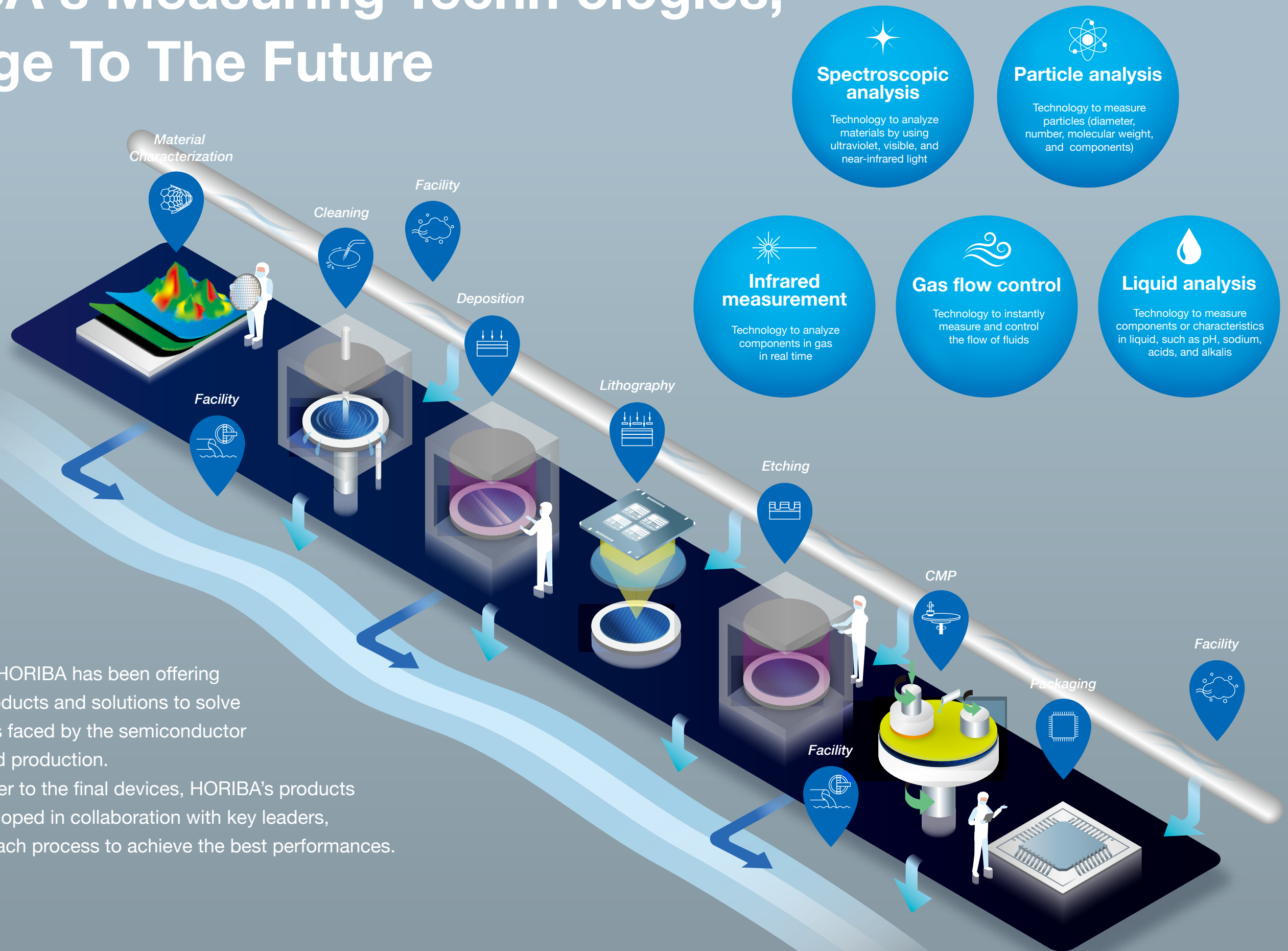


HORIBA

Answer to
SEMICONDUCTOR
Industry



HORIBA's Measuring Technologies, A Bridge To The Future



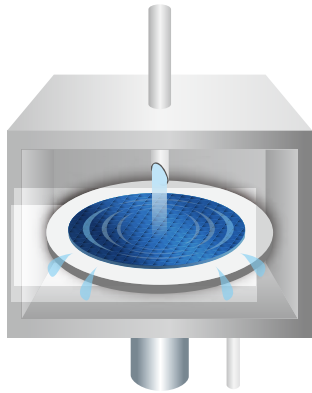
For over 50 years, HORIBA has been offering a wide range of products and solutions to solve different challenges faced by the semiconductor industry in R&D and production.








