative measurement of phosphorus and boron in silicon wafers Measurement of lubricant oil film thickness on hard drive discs Measurement of epitaxial film thickness on semiconductors
	Measurement of reflectance and transmittance	Ultraviolet-visible-near infrared (UV-VIS-NIR) spectrophotometer	Measurement of antireflection coating reflectance Transmittance measurement of smartphone proximity sensor window
Evaluation of Additives and Hazardous Substances	Measurement of hazardous substances	Energy dispersive X-ray fluorescence spectrometer (EDX)	Screening for elements regulated by RoHS/ELV Directives Analysis of elements in layer structure and elemental analysis of contaminants
		Pyrolysis gas chromatograph mass spectrometer (Py-GC/MS)	Analysis of phthalate esters and brominated flame retardants specified in the RoHS Directive
		ICP emission spectrometer and ICP mass spectrometer	Accurate quantitative analysis of substances regulated by RoHS/ELV Directives
		Ion chromatograph	Evaluation of halogen-free state in electrical / electronic materials Measurement of sulfur components in chemical materials

Testing/Evaluation Parameter	Testing/Evaluation Parameter (Details)	Instrument	Application Examples
Evaluation of Properties	Evaluation and characterization of thermal degradation and thermal resistance	Thermal analyzer	Evaluation of thermal degradation and thermal resistance Characterization of liquid crystal materials
Evaluation of Particle Size Distribution	Measurement of coarse particles	Dynamic image analyzer (DIA)	Evaluation of silica shape and coarse particle content in electronic component sealing materials
Environmental Measurement	Measurement of emission gases Measurement of air pollutants	Headspace gas chromatograph mass spectrometer (GCMS)	Measurement of gases emitted from components Measurement of clean room atmospheres
	Measurement of emission gases	Trap headspace gas chromatograph mass spectrometer (GCMS)	Analysis of gases emitted from components
	Measurement of trace impurities	Atomic absorption (AA) spectrophotometer	Measurement of trace metals in rinse water
	Analysis and management of water	Total organic carbon (TOC) analyzer	Management of ultrapure water, recovered water, effluents, and plating solutions
Evaluation of Mechanical Properties	Evaluation of strength	Precision universal testing machine Compact tabletop testing machine	Various strength evaluations of electronic components, circuit boards, etc. (peeling test, shearing test, etc.)
	Evaluation of endurance	Magnetic micro force testing machine	Evaluation of endurance of electronic components, circuit boards, etc. (cyclic bending test, etc.)
	Evaluation of strength	Micro compression testing machine	Evaluation of strength of liquid crystal spacers and conductive particles
	Evaluation of surface hardness	Dynamic ultra micro hardness tester	Evaluation of film thickness, surface treatment layer, and microelectronic components
	Measurement of viscosity	Flowtester (capillary rheometer)	Measurement of viscosity of sealing epoxy resins for printed circuit boards and ICs
Evaluation of Mass	Measurement of weight	Balance	Confirmation of electronic circuit board weight during manufacturing and measurement of semiconductor microcomponent weight

Observation and Analysis/Evaluation

Micro-Area Observation and Elemental Analysis

● Submicron Contaminant Analysis and Elemental Analysis of Intermetallic Compounds, Such as Solder Joints for Mounted Devices

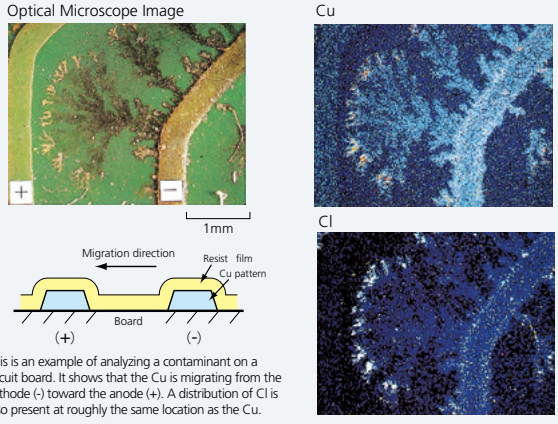
Electron Probe Microanalyzer

EPMA-1720 Series

Using only simple mouse operations, EPMA-1720 series microanalyzers can reveal the micron, submicron, and even nano-level microstructures in electrical/electronic materials.

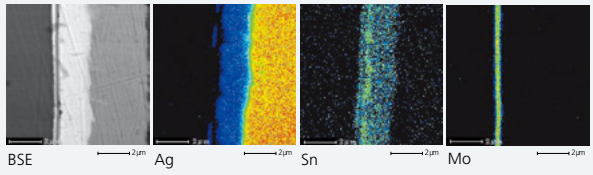
- Enables analysis of submicron-level contaminants or the identity, shape, and quantity of impurities.
- Non-uniformities and segregations can be determined from element distributions over a large 90 × 90 mm area.
- Multiple samples can be analyzed successively without human intervention.

Cu Migration between Printed Circuit Boards



This is an example of analyzing a contaminant on a circuit board. It shows that the Cu is migrating from the cathode (-) toward the anode (+). A distribution of Cl is also present at roughly the same location as the Cu.

Analysis of LED Eutectic Mount Plating Layer

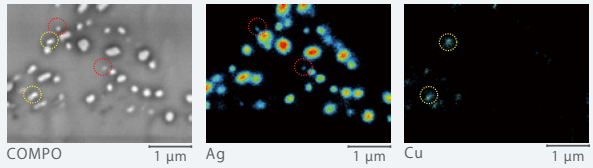


An EPMA-1720H model equipped with a high-resolution CeB6 electron gun clearly shows the fine structure of the LED eutectic mount plating layer. It shows that the Sn in the plating layer applied to the Ag layer is bleeding into the Ag layer.
The thin film of Mo is about 0.4 µm thick.

EPMA-8050G

The EPMA-8050G features a high-intensity Schottky emitter and a new electron optical system that can focus the electron beam to a smaller diameter, which achieve high spatial resolution even during irradiation at high current levels.

- Achieves the world's highest spatial resolution performance during high-current irradiation.
- Enables ultra-high-sensitivity analysis with irradiation at high current levels up to 3 µA.
- With a large 52.5-degree X-ray take-off angle, it can even analyze bumpy samples with excellent accuracy.



This data is from mapping analysis of an area of a lead-free solder that contains a high concentration of Ag. (Accelerating voltage: 10 kV, Irradiation current: 20 nA)
The particle shape in the X-ray image of Ag closely matches the particle shape in the BSE image (COMPO). It shows that the particles circled with a red dashed line, which appear to have a 0.1 µm diameter, are also Ag particles. It also shows the presence of particles that contain Cu, which are indicated circled with a yellow dashed line.

Elemental Analysis and Chemical State Analysis

● Composition/Bond State Analysis of a Sample's Surface and Metal Surface Discoloration Analysis

Imaging X-Ray Photoelectron Spectrometer

KRATOS ULTRA2

Automated Imaging X-ray Photoelectron Spectrometer

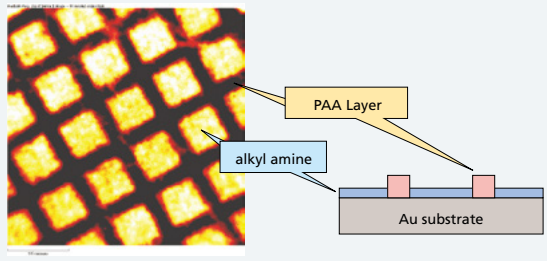
● Overview

XPS (or ESCA) is a method that measures the bond energy of photoelectrons emitted from solid surfaces irradiated with soft X-rays to analyze the type of elements present in substances and their chemical bond state.
Given that the escape depth of photoelectrons is only a few nanometers, information can only be obtained from layers closest to the surface of solids.
This method contributes to applications essential for developing nanotechnologies, such as evaluating thin films or multilayer films, controlling contamination of material surfaces, and evaluating polymer surface treatments.

● Features

Equipped with high-speed XPS imaging functionality based on an imaging-specific analyzer, the system can instantaneously determine the distribution status of elements or chemicals on substance surfaces.

● Application



This is an XPS image of Au 4f peaks measured from a sample with a pattern formed by microcontact printing on a thin film of gold. The Au peaks from the pattern were detected through a monomolecular film of alkylamine less than a few nm thick. The results show that the polyacrylic acid (PAA) thin film between the pattern lines (lattice area), which is at least 10 nm thick, blocks the signal from the substrate.

(Source: Prof D. Crooks, Texas A&M University)

Imaging X-Ray Photoelectron Spectrometer

KRATOS NOVA

Automated X-ray Imaging Photoelectron Spectroscopy

Ar Gas Cluster with Ion Gun

● Overview

This micro-XPS system (15 μm minimum analysis diameter) automates all process steps from loading samples until measurements are finished.
Analysis positions can be quickly specified at any position in the CCD camera image or the real-time photoelectron image of the large 110 mm square sample platen. Three sample platens are available, which can be installed in the loading area and automatically exchanged. Furthermore, large samples can be measured directly as they are.
The system successfully automates the entire process without sacrificing the performance levels required in research fields.

