*i*PHEMOS series

Inverted emission microscope

HAMAMATSU

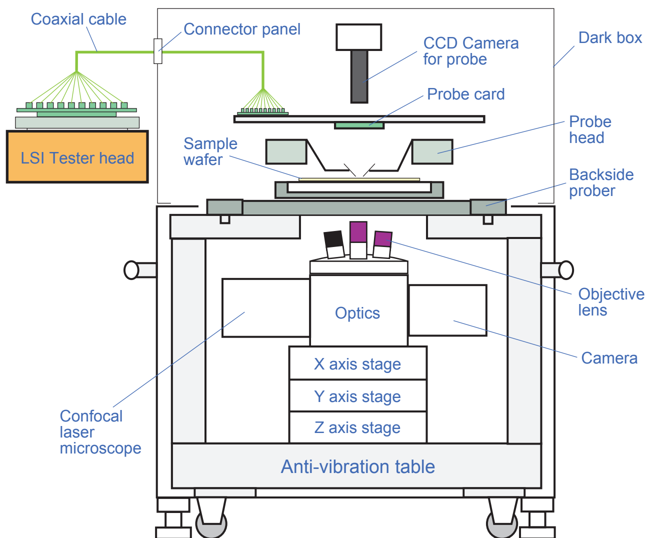
PHOTON IS OUR BUSINESS

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.

*i*PHEMOS-MP C10506-06-16

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.

Example of connection to the LSI tester

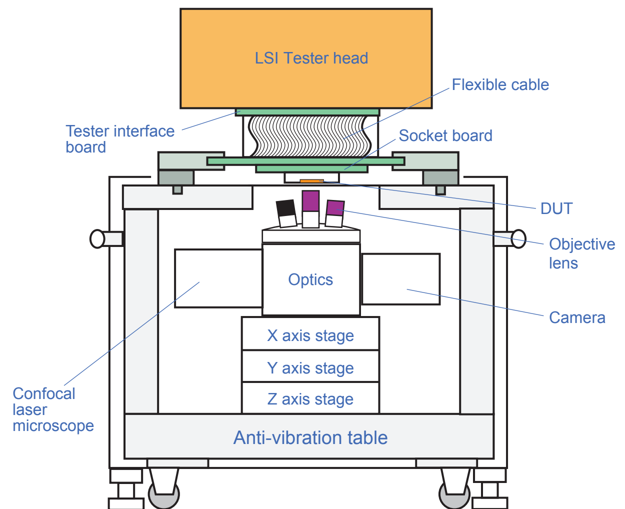


Cable connection

*i*PHEMOS-DD C10506-05-16

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



Direct tester docking

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**

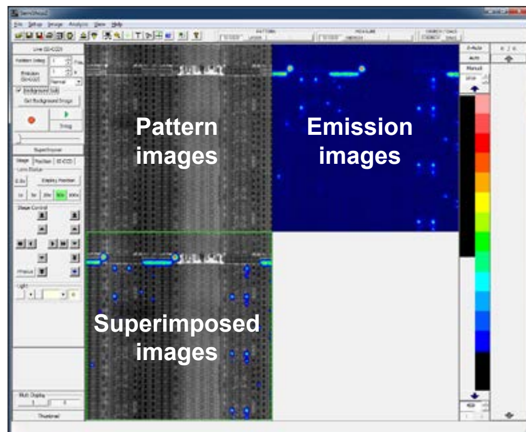
Options

- 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.

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	C10656-21A

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

Product name	Product number	Wavelength	Output
IR-LD module 100 mW	M7635-01	1.3 μm	100 mW
High power IR-LD module 400 mW	M10902-01	1.3 μm	400 mW or more
LD pulse laser 1.1 μm	C9215-06	1.1 μm	200 mW Pulse(CW) 800 mW Impulse

* 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.

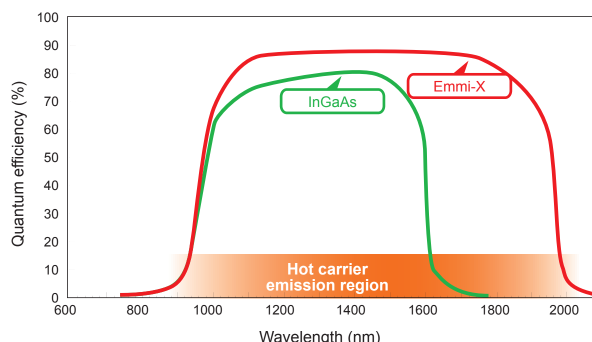
Features

- 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

Product name	InGaAs camera Peltier cooling	InGaAs camera 1k×1k LN2 cooling for iPHEMOS	Emmi-X camera 1k×1k LN2 cooling for iPHEMOS
Product number	C8250-27	C8250-35-20	C8250-45-20
Effective number of pixels	640(H) × 512(V)	1000(H) × 1000(V)	
Cooling method	Peltier cooling	Liquid nitrogen cooling	
Cooling temperature	-70 °C or less	-180 °C or less	
Spectral response	900 nm to 1550 nm	1000 nm to 1600 nm	1000 nm to 2000 nm

