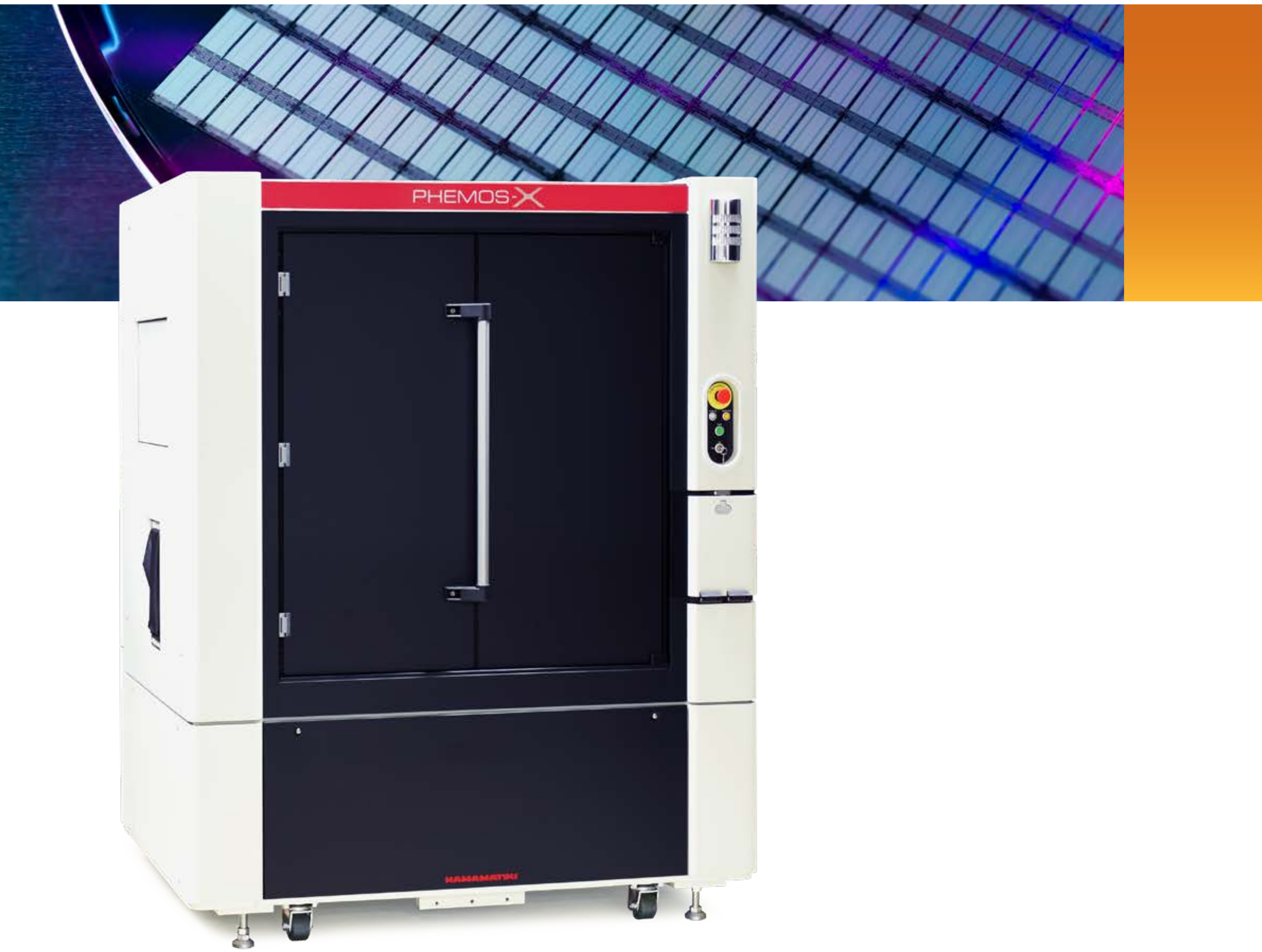
PHEMOS®-X

Emission microscope C15765-01



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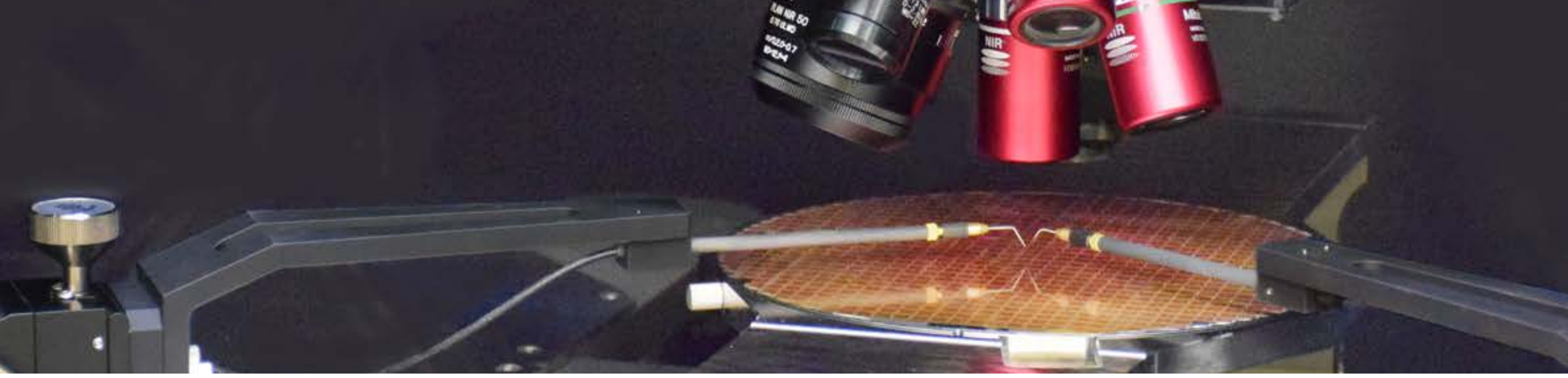


PHEMOS®-X

The PHEMOS®-X is a high-resolution emission microscope that pinpoints failure locations in semiconductor devices by detecting the weak light emissions and heat emissions caused by semiconductor device defects.
Since the PHEMOS®-X is usable in combination with a general-purpose prober, you can do various analysis tasks by using the sample setups you are already familiar with. Installing an optional laser scan system allows acquiring high-resolution pattern images. Different types of detectors are available for various analysis techniques such as emission analysis, thermal analysis, and IR-OBIRCH analysis. The PHEMOS®-X supports a wide variety of tasks and applications ranging from prober socket boards to 200 mm wafer prober.

Features

- **Two ultra-high sensitivity cameras are mountable**
  Coverage of different detection wavelength ranges for emission analysis and thermal analysis allows easy selection of an analysis technique that matches the sample and failure mode.

- **Up to 7 light sources for OBIRCH, DALS, EOP and laser marker are mountable**

- **High accuracy stage designed for advanced devices**
