PHEMOS® -1000

Emission microscope C11222-16

HAMAMATSU

PHOTON IS OUR BUSINESS

Emission microscope

PHEMOS-1000

The PHEMOS-1000 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-1000 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-1000 supports a wide variety of tasks and applications ranging from prober socket boards to a large-size 300 mm wafer prober.

Features

- Two ultra-high sensitivity cameras mountable
  Coverage of different detection wavelength ranges for emission analysis and thermal analysis, or visible light and near-infrared light, allows easily 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
- Equipped with optical stage suitable for diverse samples

Working range of optical stage

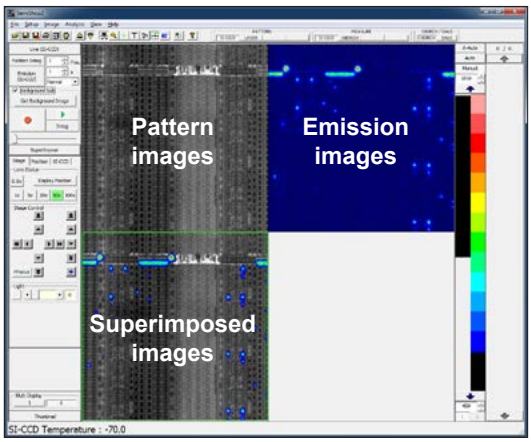
X	±20 mm
Y	±20 mm
Z	+75 mm

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

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 FA-Navigation
- Connects to CAD Navigation
- Connects to LSI tester

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.

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.

Product name	Product number
Laser scan system	C10656-21

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 (sec/image)			
512 × 512	1	2	4	8
1024 × 1024	2	4	8	16

• Laser*

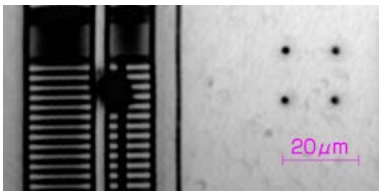
1.3 µm laser diode	Output: 100 mW
1.3 µm high power laser (option)	Output: 400 mW or more
1.1 µm laser diode (option)	Output: 200 mW (CW), 800 mW (pulse)

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

Laser marker

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.



Product name	Product number
Laser marker unit	C7638-04

High-sensitivity near-infrared camera for emission analysis

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).

NIR camera lineup

Product name	InGaAs camera LN2 cooling for P-1K, T-1K	InGaAs camera Peltier cooling	InGaAs camera 1K x 1K for PHEMOS/THEMOS
Product number	C8250-21	C8250-27	C8250-31
Cooling type	Liquid nitrogen cooling	Peltier cooling	Liquid nitrogen cooling
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

SI-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 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.

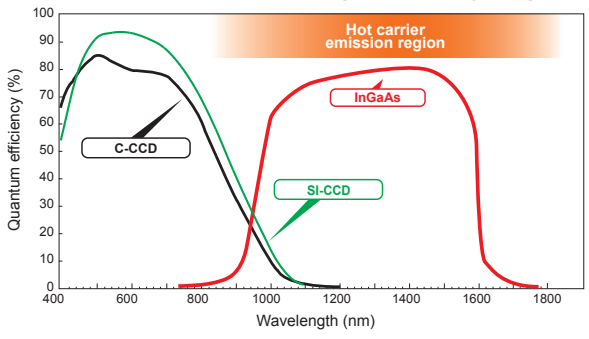
Product name	Product number
SI-CCD camera for PHEMOS/THEMOS	C11231-01

C-CCD camera

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.

Product name	Product number
Cooled CCD camera	C13896-01

A comparative chart of wavelength sensitivity ranges



High-sensitivity mid-infrared camera for thermal analysis

The C9985-05 InSbHS camera 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 C9985-05 InSbHS camera since it has high sensitivity in the mid-infrared range and so can pinpoint those weak thermal emissions.

