Emission Microscope

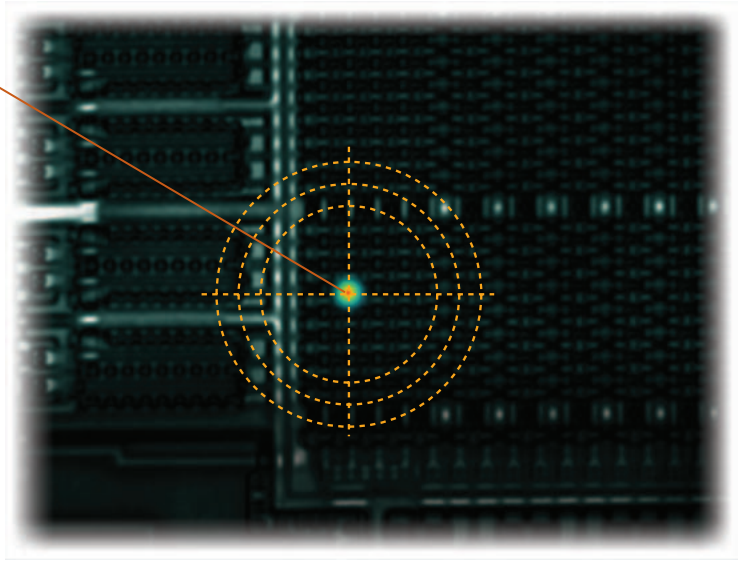
PHEMOS®-1000

HAMAMATSU

PHOTON IS OUR BUSINESS

Reveals “Invisible” Defects and Failures

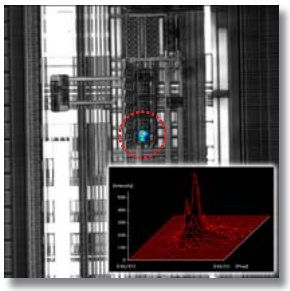
Detects very faint emissions caused by anomalies quickly and accurately to determine failure locations.



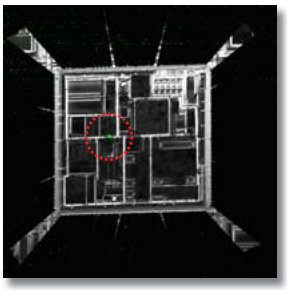
The PHEMOS series of emission microscope is a group of semiconductor failure analysis tools that detect faint emissions caused by semiconductor device anomalies to specify the failure location.

They can be used on anything from memory and logic devices to power and flat panel devices.

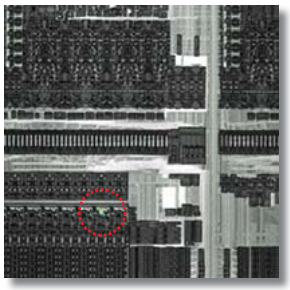
They have a wide range of applications, from failure analysis in the design stage to defective product analysis in the field.



ESD damage localization



Standby current failure



FET rush current caused by a short or open circuit

Metal wiring defect analysis using the IR-OBIRCH method

Pressure resistance defects

Latch-up analysis in CMOS, etc.

Failure analysis of LOC packages and below-multilayer metal wiring

Failure analysis on flat panel displays

Emission Microscope

PHEMOS-1000

The PHEMOS-1000 is a standard model high-resolution emission microscope that includes an IR confocal laser scan microscope. From a socket board to a 300 mm double-sided wafer prober, the PHEMOS-1000 flexibly corresponds to device environment and set-up. It can also accommodate the highly sensitive NIR camera and the high-resolution NanoLens as options. There are various options including IR-OBIRCH analysis, connection to an LSI tester and the CAD navigation function, all of which give the PHEMOS-1000 the ability to handle a wide range of measuring needs.

