C10G-E106

SHIMADZU
Excellence in Science

Full Support for Processes Ranging from Manufacturing to Defect Analysis

Equipment Used in Semiconductor Manufacturing Processes and Evaluation Examples

For Customers Involved in Semiconductor Manufacturing

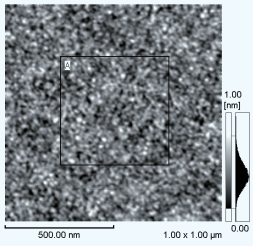
(Material Development, Processing, or Inspection)

Wafer Manufacturing Processes

Evaluation of Wafer Surface Roughness

Scanning Probe Microscope

SPM Series



Ra 0.138[nm]
Ry 1.408[nm]
Rz 0.801[nm]
Rms 0.174[nm]

SPM Observation Example

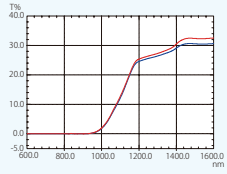
Micro and nanoscale shapes can be observed without any pretreatment. This technique can also provide height information not attainable using an SEM.

Wafer Manufacturing Processes

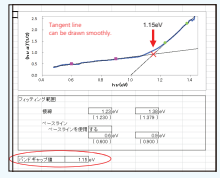
Band Gap Measurement

UV-VIS-NIR Spectrophotometer

UV-3600i Plus



Transmission Spectrum
(Blue: MPC-603A; Red: Previous Model)



Tangent Line Drawn Based on Spectrum Measured with MPC-603A

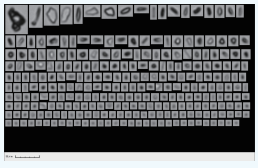
A UV-3600i Plus spectrophotometer equipped with three detectors and an MPC-603A large sample compartment unit was used to determine band gaps in polycrystalline silicon wafers. That resulted in determining band gaps with greater sensitivity than with models having two detectors.

Wafer Manufacturing Processes

Evaluation of Abrading Agents
(Measurement of Coarse Particles Included in Silica)

Dynamic Particle Image Analysis System

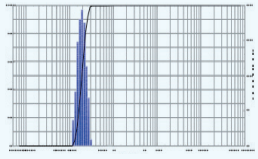
iSpect DIA-10



Spect DIA-10 Image of Silica Particles
Concentration of Micron-level Particles : 5,511/mL.

Laser Diffraction Particle Size Analyzer

SALD



Size Distribution of Silica Particles
Measured with a SALD System

These systems can be used to control the number and concentration, or the distribution, of particle sizes of coarse particles and contaminants.

Front-End Cleaning Process

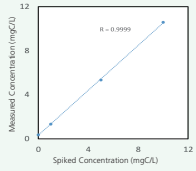
Evaluation of Cleaning Agent Contamination
(Evaluation of Total Organic Carbon in Sulfuric Acid)

TOC Analyzer

TOC-L

Sample name	TOC Concentration [mgC/L]	TOC Recovery Rate [%]
1% Sulfuric acid	0.343	-
1% Sulfuric acid + TOC 1mgC/L	1.34	99.9
1% Sulfuric acid + TOC 1mgC/L	5.35	100
1% Sulfuric acid + TOC 1mgC/L	10.6	102

1 % Sulfuric Acid Measurement Results



Correlation of TOC Spiked and Measured Concentrations

If high-purity sulfuric acid is required, total organic carbon analyzers can be used to control organic impurity levels in sulfuric acids or control reagent purity for cleaning agents and other solutions.

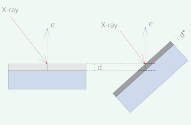
Front-End Process

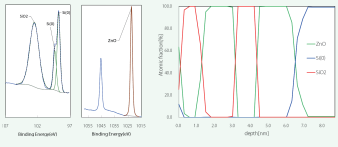
Evaluation of Thin and Multi-layer Films

Imaging X-Ray Photoelectron Spectrometer

KRATOS ULTRA2

Angle-Resolved XPS and Maximum Entropy Method (MEM)
Multi-Layer Thin Film Sample of
Si and Zn Oxide Films Deposited on Si Substrates





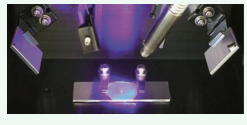
By using MEM data analysis in combination with angle-resolved XPS measurements, the distribution of chemical states of elements present at the extreme surface (about 10 nm) of samples can be analyzed in the depth direction.

