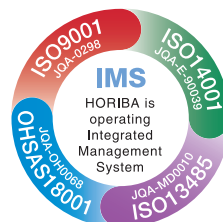
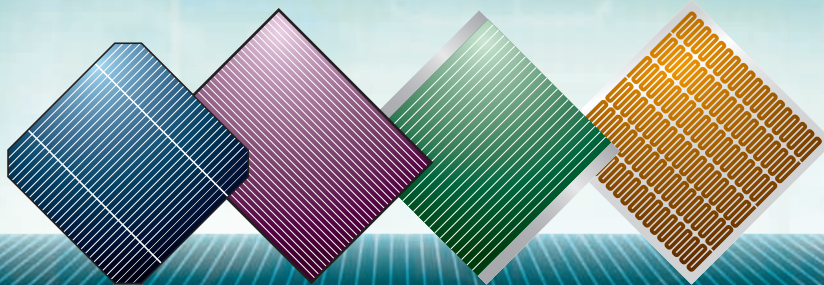


HORIBA

ANALYSIS and CONTROL PRODUCTS for PHOTOVOLTAIC MANUFACTURING PROCESS

CRYSTALLINE SILICON SOLAR CELL
THIN-FILM SILICON SOLAR CELL
CIGS SOLAR CELL
DYE-SENSITIZED SOLAR CELL

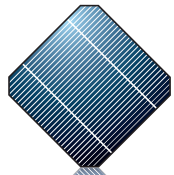
Maximized Cell Efficiency, Increased Yield, and Reduced Cost



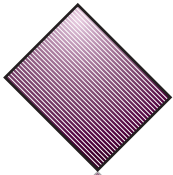
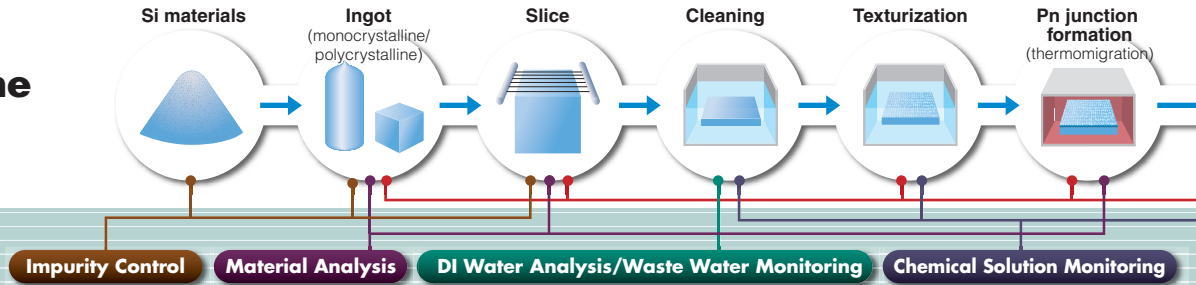
Pushing Photovoltaic Cell Manufacturing Proce

The drive for clean, renewable energy continues at pace. HORIBA's analysis, measurement and control technologies are pushing PV development towards grid parity. HORIBA products are used throughout the crystalline and thin film solar cell manufacturing processes. Adopt our extensive scientific analytical experience in your R&D laboratory. Enjoy the feeling of being in control with HORIBA's high reliable process monitors and fluid controllers in the production process. Take advantage of HORIBA's long history in the semiconductor and FPD industries for custom made inspection systems. HORIBA - let us help you meet the challenges of improving efficiency in the production of photovoltaic cells.

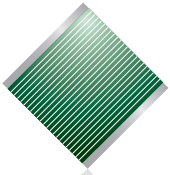
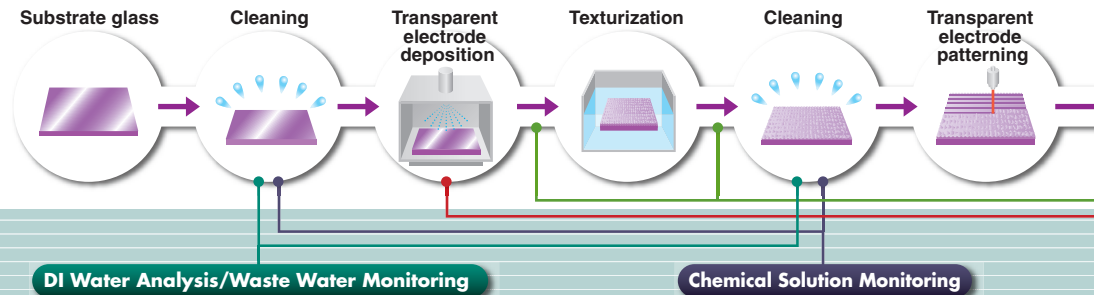
Production Process [Examples]



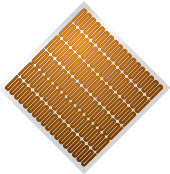
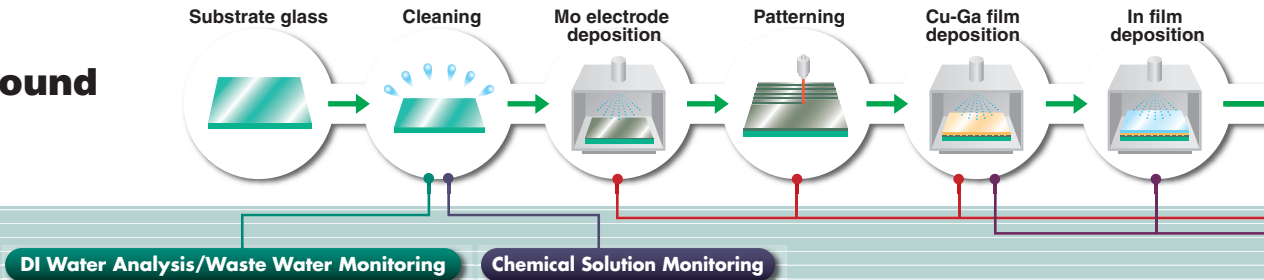
Crystalline Silicon



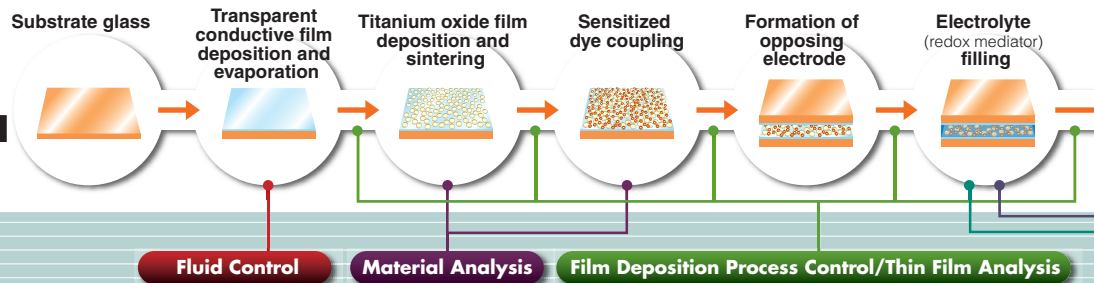
Thin Film Silicon



Compound CIGS



Organic Dye-sensitized



The HORIBA Group's technologies have diverse applications in fields related to photovoltaics (PV).

Fluid Control

P.3

- Digital Mass Flow Controller Dedicated Model for Solar Cell Process
- Digital Mass Flow Controller High-end Model
- Residual Gas Analyzer
- Liquid and Vapor Delivery/Compact Baking System
- Liquid and Vapor Delivery/Bubbling System
- Gas Concentration Monitor
- Liquid Auto Refill System