Application

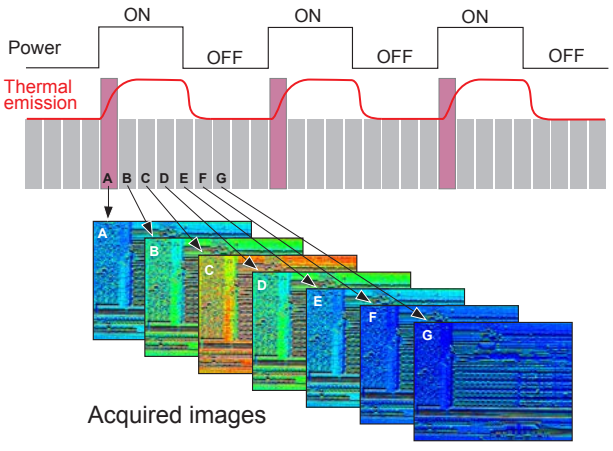
Identifying thermal emission locations

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

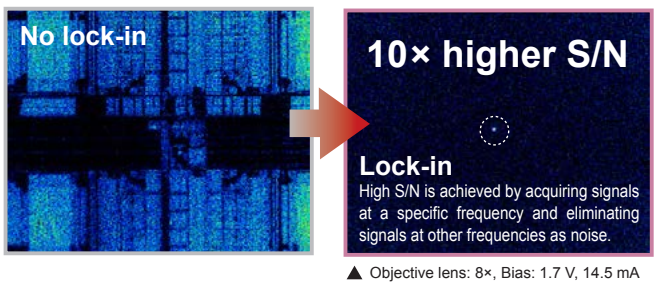
Product name	InSbHS camera
Product number	C9985-05
Cooling type	Sterling cycle cooler
Noise equivalent temperature difference(NETD)	< 25 mK @ 25 ˚C (20 mK Typical)
Effective number of pixels	640(H) × 512(V)
Field of view 8×	1.2 mm × 0.96 mm
Field of view 0.8×	12 mm × 9.6 mm

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.



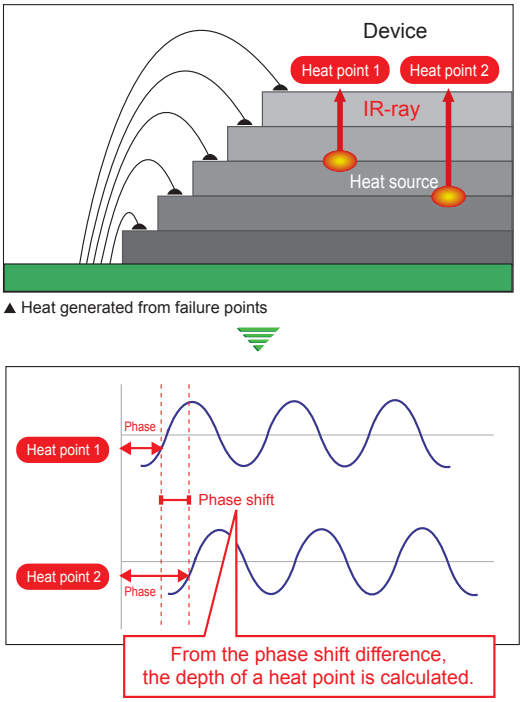
Acquired images



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

The combination with a depth measurement unit also allows detecting failure locations in a stacked IC and find what layer has failed by using the phase delay information from thermal lock-in analysis and thermal conductive properties of the device layer materials.

Principle



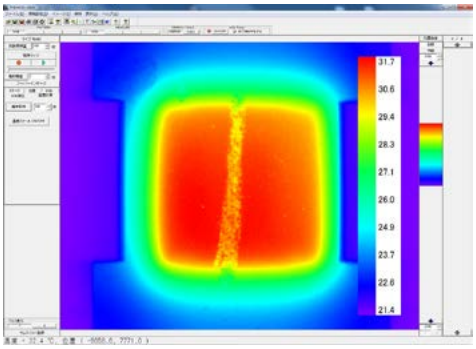
▲ Heat generated from failure points

Product name	Product number	Note
Thermal lock-in unit	C10565-21	
Thermal lock-in unit	C10565-31	Include Depth measurement unit (A12319-01)

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.

Temperature image

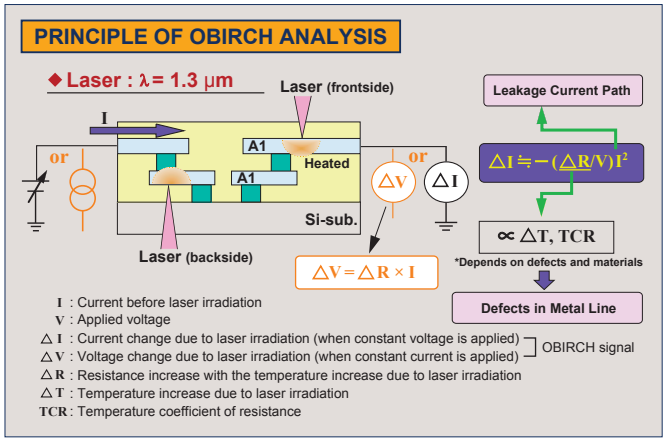


Note: Depending on measurement environment, structure of objects or material of objects, there is a case that measurement can't be carried out properly.

Product name	Product number
Temperature measurement software	U11389-01

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.



