The HORIBA PD Series: Comprehensive Particle Detection for Semiconductor and FPD Manufacturing Processes

HORIBA’s PD Series is focused toward providing the particle detection support required for next-generation semiconductor and FPD manufacturing processes. The PD Series’ great versatility, based on its outstanding detection capabilities, makes it ideal for handling mask production as well as exposure and wafer manufacturing processes. Complementing HORIBA’s HAZE-resistant monitors, the PD line-up offers models specifically for leading-edge masking processes plus compact, low-cost models. In addition, the range has now been enhanced with the introduction of new particle removal systems.

The PD Series truly meets the needs of current semiconductor and FPD manufacturing operations.
The HORIBA PD Series: Comprehensive support for current semiconductor and FPD manufacturing operations.

- **Support of advanced masking processes thanks to an improved S/N ratio**
  - Reticle/Mask Particle Detection System
  - PR-PD2HR
  - The PR-PD2HR offers a three-fold improvement in the S/N ratio over the PR-PD2. This has significantly increased operational sensitivity and thus decreased false detection. In addition to the high functionality inherited from the PR-PD2, this model provides finer pattern measurement, allowing it to effectively handle advanced masking processes.
  - • 0.35 µm sensitivity
  - • Multi-stage case capability
  - • Multi-size compatibility

- **Efficient particle detection/measurement based on 0.35 µm high sensitivity and high throughput**
  - Reticle/Mask Particle Detection System
  - PR-PD2
  - The PR-PD2 enables fine particle detection down to 0.35 µm and also boasts a multi-stage sorter plus full range of communication functions. High-throughput measurement is possible on all surfaces from basic reticle and mask to glass and pellicle.
  - • 0.35 µm sensitivity
  - • Multi-stage case capability
  - • Multi-size compatibility

- **Low running costs thanks to a compact design, plus remarkable versatility**
  - Reticle/Mask Particle Detection System
  - PR-PD3
  - The high-performance PR-PD3 offers excellent throughput, a dependable optical system, and functions that reduce false detections. These features are bundled in a compact package that is designed to minimize running costs. The PR-PD3 also demonstrates great versatility thanks to its 0.5 µm detection sensitivity.
  - • 0.5 µm sensitivity
  - • Single stage/single size
  - • Small footprint

- **Low-cost inspection with enhanced versatility and compactness**
  - Reticle/Mask Particle Detection System (Desktop/Embedded type)
  - PR-PD5
  - As well as inheriting the PD series’ high efficiency, the PR-PD5 offers outstanding cost performance thanks to its space-saving design. This model can also be integrated with reticle stockers/steppers and cleaning equipment, etc.
  - • Reticle inversion mechanism
  - • 0.5 to 50 µm selectability
  - • Single detection system
  - • Built-in and combination types

- **Particle Removal**
  - Automatic Particle Blower
  - RP-1
  - • Removal of particles from the pellicle and glass surfaces on pattern sides
  - • Use of N₂ blow and vacuum suction to prevent the escape of removed particles

- **Foreign Particles & HAZE**
  - Trace Ammonia Gas Monitor
  - CG-1000
  - The first step in preventing HAZE and foreign particle generation
  - • Ultra-high sensitivity of 0.1 ppb
  - • Real-time measurement (every 5 sec.)
  - • Straightforward operation
Leading-edge Technology that Drives Innovation across the Broad Range of Applications

Our versatile devices lower costs, improve efficiency and accommodate a variety of target sizes in inspections. What’s more, they can be used in combination with other devices. In addition to offering compatibility with mask production/exposure processes, the PD Series demonstrates its versatility in FPD process and in numerous other applications.

**ADVANCED PROCESSES**

Measuring Targets: Particles, HAZE, ESD

**Particle Detection**
- Can be used jointly with defect detecting equipment.
- Adapts to chrome surface inspection by means of pattern masking.
- Capable of inspecting relatively rough patterns only.
- Allows wall proximity inspection in pellicle frame.
- Suitable for inspection of pellicle surfaces/glass surfaces only.

The PR-PD2HR covers patterns for which a defect inspection system would not previously have even been thought necessary. This allows the usage frequency of the defect inspection system to be decreased and enables cost reductions and increases in detection speed to be targeted. The high S/N ratio likewise facilitates the measurement of even comparatively fine patterns, with a wide range of applications possible. It is also possible to mask and measure individual areas on a pattern surface. In addition, the PR-PD2HR demonstrates exceptional ability in the inspection of clear areas, such as those close to walls in pellicle frames.

**Particle Removal**
- **Automatic particle blower.**
  (For pellicle/glass surface, applicable to SMIF POD)

The RP-1 automatic particle blower system enables particles to be removed. The system does not require an operator, which helps it to prevent the various errors that can occur during manual operation. It also contributes to improved efficiency with its ability to automatically remove particles while performing inspection.