From the initial wafer to the final devices, HORIBA's products and solutions developed in collaboration with key leaders, are optimized for each process to achieve the best performances.



Cleaning

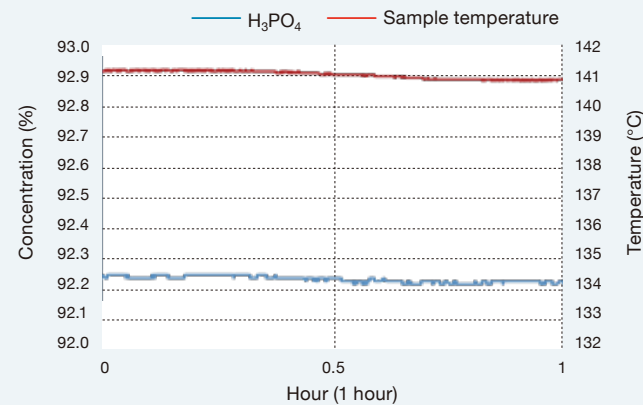
Manufacturing integrated circuits requires cleaning steps after each critical process like CMP or etching process. The cleaning process requires accurate monitoring of the chemical composition concentrations used in the process use solutions. HORIBA covers a wide range of analytical systems to optimize and monitor the cleaning process for the semiconductor manufacturing industries.



| |  |  |  |  |  |  |  |
|-----------------------------------|---|---|---|---|--|---|---|
| Fluid Control | ○ | | | | | | |
| HF Based Cleaning Solutions | | | | | | ○ | ○ |
| Liquid Surface Temperature | | ○ | | | | | |
| Nitride / Oxide Etching Solutions | | | | ○ | | | |
| Photoresist Stripping | | | | | ○ | | |
| Standard RCA Clean Process | | | ○ | | ○ | | |

Nitride / Oxide Etching Solutions

Optical Fiber Type Hot Phosphoric Acid Concentration Monitor, CS-620F, is designed for highly concentrated and high temperature phosphoric acidity analysis and its direct measurements. This monitor is applicable for the control of the chemical concentration during the SiN etching process in the 3D NAND manufacturing cycle.



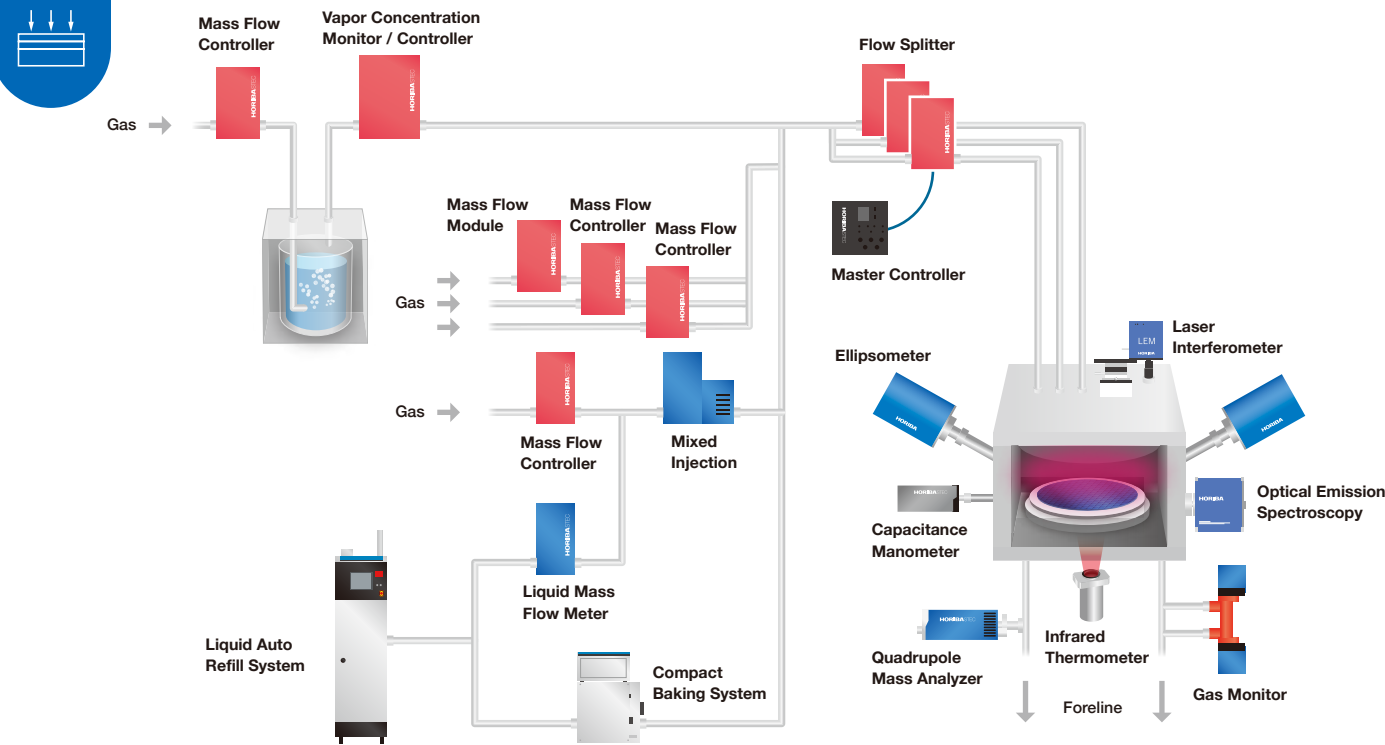
Dissolved Oxygen Monitoring of Chemical Solutions