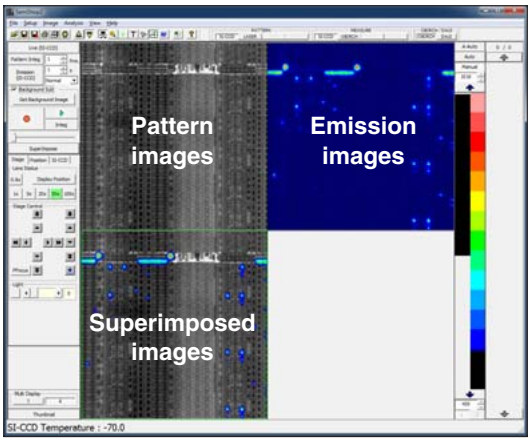
Features

- **IR confocal laser scan microscope**
- **NanoLens for high-resolution, high-sensitivity observation** (option)
- **IR-OBIRCH analysis function** (option)
- **Dynamic analysis function by laser radiation** (option)
- **EO probing unit C12323-01** (option)
- **High-sensitivity NIR camera for low-voltage samples** (option)
- **Digital lock-in kit to enhance the IR-OBIRCH detectability** (option)
- **300 mm double-sided semi-auto prober installable** (option)

Detection targets	Device emission (emission detection function) Current alteration (IR-OBIRCH function)
Applicable devices	200 mm/300 mm wafer Diced chips Cut wafers, packaged devices (Depends on the prober and sample fixtures)
Compatible probers	Double-sided semi-auto prober for use with 200 mm/300* mm wafers Double-sided manual prober for use with 200 mm/300* mm wafers Semi-auto prober for use with 200 mm/300* mm wafers (frontside observation) Manual prober for use with 200 mm/300* mm wafers (frontside observation)

*Upon request

Basic display functions



Superimposed display/contrast enhancement function

The PHEMOS-1000 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.

C-CCD camera C4880-59

The cooled CCD camera is a basic emission detector available for the PHEMOS series. High resolution and low readout noise provide high contrast and clear images. Although its main strength is for frontside detection, its sensitivity extends into the 1100 nm near-infrared range, making it useful for backside observations as well.

SI-CCD camera C11231-01

The SI-CCD camera detects low-light emissions from minute patterns in LSI devices with both high sensitivity and high position accuracy, which slashes detection time by 90% compared to ordinary cooled CCD cameras. Real time readout during emission image acquisition enables monitoring the emission state during the integration time.

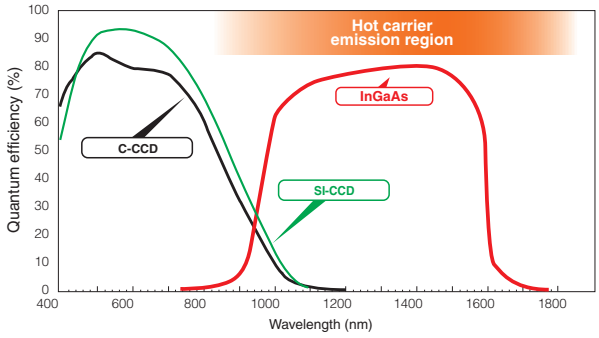
InGaAs camera C8250 series

When device design becomes smaller and driving voltage is lowered, a detector that has high sensitivity in the near-infrared range is indispensable. The C8250 series cameras are highly sensitive in the near-infrared range from 900 nm to 1550 nm, making them suitable for low-voltage drive IC chips and backside faint emission analysis.

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).
- The hermetic vacuum shield camera; C8250-27 is maintenance free from periodic re-evacuation.

A comparative chart of wavelength sensitivity ranges



NIR camera lineup

Model	C8250-21	C8250-27	C8250-31
Cooling type	Liquid nitrogen cooling	Peltier cooling	Liquid nitrogen cooling
Corresponding product	PHEMOS-1000		
Cooling temperature	-120 ˚C or less	-70 ˚C	-183 ˚C or less
Spectral sensitivity	900 nm to 1550 nm		
Effective number of pixels	640 (H) × 512 (V)		1000 (H) × 1000 (V)
Field of view 100×	128 µm × 102.4 µm		133 µm × 133 µm
Maximum field of view 0.8×	16.0 mm × 12.8 mm		16.7 mm × 16.7 mm
A/D converter	12 bit		

IR confocal laser scan microscope

The IR confocal laser scan microscope 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.

< 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.

	Scan speed (second/image)			
512 × 512	1	2	4	8
1024 × 1024	2	4	8	16

• Laser*

1.3 µm Laser diode	Output: 100 mW
1.3 µm High power laser (option)	Output: 400 mW or more
1.1 µm Laser diode (option)	Output: 200 mW (CW), 800 mW (pulse)

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

• Optical stage travel range*

X	±20 mm
Y	±20 mm
Z	75 mm

* These values may become smaller due to interference with the prober used and the sample stage.

Laser marker C7638

Failure location information can be easily transfered to another analytical instrument by marking the area of an identified failure location, or by marking around it.