● Features

Samples can be observed via the CCD camera to then accurately specify the analysis locations in the captured images.
Three large 110 mm square sample platens can be installed at the same time and automatically exchanged.
Steps for switching from micro to macro analysis modes or measuring images can be fully automated.
The system can measure real-time images with a spatial resolution of 3 μm or less using the spherical mirror analyzer (patented), measure samples with high sensitivity using the magnetic lens (patented), and measure insulation samples with high-energy resolution using a charge neutralizer mechanism (patented).

● Application

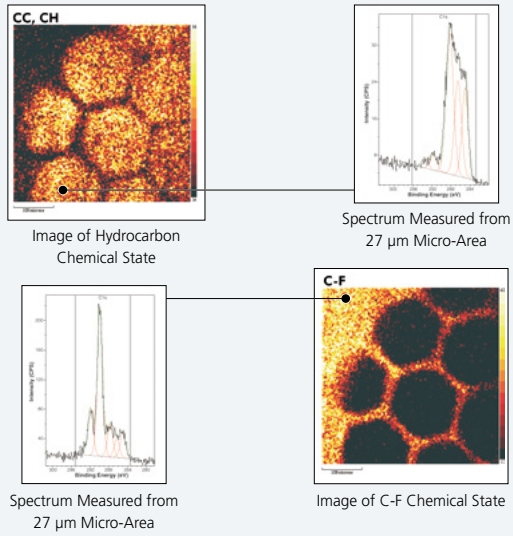


Image of Hydrocarbon Chemical State

Spectrum Measured from 27 μm Micro-Area

Spectrum Measured from 27 μm Micro-Area

Image of C-F Chemical State

Observation and Analysis/Evaluation

Micro-Area Observation

- 3D Measurement and Physical Property Measurement of Nano-regions
- Observation of Micro-Shapes on Sample Surfaces, LCD Panel Alignment Films, or ITO Membranes

Scanning Probe Microscope/Atomic Force Microscope

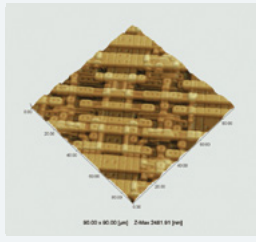
SPM-9700HT

A scanning probe microscope (SPM) is a generic term for microscopes that scan sample surfaces with a tiny probe to observe three-dimensional shapes at high magnifications. A common type of SPM is an atomic force microscope (AFM).

- Samples can be observed at high magnifications in an atmospheric environment.
- Even insulative samples can be observed directly.
- Samples can be accurately measured in their height direction.
- Physical quantities other than height, such as surface potential, magnetic force, viscosity, and elasticity, can also be measured.

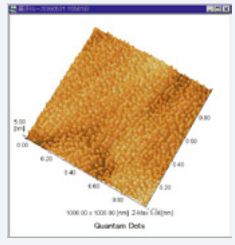
The SPM-9700HT enables observation of metals, semiconductors, ceramics, organic substances, polymers, and biological samples at high resolutions in an atmospheric environment without coating or other pretreatment. It can obtain images of sample surface unevenness at high magnification rates ranging from a few thousand times to several million times. It also offers superior resolution with respect to the vertical direction of the sample, which enables accurate measurement of material surface roughness.

LSI Circuit Observation Example



The circuit patterns and contact holes in large-scale integrated (LSI) circuits can be observed clearly.

Quantum Dots



This shows the observation of In0.7Da0.3As quantum dots grown by molecular beam epitaxy (MBE) on a GaAs (100) substrate (2-degree tilt). AFM images can provide information important for opto-electronics, such as the density, shape, and regularity of quantum dots. (Source: MJ. da Silva, Prof. A.A. Quivy, University of São Paulo)

Scanning Probe Microscope/Atomic Force Microscope

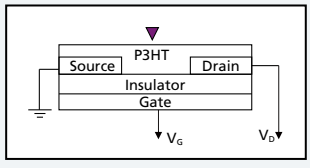
SPM-Nanoa

The SPM-Nanoa achieves high-resolution observation by adopting a high-sensitivity low-noise detection optical mechanism, and also automates the optics adjustment and observation parameter setting steps, a manual process with previous models. Consequently, even inexperienced users can easily obtain high-resolution observation data.
It can be used for a wide variety of nanotechnology or nanoscience issues by observing the shape or evaluating the physical properties of polymer materials, battery materials, nanomaterials, and so on.

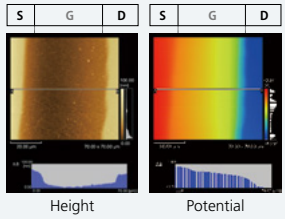
The SPM-Nanoa helps achieve stress-free observations by automating steps that required practice with previous SPM models, such as adjusting the light beam, adjusting parameter settings during observations, and processing image data.
Operating time when using standard samples and standard cantilever: About 5 minutes*

* For automatic observation with a 1 µm field of view and 256 × 256-pixel resolution. Actual operating times can vary depending on the operator.

This is an example of analyzing the shape and electric potential of organic thin film transistors, which have attracted attention for use in flexible displays and other applications. The film material is P3HT (3-hexylthiophene), which provides high electron mobility.
To use the SPM for actual measurement, the source electrode is grounded and electric potentials are applied independently to the gate and drain electrodes, as diagrammed to the right, to map the variation in surface potential at the top of the gate.



Measurement Schematic Diagram



Height Potential

Source: Prof. Fukuda, Department of Electrical and Electronic Engineering, Faculty of Engineering, Muroran Institute of Technology

VG=-10V,VD=-40V

High Resolution Scanning Probe Microscope/Atomic Force Microscope

SPM-8100FM

HR-SPM

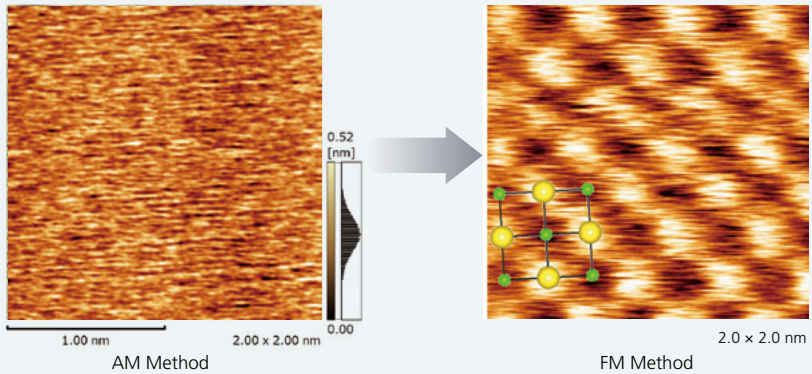
The HR-SPM represents a new generation of scanning probe microscopes based on frequency detection. Previous scanning probe microscopes (SPM)/atomic force microscopes (AFM) were generally based on amplitude modulation (AM). However, in principle, frequency modulation (FM) offers higher sensitivity for acquiring higher-resolution images.
In addition to ultra-high-resolution observation either in air or liquid, it also enables, for the first time, observation of hydration/solvation at the solid-liquid interface.

HR-SPM Features

- Uses FM-based scanning.
- Noise levels in air and liquid are reduced to 1/20 of the previous model.
- Performance levels of vacuum SPM models are achieved in air and liquid.
- Enables measurement of local structures at the solid-liquid interface.
- Equipped with an HT scanner for a larger observation area and even faster speeds.
- Dual monitors and signal display function dramatically improve flexibility.

