Semiconductor Manufacturing Process Monitor

OES (Optical Emission Spectroscopy) Etching End-point Monitor
EV-140C

Real Time Interferometric Process Monitor
DM-1000 series
LEM-CT-670-G50

HORIBA continues contributing to the preservation of the global environment.
Integrated management with an in-situ real time monitor for next-generation thin-film processes

Real time monitoring of film thickness, trench depth, and plasma is conducted to increase the yield rate with state-of-the-art etching and coating, management and control now considered essential during this process. HORIBA Semiconductor Manufacturing Process Monitors make use of advanced measurement technologies created by HORIBA Jobin Yvon in France, the leading company in optics development.
Various measurement of process gas

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Mass Flow Controller
SEC-Z500X Series
Flow control of process gas

FTIR Gas Analyzer
FG-100A Series
Efficient measurement of process gas in a compact size

Residual Gas Analyzer
MICROPOLE™ System
Gas monitoring of the chamber after the device has been cleaned

In-line Gas Monitor
IR-200
Chamber cleaning end-point monitoring

Real Time Interferometric Process Monitor
Highly precise detection of trench depth and variation in film thickness with the interferometric intensity monitor.

OES (Optical Emission Spectroscopy) Etching End-point Monitor
Multi-channel with high resolution down to 2 nm. Advanced end-point detection.

Wafer position pattern recognition

Plasma light source spectrometer

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OES
(Optical Emission Spectroscopy)
Etching
End-point Monitor

This is an emission analysis monitor intended for end-point detection or plasma condition control in the plasma-based semiconductor thin-film process. The newly-developed Rupture Intensity algorithm allows accurate end-point detection by capturing faint signal changes. The ability of capturing subtle changes in emission has significantly improved the sensitivity. The enhanced noise immunity ensures highly stable operation in hostile environments of round-the-clock manufacturing lines.

UV high-sensitivity spectroscope
A large, 70-mm-diameter, F/2 opening ratio grating manufactured by HORIBA Jobin Yvon results in a truly bright optical system. The built-in, back-thinned CCD achieves high quantum efficiency and enables highly sensitive measurement. With especially high sensitivity in the UV region, end-point detection is possible in that wavelength range that is less affected by interference.

“Sigma-P” software for advanced process control
The Sigma-P software handles the series of steps required for process control, from the analysis of plasma behavior to the creation of databases for measured data and remote control of manufacturing equipment. The programmable structure of the measurement recipe enables setting of multiple detection conditions and sequential processing, thus allowing the monitor to be used not only for end-point applications but also for development of comprehensive plasma condition monitoring as well.

Spectral data can be converted into time course graphs while the screen layout, operation waveforms, and comparative calculation waveforms against reference data as well as other information can be freely arranged on-screen.

Strong end-point algorithms
“Rupture Intensity”, an end-point algorithm, has been newly developed in addition to the standard end-point detection of threshold deviations in general operation signals. This new algorithm ensures that points of change are adequately captured even amongst the significant noise and without the delay caused by filter processing. Extremely small signal changes, such as end-points with small opening areas, are accurately detected as well.

Example application setting Warning of both abnormal plasma conditions as well as end-points using the luminous intensity ratio between the reactive species and the active living organisms.

Example application of Rupture Intensity to a small opening process
Synthesized wavelength signal with increasing change
The algorithm searches for the optimal point of change to achieve 2 straight lines as Range A moves.

Rupture Intensity
“Rupture Intensity” converts the change in the intersecting angle between the two straight lines and amplifies the small change in intensity of the original signal.
**Full reprocessing function**

This function enables recipe optimization and end-point simulation to be repeated as often as desired with new recipe conditions using a single sampling of spectral data. A library to identify the emission species in plasma comes standard.

**Advanced statistical processing: Feedback to recipes**

The statistical processing function enables changes in the end-point detection time to be visualized and evaluates the appearance and reproducibility of drift over the entire process. Combined with the reprocessing function, recipe optimization is possible as well.

**“Recipe Designer” recipe-generation tool automatically synchronizes with analytical results**

To support of data analysis and recipe creation, Recipe Designer enables the optimum “Rupture Intensity” algorithm to be generated and easily built into the actual recipe by simply following on-screen instructions for analysis and simulation.