**GENERAL PROCESSES**

Measuring Targets: Particles, HAZE, ESD

**Particle Detection**
- Capable of detection on surfaces (pattern/glass/pellicle).
- Accommodates a variety of stepper cases.
- Offers a broad range of measuring sensitivities (0.35 - 5 µm).

The PR-PD2 and PR-PD3 are able to handle all the different sizes and thicknesses for reticles/masks and also bare wafers, plus they are compatible with the stepper cases available from each manufacturer. Their broad range of measuring sensitivities also allows them to meet a wide variety of application requirements.

**Particle Removal**
- **Automatic particle blower**

Reticle/Mask Particle Detection System
PR-PD2

Reticle/Mask Particle Detection System
PR-PD3

Automatic Particle Blower
RP-1

Reticle/Mask Particle Detection System
PR-PD2HR

Automatic Particle Blower
RP-1

Reticle/Mask Particle Detection System
PR-PD5

Automatic Particle Blower
RP-1

Reticle/Mask Particle Detection System
CG-1000

Trace Ammonia Detection System
NH3
the Broad Range of Applications

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For Other Processes

● Bare wafer measurement.
● Glass substrate measurement.
● Measurement of particles on various flat surfaces.
The compact and low-cost PR-PDS is an easy-to-use system that facilitates straightforward measurement. In addition to being optimal for specialized small-format devices such as 2- to 4-inch bare wafers, the PR-PDS is able to perform measurement of blank masks. If holders are used, it is also possible to measure film shapes and various other flat surfaces. Please contact your HORIBA representative regarding this feature.

For Use in Combination with Manufacturing Devices

● Reticle/mask stocker (pellicle/glass surface).
● Reticle/mask exchanger (pellicle/glass surface).
● Reticle/mask cleaner (pattern surface).
The PR-PDS has been designed so that it can be integrated with any other system as a space-saving measure. Installing the PR-PDS to the conveyor, or the reticle stocker, allows the performance of simultaneous inspection, while combining it with the cleaning device enables inspection during the cleaning process. These and other possible configurations mean that inspection can be completed within the main system.

Particle Generation and HAZE Countermeasures

● Monitors atmosphere in the exposure process area.
● Monitors the atmospheres of various manufacturing devices.
● Monitors failure of chemical filters.
The CG-1000 uses the CRDS method to provide ultra-sensitive, real-time (every 5 sec.) measurement of trace ammonia gas at 0.1 ppb. This system offers effective control of trace ammonia gas, which has been identified as one of the causes of hazi,
Outstanding Detection Capabilities Plus a Full Range of Functions

The multi-purpose PD Series delivers flexible, top-level performance.

Detection capabilities

Detection of particles on patterns with attached pellicles

A function for measuring pellicle permeability enables particle inspection to be conducted at an appropriate sensitivity. By switching the light path, measurement can be performed within the pellicle frame without creating shadowed areas, which also allows regular inspections to be run after pellicles have been applied.

Incorporation of functions for preventing false detections

The introduction of a proprietary signal processing system enables false detections to be avoided. A pattern discrimination function that uses a low-pass filter also helps to reduce pseudo-detections to a minimum. This function represents an effective countermeasure against false detections even on dense patterns.

Incorporation of an upper/lower surface particle review function

Microscopes: x440 for the upper surface; Up to x2200 for the lower surface

A single objective microscope lens is installed for inspecting the upper surfaces of reticles and masks, while four are mounted for the lower surfaces. A function that enables direct observation of particles on the upper and lower surfaces is also available. While the magnification for the upper surfaces is fixed at x440, the view for the lower surfaces can be switched between x220, x440, x880, and x2200.

PR-PD3 functions for preventing false detections

The PR-PD3 is equipped with both a polarized differential function for coarse patterns and a low-pass difference function for fine patterns. Utilizing these two methods, erroneous detection can be effectively countered in OPC patterns, etc., that possess both characteristics.

Compatibility with all types of stepper case (excluding PR-PD5)

As well as the stepper cases available from each manufacturer, SMIF-PODs can also be processed. This enables various combinations of stepper case sizes from different manufacturers to be used.

Compatibility with all types of sample size and thickness

If holders or cases are used for reticles and masks, a wide range of sizes from 3.5- to 9-inch can be accommodated. Likewise, bare wafers up to 5-inch can be handled using holders. This also provides flexibility in processing different thicknesses.

Note: Consult your HORIBA representative regarding special sizes.