Differences from Previous SPM/AFM Systems

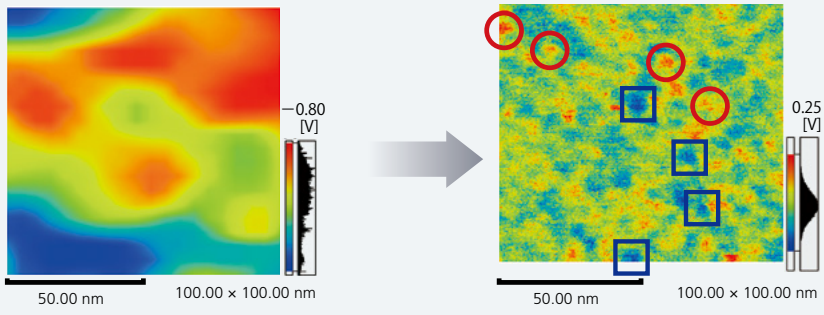
Observation of Atomic Resolution in Liquid



AM Method　　FM Method

KPFM* Observation of Pt Catalyst Particles in Air

*KPFM: Kelvin Probe Force Microscope



AM Method　　FM Method

Observation and Analysis/Evaluation

Non-Destructive Observation of Interior Objects

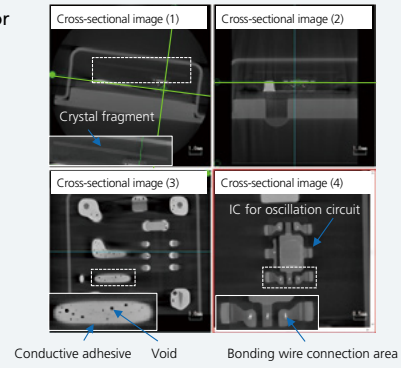
● Observation of Internal Structures in Electrical/Electronic Components and Failure Analysis

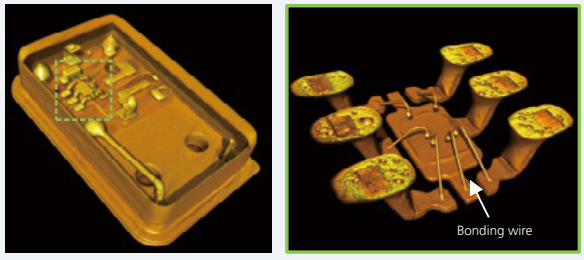
Microfocus X-Ray CT System

inspeXio SMX-225CT HR Plus

- With an exterior camera for CT scan positioning, functionality for automatically setting X-ray parameters based on the given sample, and other features, high-definition three-dimensional CT images can be obtained using simple operations without any need for tedious steps.
- Due to the powerful X-ray generator, with a 4 µm focus size and 225 kV tube voltage, the system can be used to inspect a wide range of items.

Crystal Oscillator





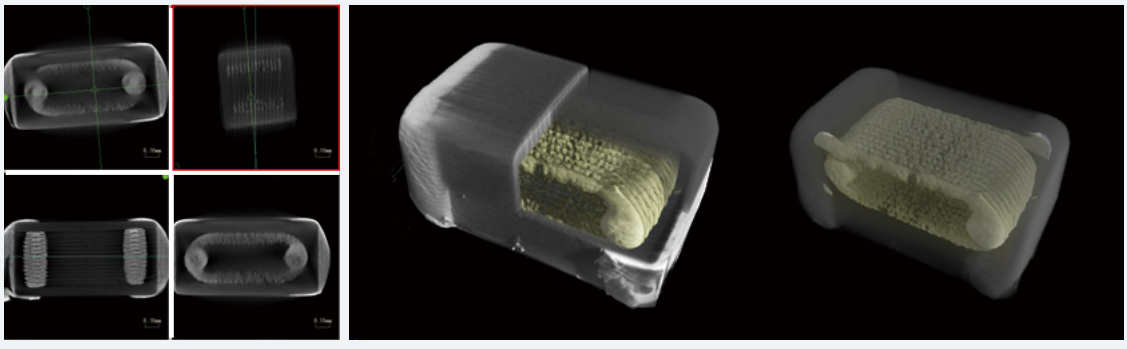
The presence of voids (bubbles) in the conductive adhesive can be determined from the cross-sectional image (3). The bonding wire connection status to the oscillation IC can be determined from the cross-sectional image (4). The status of solder joints and the shape of bonding wires can be confirmed by magnifying images and displaying them three-dimensionally.

Microfocus X-Ray CT System

inspeXio SMX-100CT Plus

- **Achieves low noise and high definition**
  New image processing technology achieves both low noise and high definition. That means more vivid images can be obtained.
- **CT scan area display function**
  The CT scan area display function shows a real-time image of the CT scan region in overview image data of the sample, ensuring that CT scans for the position of interest can be obtained.

Chip Inductor
(1005 size)



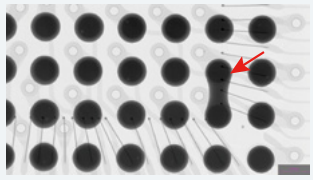
● Inspection of Solder Joints on Mounted Circuit Boards (BGA Joints, etc.)

Microfocus X-Ray Inspection System

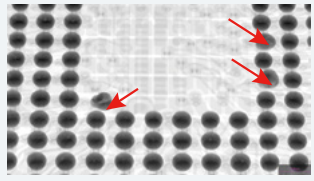
Xslicer SMX-1010 / 1020

- In addition to easier operation, the stage movement and detector acquisition speeds were increased to significantly shorten inspection times. Consequently, inspection operations can be accomplished more efficiently. Xslicer SMX-1010/1020 systems can be used to inspect a wide range of electrical and electronic components, from surface mounted circuit boards to various sensors and cable harnesses.
- CT functionality is available as an option.
- A dedicated NDI X-ray pay-as-you-go X-ray generator maintenance service is available for paying only for the X-ray emission time actually used.

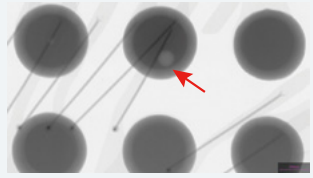
BGA



Short

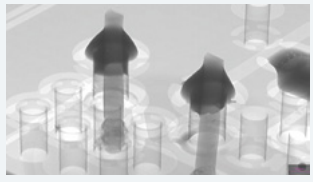


Open

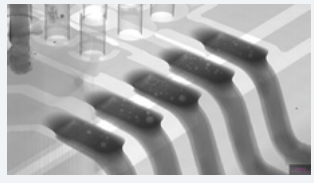


Void

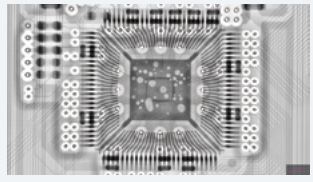
Surface Mounted Devices



Solder Wicking



Terminals

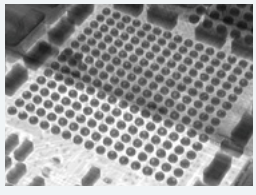


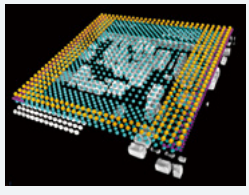
QFP Solder Wetting

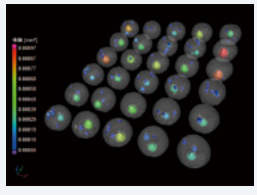
Microfocus X-Ray Inspection System

Xslicer SMX-6010

This X-ray inspection system is equipped with a Shimadzu microfocus X-ray generator and high-resolution flat panel detector and features tilted CT scanning capability. By seamlessly switching between X-ray fluoroscopy and CT observation modes, the system is well-suited for inspecting complex surface-mounted circuit boards.







This is an example of observing BGA connections on a circuit board installed in a smartphone. It shows that internal structures can be accurately understood using CT in combination with X-ray fluoroscopy, even for double-sided surface-mounted circuit boards that are difficult to observe adequately with X-ray fluoroscopy alone. In addition, optional software allows for quantitatively evaluating the volume of voids inside BGA connections.

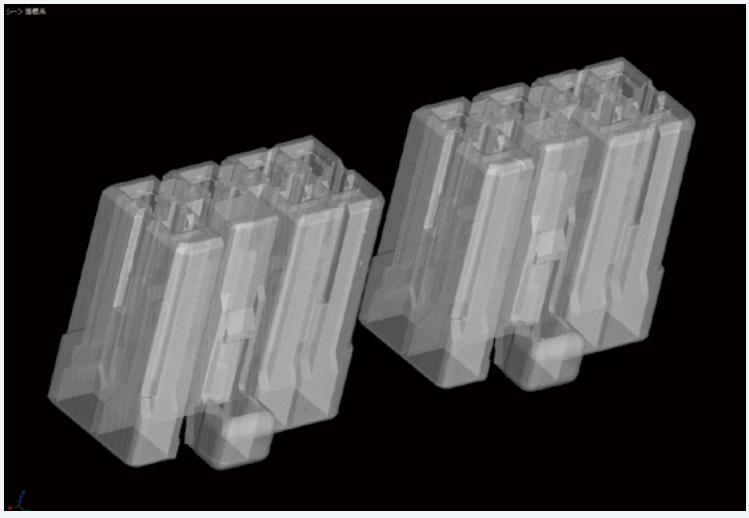
Observation and Analysis/Evaluation

● Non-Destructive 3D Measurement of Plastic Connectors and Other Molded Parts

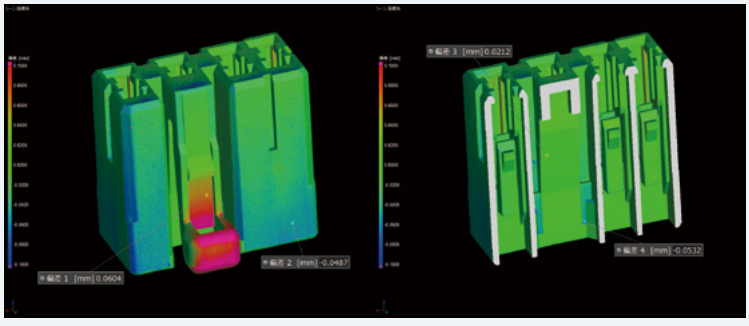
Dimensional X-Ray CT System

XDimensus 300

The XDimensus 300 is a dimensional X-ray CT system that can measure the 3D internal and external geometry of sample interiors. In addition to a high-resolution X-ray detector with a large field-of-view, a new Shimadzu X-ray generator, and new software with outstanding operability, the system features an air conditioning system that maintains a constant temperature inside the instrument, a frame that ensures high geometric stability, and a stage with ultra-accurate sample positioning. Those features achieve a dimensional X-ray CT system with the highest measurement accuracy available in Japan. The XDimensus 300 system can be expected to help improve operating efficiency and quality control systems for various product inspections or drawing verifications.