Film Deposition Process Control/Thin Film Analysis

P.5

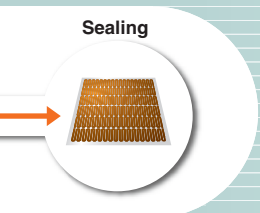
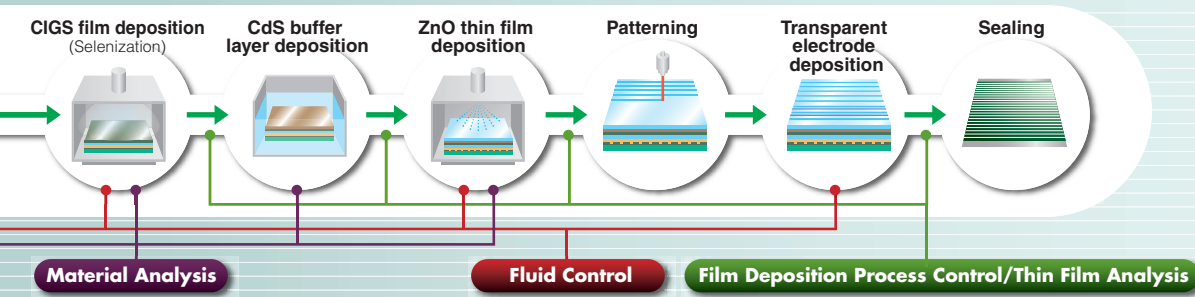
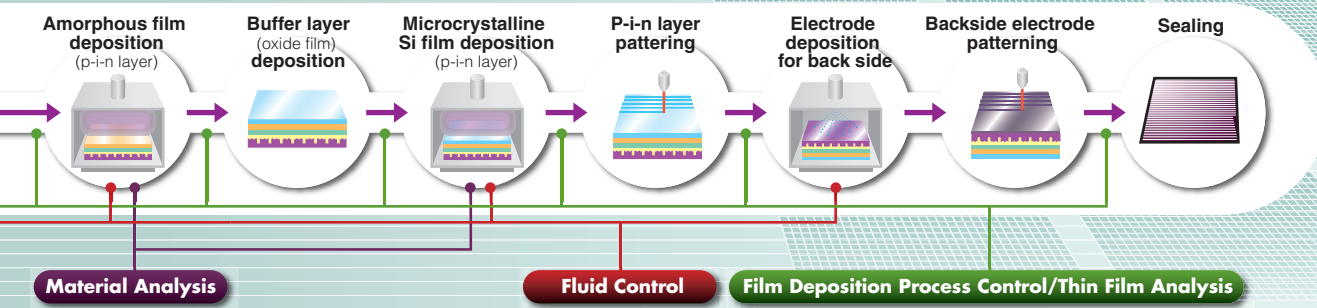
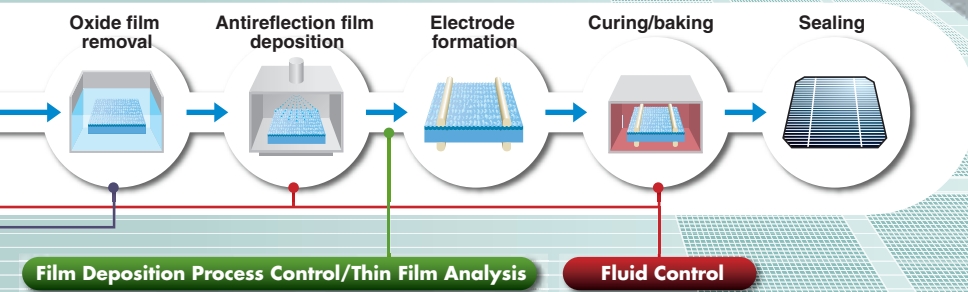
- Fully Automatic Thin Film Analyzer
- Plasma Diagnosis Endpoint Monitor
- Spectroscopic Ellipsometer
- Automatic Film Analyzer
- Glow Discharge Optical Emission Spectroscopy
- Gloss Checker

Chemical Solution Monitoring

P.7

- Chemical Solution Concentration Monitor
- Dissolved Ozone/H₂O₂ Monitor
- Hydrofluoric Acid Monitor
- HF/HCl Concentration Monitor
- Low Concentration HF/HCl/NH₃ Monitor
- Carbon Sensor Conductivity Meter (High-concentration type)
- Resistivity Meter
- IPA GAS Concentration Monitor

sses to Grid Parity



Impurity Control P.9

- Carbon Analyzer
- Oxygen/Nitrogen Analyzer
- Hydrogen Analyzer
- ICP Emission Spectrometer
- Energy Dispersive X-ray Analyzer
- X-ray Analytical Microscope

Material Analysis P.11

- Raman Spectroscopy System
- Photoluminescence Spectrophotometer
- Near-infrared Spectrofluorometer
- Fluorescence Lifetime System
- Stand-alone Filter-based Lifetime System
- Energy Dispersive X-ray Analyzer
- X-ray Analytical Microscope
- Cathodoluminescence Spectrophotometer
- Glow Discharge Optical Emission Spectroscopy

DI Water Analysis/Waste Water Monitoring P.13

- Automatic Total Nitrogen/Total Phosphorus Monitoring System
- Fluoride Ion Monitor
- Automatic COD Monitoring System
- Free Fluoride Ion Monitor
- High Sensitivity Silica Monitor
- Portable DO Monitor
- 2-channel Resistivity Meter
- 2-channel Conductivity Meter

Fluid Control

Controlling flow, pressure, and chemical concentration with world-class fluid control technologies.

HORIBA offers a wide range of accurate and repeatable flow, pressure, and concentration control components which are essential to the development and manufacture of solar cell technologies. HORIBA's products contribute greatly to improved yield and quality enabling better control over conversion efficiency.

Digital Mass Flow Controller

Dedicated Model for Solar Cell Process

SEC-N100 Series

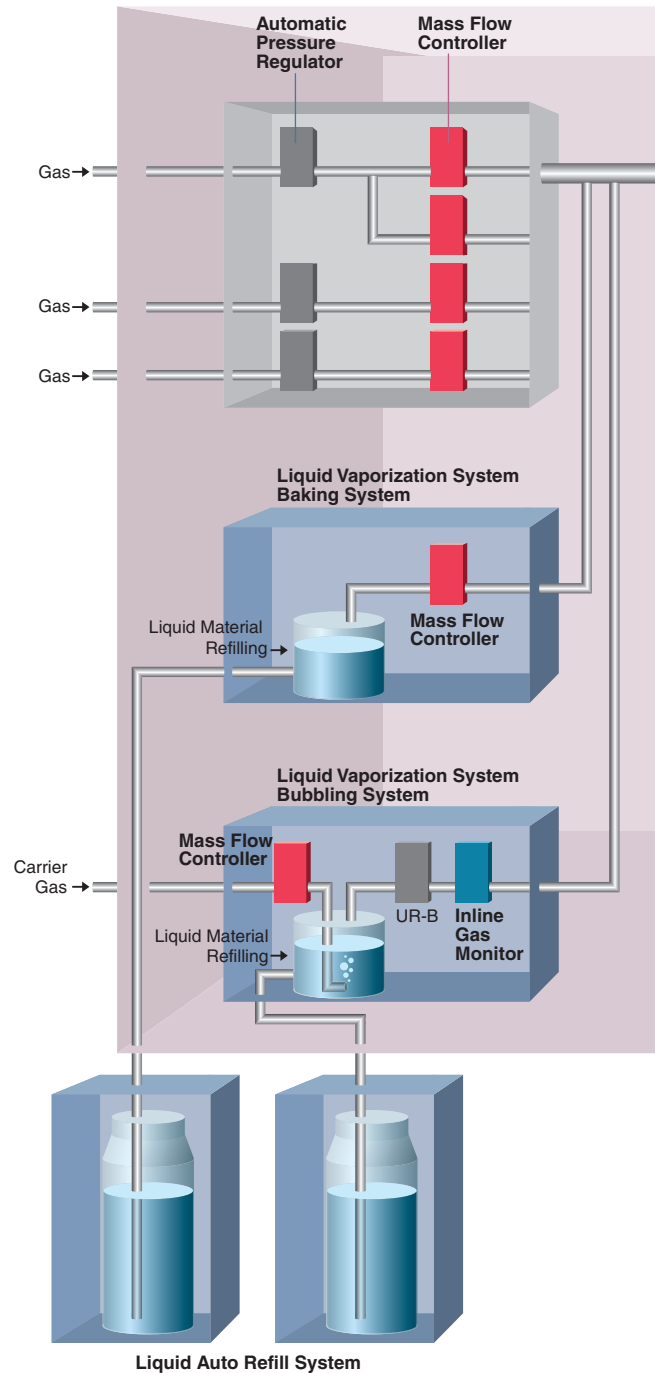
The SEC-N100 digital mass flow controller has been designed for solar cell manufacturing processes where high performance and moderate cost are desired. It controls the flow of both process gases and cleaning gases. Multi-gas and multi-range functions reduce overall costs, for example by decreasing flow controller inventory. This series also features analog/digital communication (RS485) and DeviceNet communication functions, as well as PROFIBUS communication functions, which are compatible with solar cell manufacturing equipment.



High-end Model

SEC-Z500X Series

The SEC-Z500X is a high-end digital mass flow controller that offers high precision and high-speed response. It features Multi-gas and Multi-range functions, and is compatible with analog/digital communication (RS485) and DeviceNet communication. The extensive lineup of models in this series covers a wide variety of flow ranges, from microscopic flow to 200 SLM.



Multi-gas, Multi-range functions

These functions enable the user to change the type of gas and the full-scale flow volumes. Specs can be changed easily using the dedicated software, so there is no need to remove the mass flow controller from the gas panel or pipe. This reduces operating time, and reduces costs because fewer spare mass flow controllers need to be kept in stock.

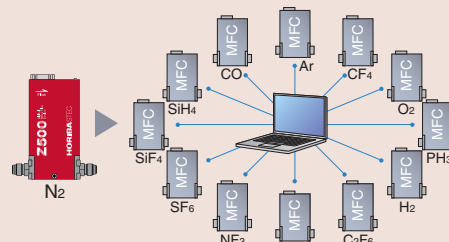
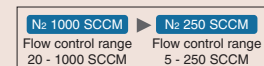
Multi Gas function

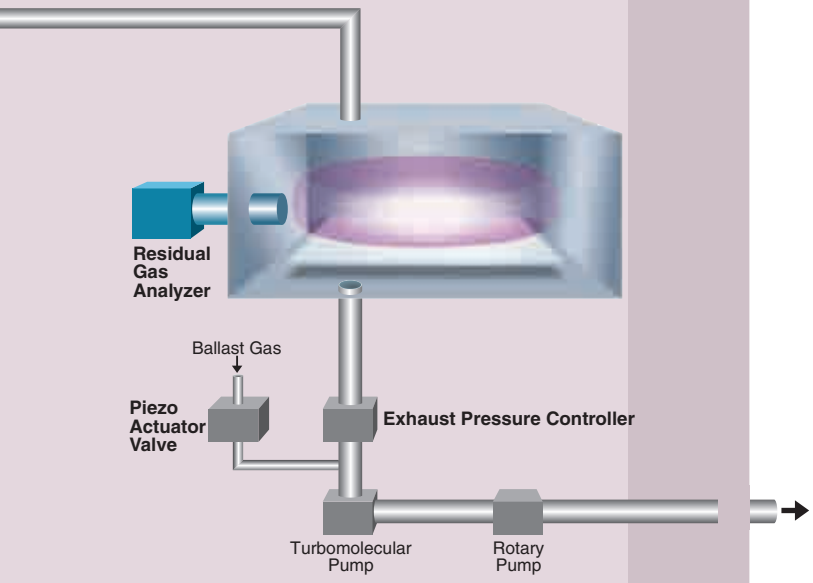
Change gas types freely.