Handling of patterns with/without pellicles

Along with patterns with attached pellicles, particle inspection can also be performed on surfaces without pellicles. Similarly, particle measurement can also be conducted on individual pellicles before they are applied (option).
Measurement principle (In case of PR-PD3)

The PR-PD3 uses the laser scattering method to detect particles. When a laser beam is directed at the microcontaminant, the beam scatters. The particle is detected by measuring the strength of this scattering. The entire inspection surface is scanned by the laser beam using a galvanometer mirror. Although the pattern on the reticle and mask also causes the laser beam to scatter, since the polarization characteristics of the particles and pattern differ, the PR-PD3 is able to distinguish these by using a polarizing element inserted into the optical system. Taking advantage of the fact that the particle and pattern signals differ, HORIBA developed a unique low-pass filter to increase the ability to distinguish between the two. Furthermore, the well-proven He-Ne laser (633 nm) is used because of its stable operation. These technical improvements make the PR-PD3 able to handle a wide range of masks, from the cutting edge to the multi-purpose.

Ability to jointly access a database

Measurement results are mapped according to the size of the particles and can be displayed in real-time during the detection operation using a matrix. These inspection results are saved to a database server, from where DMS (data management software) can be used to perform data management and output various types of report, etc. Connecting the server to a LAN also enables bidirectional communication, facilitating shared use of the database by other system components.

Typical connectivity (In case of PR-PD2)

- Host PC
- Ethernet cable
- Hub
- PD external terminal PC
- Optional specifications
  - GEM transmission data software (GEM, HORIBA standard specification)
  - Ethernet cable
- Printer output port
- Color printer
- Customer must provide Ethernet cabling when terminal PCs (installed with data management software) are installed in an office or elsewhere.
Related Products

**Wet Process**

**SC-1 Monitor CS-131**
This monitor measures in real time the concentration of NH3, H2O2 and H2O in SC-1 solution and indicates the timing of automatic chemical spiking by an alarm. The quick response and short measuring period allow changes in concentration, while its compact design ensures easy installation in cleaning equipment.

**SPM Monitor CS-150**
This monitor measures in real time the concentration of H2SO4, H2O2 and H2O in SPM solution and indicates the timing of automatic chemical spiking by an alarm. The quick response and short measuring period allow changes in concentration, while its compact design ensures easy installation in cleaning equipment.

**Hydrofluoric Acid Monitor CM-200A/210A**
The lightweight, compact design of this monitor ensures easy installation in hydrofluoric acid dilution and wafer cleaning equipment. Two sensor versions may be selected: the dipped type, added directly to the solution, and the distribution type, integrated in the process piping (standard and high flow rate types).

**IPA Gas Concentration Monitor IR-150A**
IPA (IsoPropyl Alcohol) is widely used in the drying processes required for effective wet cleaning during semiconductor manufacturing. The IPA gas concentration monitor can be combined with a mass flow controller or vaporizer, and is perfect for use in combination with a vaporizer or bubbler as a secondary gas concentration monitor.

**Low Concentration HF/HCL/NH3 Monitor HF-960M**
Along with the evolution of 65 nm and 45 nm devices, the chemical solutions conventionally used in RCA cleaning are requiring greater and greater low-concentration control. The HF-960M uses sensors that offer outstanding corrosion resistance for high precision, high-speed measurement of low concentrations of hydrofluoric acid, hydrochloric acid and ammonia, and is thus perfect for single-bath and wafer cleaning.

**Dissolved Ozone Monitor HZ-960**
From the consideration of reducing costs and reducing the burden on the environment through chemical-less processes, the use of ozone water is expected to be more and more effective. The HZ-960 measures ozone water concentrations and supports process controls. Two types of detectors are available, as sampling type and inline type, a selectable as appropriate to the environment.

**Resistivity Meter HE-460R**
As part of the final process for cleaning silicon wafers, over-stripping monitoring of the purity of the ultra-pure water used in the final rinse process is being demanded. The HE-460R has a built-in microprocessor and measures ultra-pure water at high precision during that process.

**OES (Optical Emission Spectroscopy) Etching End-point Monitor EV-140C**
This monitor has a 2048x8200 CCD detection element that can simultaneously measure a wide range of wavelengths (200 - 800 nm) with a minimum retrieval resolution of 20 microns and a maximum resolution of 2 nm. The use of a programmable end-point algorithm with a broad range of applications makes it possible to control endpoints that cannot be determined with conventional systems. Advanced analysis software is included as a standard item.

**Real Time Interferometric Film Thickness Monitor DM-1000 Series**
This monitor is used to calculate variations in film thickness with great precision during the deposition and etching processes. It detects endpoints by setting the desired film thickness. It can accommodate complex multi-layer films and helps to ensure highly stable control.

**FTIR Gas Analyzer FG-100A Series**
The FG-100A is a highly advanced FTIR gas analyzer for the analysis of VOCs and other gases in semiconductor process. It includes a dedicated sampling unit for gas analysis and more than 260 gas spectral library. The FG-100A can respond to a variety of applications, such as optimization of the CVD chamber cleaning and dry-etching processes, performance checks on abatement systems, and monitoring of the ambient gases in clean rooms.

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

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

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