- 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

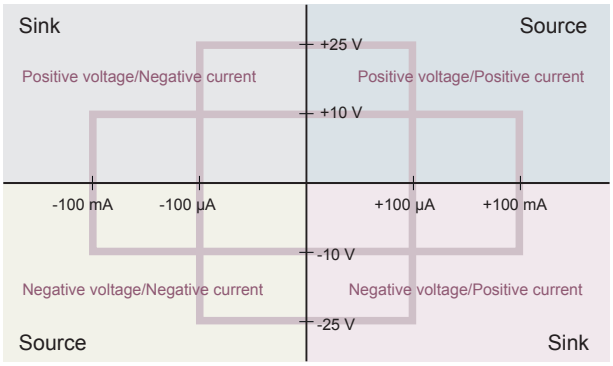
Fixed voltage mode, fixed current mode, and high-sensitivity current mode (fixed current mode) are selectable via software. The A8755 also uses a new OBIRCH amp. It has 10× better detectability than before.

	Fixed voltage mode	Fixed current mode	High-sensitivity current mode
Applied voltage range	-10 V to +10 V	-10 V to +10 V	-25 V 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

Possible to measure at 4 quadrant voltage/current

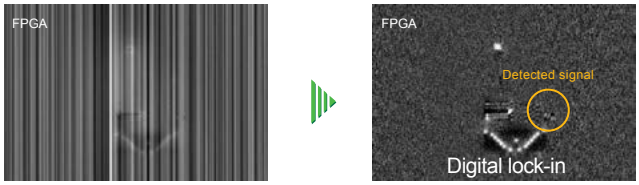
New OBIRCH amp. can work for devices, which need to apply negative voltage/current. The new amp is also effective to detect reverse current flowed differently from design.



Product name	Product number	Note
IR-OBIRCH function set	A8755-06	Include OBIRCH amp (C7636-06)

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.



Product name	Product number
Digital Lock-in unit for C10656	M10383-03

Analysis using the current detection head

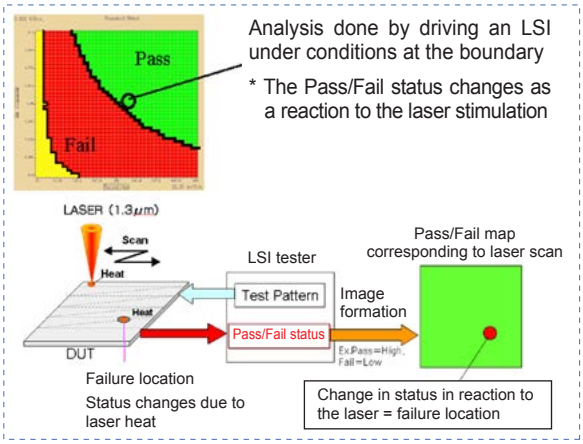
A current detection head can be used to measure devices that require higher voltage or higher current than the range of standard OBIRCH amp (10 V/100 mA or 25 V/100 µA).

Product name	High current probe head*1
Product number	A9187-01
Applicable voltage	Max. 250 V
Applicable current	6.3 A
Detectability	10 nA*2

*1 The A9187-01 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)

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

Product name	Product number
DA function kit	A9771-07

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.

Product name	Product number
EO probing unit	C12323-11

EOP Function

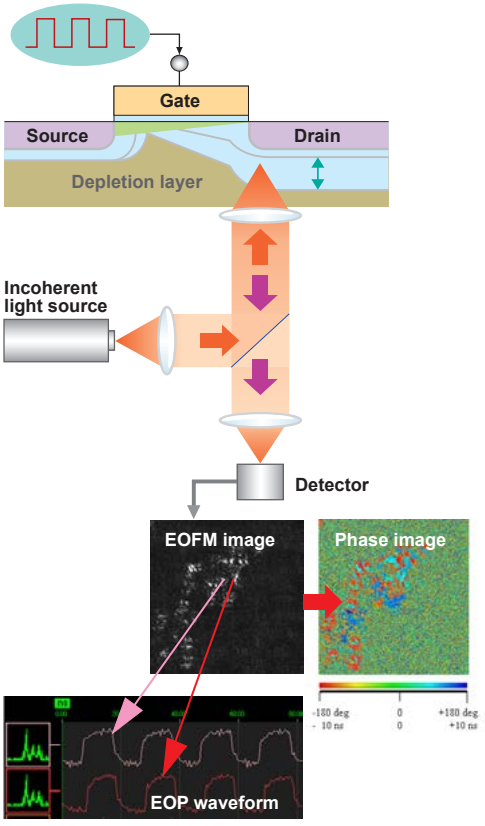
This function acquires switching timing of a specific transistor rapidly by high speed sampling. As an extended analysis of emission and OBIRCH, the EOP function improves accuracy of failure point localization, enabling a much smoother follow-up physical analysis.

