iPHEMOS series
Inverted emission microscope
The inverted emission microscope is a backside analysis system designed to identify failure locations by detecting the light and heat emitted from the defects in semiconductor devices. The signal detection from backside facilitates the use of probing and probe card to the wafer surface, and the sample setting can be performed smoothly. The platform, possible to mount multiple detectors and lasers, enables the selection of the optimum detector for performing various analysis methods such as light emission and heat generation analysis, IR-OBIRCH analysis, and others; moreover, letting dynamic analysis perform efficiently by tester connection.

Support for measurement from a single chip to a wafer by mounting a 300 mm wafer prober. Multi-pin needle contact by probe card and sample observation on PC board are available. Dynamic analysis with LSI tester drive is also possible by cable connection.

By connecting directly to the LSI tester, signal delay due to the connection cable length can be reduced, and the analysis of high-speed driving samples is possible. Direct docking dedicated prober enables multi-pin needle attachment to 300 mm wafers and with the additional option, it is possible to perform package analysis as well as pin-needle attachment by a manipulator.

Example of connection to the LSI tester

Example of connection to the LSI tester
Features

- Two ultra-high sensitivity cameras mountable for emission analysis and thermal analysis
  Coverage of different detection wavelength ranges needed for emission analysis (near-infrared range) and thermal analysis (mid-infrared range) allows selecting an analysis technique that matches the sample and failure mode.

- Lasers for up to 3 wavelengths and a probe light source for EOP are mountable

- Multi-platform capable of mounting multiple detectors

- High sensitivity macro lens and up to 10 lenses suitable for each detector sensitivity wavelength

Options

- Includes laser scan system
- Emission analysis with high-sensitivity near-infrared camera
- Thermal analysis with high-sensitivity mid-infrared camera
- IR-OBIRCH analysis
- Dynamic analysis by laser irradiation
- EO probing analysis
- High-resolution and high-sensitivity analysis using NanoLens
- Connects to CAD Navigation
- Connects to LSI tester

Basic display functions

Superimposed display/contrast enhancement function

The iPHEMOS series superimposes the emission image on a high-resolution pattern image to localize defect points quickly. The contrast enhancement function makes an image clearer and more detailed.

Display function

- **Annotations**
  Comments, arrows, and other indicators can be displayed on an image at any location desired.

- **Scale display**
  The scale width can be displayed on the image using segments.

- **Grid display**
  Vertical and horizontal grid lines can be displayed on the image.

- **Thumbnail display**
  Images can be stored and recalled as thumbnails, and image information such as stage coordinates can be displayed.

- **Split screen display**
  Pattern images, emission images, superimposed images, and reference images can be displayed in a 4-window screen at once.
Inverted emission microscope

**iPHEMOS series**

### Laser scan system

The laser scan system obtains clear, high-contrast pattern images by scanning the backside of a chip with the infrared laser. Within 1 second a pattern image can be acquired. By the flexible scan in 4 directions, it is possible to scan a device from different directions without rotating it. Scanning in parallel with a metal line makes OBIRCH image clearer. The function is also useful in OBIRCH analysis using a digital lock-in and dynamic analysis by stimulation by laser stimulation.

<table>
<thead>
<tr>
<th>Product name</th>
<th>Product number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser scan system</td>
<td>C10656-21A</td>
</tr>
</tbody>
</table>

**Standard function**

**Dual scan:** Obtain a pattern image and an IR-OBIRCH image simultaneously

**Flexible scan:** Normal scan (1024 × 1024, 512 × 512), Zoom, Slit scan, Area scan, Line scan, Point scan, Scan direction changeable (0°, 45°, 90°, 180°, 270°)

Reflected images and OBIRCH images are obtained, and then both images are superimposed.

<table>
<thead>
<tr>
<th>Scan speed (sec/image)</th>
<th>512 × 512</th>
<th>1024 × 1024</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>16</td>
</tr>
</tbody>
</table>

**Laser**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Product number</th>
<th>Wavelength</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR-LD module 100 mW</td>
<td>M7635-01</td>
<td>1.3 μm</td>
<td>100 mW</td>
</tr>
<tr>
<td>High power IR-LD module 400 mW</td>
<td>M10902-01</td>
<td>1.3 μm</td>
<td>400 mW or more</td>
</tr>
<tr>
<td>LD pulse laser 1.1 μm</td>
<td>C9215-06</td>
<td>1.1 μm</td>
<td>200 mW Pulse(CW) 800 mW Impulse</td>
</tr>
</tbody>
</table>

* For 1.3 μm laser, one of two laser can be integrated.