Multi Range function

Change the full-scale flow rate freely.





Models for Solar Cell Manufacturing Processes

Mass Flow Controller

- Dedicated Model for Solar Cell Process**
SEC-N100 Series
- High-end Model**
SEC-Z500X Series
- High-temperature model**
SEC-8000D/F
- Microscopic liquid material model**
LV-F

Automatic Pressure Regulator

- Digital Model**
UR-Z700

Residual Gas Analyzer

MICROPOLE System

Exhaust Pressure Controller

EC-5000

Liquid and Vapor Delivery

- Baking System**
- Bubbling System**
- Automatic Pressure Regulator**

Liquid Auto Refill System

LU-A1000

Piezo Actuator Valve

PV-1000/2000

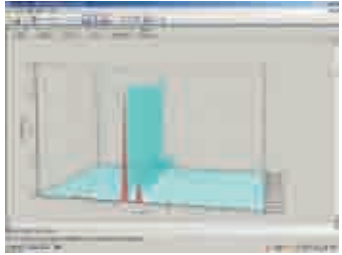
Residual Gas Analyzer ●●●●

MICROPOLE System

The Micropole is one of the world's smallest quadrupole mass spectrometer systems. It quickly analyzes the components of trace residual gas in the process chamber, contributing to increased throughput and increased power generation efficiency in the solar cells. The compact size of the analyzer components allows the system to be easily incorporated into existing production systems.



3-D graph



Changes in the chamber can be confirmed using a 3-D graph showing measurement data (scan data) over time. A variety of other graphs can also be displayed depending on usage requirements, including bar graphs, analog graphs, and trend graphs.

Liquid and Vapor Delivery Compact Baking System

LSC-A100



The LSC-A100 system has been adopted in many customer applications as a vaporization system for Tetraethoxysilane (TEOS: Si (OC₂H₅)₄), a diversified liquid material used as a thin film material in semiconductor devices. It offers direct control through high-temperature mass control of vaporized (gasified) liquid materials without the use of carrier gases.



This system is ideal for the stable vaporization of transparent conductive film materials with added H₂O in solar cell manufacturing processes.

Liquid and Vapor Delivery Bubbling system



These systems are used in solar cell manufacturing processes along with baking systems to vaporize liquid materials. By using carrier gas to vaporize the liquid materials in a bubbling tank, bubbling sizes can be adjusted as required to ensure stable concentrations. HORIBASTEC's original tools allow precision control of the bubbling tank temperature and pressure, to enable the construction of systems ideally suited to each application.



Gas Concentration Monitor

IR-150AS/AL



These gas units are used to monitor material gas concentrations in bubbling supply lines for liquid and solid materials. They offer in-line, real-time concentration measurements of DEZn and other materials.



Liquid Auto Refill System

LU-A1100 Series



The LU-A1100 is a liquid source auto recharge system that automatically supplies liquid materials to vaporization systems (direct injection/baking/bubbling systems) safely and without waste. Liquid materials can be continuously supplied even during the vaporization processes. The LU-A1100 reduces downtime and increase security for both the operators and the production process. This system is ideal for the delivery of liquids used in the solar cell manufacturing process.

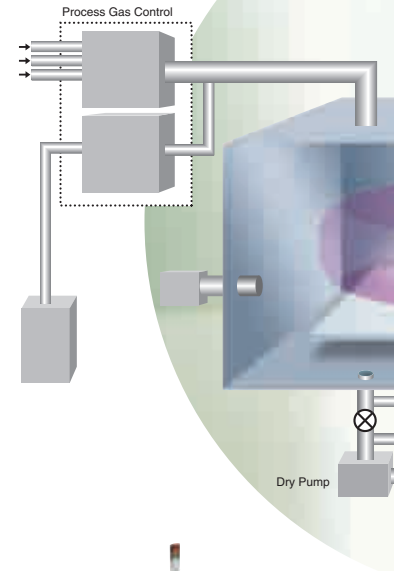


- Transparent conductive film materials:
 - Zinc oxide type: DEZ, tin oxide materials
 - Silicon extraction: SiHCl₄
- Addition of moisture: H₂O

Film Deposition Process Control Thin Film Analysis

Quickly evaluate and analyze various film characteristics, including thickness, composition, and degree of crystallization, to improve cell quality management and yield.

HORIBA's products support the formation of ideal films for solar cells, by measuring the thickness and degree of crystallization in each film layer, and selecting the optimum deposition conditions. This enables effective cell quality management, and promotes more stable conversion efficiency. The FF-2000 Series is suitable for non-destructive analysis of full-sized substrates.



Fully Automatic Thin Film Analyzer

FF-2000 Series



This automatic thin film measurement system features XY mapping and metrology tools for thin film solar cell manufacturing lines. It enables non-destructive measurement of thickness and degree of crystallization in full-sized substrates, contributing to greater yield and more effective quality management.

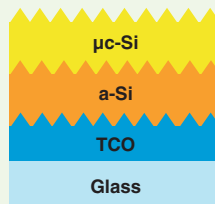
* Applicable substrate (example): 1100 x 1300 mm (G5), 2200 x 2600 mm (G8)



Sensor: Spectroscopic Ellipsometer

On thin film solar panel production lines, it is important to ensure stable control of conversion efficiency in the final product based on film thickness management. The FF-2000 with a Spectroscopic Ellipsometer monitors film thickness, roughness, surface distribution, and other properties of single and multiple film layers.

- **Specifications**
- Measurable wavelengths: 510 nm – 1000 nm
- Measurement target: Film thickness, film quality, roughness



Other Sensors

Spectroscopic Reflectometer

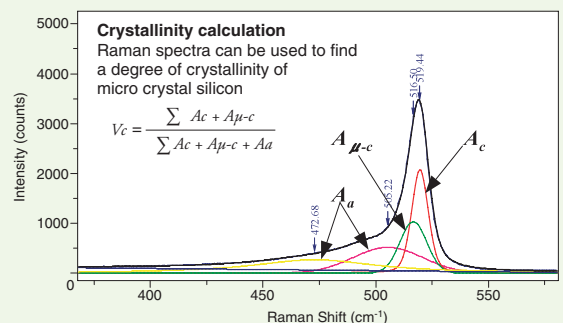
Measurable wavelengths: 450 nm – 1700 nm

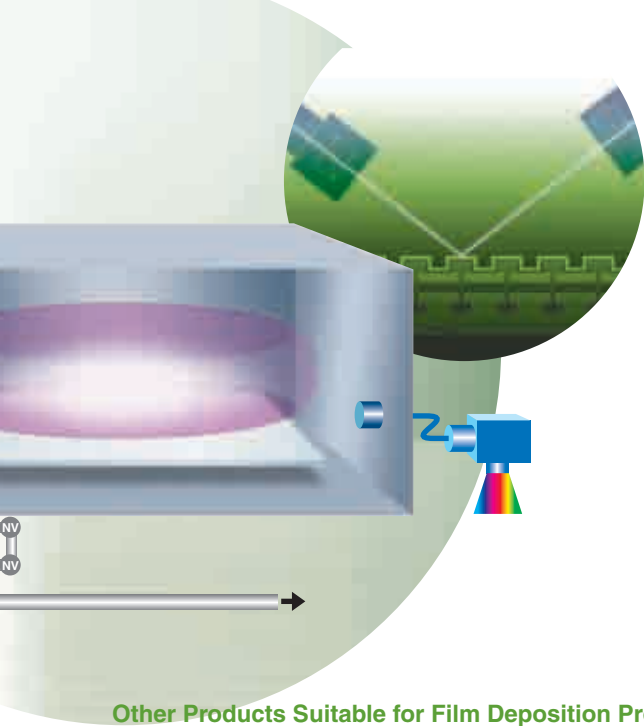
Four-point Probe

Sensor: Raman Spectroscopic Analyzer

Monitoring the degree of crystallization in $\mu\text{C-Si}$ is an essential process on thin film solar panel production lines. The FF-2000 with a Raman analyzer mounted on a large XY mapping stage, allows easy, non-destructive measurement of crystallization across the entire product surface.