Surface Data (Simultaneous Scan of Identical Products)



Comparison of Shape Measurements in Two Sets of CT Data

Unlike optical coordinate measuring devices, the XDimensus 300 is unaffected by the color of sample surfaces. Dimensions can be measured even if sample surfaces are transparent or reflective like a mirror. In addition to measuring dimensions, it can compare shape measurements from two sets of CT data. Deviations in three-dimensional shapes can be represented as color-coded maps to compare the shapes of molded plastic parts and evaluate mold deterioration over time.

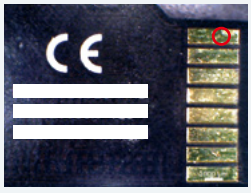
Elemental Analysis and Contaminant Analysis

● Identification of Organic Matter and Analysis of Contaminants on Electronic Components

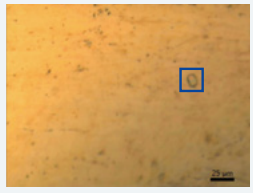
Automatic Failure Analysis System

IRTracer-100 + AIM-9000

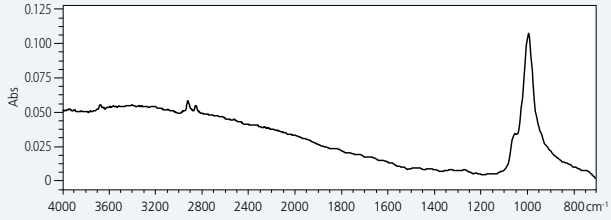
Using an infrared microscope is one of the most effective ways to identify organic contaminant matter originating from raw materials used in manufacturing processes or from dust in the atmosphere. In this example, a contaminant attached to the terminal of an electronic component was analyzed. Using a camera with a large field-of-view allows all steps from observing the overall component to deciding measurement locations to be accomplished smoothly. The ATR method (with a Ge prism) can provide an effective way to measure thin stains, small contaminants, and other substances from which good reflectance spectra are difficult to obtain.



Observation Image of the Entire Electronic Component via Wide-View Camera



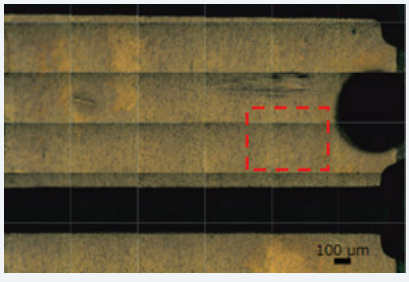
Observation Image of Contaminant on Terminal Magnified by 15x with Cassegrain Mirror



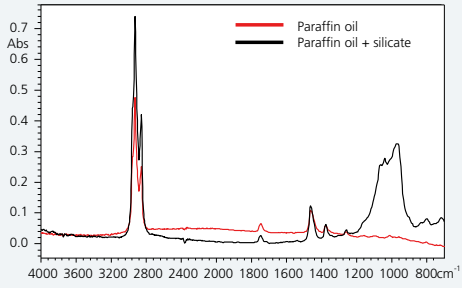
Reflection Mode Spectrum of Contaminant Identified as Silicate

Example of Electronic Circuit Board Failure Analysis — Imaging with an AIM-9000 Infrared Microscope —

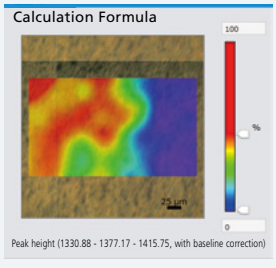
The microscope reflection method was used for imaging analysis of a relatively large range.
An area 200 µm tall by 325 µm wide was measured.

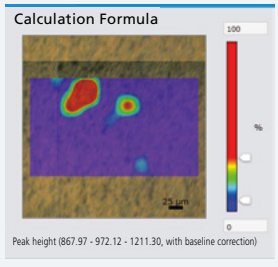


Tiled Image of Electronic Circuit Board



Infrared Spectrum Obtained from Area on the Circuit Board Indicated with Red Box





Left: Distribution of Paraffin Oil (Height of Peak at 1377 cm-1)
Right: Distribution of Silicate (Height of Peak at 972 cm-1)

Evaluation of Optical Properties

Evaluation of Film Thickness

Infrared Spectrophotometer

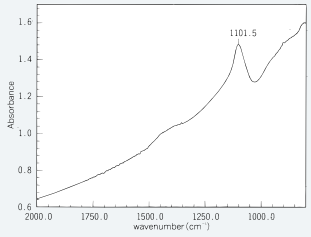
IRSpirit Series / IRAffinity-1S / IRTracer-100

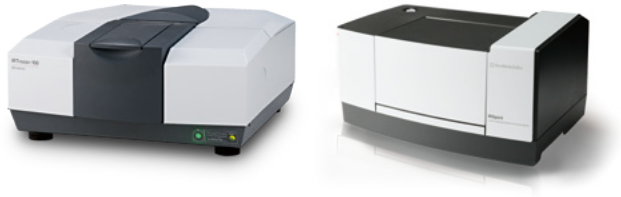
● Quantitative Measurement of Phosphorus and Boron in Silicon Wafers by the PLS Method

IRSpirit series, IRAffinity-1S, and IRTracer-100 spectrophotometers have earned an excellent reputation for use in a wide variety of structural analysis and non-destructive measurement applications, such as for qualitative analysis of defect locations on IC chips or other small parts in the electronic/electrical/semiconductor field.

The infrared spectrum from transmission through a silicon wafer that contains phosphorus and boron as a dopant shows a peak at 1100 cm^{-1} due to Si-O stretching vibration. However, it is difficult to quantify both the phosphorus and boron at the same time, due to the P-O stretching vibration peak that should be visible at 1330 cm^{-1} being obscured by an overlapping B-O band peak centered at 1390 cm^{-1}. However, by using PLS quantitative calculation software with a Fourier transform infrared spectrophotometer, both can be quantified at the same time by the PLS method, an advanced version of principal component analysis (PCA), as shown in the table. (The table shows a comparison of concentrations in a solution from a silicon wafer dissolved in acid, measured using a high-frequency plasma emission spectrometer.) The system can also be used to predict the thickness of silicon wafers used as samples.

Infrared Spectrum of a Silicon Wafer





Quantitative Calculation Results

Table 1 Quantitative Calculation Results by the PLS I Method

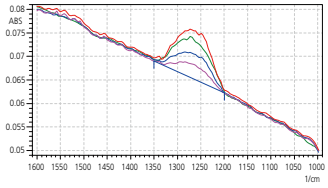
Result of quantitative calculation by PLS I

Concentration of Phosphorus (wt%)		Concentration of Boron (wt%)		Concentration of Silicon (wt%)		Thickness (Å)	
Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted
9.83	12.57	6.09	6.29	84.08	81.65	1948	1937
14.07	13.13	5.76	6.16	80.25	81.47	1966	1951
8.19	8.04	9.07	9.15	82.74	82.54	1956	1955
9.81	9.43	8.82	8.79	81.37	81.47	1930	1957
12.1	11.21	8.43	8.59	79.47	80.56	1927	1982
6.24	7.01	2.16	1.79	81.6	81.69	1930	1891
7.05	8.13	11.59	11.56	81.36	80.71	1947	1921
8.76	9.01	11.03	11.06	80.2	80.11	2005	2013
10.23	9.41	6.07	6.07	83.7	83.88	3984	3939
13.58	13.30	5.77	5.75	80.65	81.03	3924	3950
16.18	15.67	5.79	5.84	78.03	79.34	3924	3903
12.41	11.19	5.76	6.03	81.83	82.33	1910	1931
9.44	9.44	9.31	9.12	81.25	81.28	3849	3883
11.72	12.31	8.75	8.83	79.53	78.97	3963	3993
14.29	14.26	8.4	8.48	77.31	77.50	3836	3884
7.99	8.43	12.05	11.71	79.96	79.55	3837	3809
10.5	10.55	11.63	11.32	77.87	77.88	3903	3895
12.33	11.77	10.96	11.05	76.71	76.62	3973	3911
10.29	10.21	6.18	6.14	83.52	83.60	5790	5823
13.96	14.00	5.43	5.30	80.61	80.98	5702	5665
16.97	17.38	5.53	5.48	77.5	78.06	5861	5795
9.64	9.94	9.17	9.39	81.19	80.62	5705	5701
12.31	12.84	9.16	9.17	78.53	77.73	5864	5956
15.65	15.60	8.42	8.29	75.93	75.83	5825	5884
8.9	8.71	11.98	12.13	79.11	78.38	5859	5829
12.82	12.66	11.06	11 06	76.12	76.36	5848	5836
15.13	14.72	10.42	10.54	74.45	74.73	5810	5782

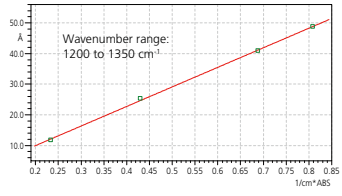
● Measurement of Fluoropolymer Film Thickness on Hard Drive Discs

The disc surfaces in computer internal hard drives are coated with a fluoropolymer as a lubricant. High-sensitivity reflection absorption spectroscopy (RAS) is an effective method for measuring the thickness of fluoropolymer film coatings. At incident angles of 70 degrees or more, thin films less than 1.0 µm thick can be measured.