The laser marker uses a pulse laser, and its spot size is ϕ5 µm under a 100× lens.

Lens magnification

Up to 5 lenses selectable for a turret

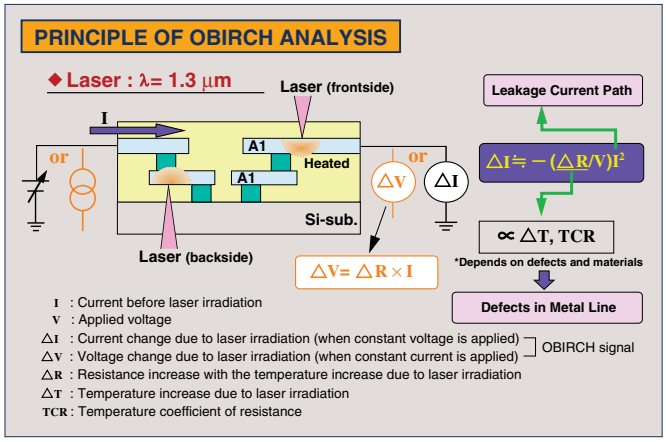
Lens	Analysis	N.A.	W.D. (mm)	
0.8× : A7909-13	Emission	0.40	24	✓
1× : A7649-01	OBIRCH	0.03	20	Optional
2× : A8009	OBIRCH/Emission	0.055	34	Optional
M-PLAN-NIR-5× : A11315-01	OBIRCH/Emission	0.14	37.5	✓
M-PLAN-NIR-20× : A11315-03	OBIRCH/Emission	0.40	20	✓
M-PLAN-NIR-50× : A11315-04	OBIRCH/Emission	0.42	17	Optional
NIR 50× : A8756-01	OBIRCH/Emission	0.42	17.3	Optional *
High NA50× : A8018	OBIRCH	0.76	12	Optional
M-PLAN-NIR-100× : A11315-06	OBIRCH/Emission	0.50	12	✓
NIR 100× : A8756-02	OBIRCH/Emission	0.50	12.3	Optional *
M-PLAN-NIR-100×HR : A11315-07	OBIRCH/Emission	0.70	10	Optional
G-PLAN-APO-NIR-100× HR : A11315-08	OBIRCH/Emission	0.70	6	Optional *

✓ : Standard * for backside observation

A8756-01: 2 mm glass thickness; 50× lens with Si thickness aberration correction
A8756-02: 2 mm glass thickness; 100× lens with Si thickness aberration correction

IR -OBIRCH analysis A8755

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.



- 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 since using an infrared laser

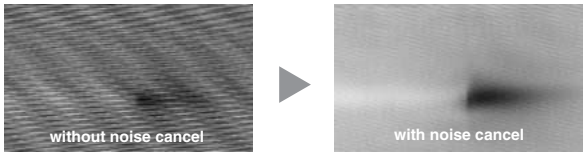
Fixed voltage mode, fixed current mode, and high-sensitivity current mode (fixed current mode) are selectable via software. The A8755 also uses a new OBIRCH amp. It has 10× better detecta bility before.

	Fixed voltage mode	Fixed current mode	High-sensitivity current mode
Applied voltage range	±10 mV to ±10 V	±10 mV to ±10 V	±10 mV to ±25 V
Max. current	100 mA	100 mA	100 μA
Detectability	1 nA*1	1 μV*2	3 pA*1