**Example Recipe Designer settings**

![Graphs and charts related to Recipe Designer settings]

**EV-140C Specifications**

- **Sensor unit**
  - Optical unit
    - Wavelength range: 200 to 800 nm
    - Optical resolution: <2.0 nm @ =200 to 500 nm, <2.5 nm @ =500 to 700 nm (FWHM theoretical resolution)
    - Focal length: 140 mm
    - 2nd order filter: Built in
  - Detector
    - CCD type: Back-thinned linear CCD image sensor
    - Pixels: 2048 x 64
    - A/D resolution: 16 bit
    - Integration time: 20 ms to 2.5 sec (10-ms steps)

- **General specifications**
  - Sensor unit dimensions: 170 (W) x 201 (H) x 257 (D) mm (AC type)
  - Sensor unit weight: 6.5 kg (AC type)
  - No. of connecting chambers: 1
  - Power supply: 90 to 264 V AC, 24 V DC (selectable)
  - Power consumption: 12 VA

- **IN/OUT**
  - Analog output (Real time output of operation result according to the recipe)
    - Data output: 2 channels
    - Voltage output: 0 to 5 V DC
  - Digital I/O (Recipe setting and end-point output using the external remote protocol)
    - Digital output: PIO / DI = 8 bit / DO = 8 bit
    - External general-purpose connector: Dsub25SS (for PIO port and analog output)
  - Controller interface: Ethernet port

- **Controller unit (FA-spec computer)**
  - Dimensions: 197 (W) x 148 (H) x 250 (D) mm
  - OS: Windows XP embedded (English version)
  - CPU: Celeron 1.3 GHz
  - Main memory: 1 GB
  - Hard disk: 80 GB
  - Power supply: 90 to 264 V AC, 50/60 ±3 Hz
  - Mobile computer specifications also available.

- **External remote protocol**
  - Communication: PIO / RS-232C serial
  - LAN connection capability also available.

- **Certification**
  - Standards: CE/FCC

- **Accessory**
  - Optical fiber
  - External fiber grade: VIS / UV-resistant
  - Length: 2m or 5m (select the fiber length)

- **Option**
  - Condenser optics
  - Chamber adapter: Condenser lens unit
  - PC battery option: External Light Source Interference Camera

**Multi-chamber configuration diagram**

![Diagram of EV-140C multi-chamber specifications]
HORIBA’s Real Time Interferometric Process Monitors provide high precision detection of film thickness and trench depth during the etching and coating process. Interference occurs when monochromatic light hits the sample surface, resulting in different optical path lengths due to film thickness and height variations in the film. This system uses time course monitoring of the interference intensity to calculate the etching and coating speed of the monitored area for each cycle, leading to detection of the end-point based on the prescribed film thickness and trench depth. These units are extremely stable and can be used with complex multi-layer films.

**Features**

With the spectrometry-capable EV-140C adopted as a controller, this series delivers high-stability operation and high sensitivity. Thanks to the ability to select the desired wavelength in the ultraviolet (UV type) and visible light (V5 type) regions, it is now possible to measure interference for films with which reflection is difficult to obtain due to small variations in their refractive index at this laser wavelength, as well as for those with thin, complex structures.

**Laser device etching monitor screen**

Select between ultraviolet (300 to 400 nm) and visible light (450 to 700 nm) for application to a broad range of film types. More detailed film information can be detected by selecting the wavelength in the vicinity of the band gap for that particular film type.

**External Light Source Camera Unit**

An unrestricted objective lens design has enabled a long lens-tube structure in our newly-developed, newly-designed camera unit. Shortening the distance between the objective lens and wafer in this way allows measurement of a smaller spot diameter. And, in consideration of possible installation near a high frequency antenna, no metallic parts were used for the objective lens tube. Choose between the manual and motorized stage types.

**Equipment configuration diagram**

Using UV range with a Xe light source or a preferred visible band wavelength with a halogen light source, a 100- to 500-µm spot diameter is used to capture the interference light from the wafer.
Monitor Process Interferometric Real Time

These units integrate the light receiver of a 670-nm-wavelength laser light source and a compact CCD imaging camera for improved ease of handling/operation and cost performance. The use of lasers enables a spot diameter as small as 20 to 100 µm depending on distance between wafer and camera. As a pre-amp is built into the camera, simple monitoring of 0 to 10 V outputs is possible using only that camera when connected to devices such as a data logger.

Software that’s ready for integrated use in processing lines

This system achieves high yield rates with semiconductors. Included as standard features are statistical processing through batch database compilation, remote control I/O in common with HORIBA’s Semiconductor Manufacturing Process Monitor, and RS-232C serial communication.

End-point detection algorithms with improved flexibility

Includes a large number of algorithms compatible with special signal detection and detection of signals with poor S/N ratios.