Infrared Spectrum of Fluoropolymer on a Hard Drive Disc



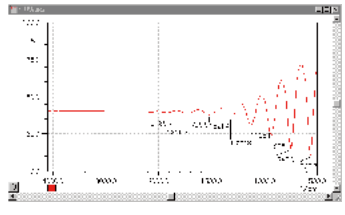
Calibration Curve for Fluoropolymer Film Thickness on Hard Drive Disc



● Measurement of Epitaxial Film Thickness on Silicon Wafer

Using a Fourier transform infrared (FTIR) spectrophotometer, the film thickness can be calculated from the interference fringe spectrum based on the equation to the right, where n is the sample refractive index, Θ is the infrared light angle of incidence onto the sample, m is the number of peaks or valleys within the wavenumber range being calculated, and v1 and v2 are the maximum and minimum values within the wavenumber range.

$$d = \frac{\Delta m}{2\sqrt{n^2 - \mathrm{Sin}^2\,\theta}} \quad \frac{1}{(\nu_1 - \nu_2)}$$



Measurement of Reflectance and Transmittance

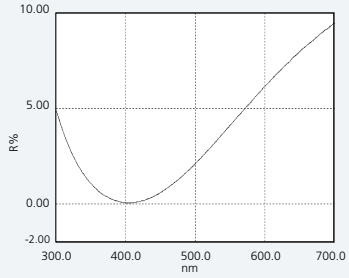
● Measurement of Antireflection Coating Reflectance

UV-VIS-NIR Spectrophotometer

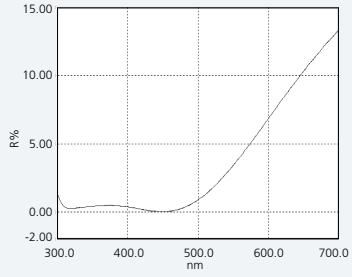
SolidSpec-3700i / 3700i DUV

As the world's first spectrophotometer to include three detectors, these systems offer higher sensitivity, a broad measurement range extending from near-infrared to deep ultraviolet regions, and an extra-large sample compartment that can accommodate large samples up to 700 × 560 mm. In particular, they offer solutions for applications in the semiconductor, flat panel display, and optics industries.

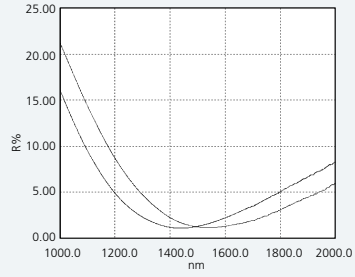
Currently, antireflection (AR) coatings are used in a wide variety of products, such as lenses, eyewear, various displays, automotive windshields, solar panels, and optical communication devices. For example, applying an AR coating on a display screen surface can improve visibility by reducing the amount of external light penetrating the screen. Since the reflectance level of AR coatings is a key factor that determines their quality, there is an important need to measure the reflectance accurately.



Reflectance Spectrum of AR Coating
(Antireflection near 400 nm)



Reflectance Spectrum of AR Coating
(Antireflection between 300 to 500 nm)



Reflectance Spectrum of AR Coating
(Antireflection near 1500 nm)

● Transmittance Measurement of Smartphone Proximity Sensor Window

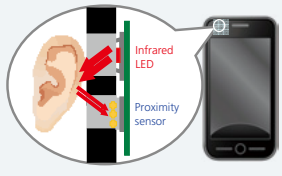
UV-VIS Spectrophotometer

UV-1900i

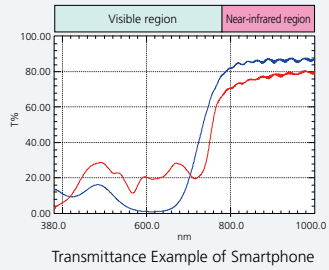
This double-beam UV-VIS spectrophotometer features Shimadzu's proprietary Lo-Ray-Ligh grating. Low stray light levels and high reproducibility (photometric repeatability) enable accurate quantitative analysis of both low and high concentrations.

Transmittance Measurement of Smartphone Proximity Sensor Window

The proximity sensor window in smartphones must maintain high transmittance levels in the near-infrared region used for detecting the proximity of objects. Meanwhile, they also must suppress the transmittance of visible light to reduce visibility into the smartphone from the outside. Therefore, it is extremely important that the transmittance properties of proximity sensor windows are appropriate for respective wavelength regions. Those transmittance characteristics are checked using a UV-VIS spectrophotometer.



Proximity Sensor Configuration



Transmittance Example of Smartphone Proximity Sensor Window

Evaluation of Additives and Hazardous Substances

Measurement of Hazardous Substances

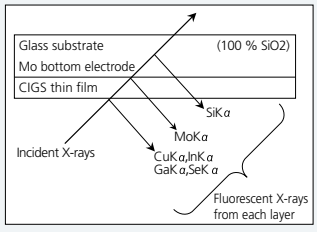
- Screening for Elements Regulated by RoHS/ELV Directives
- Analysis of Elements in Layer Structure and Elemental Analysis of Contaminants

Energy Dispersive X-Ray Fluorescence Spectrometer

EDX-7200 / 8100

Compound-type solar cells are made by depositing a thin film of a compound on a substrate by sputtering or another method. Energy dispersive X-ray fluorescence spectrometers provide a very convenient means of quickly and non-destructively measuring CIGS thin films.

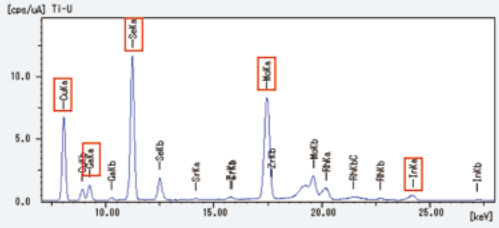
Diagram of Measurement Sample



CIGS Quantitative Analysis (Quantity Deposited) Results

Layer	Sample	No.1	No.2	No.3	No.4
CIGS Thin Film	Coating quantity (μg/cm2)	798	808	814	889
	Cu (mol %)	24.60	24.62	24.77	24.65
	In (mol %)	19.74	19.61	19.44	19.55
	Ga (mol %)	4.85	5.00	4.86	4.83
	Se (mol %)	50.81	50.77	50.93	50.98
Mo Thin Film	Coating quantity (μg/cm2)	400	391	389	395

Qualitative Analysis Results from CIGS Film Sample No. 1



Energy Dispersive X-Ray Fluorescence Spectrometer

EDX-LE Plus

This system can quickly measure samples to screen for the five elements and six substances governed by the environmental regulations in the Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive), and to screen for the four elements and four substances governed by the environmental regulations in the End-of-Life Vehicle Directive (ELV Directive) in Europe. It can also be used for general material analysis, failure analysis, or plating thickness analysis.

- Analysis of Phthalate Esters and Brominated Flame Retardants Specified in the RoHS Directive

Phthalate Ester Screening System

Py-Screener Ver.2

The Py-Screener system is designed to screen for phthalate esters in plastics.
In Europe, the use of phthalate esters is restricted under the Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS (II) Directive). Phthalate esters are thermally extracted from samples using a pyrolysis GC/MS (Py-GC/MS) system to selectively detect and quantify any phthalate esters. This screening system includes dedicated software, special standard samples, a sampling tool kit, and other items prepared specifically for easy screening of phthalate esters by Py-GC/MS. That ensures the system can be easily operated even by inexperienced users.