- **Specifications**
- Measurement target: Microcrystal Si ($\mu\text{C-Si}$) crystallinity, CIGS composition





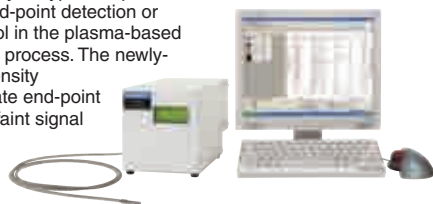
Other Products Suitable for Film Deposition Process Control and Thin Film Analysis

Plasma Diagnosis Endpoint Monitor

EV-140C



This is an emission analysis type end-point monitor intended for end-point detection or plasma condition control in the plasma-based semiconductor thin-film process. The newly-developed Rapture Intensity algorithm allows accurate end-point detection by capturing faint signal changes.



■ Specifications

Wave range: 200 – 800 nm

Optical resolution:

<2.0 nm @ λ = 200 nm – 500 nm

<2.5 nm @ λ = 500 nm – 700 nm

Spectroscopic Ellipsometer



UVISEL Series

This spectroscopic ellipsometer for R&D applications uses phase modulation to achieve greater accuracy and sensitivity in the measurement of film thickness and optical properties. The high-performance, user-friendly software allows you to easily evaluate a wide range of single-layer and multi-layer samples.



■ Specifications

Measurable wavelengths: 190 nm – 2100 nm

Mapping stages for substrates up to 300 mm x 300 mm (optional)

Automatic incidence angle adjustment

Automatic Film Analyzer



Auto SE

The Auto SE is a turnkey device that is ideal for routine work in the measurement of film thickness and optical constants. It enables mapping measurements and confirmation of strict measurement positions, and accommodates eight spot sizes (min. 25 x 60 μ m). The "Auto Soft" software ensures maximum ease of operation.



■ Specifications

Wave range: 500 nm – 1000 nm

Vision function makes measurement spot visible

Measures areas of 100 μ m or less

Glow Discharge Optical Emission Spectroscopy



GD-Profiler 2

Glow discharge optical emission spectroscopy (GD-OES) uses argon sputtering for rapid depth direction element analysis during sample etching. This model quickly analyzes depth directions to evaluate various types of film, including light-absorbing layers and electrode film, much like X-ray photoelectron spectroscopy or Auger electron spectroscopy.



■ Specifications

Measurable elements: H – U

Sensitivity: several tens of ppm – 100%

Depth resolution: several nm

Measurement diameter: 4 mm ϕ

Measurement time: 1 min – 10 min

Gloss Checker



IG-410

The IG-410 is a hand-held glossmeter that measures glossiness on a scale of 1 - 100 or 1 - 1,000. One-touch operations allow you to take measurements easily on the front lines of production. This model is ideal for checking the surface condition of silicon wafers, or for measuring changes over time.



■ Specifications

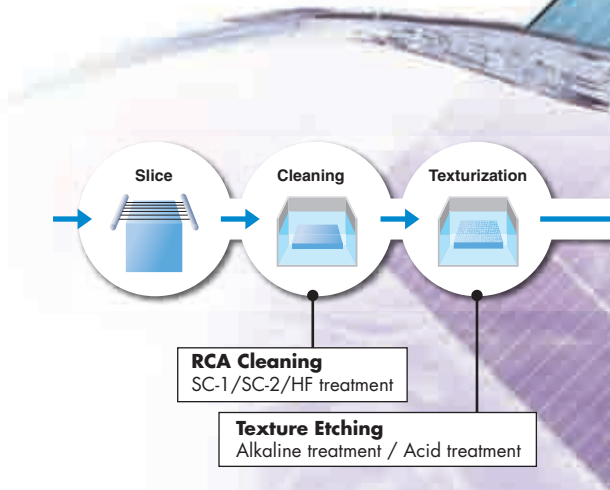
Measuring range: Switching between two ranges: 0 – 100 and 0 – 1000

Repeatability: Full scale \pm 1%

Chemical Solution Monitoring

Optimize processes and increase cell supply stability and conversion efficiency and reduce waste through real-time monitoring of chemical solution concentrations.

HORIBA's chemical solution concentration monitors support the optimization of solar cell manufacturing processes through real-time measurement of chemical solution concentrations in cleaning and etching processes. This enables greater accuracy in chemical-based texture formation and the removal of impurities, contributing dramatically to improved conversion efficiency in crystalline silicon solar cells.



Chemical Solution Concentration Monitor

CS-100 Series



The CS-100 Series monitors measure in real time the concentrations of various types of chemical solutions and have the capability to control the timing of automatic chemical spiking.

Purpose

- Optimize processes through continuous measurement of chemical solutions
- Reduce usage volumes by extending life of chemical solutions
- Reduce lot defects and increase product yield

Features

• Real-time tracking of concentrations

A roughly 3-second measurement cycle ensures effective concentration control in chemical processes during solar cell manufacturing. The CS-100 series supports detailed concentration control in both multi-bath and single-bath cleaning equipment.

• Fully automatic continuous measurement

Measurement is fully automatic, so absolutely no operator control is required. Users can easily manage concentrations just by adding the solution. In addition, the reference spectrum measurement uses air, so water is not required as a utility in day-to-day measurements.

• Compact, lightweight design

The compact design requires only 2/3rds the floor area of previous models, allowing more efficient use of space for cleaning equipment. It can be easily incorporated into existing cleaning facilities, and is lightweight, so it can even be installed on top of cleaning devices.

• Suitable for low-temperature and high-temperature chemical solutions

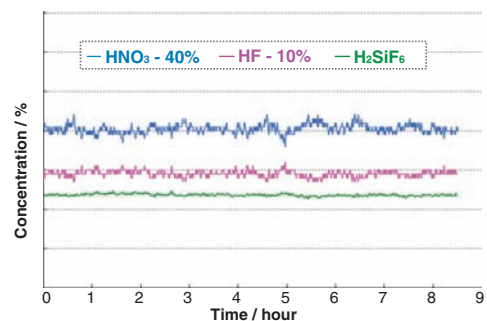
Some models feature an air-cooled temperature adjustment function, so can accommodate a wide range of sample temperatures.

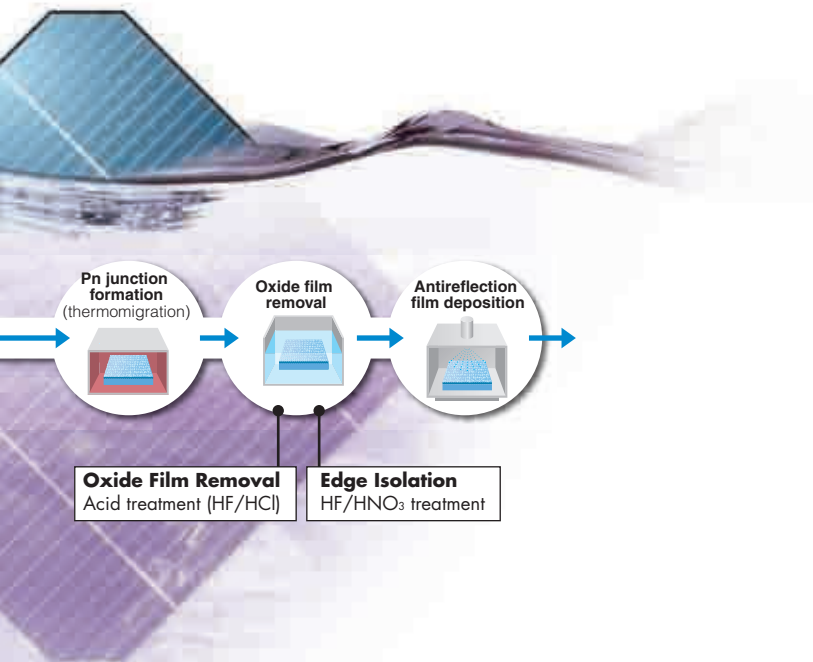
• Resistant to effects of chemical by-products

Computer processing ensures that these monitors are unaffected by the chemical by-products generated during the etching process, for even more accurate measurement of concentrations.



Chemical	Application	By-product (Estimated)
HNO ₃ /HF	Multicrystalline Si etching Edge Isolation	H ₂ SiF ₆
KOH	Si etching	K ₂ SiO ₃
KOH/IPA	Si etching	K ₂ SiO ₃
NaOH	Si etching	Na ₂ SiO ₃
NaOH/IPA	Si etching	Na ₂ SiO ₃
HCl/HF	Oxide removal	-
HNO ₃ /HF/H ₂ SO ₄	Edge Isolation	H ₂ SiF ₆
HF	Si etching/Cleaning	H ₂ SiF ₆





Other Products Suitable for Chemical Solution Monitoring

Dissolved Ozone/H₂O₂ Monitor ●●●●

HZ-960

The HZ-960 concentration monitor is able to measure low-concentration aqueous hydrogen peroxide and a wide range of ozone water concentrations. This makes it ideal for control of the wet processing for solar cells.

■ **Specification**

Measuring range:
 H₂O₂: 0 – 0.800% (standard)
 Dissolved Ozone: 0 – 100 mg/L (standard)



Hydrofluoric Acid Monitor ●●●●

CM-200A/210A

The CM-200A/210A are real-time monitors for hydrofluoric acid concentrations. These superior units offer high repeatability even at low concentrations. The CM-200A/210A can be used for a variety of purposes ranging from monitoring etched wafer cleaning processes to any other application of hydrofluoric acid. The monitors can be installed in wafer cleaning, hydrofluoric acid dilution, and supply equipment.