### High-sensitivity near-infrared camera for emission analysis

The C8250 series is a family of high-sensitivity cameras capable of detecting weak light emissions and designed specifically for emission microscopes. Due to ultra-miniaturization and higher integration, semiconductor devices now have lower operating voltages that weaken the light intensity emitted from failure locations becomes weak and also cause light emissions to occur at longer wavelengths. To detect such weak light emissions, a detector with high sensitivity in the near-infrared range longer than 900 nm is an absolute necessity. The C8250 series has high sensitivity in the near-infrared range, making it a powerful tool for detecting the faint light emissions from IC with low operating voltages and for analyzing weak light emissions from the device backside.

**Features**

- High-sensitivity (high quantum efficiency) in the infrared region
- Powerful tool for low-voltage drive IC chips and backside observation through silicon
- High resolution and highly sensitive analysis possible when combined with a laser confocal microscope
- Peltier cooling systems are maintenance free (without LN2).

**Near-infrared camera lineup**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Product number</th>
<th>Wavelength</th>
<th>Cooling method</th>
<th>Effective number of pixels (H) × 512(V)</th>
<th>Temperature</th>
<th>Spectral response</th>
</tr>
</thead>
<tbody>
<tr>
<td>InGaAs camera</td>
<td>C8250-27</td>
<td>1000 nm to 1550 nm</td>
<td>Peltier cooling</td>
<td>640(H) × 512(V)</td>
<td>-70 °C or less</td>
<td>900 nm to 1550 nm</td>
</tr>
<tr>
<td>InGaAs camera</td>
<td>C8250-35-20</td>
<td>1000 nm to 1600 nm</td>
<td>LN2 cooling</td>
<td>1000(H) × 1000(V)</td>
<td>-180 °C or less</td>
<td>1000 nm to 1600 nm</td>
</tr>
<tr>
<td>InGaAs camera</td>
<td>C8250-45-20</td>
<td>1000 nm to 2000 nm</td>
<td>LN2 cooling</td>
<td>1000(H) × 1500(V)</td>
<td>-180 °C or less</td>
<td>1000 nm to 2000 nm</td>
</tr>
</tbody>
</table>

**A comparative chart of wavelength sensitivity ranges**

![A comparative chart of wavelength sensitivity ranges](image)

*Emmi-X camera 1k × 1k LN2 cooling for iPHEMOS C8250-45-20*
High-sensitivity mid-infrared camera for thermal analysis

The C9985 series is a high-sensitivity camera capable of detecting thermal emissions and designed specifically for emission microscopes. Due to the ultra-miniaturization and higher integration of semiconductor devices and their low-voltage operation, the infrared light from heat emitted at failure locations has become increasingly weak and difficult to detect. This is not a problem on the C9985 series since it has high sensitivity in the mid-infrared range and so can pinpoint those weak thermal emissions.

Application

Identifying thermal emission locations
- Short-circuits in metallic layers and wiring
- Abnormal resistance at contact holes
- Microplasma leakage in oxide layer
- Oxide layer breakdown
- LCD/organic EL leakage

Thermal lock-in measurement

The lock-in measurement method deducts noise by synchronizing the timing of power supply to a device and image capture. With this method, a thermal lock-in unit can provide high quality images even for low voltage devices.

Principle

Device

Heat point 1
Heat point 2
IR-ray
Heat source

Heat generated from failure points

From the phase shift difference, the depth of a heat point is calculated.

Temperature measurement function

By knowing the true temperature of a device under operation and feeding it back to the design process at an early stage, device verification time can be shortened as well as enhance product reliability. The function is also useful to observe temperature behavior which changes depending on operating environment. The measurement can be available easily by adding the temperature measurement function.

<table>
<thead>
<tr>
<th>Product name</th>
<th>Product number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal lock-in unit</td>
<td>C10565-71</td>
</tr>
</tbody>
</table>

Temperature image

Note: Depending on measurement environment, structure of objects or material of objects, there is a case that measurement can’t be carried out properly.

<table>
<thead>
<tr>
<th>Product name</th>
<th>Product number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature measurement software</td>
<td>U11389-01</td>
</tr>
</tbody>
</table>

* For InSbHS camera C9985-05

<table>
<thead>
<tr>
<th>Product name</th>
<th>Effective number of pixels</th>
<th>Cooling method</th>
<th>Noise equivalent temperature difference (NETD)</th>
<th>Cooler MTTF</th>
</tr>
</thead>
<tbody>
<tr>
<td>InSbHS camera</td>
<td>640(H) × 512(V)</td>
<td>Sterling cycle cooler</td>
<td>&lt; 25 mK @ 25 °C (20 mK Typical)</td>
<td>8000 hours</td>
</tr>
<tr>
<td>ThermoDynamicV2 camera</td>
<td></td>
<td></td>
<td></td>
<td>14 000 hours</td>
</tr>
</tbody>
</table>

| Objective lens: 8×, Bias: 1.7 V, 14.5 mA |

Acquired images

10× higher S/N

No lock-in

Lock-in

High S/N is achieved by acquiring signals at a specific frequency and eliminating signals at other frequencies as noise.