Dissolved oxygen concentration measurement of dilute HF or TMAH used for semiconductor manufacturing cleaning process is very critical as it effects on the process yields. HORIBA offers high sensitivity sensor to monitor the dissolved oxygen concentration of low concentration ammonia which is lower than 1% or organic solution.



Deposition

HORIBA offers a wide range of product to optimize the deposition process, a key step in the semiconductor industry, and to increase the yield.



Chamber Cleaning Endpoint

Optical Emission Spectroscopy
Gas Monitor

Chamber Health Monitoring

Optical Emission Spectroscopy
Gas Monitor
Quadrupole Mass Analyzer
Capacitance Manometer
Infrared Thermometer

Film Thickness Monitoring

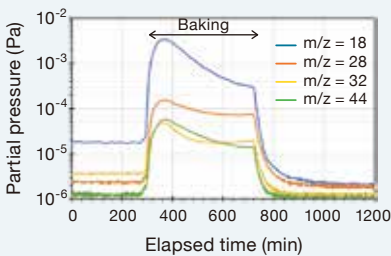
Laser Interferometer
Ellipsometer

Gas Delivery

Mass Flow Module
Mass Flow Controller
Vapor Concentration Monitor
Flow Splitter
Liquid Vapor Delivery System
Liquid Auto Refill System

Chamber Health Monitoring

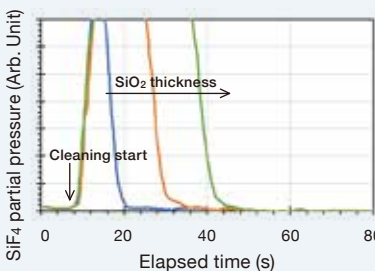
Micropole System, a compact quadrupole mass analyzer, allows the monitoring of residual gas inside a process chamber. It monitors residual H₂O absorbed on the chamber inner wall, and also removed by baking process.



Typical m/z peak trends from series of mass spectra during vacuuming.

Chamber Cleaning Endpoint

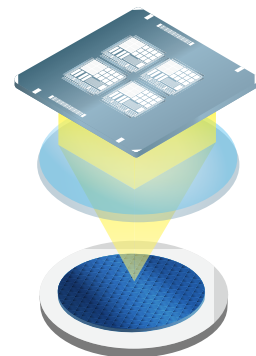
After several steps of deposition process, the chamber inner walls need to be cleaned in order to remove the contaminates. In order to maintain good reproducibility of the process, cleaning the chamber is one of the important mandatory routine operations. HORIBA's chamber cleaning endpoint monitor works for optimizing the process for adequate cleaning time.