■ **Specifications**

Measurement target: Hydrofluoric acid
 Measuring range:
 0 – 1/2/5/10/20/50 HF%
 0 – 100/200/500/1000 mS/cm
 (Specified at time of order)
 Repeatability: Full scale ±2%



HF/HCl Concentration Monitor ●●●●

HF-960H

The HF-960H performs automatic temperature compensation for high-temperature samples of up to 80°C, enabling high-precision measurement of hydrofluoric acid of up to 10%. The chemical-resistant materials used for the terminals allow the HF-960 to provide stable measurement even under high pressure. This unit is also capable of measuring HCl concentrations.

■ **Specifications**

HF concentration: 0 – 10.00%
 HCl concentration: 0 – 10.00%
 Conductivity: 0 – 1000 mS/cm



Low Concentration HF/HCl/NH₃ Monitor ●●●●

HF-960M

The HF-960M provides high-precision measurement of ppm-level concentrations for HF, HCl, and NH₃. The terminals use chemical-resistant materials, enabling stable measurement even under high pressure.

■ **Specifications**

HF concentration: 0 – 1000/5000 ppm
 HCl concentration: 0 – 1000/5000 ppm
 NH₃ concentration: 0 – 2000/10000 ppm
 Conductivity: 0 – 2.000/50.00 mS/cm



Carbon Sensor Conductivity Meter (High-concentration type) ●●●●

HE-960HC

The HE-960HC measures the conductivity of the various chemicals used in the manufacturing processes of solar cells. This enables items such as the dilution, life, and exchange of these chemicals to be controlled. Conductivity to concentration conversion is also possible. (Conditions apply.)

■ **Specifications**

Measuring range: 0 – 1000 mS/cm



Resistivity Meter ●●●●

HE-480R

The HE-480R resistivity meter is ideal for purity control of the ultra-pure water for cleaning the chemicals used in the manufacturing processes of solar cells. The meter uses a variety of sensors to support a wide range of applications.

■ **Specifications**

Measuring range: 0 – 0.200/2.00/20.00/100.0 MΩ·cm



IPA GAS Concentration Monitor ●●●●

IR-150AS

The IR-150AS enables real-time, in-line measurement of IPA (isopropyl alcohol) gas. This model is ideal for concentration control in IPA drying processes for drying equipment. It can also be combined with mass flow controllers or vaporizers to control concentrations on the downstream side of vaporizers and bubblers.

■ **Specifications**

Measurement target: IPA (isopropyl alcohol) gas
 Measuring range: 0 – 5% (Please contact our staff regarding other ranges)
 Response speed: T90: 7 seconds or less

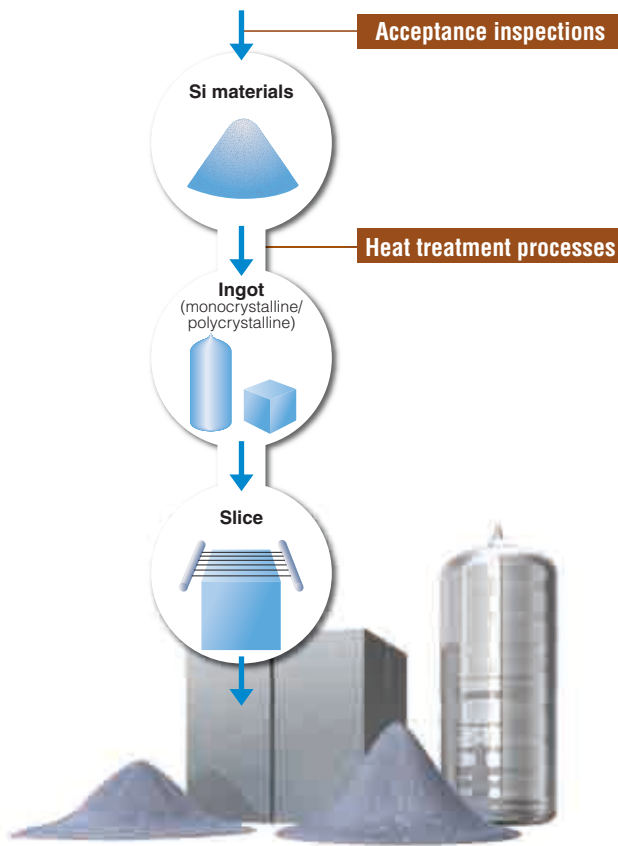


Please contact our staff regarding all your other chemical measurement requirements. HORIBA meets a wide range of user needs as a total solution supplier for concentration control in all wet processes, including cleaning and surface treatment.

Impurity Control

Precise impurity control in raw materials and manufacturing processes increases the quality of solar cells.

The solar grade silicon (SOG-Si) used in solar cells must have carbon and oxygen concentrations of just a few mass ppm or less. Some manufacturing methods use graphite receptacles, so carbon and oxygen concentrations must be strictly analyzed and controlled. Therefore, impurity control is essential in both material and manufacturing processes. HORIBA's elemental analysis tools provide high-precision, repeatable analyses of carbon, oxygen, hydrogen, and other elements, which are vital to quality control in solar cell manufacturing processes.



Analysis of carbon volumes in SOG-Si

Process: Acceptance inspections
 Sample form: Nugget
 Measurement time: About 60 seconds

Carbon Analyzer

EMIA-921V



This unit measures carbon concentration by burning the sample in a high-frequency induction heating furnace. By eliminating trace volumes of THC contained in the carrier gas, this model achieves highly precise analysis of even trace amounts of carbon. Its quick, accurate measurements contribute to increased work efficiency.

■ Specifications

Measuring range: Carbon (0 – 6% m/m), sulfur (0 – 1% m/m) * For 1 g of sample
 Measurement method:

High frequency heating in oxygen stream – Infrared absorption method

Accuracy (Repeatability):

Carbon: 0.0020% m/m or less, $\sigma_n - 1 \leq 0.00003\%$ m/m
 0.0020% m/m or more, $\sigma_n - 1 \leq 0.0001\%$ m/m or $CV \leq 0.5\%$

Sulfur: 0.0020% m/m or less, $\sigma_n - 1 \leq 0.00003\%$ m/m

0.0020% m/m or more, $\sigma_n - 1 \leq 0.0001\%$ m/m or $CV \leq 0.75\%$

* Under HORIBA's specified measurement conditions.

* The measurement range can be expanded by reducing the sample weight.

* The EMIA-920V measures carbon/sulfur concentrations.

Analysis of oxygen and nitrogen volumes in SOG-Si

Process: After heat treatment
 Sample form: Sheet or nugget
 Measurement time: About 180 seconds

Oxygen/Nitrogen Analyzer

EMGA-920



This unit measures oxygen and nitrogen concentrations by heating and melting the sample using inert gases. It achieves speedy elemental analysis with high precision and high reproducibility, contributing to greater efficiency in the overall workflow.

■ Specifications

Measuring range: Oxygen (0 – 5% m/m), nitrogen (0 – 1% m/m) * For 1 g of sample
 Measurement method:

Oxygen/Inert gas melting – Non-dispersive infrared absorption method

Nitrogen/Inert gas melting – Thermal conductivity method

Accuracy (Repeatability):

Oxygen/Nitrogen: $\sigma_n - 1 \leq 0.000002\%$ m/m or $CV \leq 0.5\%$ (standard gas)

$\sigma_n - 1 \leq 0.000002\%$ m/m or $CV \leq 1.0\%$ (standard gas)

* Under HORIBA's specified measurement conditions.

* The measurement range can be expanded by reducing the sample weight.

Other Products Suitable for Impurity Control

Hydrogen Analyzer

EMGA-921W

The EMG-921 can be used to measure hydrogen in raw silicon and a wide range of other materials. It offers high-precision control of post-processing hydrogen concentrations.



Specifications

Measuring range: Hydrogen (0 – 0.02% m/m) * For 1 g of sample
 Measurement method: Inert gas melting – Thermal conductivity method
 * Under HORIBA's specified measurement conditions.
 * The measurement range can be expanded by reducing the sample weight.

ICP Emission Spectrometer

ULTIMA 2

This ICP Emission Spectrometer offers outstanding sensitivity and resolution. It can analyze trace impurities in various materials, including raw silicon. The ULTIMA 2, which adapts flexibly to a variety of upstream processes such as solvent extraction, is indispensable for the analysis of impurities in a wide range of samples.



Specifications

Measurable elements: Li – U
 Measurable wavelengths: 160 – 800 nm (*120 – 800 nm available as an option)
 Spectrometer type: Czerny – Turner (sequential type)
 Actual resolution: 0.005 nm or less (at 310 nm or less)
 Measurement sensitivity: several ppb or less (depends on element or wavelength)

Energy Dispersive X-ray Analyzer

EMAX (X-Max detector)

This unit is combined with an electron microscope to analyze material composition and impurities on a microscopic level. Equipped with a large aperture silicon drift detector (20, 50, or 80 mm²), it is capable of high resolution mapping at low acceleration voltages of 3 kV or less. It also offers outstanding performance when handling light elements, achieving unprecedented accuracy in energy dispersive X-ray (EDX) analysis.