640(H) × 512(V)

4000 hours

< 25 mK @ 25 °C (20 mK Typical)

≤ 25 mK @ 25 °C (20 mK Typical)
IR-OBIRCH (Infrared Optical Beam Induced Resistance Change) analysis detects current alteration caused by leakage current paths and contact area resistance failure in devices by irradiating an infrared laser.

**IR-OBIRCH analysis**

Due to high integration and increased performance of LSI, functional failure analysis under LSI tester connection becomes very important. Dynamic analysis by laser stimulation (DALS) is a new method to analyze device operation conditions by means of laser radiation. Stimulate a device with a 1.3 μm laser while operating it with test patterns by LSI tester. Then device operation status (pass/fail) changes due to heat generated by the laser. The pass/fail signal change is expressed as an image that indicates the point causing timing delay, marginal defect, etc.

**PRINCIPLE OF OBIRCH ANALYSIS**

- Laser: λ = 1.3 μm
- Leakage Current Path
- Defects in Metal Line
- I : Current before laser irradiation
- V : Applied voltage
- ΔI : Current change due to laser irradiation (when constant voltage is applied)
- ΔV : Voltage change due to laser irradiation (when constant current is applied)
- ΔR : Resistance increase with the temperature increase due to laser irradiation
- ΔT : Temperature increase due to laser irradiation
- TCR : Temperature coefficient of resistance

- High-resolution, high-contrast reflection pattern images
- Backside observation capable (using a 1.3 μm wavelength laser)
- Non-OBIC signal generated in the semiconductor field by Si material since using an infrared laser

V1 mode, I1 mode, V2 mode, and V3 mode are selectable via software. The A8755 also uses a new OBIRCH amp. It has 10× better detectability than before.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Voltage Range</th>
<th>Current Range</th>
<th>Detectability</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>-10 V to +10 V</td>
<td>-100 mA to +100 mA</td>
<td>1 nA*1</td>
</tr>
<tr>
<td>I1</td>
<td>-25 V to +25 V</td>
<td>-100 μA to +100 μA</td>
<td>1 μV²</td>
</tr>
<tr>
<td>V2</td>
<td>-3 V to +3 V</td>
<td>-1 μA to +1 μA</td>
<td>3 pA²</td>
</tr>
<tr>
<td>V3</td>
<td>-25 V to +25 V</td>
<td>-100 μA to +100 μA</td>
<td>1 pA²*1</td>
</tr>
</tbody>
</table>

Possible to measure at 4 quadrant voltage/current

New OBIRCH amp. can work for devices, which need to apply negative voltage/current. The new amp is also effective to detect reverse current flowed differently from design.

**Digital lock-in**

Digital lock-in is a function of OBIRCH analysis that boosts detection sensitivity by converting the data from one pixel into multiple data using software lock-in processing.

**Analysis using the current detection head**

A current detection head can be used to measure devices that require higher voltage or higher current than the range of standard OBIRCH amp (10 V/100 mA or 25 V/100 μA).

**Dynamic analysis by laser stimulation kit (DALS)**

Due to high integration and increased performance of LSI, functional failure analysis under LSI tester connection becomes very important. Dynamic analysis by laser stimulation (DALS) is a new method to analyze device operation conditions by means of laser radiation. Stimulate a device with a 1.3 μm laser while operating it with test patterns by LSI tester. Then device operation status (pass/fail) changes due to heat generated by the laser. The pass/fail signal change is expressed as an image that indicates the point causing timing delay, marginal defect, etc.

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**Inverted emission microscope**

**iPHEMOS series** Overview of function/NanoLens Option

**EO probing analysis**

In EO (Electro Optical) probing analysis, noncoherent light is irradiated to the backside of a semiconductor device and the reflected light is measured to check whether the semiconductor device is operating normally on the basis of the transistor operating frequency and its change over time. EO probing analysis includes an EOP (Electro Optical Probing) function that measures the operating voltage at high speeds and an EOFM (Electro Optical Frequency Mapping) function that captures images of sections operating at a specific frequency. When used with a NanoLens, measurements can be made with higher resolution and sensitivity.