Lithography

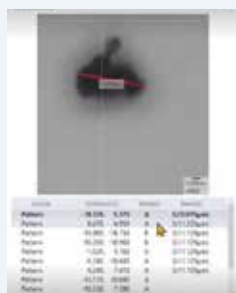
The lithography process is very sensitive to the quality and the cleanliness of the photomask. Any defects or particle on the mask will be replicated on the wafer and will lead to yield loss. From the mask to design to its final inspection, HORIBA offers a wide range of products to minimize the yield loss.



| | Reticle/Mask Particle Detection System | Reticle/Mask /Wafer Particle Remover | Laser Interferometry | Optical Emission Spectroscopy | Spectroscopy Ellipsometer | Raman Microscope | X-ray Analytical Microscope | Chemical Concentration Monitor |
|------------------------------|--|--------------------------------------|----------------------|-------------------------------|---------------------------|------------------|-----------------------------|--------------------------------|
| Mask Particle Detection | ○ | | | | | | | |
| Mask Particle Removal | | ○ | | | | | | |
| Mask Etching | | | ○ | ○ | | | | |
| Mask Wet Cleaning | | | | | | | | ○ |
| Particle Analysis | | | | | | ○ | ○ | |
| Pellicle Health Monitoring | | | | | ○ | ○ | | |
| Photoresist Characterization | | | | | ○ | ○ | | |

Particle Detection

Mask surface contamination is a yield killer. PD Xpadion is a fully-automated laser scattering based particle detection system designed to detect, analyze, and capture images of surface particulates on reticles and photomasks in wafer fabs and mask shops.

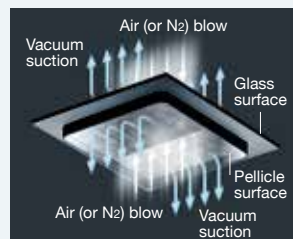


Reticle/Mask Particle Detection System
PD Xpadion



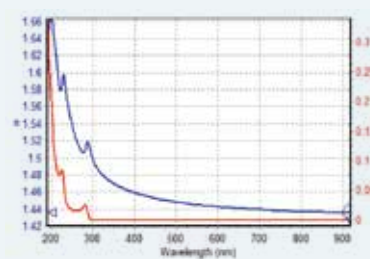
Particle Removal

Reticle/Mask/Wafer Particle Remover, RP-1, automatically removes particles on the reticle/photomask, or wafer by air (or N₂) blow and vacuum suction.

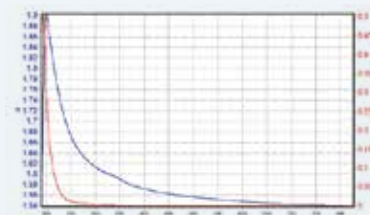


Photoresist Characterization

A photoresist is a light-sensitive material used in lithography process, to form a patterned coating on a surface. Accurate measurement of the optical properties and thickness of the photoresist layer is critical for the success of the lithography process.