  Working range of the optical stage

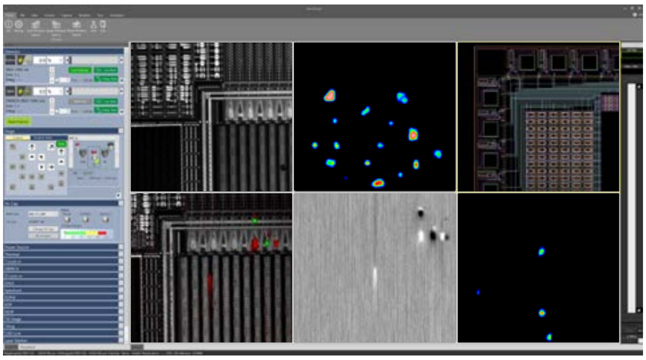
X	±20 mm
Y	±20 mm
Z	+80 mm

* Working range might be narrower than these values due to the prober being used and interference with the sample stage or mounting of a NanoLens.

Basic display functions

Superimposed display/contrast enhancement function

The PHEMOS®-X 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.



* The actual display may differ depending on your software version, environment, etc.

■ Display function

- **Annotations**
  Comments, arrows, and other indicators can be displayed on an image at any locations 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 6-window screen at once.

Camera

CCD camera for photo emission Visible

This is a CCD camera for emission microscopes that has achieved low noise with Peltier cooling. It has a peak detection sensitivity in the visible light region, making it suitable not only for surface analysis but also for bottom side analysis of compound semiconductors such as SiC.

Application

- Bottom side analysis of compound semiconductor devices
- Withstand voltage failure of high voltage drive devices

Cooled CCD camera

The cooled CCD camera is a basic emission detector for the PHEMOS®-X. Its low readout noise and longer exposure time provide high contrast and clear images.