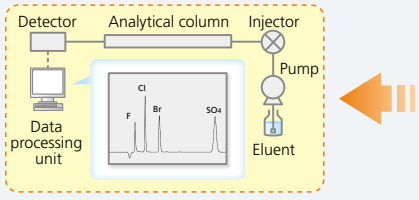
● Evaluation of Halogen-Free State in Electrical/Electronic Materials
● Measurement of Sulfur Components in Chemical Materials

Anion Chromatograph

HIC-ESP

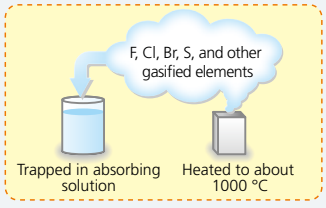
In an effort to reduce environmental impact, halogen-free soldering materials are now commonly used to address increasing requirements for reducing the content of halogen compounds in solder materials used in electrical/electronic equipment. The Japan Electronics and Information Technology Industries Association (JEITA) has established standards for halogen-free soldering materials, both in terms of ensuring inherent solder bonding characteristics and reducing environmental impact. Those standards specify using pyrolysis to decompose flux solids and ion chromatography to measure the halogens as the test method to be used for determining the halogen content.

Ion Chromatograph

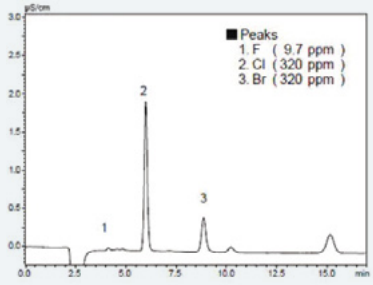


This system is used to analyze the halogen and sulfur content in plastics, lubricant oils, and electronic materials.

Combustion Unit



Combustion gases from combusting the sample at a high temperature are trapped in an absorbing solution, and then accurately analyzed with an ion chromatograph.



Analysis of Solder Flux

● Accurate Quantitative Analysis of Substances Regulated by RoHS/ELV Directives

ICP Emission Spectrometer and ICP Mass Spectrometer

ICPE-9800 Series / ICPMS-2030

The international standard IEC 62321 specifies using ICP optical emission spectrometry, ICP mass spectrometry, and atomic absorption spectrometry for accurate measurement of lead, cadmium, and mercury.

Polyethylene Plastic Analysis Results by Calibration Curve Method

Element	Sample: RoHS Max Limit	Sample: Detection Limit (3σ)	BCR680: Pretreatment: Dry Method	BCR680: Pretreatment: Wet Method	BCR680: Pretreatment: MW Method	BCR680: Certified Value	BCR681: Pretreatment: Dry Method	BCR681: Pretreatment: Wet Method	BCR681: Pretreatment: MW Method	BCR681: Certified Value
Cd	100	0.02	140	140	141	140.8	21.1	21.3	21.6	21.7
Pb	1000*	0.2	106	<	107	107.6	13.2	<	13.7	13.8
Cr	1000	0.03	106	112	115	114.6	16.1	17.3	17.9	17.7
Hg	1000	0.2	<	24.2	25.3	25.3	<	4.3	4.4	4.5
As	-	0.5	27	30	31	30.9	3	4	4	3.93

Detection limit with 0.2 g sample pretreated with 20 mL diluent

< symbol: Less than detection limit *: Max allowable Cr6+

Evaluation of Properties

Characterization of Thermal Degradation and Thermal Resistance

● Characterization of Liquid Crystal Materials

Thermal Analyzer

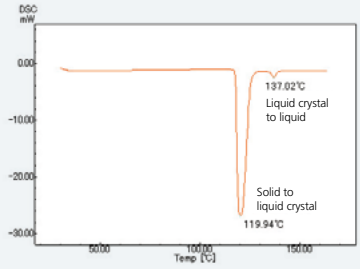
Differential Scanning Calorimeter

DSC-60 Plus

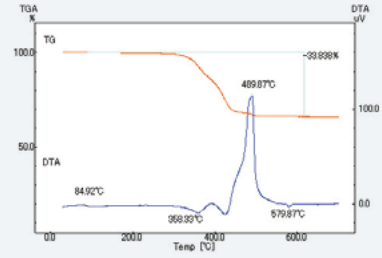
Simultaneous Thermogravimeter and Differential Thermal Analyzer

DTG-60(H)

DSC Measurement of Liquid Crystal Material (Azoxydianisole)



TG-DTA Measurement of Epoxy Resin



Evaluation of Particle Size Distribution

Measurement of Coarse Particles

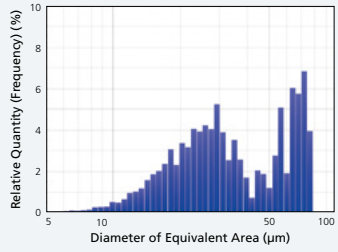
● Evaluation of Silica Particle Shape and Coarse Particle Content in Electronic Component Sealing Materials

Dynamic Particle Image Analysis System

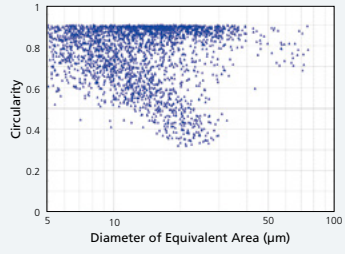
iSpect DIA-10

The iSpect DIA-10 integrates a particle counter, particle size analyzer, particle shape analyzer, and other functionality in a single system. That means a single system can be used to analyze particle images, analyze particle shapes, measure particle size distributions, detect contaminants, and measure the number or concentration of particles, which previously were accomplished using multiple specialized instruments, such as a particle size analyzer and various types of microscopes.

(a) Particle Size Distribution (by Volume)



(b) Scatter Plot
X: Diameter of equivalent area
Y: Circularity



(c) Particle Images

Results are from measuring commercial spherical silica powder with a nominal diameter of 50 μm. Only non-spherical particles (with a circularity less than 0.9) were taken from all particles.
The particle images confirm that non-spherical particles are fragmented or chipped particles.

Environmental Measurement

Measurement of Emission Gases and Air Contaminants

- Measurement of Gases Emitted from Components
- Measurement of Clean Room Atmospheres

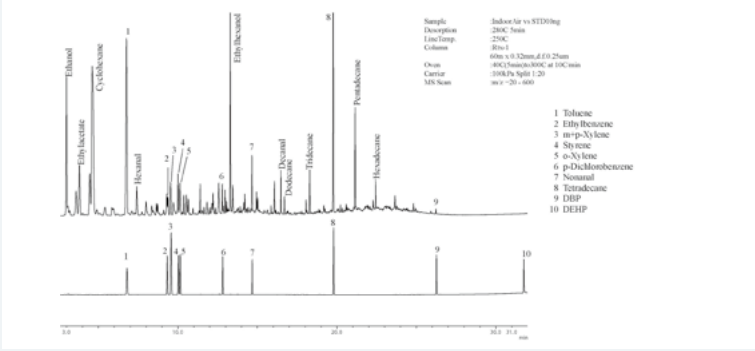
Thermal Desorption GCMS System

TD-30 Series

This system adsorbs volatile organic compounds (VOCs) with an adsorbent and then desorbs them by thermal desorption for injection into a GS-MS system. The solid adsorption-thermal desorption method is better-suited for measuring trace components than solvent extraction.

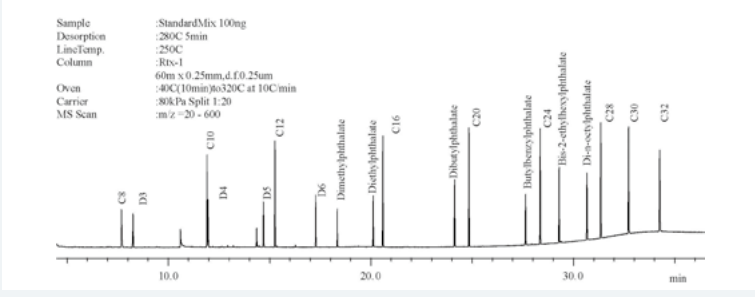
Simultaneous Analysis of SVOCs from VOCs in Indoor Air

To measure indoor air contaminants, a pump with a constant flowrate is connected to the downstream end of a Tenax-TA sorbent tube to collect samples by suction for 30 minutes to 24 hours. Then the contaminants are isolated by thermal desorption. That enables simultaneous analysis of contaminants ranging from toluene to DEHP. (Upper: Collected from indoor air for 24 hours; Lower: 100 ng standard mixture sample)



Simultaneous Analysis of Cyclosiloxanes, Alkanes, and Phthalate Esters

Because cyclosiloxanes are an ingredient in silicone, trace residues are often contained in oils, liquid rubbers, and other products. Due to the volatility of cyclosiloxanes, it is extremely important to control their concentration because they can cause electronic component failures at contact points or other areas. TD-30 systems can measure components ranging from cyclosiloxanes to phthalate esters using the same parameter settings.