Photoresist optical properties as a solution

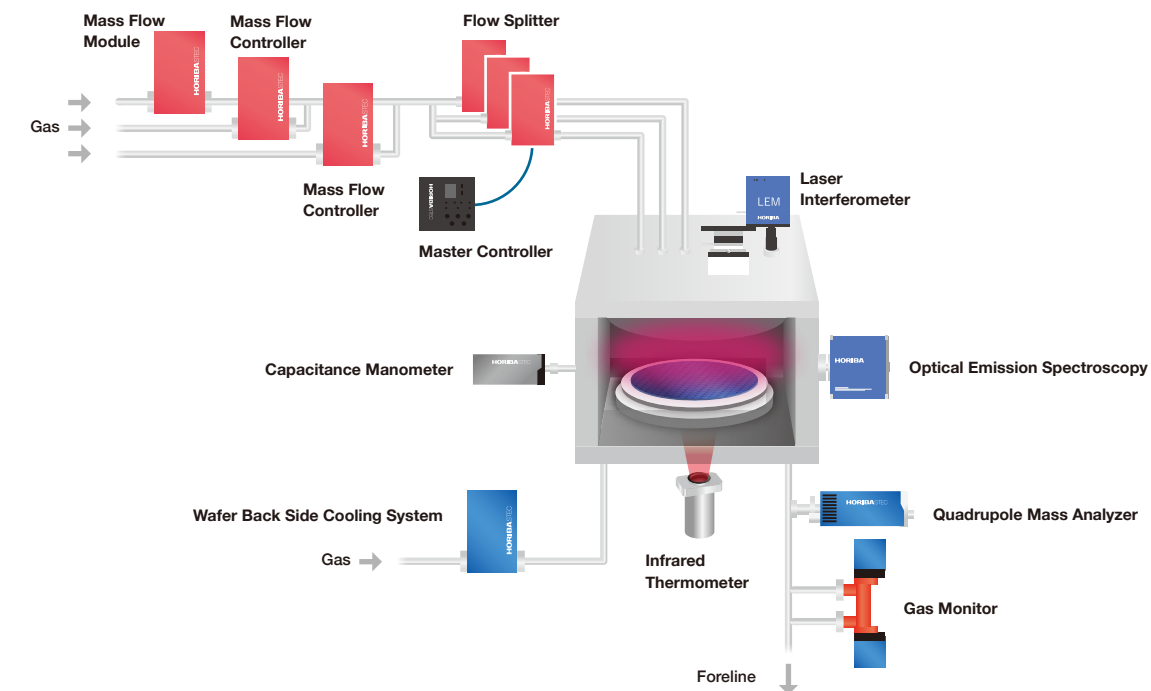


Photoresist optical properties as a thin film on a substrate



Etching

To reduce the chamber-to-chamber variation and to optimize the yield of an etching tool, HORIBA offers various fluid control modules and smart sensors for endpoint detection and chamber health monitoring. Compact and robust, they can be used for R&D and Production.



Chamber Cleaning Endpoint

Optical Emission Spectroscopy
Gas Monitor

Chamber Health Monitoring

Optical Emission Spectroscopy
Quadrupole Mass Analyzer
Capacitance Manometer
Infrared Thermometer

Endpoint Detection

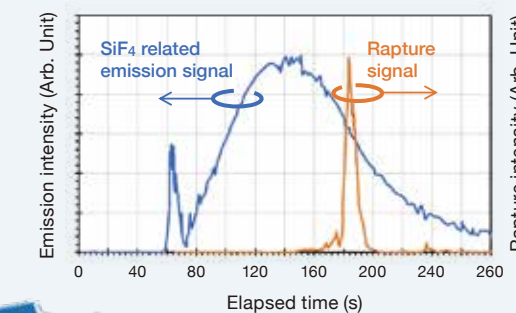
Optical Emission Spectroscopy
Gas Monitor
Laser Interferometer

Fluid Control

Mass Flow Module
Mass Flow Controller
Flow Splitter

Endpoint Detection by OES

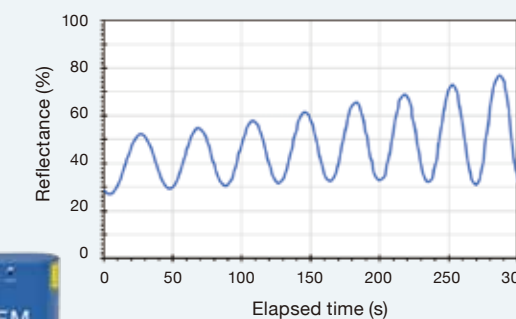
Optical Emission Spectroscopy (OES) is a common method used in semiconductor technology during plasma etching processing for Endpoint Detection. HORIBA offers state of the art end point detectors combining high class spectrometers and robust end point detection algorithm for low open area.



Smart OES Endpoint Monitor
EV 2.0

Real-time Etching Depth Measurement

From shallow trench to deep trench, HORIBA offers the right interferometer to monitor the trench depth. By selecting the right wavelength, the LEM interferometers can be used for different applications.



Camera Endpoint Monitor based on
Real Time Laser Interferometric Process Monitor
LEM Series



Chemical Mechanical Polishing (CMP)

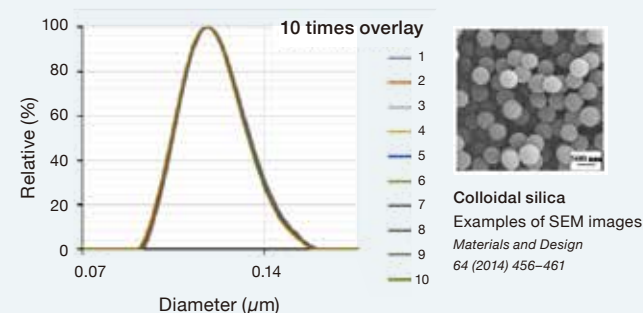
CMP slurry health or quality control is critical to achieving the lowest defectivity and desired yields in CMP process. Control over slurry properties including the concentration of chemical components, working particle size, and particle size distribution helps achieve the desired polishing rate and minimize CMP-induced defects.



| | Particle Characterization Analyzers | Micro Volume pH Meter | Chemical Concentration Monitor | Flat Carbon Sensor Conductivity Meter | Spectroscopic Ellipsometer | Raman Microscope | NanoRaman Microscope (AFM-Raman) | X-ray Analytical Microscope |
|---------------------------------|-------------------------------------|-----------------------|--------------------------------|---------------------------------------|----------------------------|------------------|----------------------------------|-----------------------------|
| Cleaning | | | | | | | | |
| Damages and Defects | | | | | | | | |
| Film Thickness | | | | | | | | |
| Slurry Characterization | | | | | | | | |
| Slurry Concentration Monitoring | | | | | | | | |