SI-CCD (Si Intensified CCD) camera

The SI-CCD camera detects low-light emissions from minute patterns in LSI devices with both high sensitivity and high position accuracy, which slash 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 for photo emission NIR

The low operating voltage that accompanies the miniaturization of semiconductor devices leads to a decrease in the intensity of light emitted from the failure location as well as to longer wavelengths. A detector with high sensitivity to near-infrared light of 900 nm or longer is essential for detecting such faint light emission.
The InGaAs camera series offers high sensitivity (high quantum efficiency) in the near-infrared wavelength range and is effective for low-voltage drive IC measurement and weak light analysis from the device's bottom side. Combined with a laser scan system, it also enables high-resolution and high-sensitivity analysis. Peltier cooling or LN2 cooling can be selected for the camera cooling system.

Application

- Bottom side analysis of Si semiconductor devices
- Junction failure of low-voltage drive devices

ThermoDynamic camera for thermal emission MIR

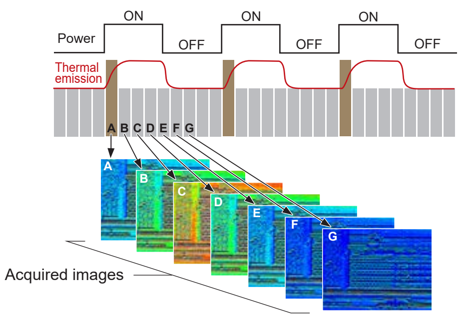
With miniaturization and low-voltage drive of semiconductor devices, infrared light originating from heat generated at failure locations is becoming increasingly weak and difficult to detect. The ThermoDynamic camera has high sensitivity in the mid-infrared wavelength range and can capture such weak thermal signals with high sensitivity.

Application

- Short-circuits in metallic layers and wiring
- Abnormal resistance at contact holes
- Insulation leakage

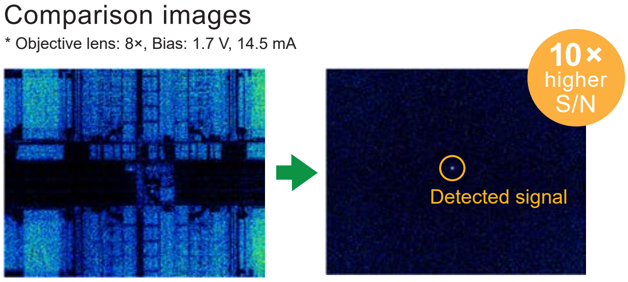
Thermal lock-in measurement

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.



Comparison images

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



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.

Laser

Laser scan system

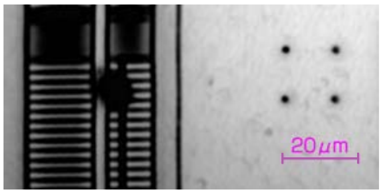
The laser scan system obtains clear, high-contrast pattern images by scanning the bottom side of a chip with the infrared laser (1.3 μm and/or 1.1 μm) and visible laser (Green OBIRCH® laser). Within 1 second, a pattern image can be acquired. By the flexible scan in 6 directions, it is possible to scan 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 laser stimulation.

Standard function

- **Dual scan**
  Obtain a pattern image and an IR-OBIRCH image simultaneously
- **Flexible scan**
  Normal scan (2048 × 2048, 1024 × 1024, 512 × 512, 256 × 256), Area zoom, Slit H, Slit V, Area Flexible, Mask, Point scan, Scan direction changeable (0°, 45°, 90°, 180°, 225°, 270°)

Laser marker

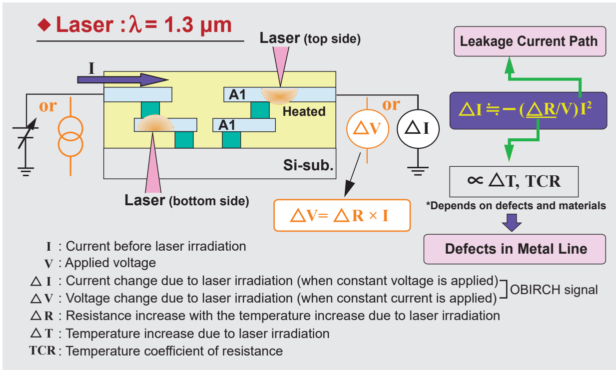
Failure location information can be easily transferred to another analytical instrument by marking the area of an identified failure location, or by marking around it.
The laser marker uses a pulse laser, and its spot size is Φ5 μm under a 100× lens.



IR-OBIRCH analysis

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.