Specifications

Measurable elements: Be – U
 Latest liquid nitrogen – free detector

X-ray Analytical Microscope

XGT-5000 Series
 XGT-7000 Series

These units combine the functions of PL microscope observation and non-destructive elemental X-ray analysis. They are suited to a wide range of applications, including impurity analysis using a $\phi 10 \mu\text{m}$ X-ray probe and transmission X-ray imaging to confirm the internal characteristics of samples. It can also measure film thickness on $\phi 10 \mu\text{m}$ spots using thin film FPM.



XGT-5000 Series

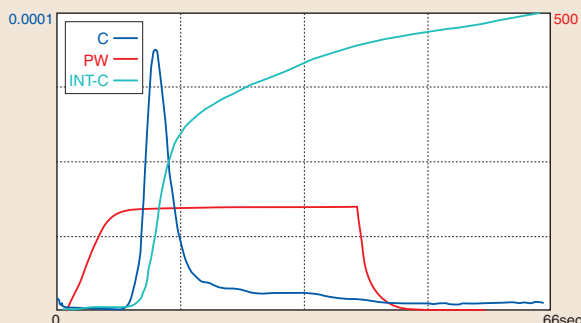


XGT-7000 Series

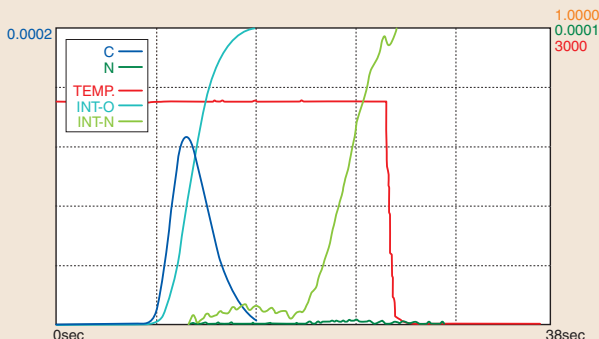
Specifications

X-ray guide tube: 10 μm or more
 Measurable elements: Na – U
 Sample size (example): 300 mm (W) \times 250 mm (D)

Sample	Mass (g)	Carbon (mass ppm)
Silicon (Si)	0.1951	30
	0.2045	52
	0.2014	40
	0.2024	45
	0.2015	35
	Average	40
Standard deviation	0.0009	

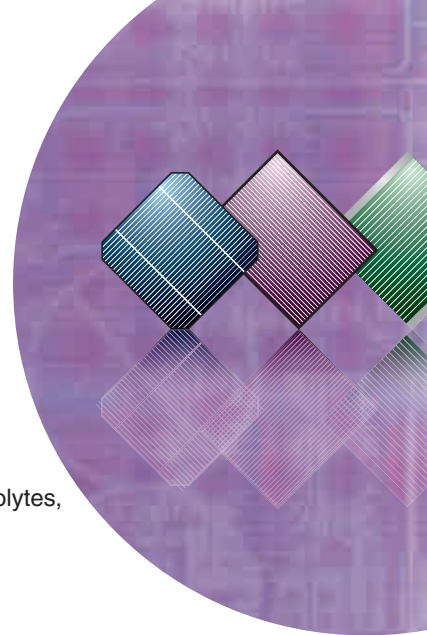


Sample	Mass (g)	Oxygen (mass ppm)
Silicon (Si)	0.3012	13.34
	0.3154	13.81
	0.3023	13.11
	0.3263	12.89
	0.3052	13.05
	Average	13.24
Standard deviation	0.36	



Improving cell life and durability through the analysis and evaluation of solar cell components, from semiconductor materials to sensitized dyes.

Solar cells comprise a variety of materials. Effective structural analysis and evaluation of these component materials, along with evaluations of optical characteristics, help to ensure the stability of electrodes, electrolytes, and sensitized dyes. By taking a material-oriented approach, this unit contributes to increased conversion efficiency, as well as improved life and durability of the cells.



Raman Spectroscopy System LabRAM HR-800



Evaluates crystallinity based on the half maximum full-width and peak position in the silicon's Raman spectrum.

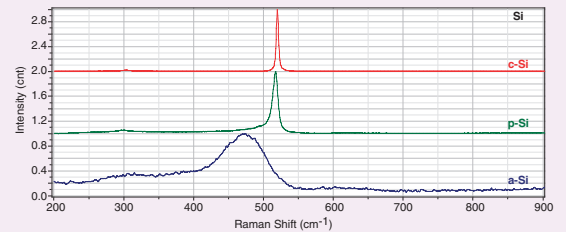
Raman spectroscopy is a simple structural analysis method used in the measurement of stress and crystallinity in silicon for semiconductors. It is used extensively to monitor crystallization rates in the evaluation of Si crystals for thin film or crystalline solar cells. Raman spectroscopy, which can evaluate the structures of organic or inorganic compounds regardless of whether the samples are liquid or solid, is also used to evaluate compound, organic, or dye-sensitized materials for next-generation solar cells.

- Raman measurements can be combined with photoluminescence (PL) measurements
- Automated stage accommodates wafers up to 300 mm
- 3-D mapping
- High spatial resolution imaging



Specifications

Spectrometer focal length: 800 mm
Gratings: 2
Laser wavelength: 244 nm – 1064 nm
Scope of detection: 200 nm – 1600 nm (CCD + InGaAS detector)
Confocal optical system



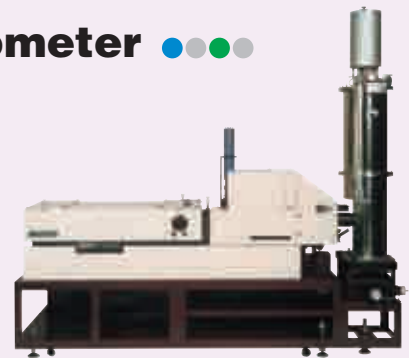
Photoluminescence Spectrophotometer



Photoluminor-D*

Enables high sensitivity quantitative analysis of impurities (P, B, Al, As) in silicon.

The photoluminescence (PL) measurement method is used in the identification and quantitative analysis of added or residual impurities in monocrystalline silicon, including electrically active elements such as phosphorus, boron, aluminum, and arsenic. This method can be used to measure samples in the form of wafers cut from ingots, or pellets that have been chemically or mechanically polished. It is also effective in confirming the band gap of compounds after crystal growth.



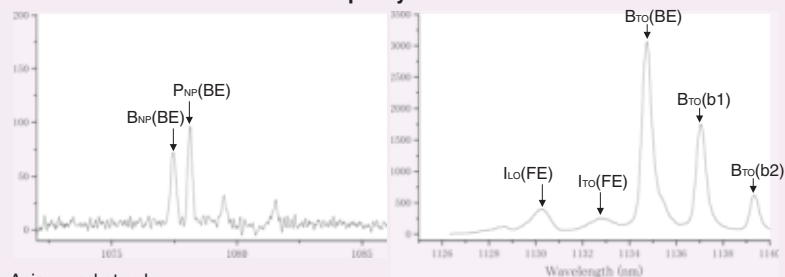
[Detection limits]

Upper limit: 5×10^{15} atm/cm³
Lower limit: 2×10^{15} atm/cm³ (P, B)
 5×10^{15} atm/cm³ (Al, As)

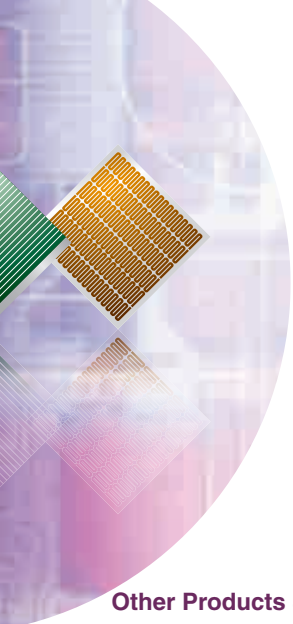
Specifications

Spectrometer focal length: 1000 mm
Gratings: 1200 gr/mm
Laser wavelength: YAG532 nm
InGaAS detector
Uses 4.2 k cryostat

Impurity B



* The Photoluminor-D is available in the Asian market only.



Other Products Suitable for Material Analysis

Near-infrared Spectrofluorometer ●●●●●
FluoroLog-NIR

Fluorescence Lifetime System
FluoroLog3-TCSPC



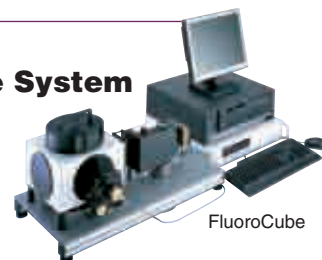
Organic and dye-sensitized solar cells were developed using photochemistry and polymer chemistry. We can gain a more dynamic understanding of transient luminous events by analyzing the process of molecular and crystalline reactions, and measuring the fluorescence lifetime of various substances.

■ **Specifications**

Ultra high sensitivity luminescence measurement
Works in ultraviolet and visible to infrared wavelength bands
Suitable for a wide range of applications, including measurement of fluorescence lifetimes and quantum yield

Fluorescence Lifetime System
FluoroCube ●●●●●

Stand-alone Filter-based Lifetime System ●●●●●
TemPro



Sensitized dye is the component element that has the most significant effect on the conversion efficiency of solar cells. The FluoroCube series can measure fluorescence lifetimes from the sub-picosecond level to several seconds, to evaluate the optical characteristics of complex metals such as dye-sensitized ruthenium (II) complex.