Environmental Measurement

Measurement of Emission Gases

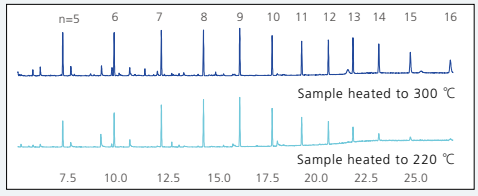
● Analysis of Gases Emitted from Components

Trap Headspace GCMS System

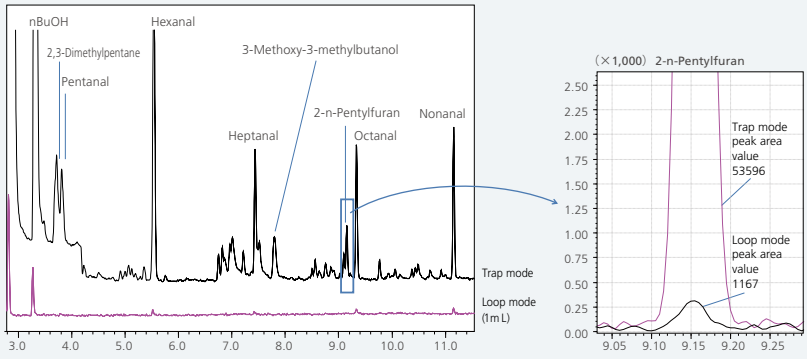
HS-20 NX Trap

Headspace GCMS systems heat samples sealed in a vial and then inject the evolved gas phase into a GCMS system. Due to their ability to heat samples to temperatures up to 300 °C, they can be used to measure gases emitted from electronic components. High heat-resistance septa with minimal cyclosiloxane leaching are also available.

Cyclosiloxanes (m/z 73) Outgassed from Plastic
High Recovery Rates Achieved Even for High-Boiling Components



Measurement of Gases Emitted from Electronic Components



Measurement of Trace Impurities

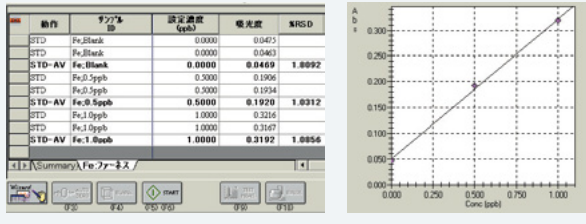
● Measurement of Trace Metals in Rinse Water

Atomic Absorption Spectrophotometer

AA-7000 Series

During semiconductor manufacturing, trace metals attached on wafer surfaces are typically rinsed with ultrapure water or a reagent. The method best suited to measuring such ultra-trace metals in ultrapure water is furnace (electrically heated) atomic absorption spectrometry.
The method enables highly sensitive measurements by increasing the injection volume.
An example of measuring Fe with an AA-7000G (furnace model) system is shown to the right.
About 0.02 ppb of Fe can be measured from a 100 µL sample injection volume.

Measurement of Trace Metals in Rinse Water



Analysis and Management of Water

● Management of Ultrapure Water, Recovered Water, Effluents, and Plating Solutions

Combustion-Type Laboratory TOC Analyzer

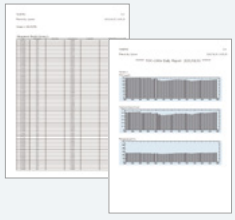
TOC-L CPH / CSH

These analyzers are useful for a wide range of applications, from managing ultra-pure rinse water for semiconductor manufacturing processes to managing recovered water that contains acids, alkalines, and salts.

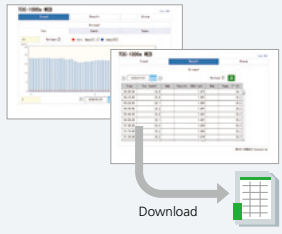
Online TOC Analyzer for Purified Water

TOC-1000e

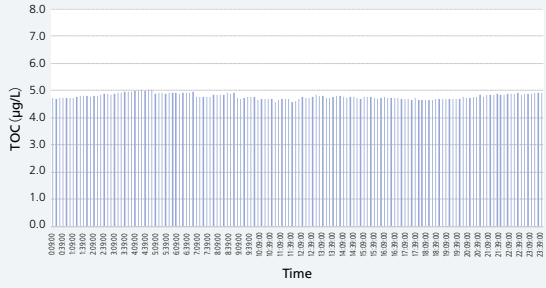
This mercury-free model features the world's smallest and lightest body and uses an excimer lamp.
The ultra-high sensitivity with a detection limit of 0.1 µg/L achieved by the conductivity measurement method makes this model ideal for continuous monitoring of ultrapure water. In addition to functionality for viewing data via a web browser by outputting results to a USB port or tablet, it includes extensive security functionality, such as an operation log function.



Daily Reports (PDF Files)
These reports summarize daily measurement results as numeric values and trend graphs to improve visibility.



√ Use a web browser to view instrument data loaded via a company LAN.
√ CSV files can also be obtained.



Ultrapure water with TOC levels of about 5 µg/L can be measured reliably.

Online TOC Analyzer

TOC-4200

This analyzer is useful for a wide range of applications within plant operations, from continuous water monitoring to management of overall plant effluents. Abnormalities can be detected quickly using the advantage of a minimum 4-minute measurement frequency.

Evaluation of Mechanical Properties

Evaluation of Strength

● Various Strength Evaluations of Electronic Components, Circuit Boards, etc. (Peeling Test, Shearing Test, etc.)

Precision Universal Testing Machine

AGX-V Series

These motor-actuated precision universal testing machines provide high performance, easy operability, and safety. In addition to a wider range of speeds, higher rigidity, a load cell that increases the guaranteed measurement precision range to 1/2000, and other basic performance improvements, these models also feature a newly designed controller that supports even more complex testing methods. Furthermore, the crosshead position is remembered even when the power is switched OFF to make setting the grip space easier and built-in functionality prevents instrument collisions. The software includes additional functionality without sacrificing ease of operation.

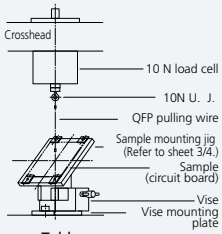
- Evaluate the solder joint strength of electronic components soldered to printed circuit boards.
- Measure the tensile strength of resist and insulator films on printed circuit boards.
- Evaluate the force required to connect/disconnect connector pins.
- Perform solder joint peeling tests.

Tabletop Precision Universal Testing Machine

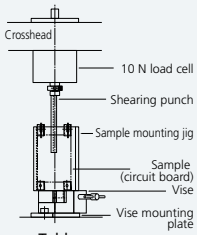
AGS-X Series

Developed for low-capacity strength evaluations, these cost-effective models include all the functionality necessary for material testing in a compact unit. The dedicated data processing software (TRAPEZIUM LITE X) enables even further efficiency improvements.

45-Degree Circuit Board Peeling Test Jig



Electronic Component Shearing Test Jig



45-Degree Circuit Board Peeling Test Jig

The circuit board is mounted at a 45-degree angle, the pulling wire is attached to a lead wire, such as on a soldered IC chip, and tension is applied to peel off the device.

Electronic Component Shearing Test Jig

Shear tests are performed by mounting the circuit board vertically and applying a vertical shearing force to a soldered IC chip or other device.

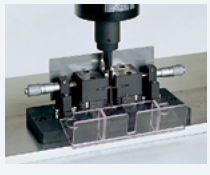
Compact Tabletop Testing Machine

EZ-X Series

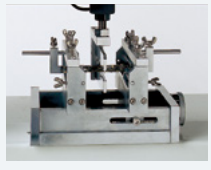
This stylish compact testing machine is packed with extensive functionality for convenient and efficient testing operations.

Circuit Board Peeling Test

Circuit Board Shearing Test



Silicon Chip Bending Test



Circuit Board Cyclic Bending Test

EZ-SX EZ-LX

Evaluation of Endurance

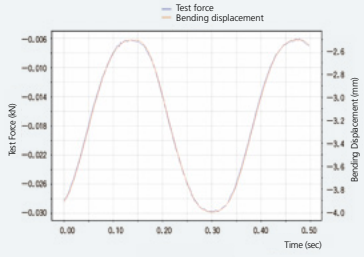
● Evaluation of Endurance of Electronic Components, Circuit Boards, etc. (Cyclic Bending Test, etc.)

Magnetic Micro Force Testing Machine

Microservo MMT Series

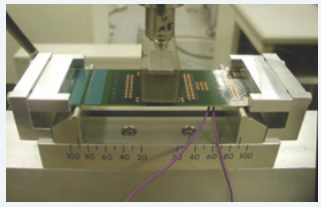
Microservo MMT models feature a loading mechanism with a fast-responding electromagnetic actuator. In combination with closed-loop control they can be used to quickly and precisely test samples with micro test forces and micro displacements. They are especially useful for evaluating the reliability of electronic components and materials.