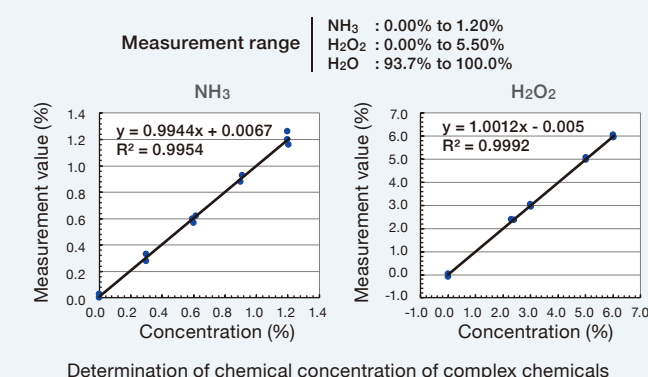
Slurry Characterization

Partica CENTRIFUGE, a centrifugal nanoparticle analyzer, measures particle size distribution. Even though the particle size of colloidal silica, widely used as CMP slurries for very precise polishing, is extremely small, Partica CENTRIFUGE is able to measure particle size distribution with ultra-high resolution and repeatability.



Post-CMP Clean Concentration Monitoring

Chemical concentration monitors, based on absorption spectroscopy, are used for real-time in-line and on-line monitoring of chemical components which are crucial to CMP process. CS-900, a chemical concentration monitor, is capable of completely non-contact measurements, and offers stable operation to reduce downtime.



Determination of chemical concentration of complex chemicals



Facility

"Measurement" is significant to keep the environment conservation. HORIBA's measuring techniques contribute to the safe and secure work environment in the fab as well as the preservation of the natural environment through the monitoring of AMC, emission gas, gas purity, and wastewater treatment.

Exhaust Gas Emission Monitoring

Stack Gas Analyzer
Portable Analyzer

Gas Purity Monitoring

Trace Gas Analyzer
Multi Gas Analyzer

Airborne Molecular Contamination

AMC Monitoring System

Ultra Pure Water

Silica Monitor
Resistivity Meter

N₂ Purge

Mass Flow Controller
Quadrupole Mass Analyzer

Wastewater Treatment

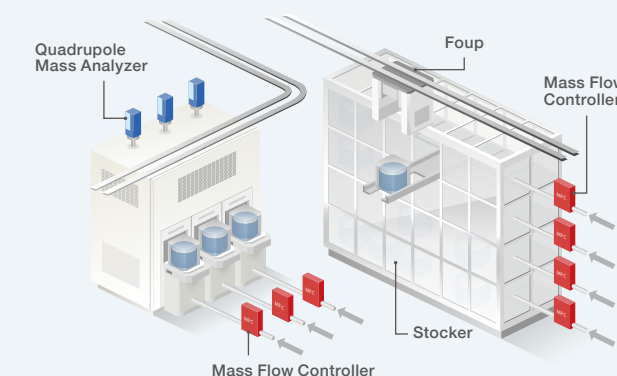
Self Cleaning Electrode
Field-installation Type Industrial Water Quality Meter

Laboratory / Field

Water Quality Meter

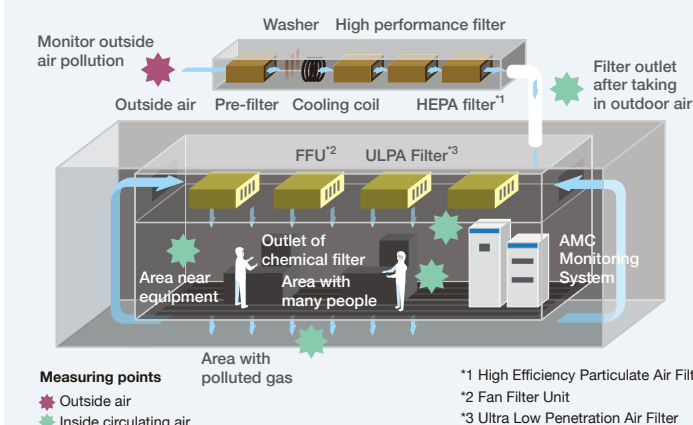
N₂ Purge System

The control of wafer quality affected by oxide, moisture and atmosphere between processes is important. When wafers are transported or stored in the semiconductor industry, large flow of N₂ purge by MFC in the stocker or in a foup is effective to prevent oxygen from oxidizing wafers and protect them from undesired chemical reactions or any other contaminations.