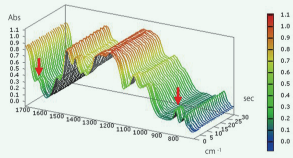
Front-End Process

Evaluation of Resist Films
(Tracking the Reaction of Ultraviolet-Curing Resins)

Fourier Transform Infrared Spectrophotometer

IRTracer-100





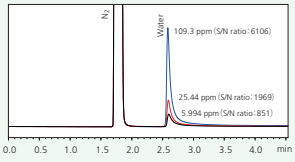
A thin coating of UV-curing acrylate resin was applied to a metal substrate and then the curing reaction process was tracked using specular reflectance. Reactions and changes can be observed in detail using a rapid scan mode that acquires 20 data points per second, which is provided as a way to track reactions and changes that occur very quickly.

—Support Available from Shimadzu—

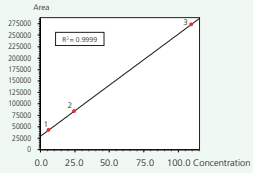
Front-End Process

Measurement of Trace Moisture Content in N2

High-Sensitivity Trace Moisture Content Measurement System (GC)



Chromatogram of Nitrogen Gas with Trace Moisture Content



Calibration Curve

A calibration curve was created according to the absolute calibration curve method using standard nitrogen gas samples containing about 5 ppm, 25 ppm, and 100 ppm of moisture. Good separation and linearity were achieved.

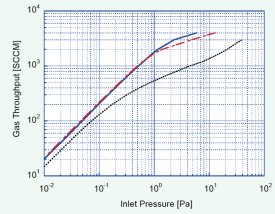
Front-End Process

Improvements to Evacuation Performance of Semiconductor Manufacturing Equipment

Magnetically Levitated Turbomolecular Pump

TMP-4304LMTF

Notes.
With a protective net
Backing Pump : 10000 L/min
Pipe : I.D. 50mm, Length 2000mm
Purge gas : —
Cooling water : 25 ℃, 2 L/min
SCCM : gas throughput at 0 ℃, 1 atm



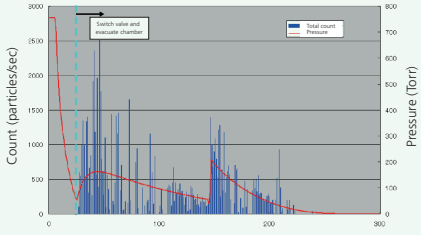
Structural optimization of the evacuation system enabled evacuation of process gases at high flowrates and achieved lower process chamber pressures. A structure that prevents process gas from flowing back to the temperature control (heating) and mechanical areas contributes to a longer turbomolecular pump service life and lower running costs.

Front-End Process/Back-End Process

Monitoring Manufacturing Equipment

Tubing-type Particle Monitor

ISPM



Measurement Results during Vacuum Equipment Evacuation

Monitoring the particle count of manufacturing equipment can potentially improve semiconductor yield and reduce downtime.

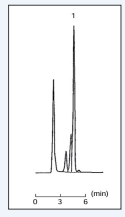
Back-End Process

Measurement of Plating Solutions

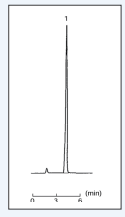
High Performance Liquid Chromatograph

Nexera Series

Analysis of Cyanides



Analysis of Cyanides in Plating Solution



Analysis of Cyanides in Copper Plating Solution

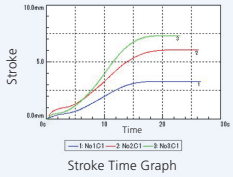
In addition to the principle metal, a plating solution also contains other components, such as complexing, buffering, and reducing agents. Such components can be quickly and accurately analyzed using a high performance liquid chromatograph.

Back-End Process

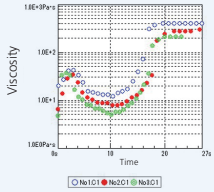
Evaluation of Sealants
(Evaluation of Thermoset Plastic Fluidity)

Constant Test Force Extrusion Type Capillary Rheometer Flowtester

CFT-EX Series



Stroke Time Graph



Viscosity vs. Time Graph

Sample No.	Shear Velocity (s-1)	Viscosity (Pa-s)
1	2,471	12.4
2	4,073	7.5
3	5,810	5.3

Test Results

Optimal molding parameters can be determined by evaluating the viscosity properties of rheological materials.

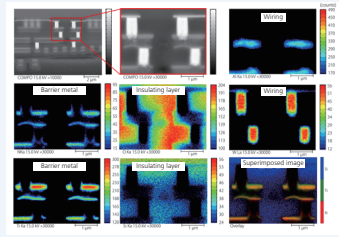
Back-End Process

Evaluation of the Distribution of Elements in the Cross-section of IC Chips

Electron Probe Microanalyzer

EPMA-8050G

These images show how multilayered Al wires are connected vertically by W plugs within the SiO_2 insulating layer, with a TiN barrier metal present between those layers.