Example of Surface Mounted Circuit Board Cyclic Bending Test



Test Force and Displacement Waveform

Sample and Testing Jig



Sample
Surface mounted circuit board

Test Parameters
Control quantity: Displacement
Test waveform: Sine
Test speed: 3 Hz

● Evaluation of Strength of Liquid Crystal Spacers and Conductive Particles

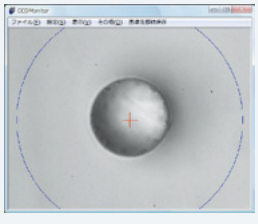
Micro Compression Testing Machine

MCT Series

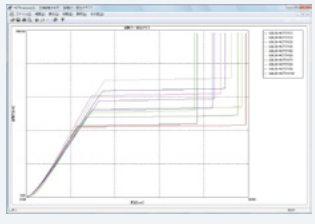
These models can measure the compression strength of single particles (1 µm diameter or larger).
They can be used to evaluate the strength of individual particles, such as LCD panel spacers or plasma display ribs, or the strength in extremely small areas.

*This photo shows a system with a high-temperature evaluation system (optional).

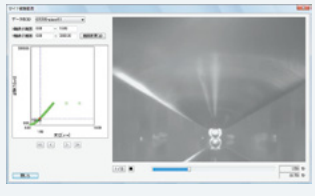
Example of Strength Test (Approx. 30 µm-Diameter Glass Beads)



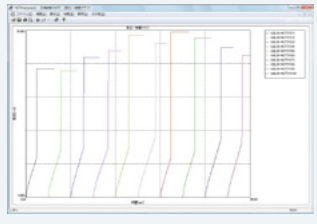
Sample Image Using Length Measurement Kit (Optional)



Test Force vs. Displacement Curve



Sample Image Using Side Observation Kit (Optional)



Displacement vs. Time Curve

Evaluation of Surface Hardness

● Evaluation of Film Thickness, Surface Treatment Layer, and Microelectronic Components

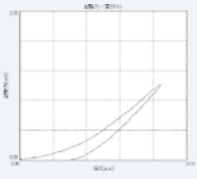
Dynamic Ultra Micro Hardness Tester

DUH-211 / 210 Series

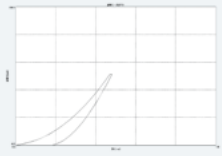
These models evaluate hardness related to mechanical strength or friction properties based on the penetration depth of an indenter in response to a micro test force applied.

Plating Layer on Metal Plate
(Plating layer: About 10 μm)

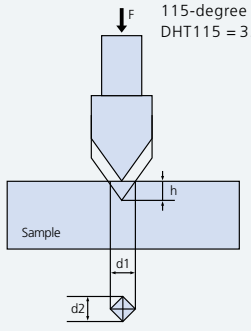
SiO2 Film (1 μm) Test Force: 1 mN



DLC Film Test Force: 50 mN



Dynamic Hardness Calculation Formula



115-degree triangular pyramid indenter
DHT115 = 3.858×F/h2

F : Load (mN)
h : Penetration depth (μm)
d1 and d2: Diagonal length (μm)
(using Vickers indenter)

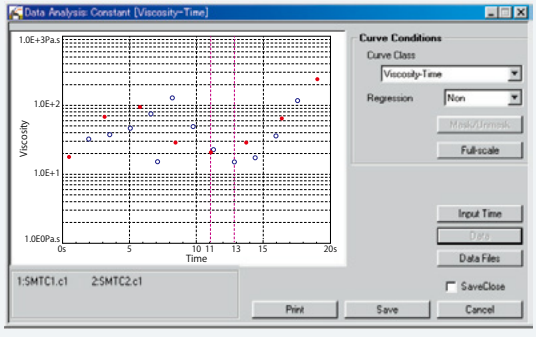
● Measurement of Viscosity of Sealing Epoxy Resins for Printed Circuit Boards and ICs

Flowtester (Capillary Rheometer)

CFT-500EX / 100EX

These flowtesters are a type of capillary rheometer that can provide data necessary for determining plastic molding parameters by measuring the melt viscosity and other aspects of plastics, including thermoset plastics, which are difficult to measure using a regular rheometer. They are especially useful for determining molding parameters for epoxy resins and other resins commonly used in electronic devices.

Time vs. Viscosity Curve of Epoxy Resin



● : 165 ℃ ○ : 175 ℃

This data shows how viscosity varies as a function of time and how the minimum viscosity value can differ depending on the testing temperature.

Evaluation of Mass

Measurement of Weight

● Confirmation of Electronic Circuit Board Weight during Manufacturing and Measurement of Semiconductor Microcomponent Weight

Shimadzu Analytical Balances

AP Series

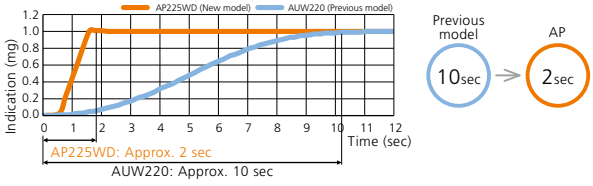
*This photo shows an AP135W model.
*The ionizer is an optional product.

- High Speed
  The response time for trace measurements (from 1 mg) is about 2 seconds. This significantly improves weighing efficiency.
- Stress Free
  Supports installing a STABLO-AP ionizer. This eliminates the influence of static electricity, achieving reliable measurements with a simpler procedure.
- For Regulation
  Interlocking with LabSolutions Balance enables compliance with a variety of data integrity regulations, including ISO 17025 for testing laboratories, ISO 9001 and ISO 14001 for the manufacturing industry, and GLP/GMP and the United States Pharmacopeia (USP) for the pharmaceutical industry.
- For HPLC
  Includes functionality for preparing buffer solutions used in HPLC operations and supports complicated preparation processes. As a result, operation can be performed accurately and easily, even by non-specialists.
- Save Your Operation
  Equipped standard with a USB port. Includes many diverse functions to support users.
  AP-W/AP-X series (with internal weights) AP-Y series (without internal weights)

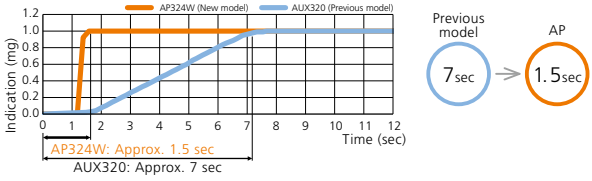
Fast Response with UniBloc AP Technology

Shimadzu analytical balances boast the one-piece UniBloc weighing sensor, which is now even more advanced.
The response time is reduced to about 1/5 the time of previous models.

Response during Trace Measurements with the 0.01 mg Model
(Equivalent to 1 mg, with Conditions Set by Shimadzu)



Response during Trace Measurements with the 0.1 mg Model
(Equivalent to 1 mg, with Conditions Set by Shimadzu)



Built-in STABLO-AP Ionizer

A separately sold STABLO-AP ionizer can be installed (except in AP-Y model).
The ionizer can eliminate invisible static electricity to achieve more reliable measurements.

Greater Expandability with a USB Port

All models are equipped with a USB port. That enables the balance to be connected to a computer.
A USB host is installed in AP-W series models for saving data on a USB flash drive, connecting a keyboard, or connecting a barcode reader.

Equipped Standard with a USB Port

AP-W Series

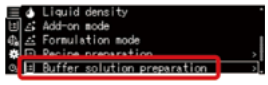
For Customers Using a High-Performance Liquid Chromatograph (HPLC)

Buffer Solution Preparation Mode (AP-W Only) Supports 13 types of buffer solutions commonly used for HPLC.
Specify the type and quantity of buffer solution and then simply follow the instructions displayed to prepare buffer solutions easily.
That will help increase the efficiency of routine analytical operations and prevent measurement errors.

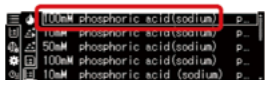
Registered Buffer Solutions (Partial List)

No.	List of Buffer Solution		
1	100 mM	Phosphoric acid (sodium) buffer solution	pH=2.1
2	10 mM	Phosphoric acid (sodium) buffer solution	pH=2.6
3	50 mM	Phosphoric acid (sodium) buffer solution	pH=2.8
4	100 mM	Phosphoric acid (sodium) buffer solution	pH=6.8
5	10 mM	Phosphoric acid (sodium) buffer solution	pH=6.9

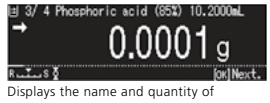
Buffer Solution Preparation Procedure



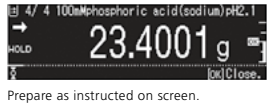
Select the buffer solution mode.



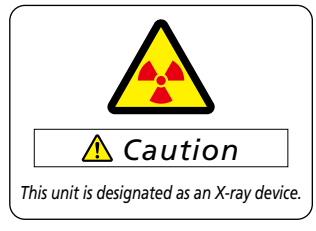
Specify the type and quantity of buffer solutions.



Displays the name and quantity of acids and bases.



Prepare as instructed on screen.



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