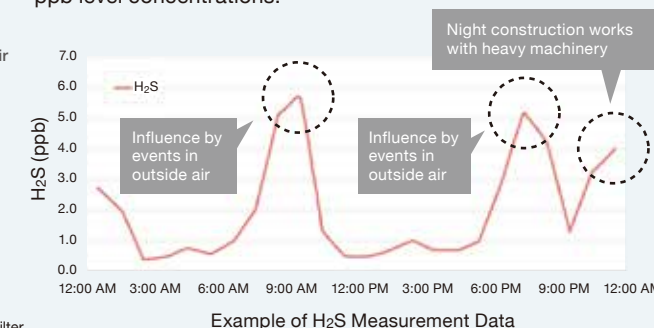


AMC* Monitoring *Airborne Molecular Contaminants

Continuous multi-point measurement of AMC without relying on the skills of manual analysis engineers.



AMCs is contamination of the air existing in the molecular form and playing a critical role in the product quality of modern semiconductor fabrication even when existing at extremely low ppb level concentrations.












Example of H₂S Measurement Data

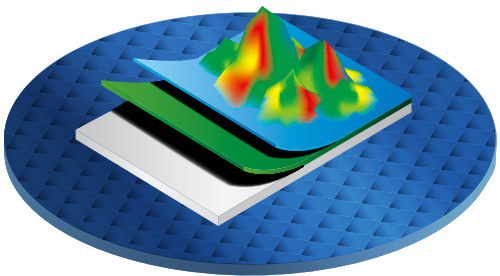


Material Characterization

In all stages, from materials evaluation to final inspection, HORIBA's products help maintain high efficiency in the manufacture of cutting-edge electronic devices. From blank wafers to the final device, HORIBA's analytical instruments for material characterization have been used by leading end-users and research organizations for over 50 years. HORIBA's wide range of measurement techniques support your fabrication processes by providing critical data that ensures your process efficiency. Designed to achieve optimal performance, these instruments are the right tools to accelerate time to market.

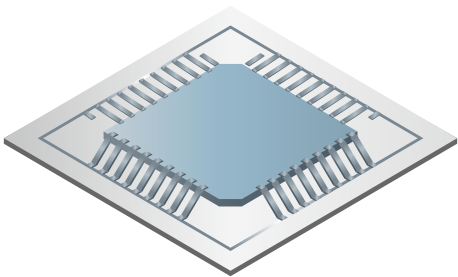



| |  |  |  |  |  |  |  |  |  |
|---------------------------------|---|---|---|--|---|---|---|---|---|
| | Raman Microscope | NanoRaman Microscope (AFM-Raman) | Photoluminescence Microscope | Spectroscopic Ellipsometer | Cathodoluminescence | Fluorescence Spectrometer | O/N/H Analyzer | GD-OES Depth Profiler | X-ray Analytical Microscope |
| Band-gap | | | ○ | ○ | ○ | ○ | | | |
| Crystallinity / Stoichiometry | ○ | ○ | | ○ | | | | | |
| Defects / Impurities Analysis | ○ | ○ | ○ | | ○ | | | | ○ |
| Electrical Properties | | ○ | | | | | | | |
| Elemental Analysis | | | | | | | ○ | ○ | ○ |
| Film Thickness | ○ | ○ | | ○ | | | | ○ | ○ |
| Stress and Chemical Composition | ○ | ○ | | | ○ | | | | |



Packaging

HORIBA's XGT systems offer high performance energy dispersive X-ray fluorescence (EDXRF) analysis with unique capabilities. The patented XGT technology combines traditional X-ray fluorescence methodology with small spot analysis for diameters down to a unique 10 µm.