Mapping Analysis of Wiring Pattern within an IC Chip

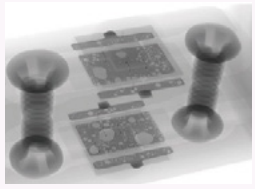
An EPMA system can visually show the correspondence between elements in each layer of wiring patterns, allowing users to evaluate the reliability of materials.

Wafer Manufacturing Processes

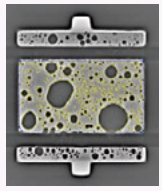
Observation of Voids and Calculation of Area Ratios

Microfocus X-Ray Inspection System

Xslicer SMX-6010



Fluoroscopic Image of Automotive LED



Cross-sectional Image of Automotive LED
39.6 % Void Ratio

By obtaining high-definition fluoroscopic and CT images, voids within solder materials inside workpieces can be observed and void ratios calculated.

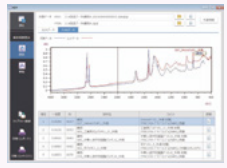
Wafer Manufacturing Processes

Example of Integrated Analysis Using EDX and FTIR

EDX-FTIR Contaminant Finder / Material Inspector

EDXIR-Analysis

EDX Profile and Hit List
(Inorganic Substance)



Infrared Spectrum and Hit List
(Organic Substance)

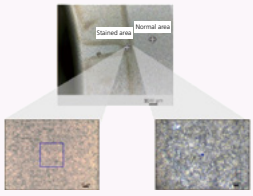
By using a combination of data from an EDX system, which is especially well-suited for measuring inorganic materials, and an FTIR system, which is especially well-suited for measuring organic materials, contaminants that are a mixture of organic and inorganic matter can be qualitatively analyzed with excellent accuracy.

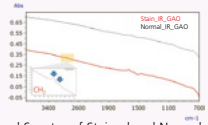
Wafer Manufacturing Processes

Infrared Raman Evaluation of Contaminants / Foreign Matter

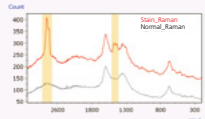
Infrared Raman Microscope

AIRsight





Infrared Spectra of Stained and Normal Areas



Raman Spectra of Stained and Normal Areas

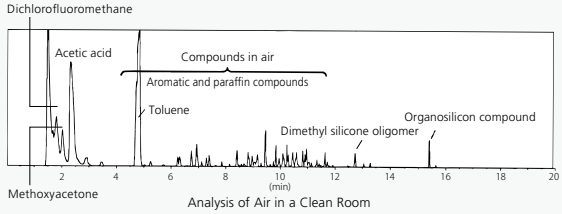
Typically analyzed using separate instruments, this single unit can analyze organic, inorganic, and microcontaminants by both infrared and Raman techniques within the same field of view.

Other

Analysis of Air in a Clean Room

Gas Chromatograph Mass Spectrometer

GCMS-QP2020 NX



Analysis of Air in a Clean Room

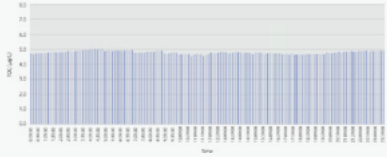
Methoxyacetone, dichlorofluoromethane, acetic acid, and other organic compounds in solvents used indoors can be analyzed with good reproducibility.

Other

On-Line TOC Measurement of Purified Water

On-Line TOC Analyzer for Purified Water

TOC-1000e



Data from ultrapure water measured continuously for 24 hours
shows that the analyzer is able to reliably measure water containing about 5 µg/L TOC.

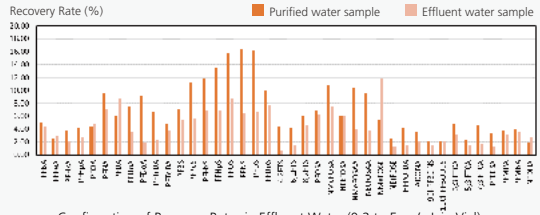
This is the industry's first TOC analyzer that can reliably detect decomposition-resistant organic substances using a mercury-free excimer lamp in the oxidation area in order to achieve high-sensitivity TOC measurements of pure and ultrapure water.