Principle



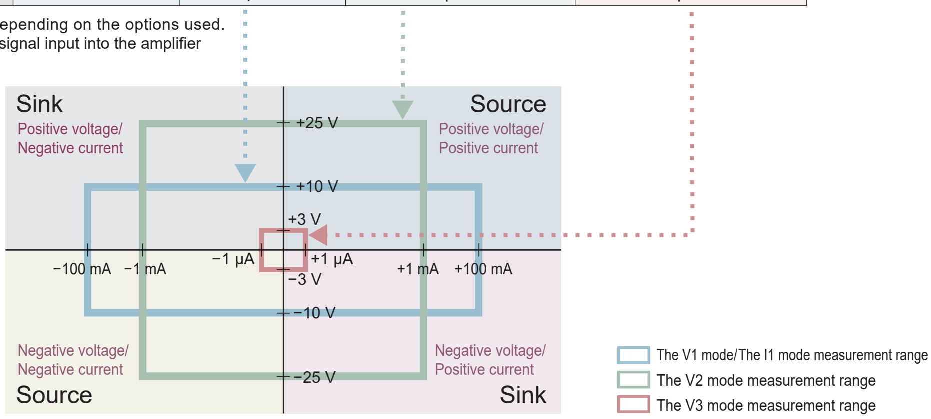
Features

- High-resolution, high-contrast reflection pattern images
- Bottom side 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
- Possible to measure at four quadrants of voltage/current

The OBIRCH amp can work for devices, which need to apply four quadrants of voltage/current.
V1 mode, I1 mode, V2 mode, and V3 mode are selectable via software.

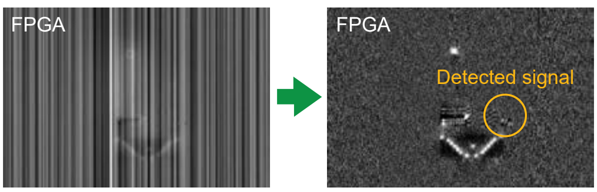
	V1 mode	I1 mode	V2 mode	V3 mode
Voltage range	−10 V to +10 V		−25 V to +25 V	−3 V to +3 V
Current range	−100 mA to +100 mA		−1 mA to +1 mA *1	−1 μA to +1 μA
Detectability	1 nA *2	1 μV *3	3 pA *2	1 pA *2

*1 Specifications may vary depending on the options used.
*2 Minimum detectable pulse signal input into the amplifier
*3 Calculated value



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.



No digital lock-in　　Digital lock-in

Analysis using the current detection head

A current detection head can be used to measure devices that require higher voltage (Max. 3 kV) or higher current (Max. 6.3 A) than the range of standard OBIRCH amp.

Green OBIRCH® analysis

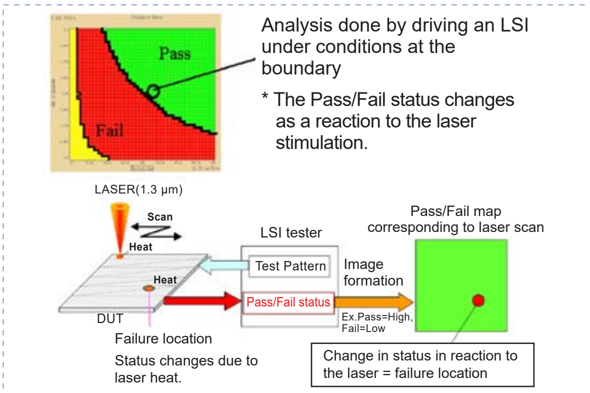
Green OBIRCH® analysis using visible laser (Green OBIRCH® laser) applies to the wide-band gap devices such as SiC (Silicon Carbide).

Features

- High-resolution against an infrared laser
- High-sensitivity because of the higher energy density against an infrared laser

DALS

Due to high integration and increased performance of LSI, functional failure analysis under LSI tester connection becomes very important. DALS (Dynamic Analysis by Laser Stimulation) 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

EO probing analysis

In EO (Electro Optical) probing analysis, incoherent light (1.3 μm and/or 1064 nm) is irradiated to the bottom side 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.

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.