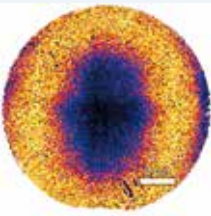
| |  |
|-----------------------|---|
| Elemental Analysis | ○ |
| Transmission Analysis | ○ |

HORIBA's wide range of measurement techniques caters to various materials of interest, including:

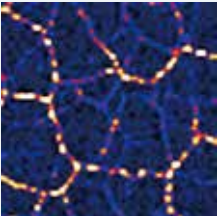
- 1D and 2D materials
- CMP slurries
- Quantum dots
- Photoresists
- Oxides, Nitrides
- Compound semiconductors
- Organic semiconductors

2D Materials

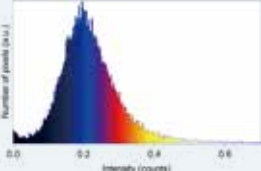
Applications: CMOS, Electrodes, and Barriers
Materials: Graphene, Transition Metal Dichalcogenides, Hexagonal Boron Nitride (h-BN)
Information:
• Layer thicknesses (Raman, Ellipsometry)
• Crystal quality, Charge carrier concentration, Stoichiometry and Band-gap (Raman, Photoluminescence)
• Defect density, visualization and identification of contaminants (Raman, Photoluminescence)



Graphene Raman image of a 4'' wafer



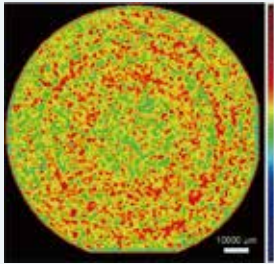
High resolution Raman image on defects



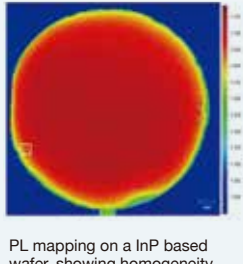
D/G distribution peak analysis

Compound Semiconductors

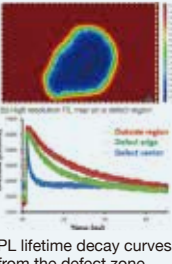
Applications: Power devices, Displays, LEDs, Laser diodes, Quantum wells
Materials: GaN, SiC, Ga₂O₃, GaAs, InGaAs, InP etc.
Information:
• Average stress measurements & Crystalline structure (Raman)
• Doping level (Raman)
• Carrier lifetime (Time-resolved Photoluminescence)
• Epitaxial layer growth uniformity & Detection of impurities (Photoluminescence)
• Optical constants, Band-gap, Film thickness (Spectroscopic Ellipsometry)
• Elemental analysis in depth (GD-OES)



Raman image of stress distribution across a SiC wafer



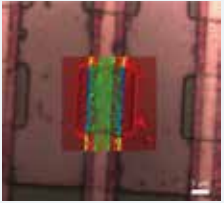
PL mapping on a InP based wafer, showing homogeneity and defects



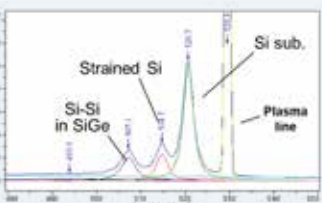
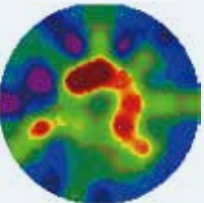
PL lifetime decay curves from the defect zone

Group IV Semiconductors

Applications: 2D/3D Transistors, Photovoltaics
Materials: Si, Ge, SiGe
Information:
• Optical constants, Band-gap, Film thickness (Spectroscopic Ellipsometry)
• Average stress and composition measurements (Raman)
• Phase identification (crystalline, micro-crystalline, amorphous) (Raman)
• Crystallographic defects detection (Raman)



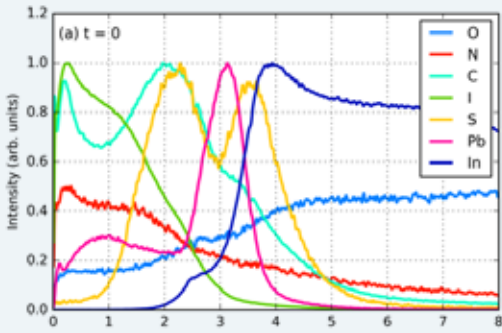
Raman image of a silicon chip with crystalline, poly and amorphous silicon regions



Stress distribution map derived from Raman data of a strained silicon layer on SiGe; Representative Raman spectrum

Organic Semiconductors & Perovskites

Applications: Solar cells, Photodetectors, Organic light-emitting diodes (OLEDs)
Materials: Perovskites, P3HT, PEDOT:PSS, Alq₃, PPV, Pentacene, etc.
Information:
• Identification of molecular structure (Raman)
• Elemental distribution (GD-OES)
• Carrier lifetime (Fluorescence Lifetime Spectroscopy)
• Optical constants, Band-gap, Film thickness (Spectroscopic Ellipsometry)



Elemental depth profile of CH₃NH₃PbI₃ thin film

Global Network



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