Other

Analysis of PFAS in Effluent Water

Liquid Chromatograph-Mass Spectrometers

LCMS-TQ RX Series



Confirmation of Recovery Rates in Effluent Water (0.2 to 5 ng/mL in Vial)

Effluent water was analyzed in accordance with Method 1633 published by the U.S. Environmental Protection Agency (EPA). This result indicates that the analysis performed satisfactorily.

Other

Spectrophotometric Solutions Available from Shimadzu

Shimadzu Engineers Offer Optimized Solutions

Confirm customer requirements	Optimal selection / design	Supply solution
Examples: Measure samples Create spectrophotometer	Examples: Spectrophotometer Internal devices Optical elements	Examples: Design information Standard products Custom-order model

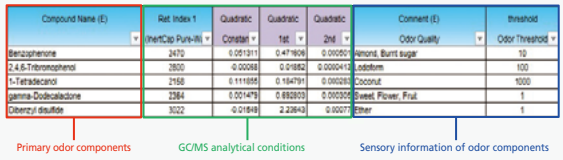
Examples of Applications
- Endpoint detection monitor for etching system
- Optical film thickness monitor for dielectric film deposition system

Other

Odor Analysis

GC/MS Off-Flavor Analyzer

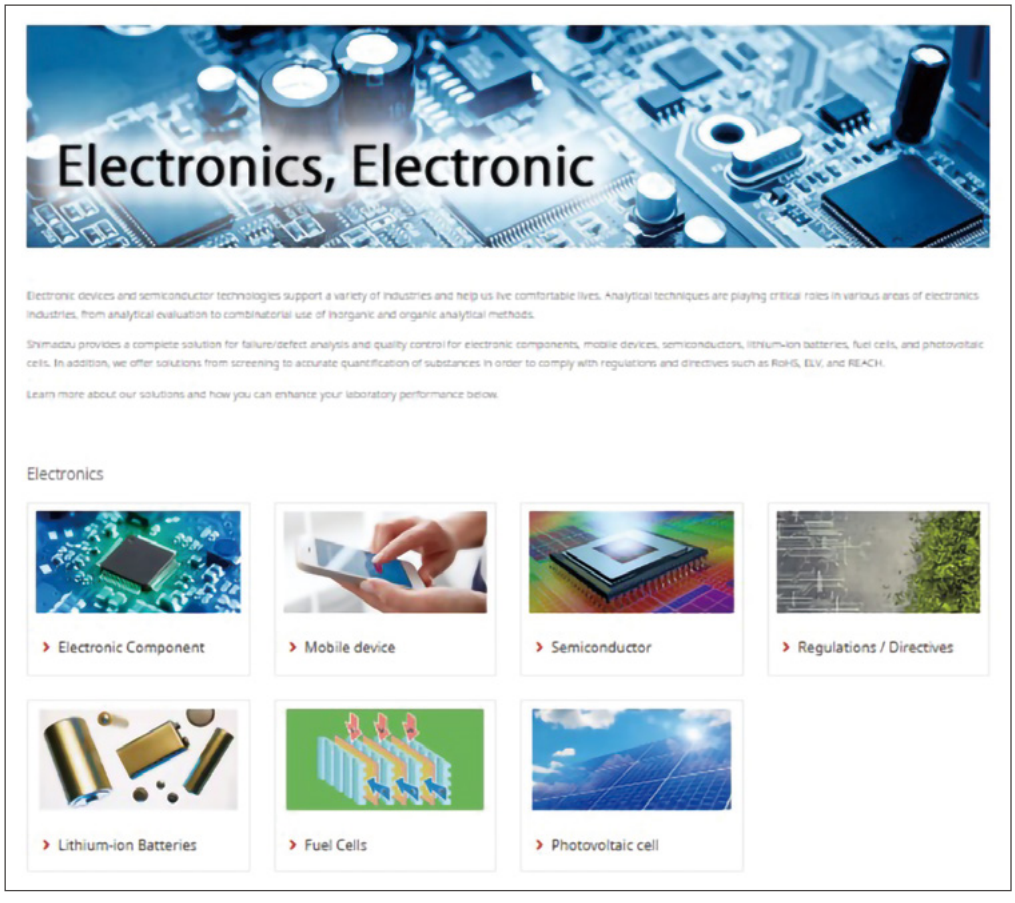
Odor Analysis Database



Confirmation of Recovery Rates in Effluent Water (0.2 to 5 ng/mL in Vial)

This system uses GC-MS analysis in combination with a database of major odor-causing substances and associated sensory information (odor characteristics and threshold levels). It is used to identify the substance that is causing an odor.