<table>
<thead>
<tr>
<th>Product name</th>
<th>Product number</th>
</tr>
</thead>
<tbody>
<tr>
<td>EO probing unit EOP/EOFM base unit</td>
<td>C12323-22</td>
</tr>
</tbody>
</table>

**EOP Function**

This function acquires switching timing of a specific transistor rapidly by high speed sampling. As an extended analysis of emission and OBIRCH, the EOP function improves accuracy of failure point localization, enabling a much smoother follow-up physical analysis.

<table>
<thead>
<tr>
<th>Measurement band</th>
<th>1 kHz to 7 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of samples</td>
<td>Up to approx. 500 000 points</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product name</th>
<th>Product number</th>
<th>Measurement band</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOP module 4GS/s</td>
<td>M14302-01</td>
<td>1 kHz to 1 GHz</td>
</tr>
<tr>
<td>EOP module 32GS/s</td>
<td>M14302-11</td>
<td>1 MHz to 7 GHz</td>
</tr>
</tbody>
</table>

**EOFM Function**

This function measures transistors switching at a specific frequency and images them. The reflected light from a drain has the power spectrum distribution. The EOFM picks up the intensity of signal under certain frequency from the distribution and visualize it as an image. By operating transistors in a specific region under certain frequency, it is possible to observe if the circuits are correctly switching or not. 4 images can be acquired simultaneously. (patented)

**Connecting to a CAD navigation system**

When performing failure analysis of complicated LSI chips on a large scale, it is possible to connect through a network (TCP/IP) and CAD navigation software. This helps the subsequent investigation of problem locations. By superimposing an area where a problem has been detected, or an image, over the layout diagram, it is possible to identify defective points. (patented)

<table>
<thead>
<tr>
<th>Product name</th>
<th>Product number</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAD navi I/F software for v2.75 or later</td>
<td>U7771-04</td>
</tr>
</tbody>
</table>

**NanoLens (solid immersion lens)**

For backside observation, near-infrared light is used to penetrate the Si layer. On the other hand, optical resolution gets worse at longer wavelengths. The NanoLens (a solid immersion lens) is a hemispherical lens that touches the Si substrate and utilizes the index of refraction of silicon to increase the numerical aperture, which improves spatial resolution and convergence efficiency. By setting the NanoLens on a point to observe on the backside of a device, it is possible to perform analysis at a sub-micron level of spatial resolution in a short period of time with greatly improved accuracy. 3 types of SIL lens cap are available in order to correspond to Si thickness from 50 μm to 800 μm.
The motorized turret 5 lens A13572-01 holds 5 lenses while the motorized turret 10 lens A10622-01 holds 10 lenses.

### Macro analysis

The 1.35×macro lens for emission analysis has a high numerical aperture (NA) of 0.38 for surefire capture of weak light emissions. The software smoothly switches from macro observation to micro observation that uses an objective lens.

### Lens selection

- **Macro lens**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Product number</th>
<th>N.A.</th>
<th>WD (mm)</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro lens 1.35× for iPHEMOS-MP</td>
<td>A13573-01</td>
<td>0.38</td>
<td>16</td>
<td>Emission</td>
</tr>
</tbody>
</table>

### Dimensions / Weight

<table>
<thead>
<tr>
<th>Main unit</th>
<th>Dimensions(mm)/Weight</th>
<th>Control rack</th>
<th>Dimensions(mm)/Weight</th>
<th>Operation desk</th>
<th>Dimensions(mm)/Weight</th>
<th>iPHEMOS-MP</th>
<th>iPHEMOS-DD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main unit</td>
<td>1740(W)×1150(D)×1770(H)</td>
<td>Control rack</td>
<td>880(W)×700(D)×1542(H)</td>
<td>Operation desk</td>
<td>1000(W)×800(D)×700(H)</td>
<td>1740 kg</td>
<td>1980 kg</td>
</tr>
<tr>
<td>iPHEMOS-MP</td>
<td>Approx. 1400 kg</td>
<td>Approx. 255</td>
<td>Approx. 300 kg</td>
<td>Approx. 60 kg</td>
<td>1400(W)×800(D)×700(H)</td>
<td>1400 kg</td>
<td>1700 kg</td>
</tr>
<tr>
<td>iPHEMOS-DD</td>
<td>Approx. 1700 kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Weight of iPHEMOS series main unit includes a prober or equivalent item.

### Utility

- **Line voltage**: AC200 V (50 Hz/60 Hz)
- **Power consumption**: Approx. 1400 VA
- **Vacuum**: Approx. 80 kPa or more
- **Compressed air**: 0.5 MPa to 0.7 MPa

### LASER SAFETY

Hamamatsu Photonics classifies laser diodes, and provides appropriate safety measures and labels according to the classification as required for manufacturers according to IEC 60825-1. When using this product, follow all safety measures according to the IEC.

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