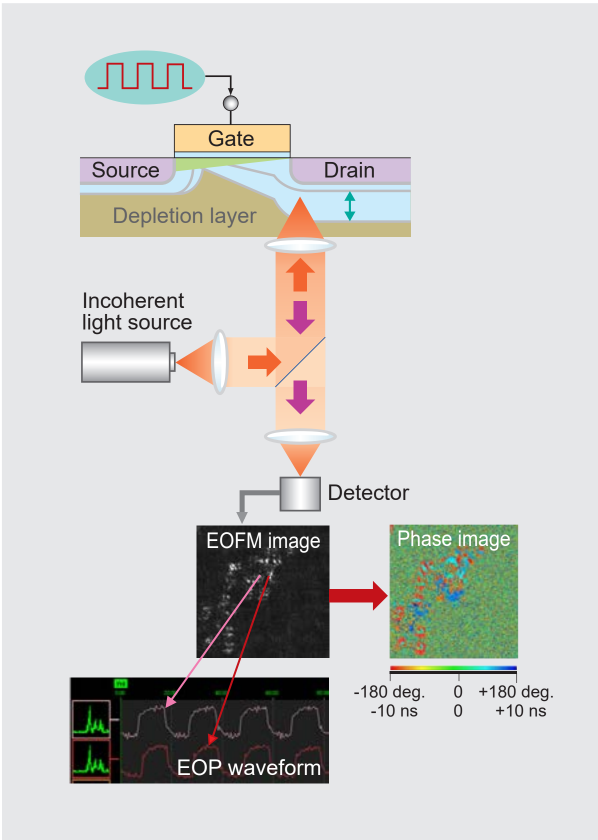
Bandwidth	1 kHz to 7 GHz

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)

Bandwidth	1 kHz to 1.5 GHz

Principle



Lens

Lens selection

Up to 5 types of objective lenses can be mounted on the motorized turret.
3 types of macro lenses are available. Only one macro lens can be installed on the system.

Objective lens

Product name	Product number	N.A.	WD (mm)	Analysis
Objective lens 1× for OBIRCH	A7649-01	0.03	20	OBIRCH
Objective lens 2× IR coat	A8009	0.055	34	Emission/OBIRCH
Objective lens NIR 5×	A11315-01	0.14	37.5	Emission/OBIRCH
Objective lens NIR 20×	A11315-03	0.4	20	Emission/OBIRCH
Objective lens PEIR Plan Apo 20× 2000	A11315-21	0.6	10	Emission/OBIRCH
Objective lens PEIR Plan Apo 50× 2000	A11315-22	0.7	10	Emission/OBIRCH
High NA objective lens 50× for IR-OBIRCH	A8018	0.76	12	OBIRCH
Objective lens NIR 100×	A11315-05	0.5	12	Emission/OBIRCH
Objective lens MWIR 0.8×	A10159-02	0.13	22	Thermal emission
Objective lens MWIR 4×	A10159-03	0.52	25	Thermal emission
Objective lens MWIR 8×	A10159-06	0.75	15	Thermal emission

Macro lens

Product name	Product number	N.A.	WD (mm)	Analysis
Macro lens 1.35× for PHEMOS®-X	A7909-16	0.4	25	Emission/OBIRCH
Macro lens 0.24× for InSb camera	A10159-08	0.08	27	Thermal emission
Macro lens 1× for InSb camera	A10159-10	0.33	52	Thermal emission

Macro lens

The 1.35× macro lens has a high numerical aperture (N.A.) of 0.4 for high sensitivity capture of weak light emission and OBIRCH signal.
The software smoothly switches from macro to micro observation that uses an objective lens.

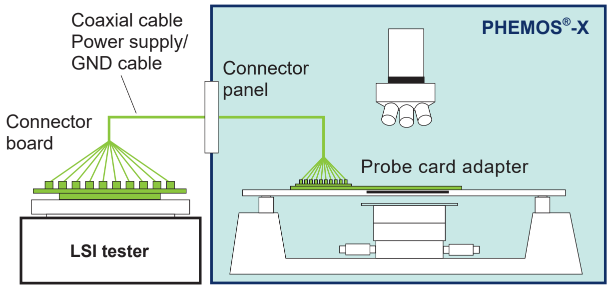
NanoLens

For bottom side 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-WR (N.A. 3.1) on a point to observe on the bottom side 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. And the Thermal NanoLens (N.A. 2.6) is appliable to thermal analysis.

External connection

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®-X by a short cable and using a probe card adapter specifically designed for the analysis under the PHEMOS®-X optics.



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.

Specification

Dimensions / Weight

Main unit	1656 mm (W) × 2000 mm (H) × 1247 mm (D) Approx. 1640 kg	
Operation desk *1	**● C16216-01 Operation desk** 1000 mm (W) × 700 mm (H) × 800 mm (D) Approx. 39.2 kg	**● C16216-02 Operation desk** 1480 mm (W) × 700 mm (H) × 800 mm (D) Approx. 48.6 kg

*1 Option

Utility

Line voltage	Single phase 200 V to 240 V
Power consumption	Approx. 3300 VA
Vacuum	80 kPa or more
Compressed air *1	0.6 MPa to 0.7 MPa

*1 Including a regulator

LASER SAFETY

The PHEMOS®-X is a Class 1 laser product. 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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- The product described in this brochure is designed to meet the written specifications, when used strictly in accordance with all instructions.
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