■ **Specifications**

TCSPC (Time Correlated Single Photon Counting) method
Fluorescence lifetime measurement: 100 picoseconds – several seconds
Works in ultraviolet and visible to infrared wavelength bands

Energy Dispersive X-ray Analyzer ●●●●●
EMAX (X-Max detector)

This unit is combined with an electron microscope to analyze material composition and impurities on a microscopic level. Equipped with a large aperture silicon drift detector (20, 50, or 80 mm²), it is capable of high resolution mapping at low acceleration voltages of 3 kV or less. It also offers outstanding performance when handling light elements, achieving unprecedented accuracy in energy dispersive X-ray (EDX) analysis.



■ **Specifications**

Measurable elements: Be – U
Latest liquid nitrogen – free detector

X-ray Analytical Microscope ●●●●●

XGT-5000 Series
XGT-7000 Series

These units combine the functions of PL microscope observation and non-destructive elemental X-ray analysis. They are suited to a wide range of applications, including impurity analysis using a $\phi 10 \mu\text{m}$ X-ray probe and transmission X-ray imaging to confirm the internal characteristics of samples. It can also measure film thickness on $\phi 10 \mu\text{m}$ spots using thin film FPM.



XGT-5000 Series



XGT-7000 Series

■ **Specifications**

X-ray guide tube: 10 μm or more
Measurable elements: Na – U
Sample size (example):
300 mm (W) \times 250 mm (D)

Cathodoluminescence Spectrophotometer ●●●●●
MP Series

The MP series is useful in a wide range of analyses, including evaluations of flaws in various types of wafers, and in gaining an understanding of the electrical and optical characteristics of crystal interfaces in the multi-crystalline Si used in solar cells.



■ **Specifications**

Monochromator: Forcal Length: 320 mm
Aperture: f/4.1
Resolution: 0.06 nm
Detector (cooling type): PMT, CCD, etc.

Glow Discharge Optical Emission Spectroscopy ●●●●●

GD-Profiler 2

Glow discharge optical emission spectroscopy (GD-OES) uses argon sputtering for rapid depth direction element analysis during sample etching. This model quickly analyzes depth directions to evaluate various types of film, including light-absorbing layers and electrode film, much like X-ray photoelectron spectroscopy or Auger electron spectroscopy.



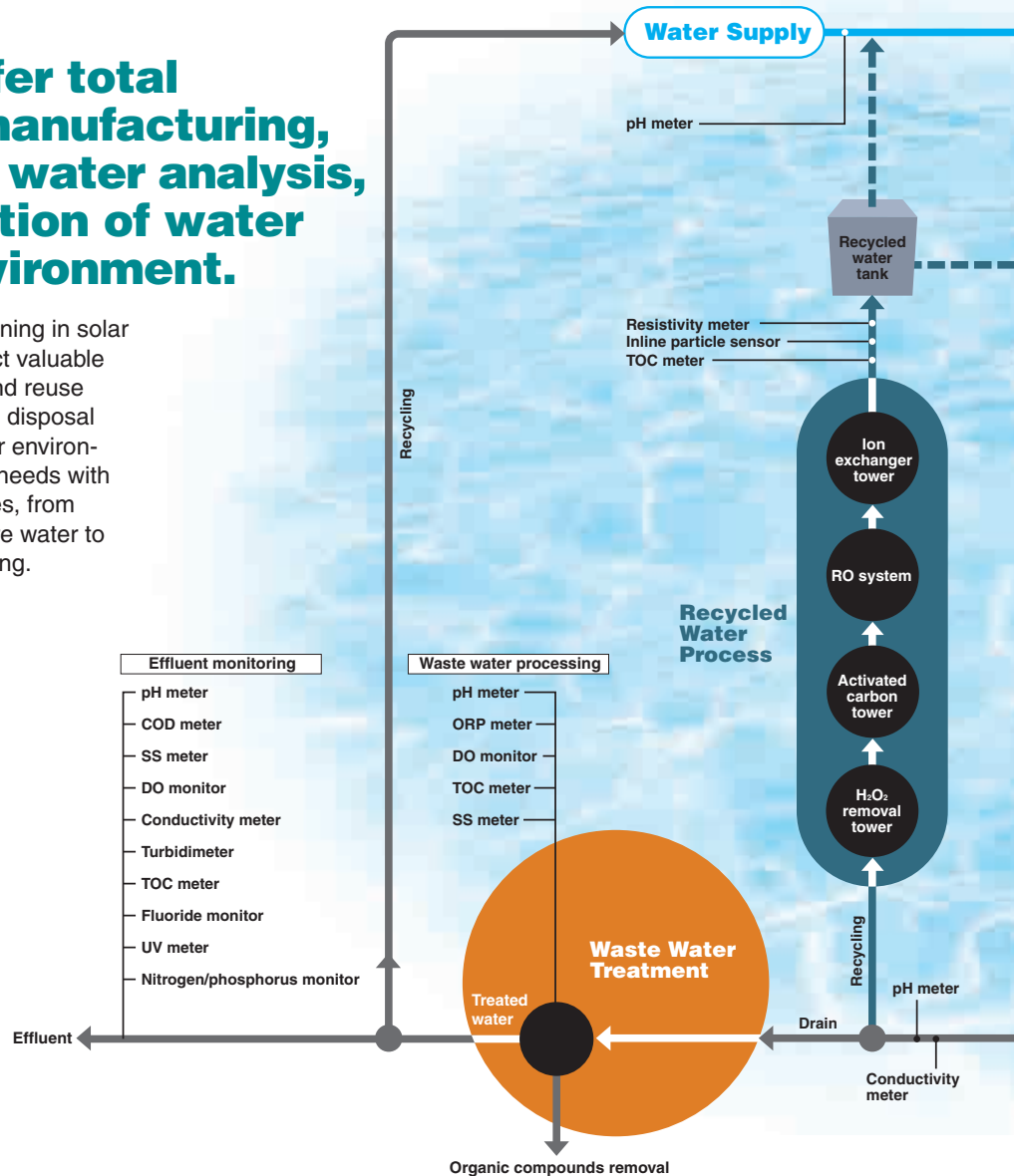
■ **Specifications**

Measurable elements: H – U
Sensitivity: several tens of ppm – 100%
Depth resolution: several nm
Measurement diameter: 4 mm ϕ
Measurement time: 1 min – 10 min

DI Water Analysis Waste Water Monitoring

HORIBA's products offer total support in solar cell manufacturing, from utilities to waste water analysis, enabling the preservation of water resources and the environment.

Large volumes of pure water are required for cleaning in solar cell production processes. It is important to protect valuable water resources by building systems to recycle and reuse much of this water. Monitoring of waste water and disposal processes is also essential to protecting the water environment. HORIBA responds to a wide range of user needs with advanced analysis and measurement technologies, from production processes involving pure and ultra-pure water to recycling and waste water treatment and monitoring.



Products for Waste Water Monitoring

Automatic Total Nitrogen/ Total Phosphorus Monitoring System

TPNA-300

The TPNA-300 meets the performance and control standards for automatic monitoring of total nitrogen and total phosphorus, which is a requirement of the Total Water Contaminants Regulation. By using ultraviolet oxidation decomposition method, easier maintenance and running-cost reduction has made this system suitable for practical use.

■ Specifications

- Measuring range: Standard
- Total nitrogen: 0 – 2 mgN/L
- Total phosphorus: 0 – 0.5 mgP/L
- Measurement points:
 - 1 (standard)
 - 2 (option)

* Quasi-standard also available



Fluoride Ion Monitor

FLIA-101

This automatic monitor continuously measures fluorine, which is required by environmental standards, using the ion electrode method. It is easy to operate, offers simple maintenance and management, and provides stable measurement data over long periods of time.