*1 Minimum detectable pulse signal input into the amplifier
*2 Calculated value

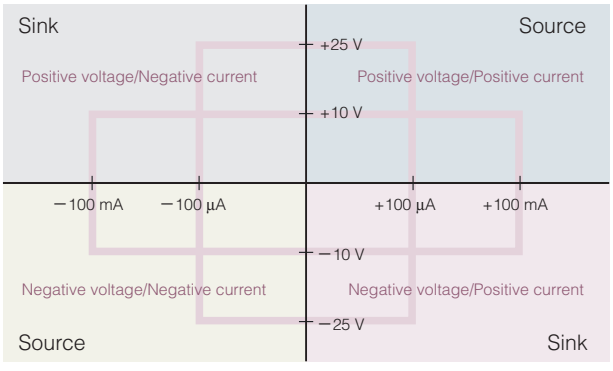
Integrate noise cancellation function

< by improving noise caused by external equipment >



Possible to measure at 4 quadrant voltage/current

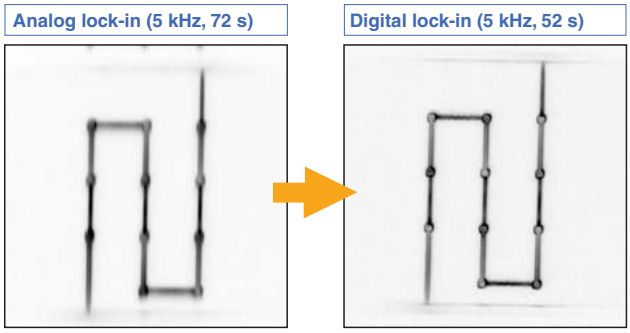
New OBIRCH amp. can work for devices, which need to apply negative voltage/current. The new amp is also effective to detect reverse current flowed differently from design.



Analysis possible range

Digital lock-in kit M10383

The M10383 digital lock-in kit is a new function added to the OBIRCH analysis, in order to boost detection sensitivity by sampling one pixel into multiple data using lock-in processing. The M10383 allows acquiring a sharp and clear image in a short acquisition time compared to the A9188-01 lock-in kit which uses an analog processing method.



Comparing analog lock-in with digital lock-in (short scan period)

Analysis using the current detection head

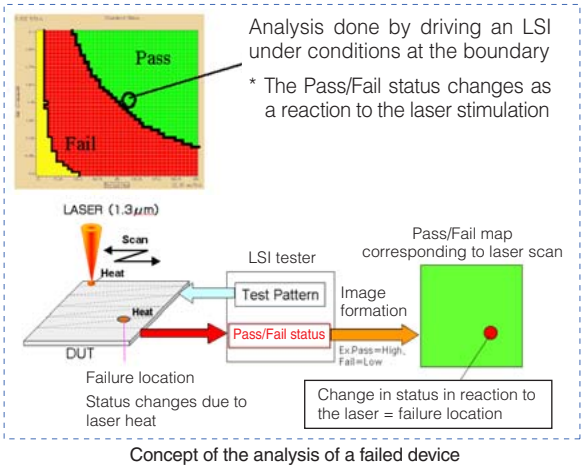
A current detection head can be used to measure devices that require higher voltage or higher current than the range of standard OBIRCH amp (10V/100 mA or 25V/100 μA).

Current detection head	Standard type*1	High voltage type (optional)
Applicable voltage	Max. 250 V	3 kV
Applicable current	6.3 A (Max. 10 A)	30 mA(90 VA)
Detectability	10 nA*2	

*1 The standard type head is included in M10383 Digital Lock-in kit.
*2 Minimum detectable pulse signal input into an OBIRCH amp. Detectability can differ by device set-up environment.

Dynamic analysis by laser stimulation kit (DALS) A9771

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.



Concept of the analysis of a failed device
by utilizing the "drive voltage – operating frequency" characteristics