Measurement band	10 kHz to 1 GHz
Number of samples	Up to approx. 500 000 points

EOFM Function

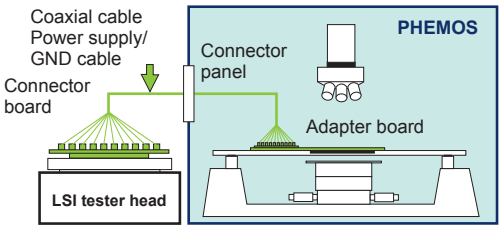
This function measures transistors switching at a specific frequency and images them. The reflected light from a drain has the power spectrum distribution. The EOFM picks up the intensity of signal under certain frequency from the distribution and visualize it as an image. By operating transistors in 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.

Light source (patented)	Wavelength:1.3 µm, Output: 60 mW
High power Incoherent Light source for EOP/EOFM: C13193-02	Low noise non-coherent light source



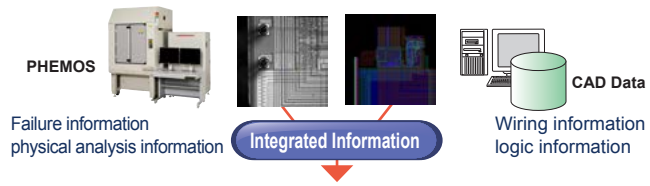
Connecting to an LSI tester

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.



Connection with the FA-Navigation failure analysis support system

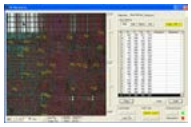
Combining detection signals from PHEMOS and design data, and automatically extracting suspicious signal lines contributes to making the work of narrowing down the malfunction locations more effective and to reducing the time needed to clarify the route cause. Analysis is easily possible using GDS II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



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.

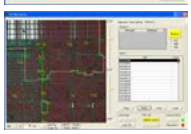


Design information overlay/Automatical signal region setting

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.

Product name	Product number
FA-Navigation CAD	U10024-21
FA-Navigation WORK	U10024-31
FA-Navigation LAB	U10024-41

Connecting to an 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)

Product name	Product number
CAD navi I/F software for v2.75 or later	U7771-04

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 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. 3 types of SIL lens cap are available in order to correspond to Si thickness from 50 µm to 800 µm.

Object lens

Product name	Product number	N.A.*1	Magnification*1
Objective lens NanoLens-SHR*2	A12913-06	3.1	250
Objective lens NanoLens-HR	A12913-07	2.3	175
Objective lens Thermal NanoLens*2	A12913-05	2.6	28

*1 At the time of the SIL cap deployment *2 Product for wafer / flip chip packages

SIL cap

Product name	Product number
SIL cap for SHR 50 µm to 110 µm	A12917-51
SIL cap for SHR 190 µm to 250 µm	A12917-52
SIL cap for SHR 735 µm to 795 µm	A12917-58
SIL cap for HR 50 µm to 150 µm	A12917-61
SIL cap for HR 150 µm to 250 µm	A12917-62
SIL cap for HR 700 µm to 800 µm	A12917-68
SIL cap for Thermal 100 µm to 400 µm	A12917-42
SIL cap for Thermal 500 µm to 800 µm	A12917-46

Macro analysis

The 0.8× macro lens for emission analysis has a high numerical aperture (NA) of 0.4 for surefire capture of weak light emissions. The software smoothly switches from macro to micro observation that uses an objective lens.

Lens selection

The motorized turret 5 lens A13572-01 holds 5 lenses.

Macro lens

Product name	Product number	N.A.	WD (mm)	Analysis
Macro lens 0.8× for InGaAs/CCD camera	A7909-14	0.4	24	Emission
Macro lens MWIR 0.24× for THEMOS-1000	A10159-08	0.08	27	Thermal emission
Macro lens 1× for InSb camera	A10159-10	0.33	52	Thermal emission

Object 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 NIR-UHR 100×	A11315-09	0.7	10	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

Dimensions / Weight

	PHEMOS-1000
Main unit (W) × (D) × (H)	1340 mm×1200 mm×2110 mm Approx. 1500 kg
Control rack (W) × (D) × (H)	880 mm×820 mm×1542 mm Approx. 150 kg
Operation desk (W) × (D) × (H)	1000 mm×800 mm×700 mm Approx. 45 kg

*Weight of PHEMOS-1000 main unit includes a prober or equivalent item.

Utility

Line voltage	AC200 V (50 Hz/60 Hz)
Power consumption	Approx.1400 (Max.3300) 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.

Description Label (Sample)

Caution Label

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