Electronics Solutions WEB Page



https://www.shimadzu.com/an/industries/electronics-electronic/index.html

Analytical/Measuring Instruments for Semiconductor Manufacturing Processes

Wafer Manufacturing

Semiconductor Substrate Materials

Measuring film thickness on wafers	FTIR
Measuring surface roughness of wafers	SPM
Measuring voids at the interface between the Si wafer and polymer	X-ray CT
Evaluating stresses (monocrystalline Si)	Raman microscope
Evaluating thickness of natural oxide films on Si	XPS
Evaluating pores and bumps (measuring surface properties)	Specific Surface Area/ Micropore Distribution
Confirming bending strength changes due to differences in how 6-inch wafers are cut	Static testing machine
Evaluating surface of rinsed wafer after Cu-CMP	XPS
Comparing strength (3-point bending test) before and after polishing	Static testing machine
Evaluating composition/thickness of ultra-thin SiON films	XPS
Observing SiC surface	SPM
Evaluating stress distribution on SiC devices	Raman microscope
Analyzing etch pit shapes on SiC wafers	X-ray CT
Evaluating bond state and film thickness on SiC surface	XPS
Evaluating gate oxide films on SiC substrates	XPS
Observing GaN substrate surface	SPM
Evaluating temperature dependence of GaN HEMT stresses	Raman microscope

Other

Evaluating blade edge and grain (cutting)	SPM/EPMA
Tensile testing wire cutters (cutting)	Static testing machine

Wafer Polishing

Bare Substrate Polishing Materials

Evaluating abrasive particles (compression testing)	Micro compression tester
Evaluating abrasive particles (particle size distribution)	Particle size analyzer
Evaluating coarse particles in polishing agents	Dynamic particle image analyzer

Lithographic Exposure/Development

Lithography Materials

Measuring neon gas used during exposure	GC
Evaluating particle size distribution in resist films	Particle size analyzer
Evaluating coarse foreign substances in resist films	Dynamic particle image analyzer
Evaluating resist film hardening	FTIR/DUH
Measuring transmittance of anti-reflective films	UV
Evaluating chemically amplified resist film composition and polymerization of base polymer	LCMS
Observing the surface of resist films	SPM
Quantitative evaluation of ions dissolving out of resist films	LCMS

Film Deposition Gas

Measuring trace moisture	GC

Etching

Etching Gas

Measuring phosgene in BCl_3	GC

Precursors

Measuring siloxane, HF, and HCl in SiF_4	FTIR (gas cell)
Observing plasma gas generated during sputtering	High-speed video camera
Analyzing residual solvents	GCMS

Washing/Rinsing

Rinsing and Wet-Processing Materials

Measuring TOC concentration in ultrapure water	TOC
Measuring transmittance of ultrapure water	UV
Analyzing isopropyl alcohol and benzyl alcohol in rinse water	GC
Measuring chemical solutions in rinse water	ICP
Regulatory analysis of substrate cleanliness	HPLC
Measuring TOC concentrations in sulfuric acid	TOC
Measuring TOC/TN concentrations in aqueous hydrogen peroxide	TOC
Controlling porous filters for rinse solution filtering	RF
Evaluating rinsing effectiveness	XPS

Equilibration

Plating Materials

Evaluating process control of plating solutions	AA

Electrode Forming

Plating Materials

Analyzing additives in plating solutions	HPLC

CMP Materials

Evaluating dispersion of CMP slurry	GCMS/LCMS
Evaluating course particles contained in CMP slurries	Particle size analyzer
Classifying and measuring CMP slurries	SPM
Analyzing metallic ions in surfactants	HPLC
Quantitative analysis of low-mass siloxane molecules	GCMS/LCMS
Analyzing components in concentrated aqueous solutions	Probe electrospray ionization mass spectrometer

Dicing

Machining/Cutting Materials

Evaluating adhesiveness of protective tape (peeling test)	Static testing machine

Bonding

Bonding Materials

Peeling, cracking, and contaminant testing wire bonding	Static testing machine, X-ray CT, FTIR, EDX
Au wire failure analysis	X-ray fluoroscopy

Pad/Bump Materials

Evaluating bonding status	X-ray fluoroscopy
Measuring Pd film thickness of bonding wire	EDX

Molding

Packaging Materials

Evaluating contaminants in silica for sealing materials	EDX
Evaluating thermoset plastics	Flowtester

Temporary Bonding Materials

Evaluating light absorbance and band gaps of semiconductors on a substrate	UV
Observing BGA shapes, misalignments, joint cracks, and voids	X-ray fluoroscopy
Measuring particle size distribution of silica and polymer powders	Particle size analyzer

Other

Evaluating clean room environments	GCMS
Analysis of PFAS in effluent water	LCMS
Managing analytical data server	LabSolutions CS software

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