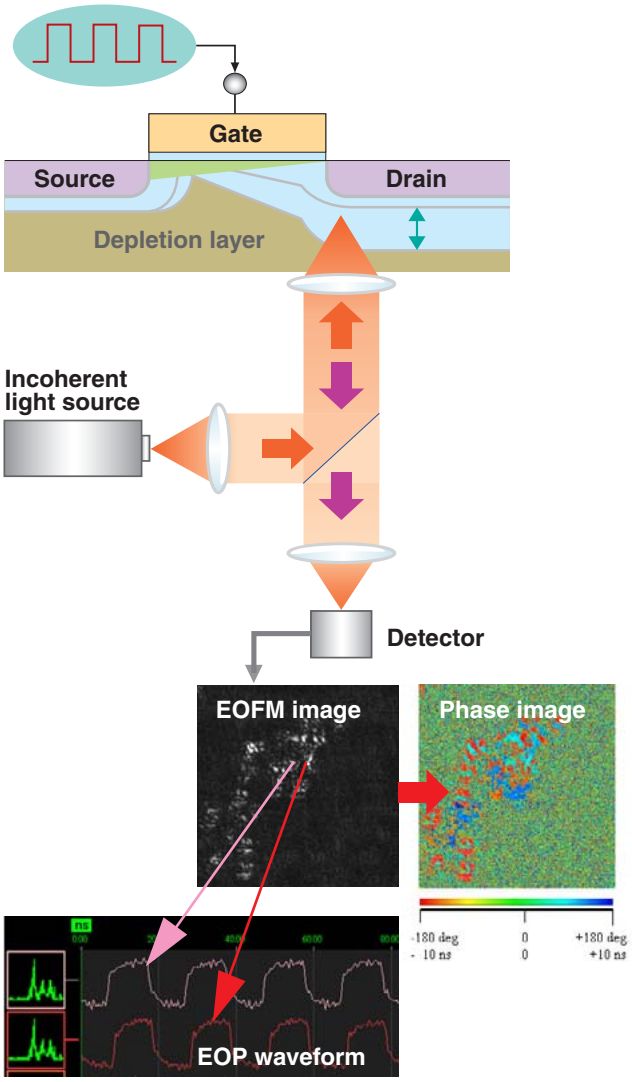
PHEMOS-1000

EO Probing Unit C12323-01

The EO Probing Unit is a tool to observe a transistor's status through the Si substrate using an incoherent light source. It is composed of the EOP (Electro Optical Probing) to measure operation voltage of a transistor rapidly and the EOFM (Electro Optical Frequency Mapping) to image active transistors at a specific frequency. With a NanoLens, high resolution and sensitivity can be obtained.

Features

- High quality pattern image with no interference fringe
- No sample damage by incoherent light source
- Low power light source and high sensitive detector provides stable and accurate measurement.
- EOP waveform with high S/N ratio in 2 seconds
- Easy-to-use software identical to the PHEMOS interface
- EOFM phase image provides intuitive interpretation of signal propagation.
- Possible to get 2 different frequency data simultaneously.
- Retrofit on PHEMOS, uAMOS, iPHEMOS, THEMOS in the field is possible.



EOP Function

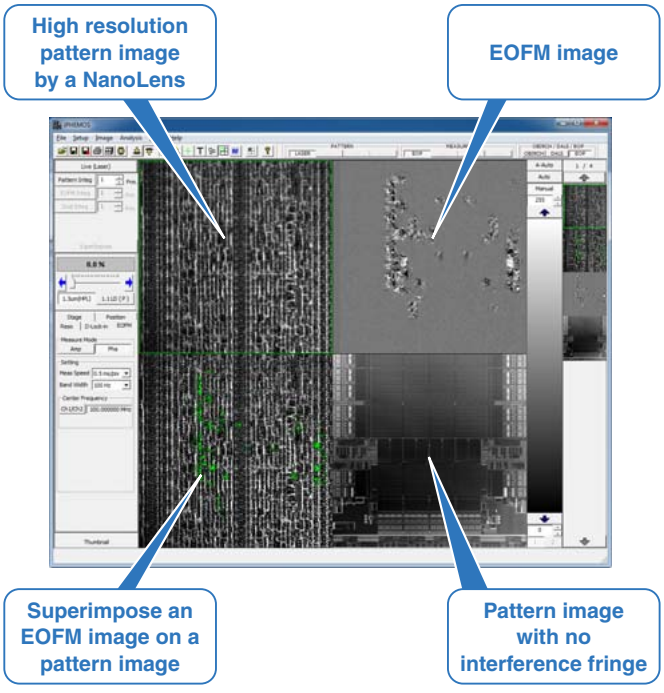
This function acquires switching timing of a specific transistor rapidly by high speed sampling. As an extended analysis of emission and OBIRCH, the EOP function improves accuracy of failure point localization, enabling a much smoother follow-up physical analysis.

EOP principle

When the drain voltage of a FET varies by switching operation, the electric field distribution at a drain boundary also changes. This induces a change of refractive index due to the electro-optical effect of each material. When irradiating a drain by a light beam through the Si substrate, the intensity of reflected light varies corresponding to the voltage level. The EOP is a newly developed method that can observe the reflected light which expresses the status of a transistor.

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.