Advanced reprocessing function

Data acquired just once can be used as a base for multiple simulations to achieve the optimum parameter settings.

**LEM-CT-670-G50 Specifications**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light source</td>
<td>Laser diode</td>
</tr>
<tr>
<td>Light source wavelength</td>
<td>670 nm</td>
</tr>
<tr>
<td>Magnification</td>
<td>50x (G50)</td>
</tr>
<tr>
<td>Spot diameter</td>
<td>20 µm to 100 µm</td>
</tr>
<tr>
<td>Depending on the camera-to-wafer distance</td>
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</tr>
<tr>
<td>Detector</td>
<td>Pin-photo diode</td>
</tr>
<tr>
<td>Camera dimensions</td>
<td>65 (W) x 160 (H) x 100 (D) mm (camera only, does not include stage)</td>
</tr>
<tr>
<td>Mass</td>
<td>1.2 kg</td>
</tr>
<tr>
<td>Controller dimensions</td>
<td>451 (W) x 400 (H) x 133 (D) mm</td>
</tr>
<tr>
<td>Mass</td>
<td>10 kg</td>
</tr>
<tr>
<td><strong>Stage specifications</strong></td>
<td></td>
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<tr>
<td>Manual X-Y stage</td>
<td>Stroke ±8.0 mm</td>
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<tr>
<td></td>
<td>120 (W) x 120 (H) x 87 (D) mm</td>
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<td>Weight 1.3 kg</td>
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<tr>
<td></td>
<td>Manual stage</td>
</tr>
<tr>
<td></td>
<td>185 (W) x 102 (H) x 185 (D) mm</td>
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<td>Weight 3 kg</td>
</tr>
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<td><strong>DM-1000 Series Specifications</strong></td>
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<tr>
<td>Light source</td>
<td>Hg-Xe lamp / Halogen lamp</td>
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<tr>
<td>Spot diameter in µm</td>
<td>100 to 500 µm*</td>
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<td>Measurement wavelength range</td>
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<td>CCD camera field</td>
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<td>Sensor unit</td>
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<td>Optical fiber (by measurement)</td>
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<td>Dimensions</td>
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<td>302 (W) x 518 (H) x 194.5 (D) mm*</td>
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<tr>
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**DM-1000 Series Common Specifications**

**Controller requirements**

Memory: 512 MB, CPU: 600 MHz or greater, HDD: 30 GB or more

**Attachment conditions**

A measurement view port of ø20 or greater is required in a vertical direction across the wafer.

“Sigma-P” software for advanced process control

The Sigma-P software, also common to the EV-140C, handles the series of steps required for process control. The programmable structure of the measurement recipe enables setting of multiple detection conditions and sequential processing. A large number of algorithms that can handle special film structures for interference measurement are included, and simultaneous processing of detection condition is possible.

**Example Sigma-P interference measurement settings**

Both sides of up to 8 signal waveforms can be displayed according to the desired function definition. Processing conditions such as process film thickness and abnormality detection can be set separately for each waveform.

**Optional pattern recognition device**

Displacement of the measurement area during wafer transfer is automatically corrected through an adjustment of the camera unit position by the pattern recognition function and the motorized stage, resulting in accurate matching of the measurement spot to the measurement area on the sample.

**Example pattern recognition screen**

Detects characteristic patterns in the acquired image, and moves the X-Y motor stage to achieve the same positional relationship as the pre-registered image.

Software that’s ready for integrated use in processing lines

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**Plasma Diagnosis End-point Monitor measurement examples**

**AC POLYSTRIP**
- Starting point
- Step: Polystrip
- EPD available with many wavelengths combination

**Dual damascene**
- Structure: open area 1-2%
- Starting point
- Step 1: SiO etch step
- Step 2: SiN etch step
- Period of signal: 46 s
- Period of signal: 75 nm etched/period
- 46 s
- 75 nm etched

**Real Time Interferometric Process Monitor measurement examples**

**DM-1000 series**
- Starting point
- Step 1: GaAs etching
- Dual damascene
- Step 1: AlO etching
- Nb/Au interface detection
- Interface: Nb(12 nm) + Au
- Nb/Au interface detection
- Hole: 75 to 150 μm
- Period of signal: 46 s
- Period of signal: 75 nm etched/period

**LEMR-CT-670-G50**
- Nb/Au interface detection
- Interface: Nb(12 nm) + Au
- Period of signal: 46 s
- Period of signal: 75 nm etched/period

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

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

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