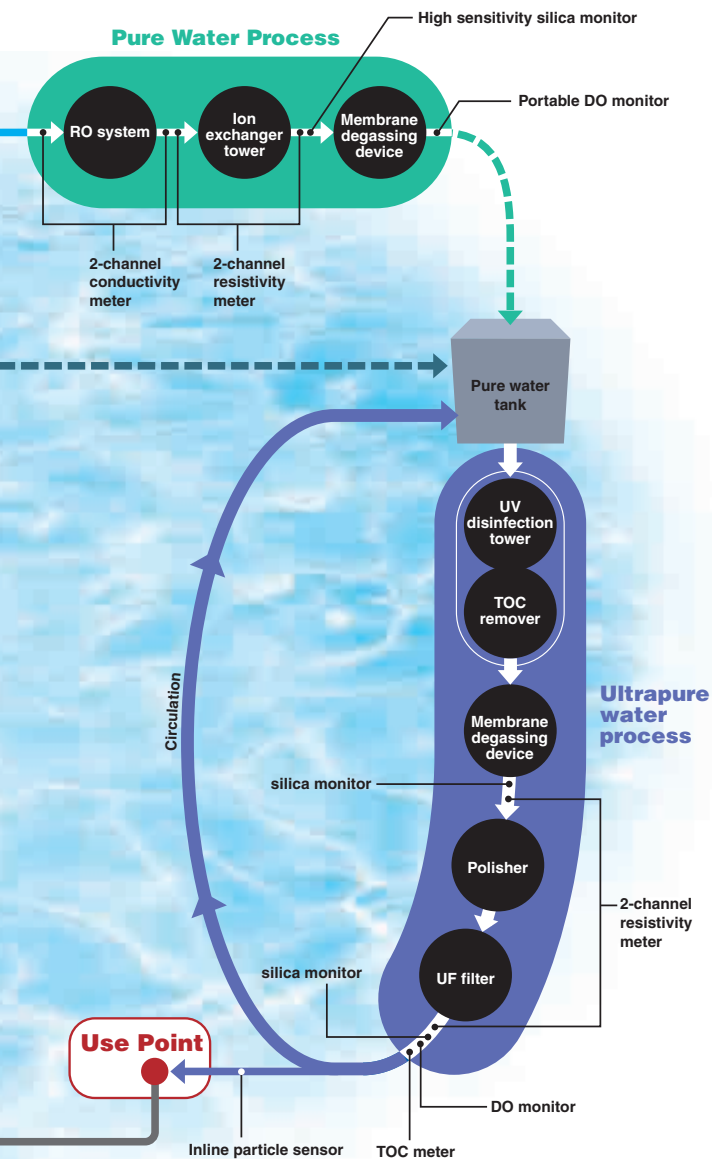
■ Specifications

- Measuring range: Standard
 - 0.1 – 10, 1 – 100, 10 – 1000,
 - 0.5 – 50, 5 – 500 ppm
- (Please specify one of the above ranges)
- * Quasi-standard also available



Total Water Contaminants Regulation

Regulation on monitoring and control of environmental standards with regard to the pollution loading amount flowing in wide and closed water area



Products for Measuring Water Purity In Cleaning Processes

High Sensitivity Silica Monitor ●●●●● SLIA-300

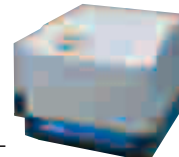
This ultra-sensitive silica monitor measures silica concentrations in pure and ultra-pure water for cleaning on the order of 1 µg/L (1ppb).

■ Specifications

Measuring range:

0 – 2 and 0 – 20 µg/L, or 0 – 5 and 0 – 50 µg/L
(Specify at time of order)

Measuring points: 1 – 6 (Specify at time of order)



Portable DO Monitor ●●●●● SD-300

This portable DO monitor measures trace amounts of dissolved oxygen (DO) in pure and ultra-pure water for cleaning.

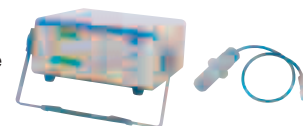
■ Specifications

Measuring range:

0 – 20, 0 – 200 µg/L (0 – 2, 0 – 20 mg/L)
(Settings can be selected from various ranges)

Response speed:

30 S/90% (At sample water temperature of 20°C or more)



2-channel Resistivity Meter ●●●●● HE-960RW

This resistivity meter, which simultaneously measures resistivity on two channels, is ideal for high-precision water quality monitoring at ultra-pure water plants.

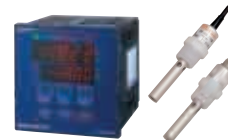
■ Specifications

Sensor input: 2 channels (simultaneous measurement)

Measuring range:

0 – 2.00, 0 – 20.00 MΩ·cm (0 – 20.0, 0-200.0 kΩ·cm)
(Cell constant 0.01/cm)

Repeatability: within ±0.1% of full scale



2-channel Conductivity Meter ●●●●● HE-960CW

This conductivity meter measures electrical conductivity in two separate locations, and calculates/outputs desalination rates in two separate locations, making it ideal for the continuous measurement of pure water.

■ Specifications

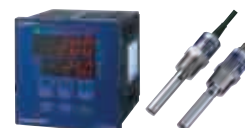
Sensor input: 2 channels (simultaneous measurement)

Measuring range:

0 – 20.00, 0 – 200.0 µS/cm (0 – 2.000, 0 – 20.00 mS/cm)
(Cell constant 0.1/cm)

0.01/cm and 1/cm cell constants also available;

Measurement ranges differ.



Other Products Suitable for Waste Water Monitoring

Automatic COD Monitoring System ●●●●●

CODA-211/212

This system meets the performance and control standards for automatic measurement of COD (chemical oxygen demand), which is a requirement of the Total Water Contaminants Regulation.

■ Specifications

Measuring range: Standard

0 – 20, 30, 40, 50, 100, 200, 500 mgO/L

* Quasi-standard also available



Free Fluoride Ion Monitor ●●●●●

IF-250

This simple automatic monitor continuously measures fluoride ions (e.g., in fluoride treatment processes) based on the ion electrode method, using measurement points with stable pH values.

■ Specifications


Measuring range:


0 – 10000 mg/L


(Switching among ten ranges)





Our worldwide service network ensures comprehensive support, when and where you need it.

U.K.
HORIBA INSTRUMENTS LIMITED

 Kyoto Close
 Summerhouse Road
 Moulton Park, Northampton
 NN3 6FL, England
 Phone: 44-1604-542600
 Fax: 44-1604-542696


China
HORIBA Trading (Shanghai) Co., Ltd.

● Shanghai Office
 Room 1701, United Plaza,
 1468 Nanjing Rd. West,
 Shanghai, 200040, China
 Phone: 21-6289-6060
 Fax: 21-6289-5553


Taiwan
HORIBA, Ltd. TAIWAN Representative Office

 3F, NO.18 Lane 676, Chung Hua Rd, Chupel City, Hsinchu Hsien, 302, Taiwan
 Phone: 886 (3) 656-1012
 Fax: 886 (3) 656-8231


Korea
HORIBA KOREA Ltd.

 112-6 Sogong-Dong Choong-ku, Seoul Korea
 Phone: 82-2-753-7911
 Fax: 82-2-756-4972


Japan
HORIBA, Ltd.

● Head Office
 2 Miyahogashi, Kisshoin Minami-ku, Kyoto, Japan
 Phone: 81-75-313-8123
 Fax: 81-75-321-5725

● Tokyo Sales Office
 1-7-8 Higashi-Kanda Chiyoda-ku, Tokyo, Japan
 Phone: 81-3-3861-8231
 Fax: 81-3-3861-8259


HORIBA Advanced Techno Co., Ltd.

 31 Miyano-nishi Kisshoin, Minami-ku Kyoto 601-8306, Japan
 Phone: 81-75-321-7184
 Fax: 81-75-321-7291

HORIBA Jobin Yvon Ltd.

 2 Dalston Gardens Stanmore Middlesex HA7 1BQ, England
 Phone: 44 20 8204 8142
 Fax: 44 20 8204 6142

France
HORIBA FRANCE SARL

 Rue L. et A. Lumière Technoparc F-01630 St-Genis-Pouilly France
 Phone: 33-4-50-42-27-63
 Fax: 33-4-50-42-07-74

Germany
HORIBA EUROPE GmbH

● Head Office
 Hans-Mess-Str.6, D-61440 Oberursel/Ts. Germany
 Phone: 49-6172-1396-0
 Fax: 49-6172-137385


● Dresden office
 Zur Wetterwarte 10 Haus 109 01109 Dresden Germany
 Phone: 49-3518-896807
 Fax: 49-3518-896808

HORIBA Jobin Yvon GmbH

● All products except Raman
 Hauptstr. 1 82008 Unterhaching Germany
 Phone: 49 89 462 31 70
 Fax: 49 89 462 31 799


● Raman Division
 Neuhofstrasse 9 D-64625 Bensheim Germany
 Phone: 49 6251 8475 0
 Fax: 49 6251 847520

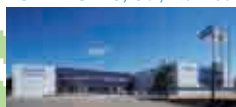

Singapore
HORIBA INSTRUMENTS PTE. Ltd.

 10 Ubi Crescent #05-11/12 UBI TECHPARK Singapore 408564
 Phone: 65-6745-8300
 Fax: 65-6745-8155

U.S.A.
HORIBA/STEC INCORPORATED

● Santa Clara Office
 3265 Scott Boulevard, Santa Clara, California 95054, U.S.A.
 Phone: 1-408-730-4772
 Fax: 1-408-730-8975

● Austin Office
 9701 Dessau Road Suite 605, Austin, TX 78754, U.S.A.
 Phone: 1-512-836-9560
 Fax: 1-512-836-8054

HORIBA Jobin Yvon Inc.

 3880 Park Avenue Edison New Jersey 08820-3012, USA
 Phone: 1 732 494 8660
 Fax: 1 732 549 5125

HORIBA STEC, Co., Ltd. Aso Factory

HORIBA Technology Center




Horiba continues contributing to the preservation of the global environment through analysis and measuring technology.

URL: www.horiba.com



Please read the operation manual before using this product to assure safe and proper handling of the product.

- The contents of this catalog are subject to change without prior notice, and without any subsequent liability to this company.
- The color of the actual products may differ from the color pictured in this catalog due to printing limitations.
- It is strictly forbidden to copy the content of this catalog in part or in full.
- All brand names, product names and service names in this catalog are trademarks or registered trademarks of their respective companies.

Bulletin:HRE-0058A

Printed in Japan ZK-N(SK)33