A comparative chart of wavelength sensitivity ranges



▲ 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

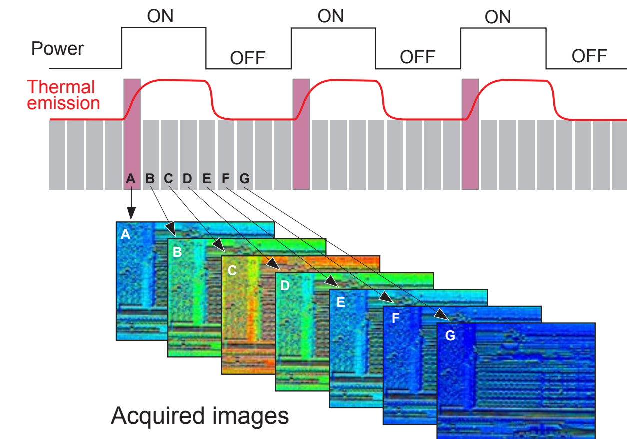
Identifying thermal emission locations

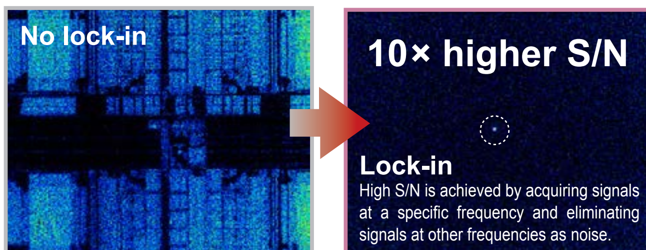
- Short-circuits in metallic layers and wiring
- Abnormal resistance at contact holes
- Microplasma leakage in oxide layer
- Oxide layer breakdown
- LCD/organic EL leakage

Product name	InSbHS camera	ThermoDynamicV2 camera
Product number	C9985-05	C9985-07
Effective number of pixels	640(H) × 512(V)	
Cooling method	Sterling cycle cooler	
Noise equivalent temperature difference (NETD)	< 25 mK @ 25 ˚C (20 mK Typical)	
Cooler MTTF	8000 hours	14 000 hours

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.

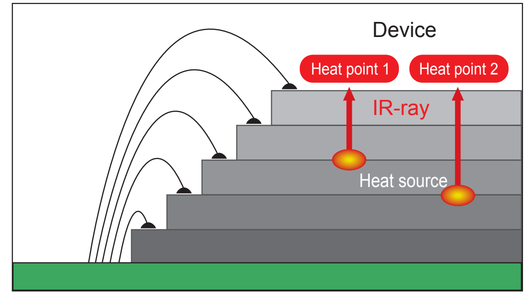




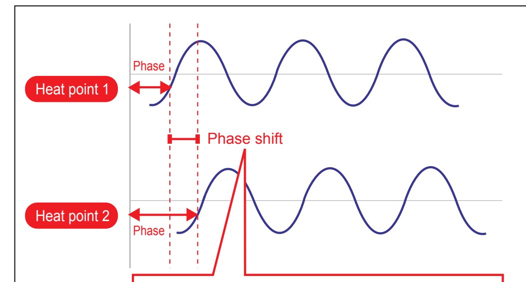
▲ Objective lens: 8×, Bias: 1.7 V, 14.5 mA