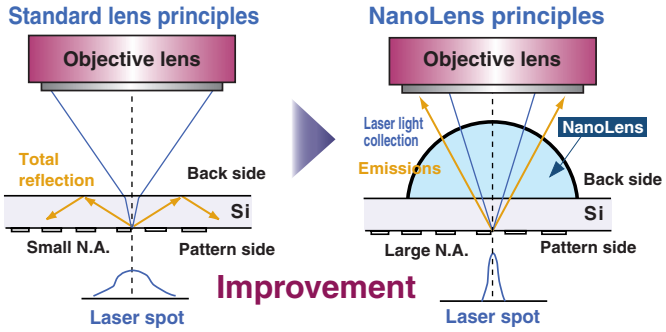


Detector	
Light source	Incoherent light source (Patent pending)
Light source output	Maximum 10 mW (Variable)
Light source wavelength	1.3 µm
Optical sensor	Photodiode
Bandwidth	Analog band (100 kHz to 1 GHz)

EOP Measurement function	
Signal processing	High speed digitizer
Digital sampling frequency	4 GHz
EOFM Measurement function	
Signal processing	Spectrum analyzer (2 ch simultaneous output)
Scan speed	0.2 seconds/line to 2 s/line

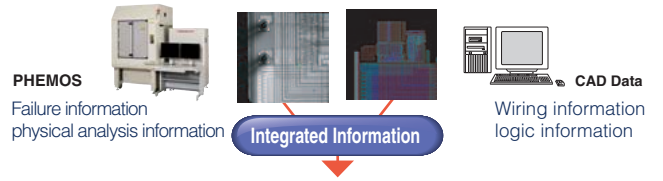
NanoLens (solid immersion lens) C9710

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 LSI 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.



Connection with the FA-Navigation failure analysis support system

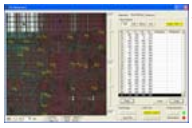
Combining detection signals from PHEMOS and design data, and automatically extracting suspicious signal lines contributes to making the work of narrowing down the malfunction locations more effective and to reducing the time needed to clarify the route cause. Analysis is easily possible using GDS II or LEF/DEF at both laboratory and office.



Failure localization supported by FA-Navigation

Pattern images / Design information

Acquires a superimposed the signal image and the pattern image provided by failure analysis system.

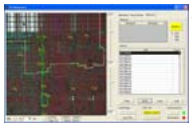


Design information overlay/Automatical signal region setting

Design data (CAD data) can also be superimposed on a failure analysis image. Allows signal region parameter setting.

Automatic NET extraction

Automatically extracts the NET passing through signal regions. Ranks the NETs in order of most number of times they pass through the signal region.



NET highlight display

This function highlights a specified NET from among the extracted NETs. Analyzing this NET assists in identifying the failure location in a short time.

CAD navigation system connections

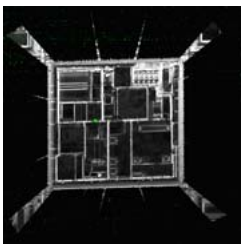
When performing failure analysis of complicated LSI chips on a large scale, it is possible to connect through a network (TCP/IP) and CAD navigation software. This helps the subsequent investigation of problem locations. By superimposing an area where a problem has been detected, or an image, over the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

Sequence software

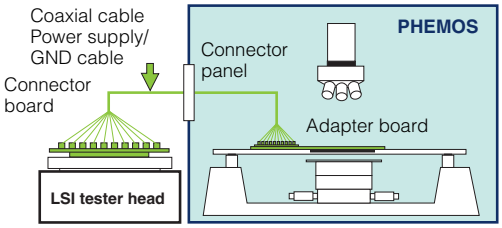
This function enables automatic measurement of IR-OBIRCH observation by following the procedure set by a user. IR-OBIRCH images can be sequentially measured and saved by combining with a semi-automatic prober. Measurements under the condition with an LSI tester or an external power source are possible as well.

Connecting to an LSI tester

As devices become more complicated, there is increased demand for analysis under an LSI tester connection to find a failure occurring at a specific point while a device is functioning. It is possible to connect an LSI tester with the PHEMOS by a short cable and using a probe card adapter specifically designed for the analysis under the PHEMOS optics.



▲ OBIRCH observation using a 256-pin probe card adapter



Utility

Line voltage	AC 220 V (50 Hz/60 Hz)
Power consumption	3000 VA
Vacuum	Approx. 80 kPa or more
Compressed air	0.5 MPa to 0.7 MPa

Dimensions/Weight

	Dimensions/Weight
PHEMOS main unit	1360 mm (W) × 1410 mm (D) × 2120 mm (H), Approx. 900 kg
PHEMOS control rack	880 mm (W) × 700 mm (D) × 1542 mm (H), Approx. 255 kg
PC desk	1000 mm (W) × 800 mm (D) × 700 mm (H), Approx. 45 kg

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

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.

Description Label (Sample)

Caution Label

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