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

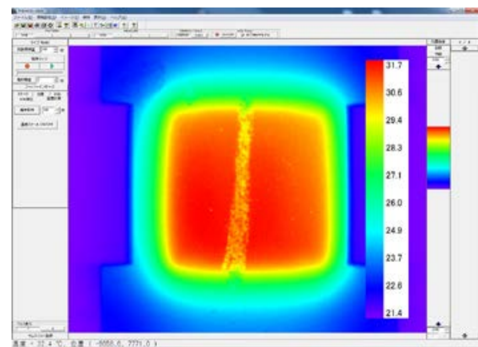


Product name	Product number
Thermal lock-in unit	C10565-71

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



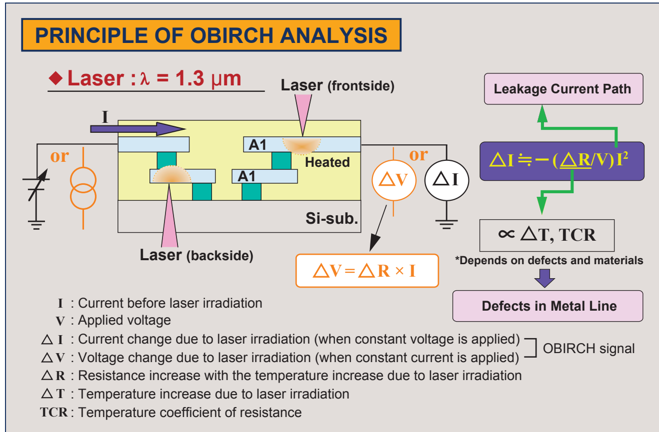
Note: Depending on measurement environment, structure of objects or material of objects, there is a case that measurement can't be carried out properly.

Product name	Product number
Temperature measurement software	U11389-01

* For InSbHS camera C9985-05

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

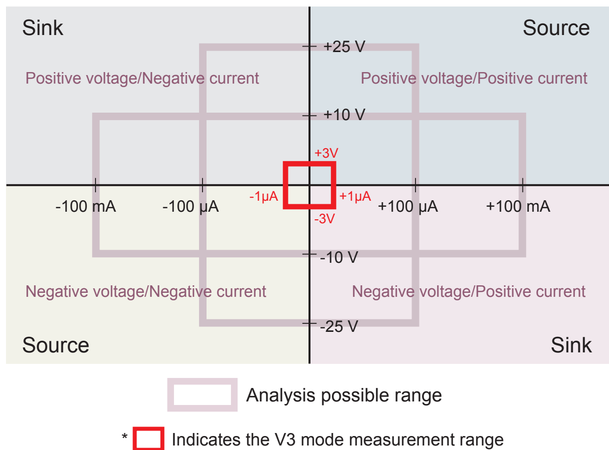
V1 mode, I1 mode, V2 mode, and V3 mode are selectable via software. The A8755 also uses a new OBIRCH amp. It has 10× better detectability than before.

	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		-100 μA to +100 μA	-1 μA to +1 μA
Detectability	1 nA*1	1 μV*2	3 pA*1	1 pA*1
IR-OBIRCH function set	A8755-06 A8755-07	A8755-06 A8755-07	A8755-06 A8755-07	A8755-07

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

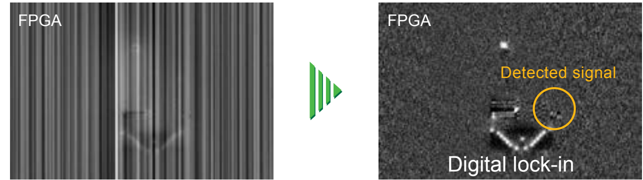
Possible to measure at 4 quadrant voltage/current

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.



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	M10383-06

Analysis using the current detection head

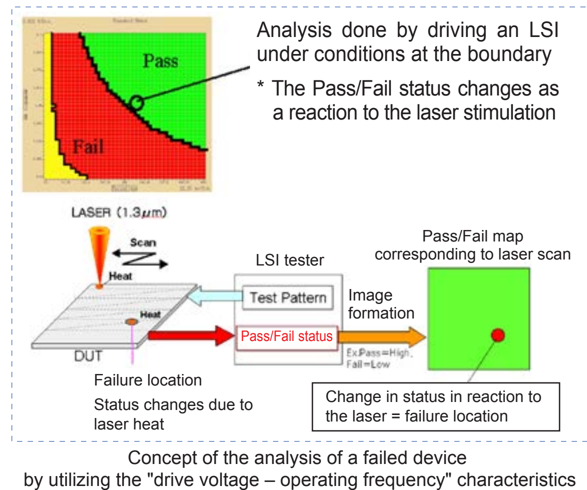
A current detection head can be used to measure devices that require higher voltage or higher current than the range of standard OBIRCH amp (10 V/100 mA or 25 V/100 μA).

Product name	High current probe head*1
Product number	A9187-02
Applicable voltage	Max. 250 V
Applicable current	6.3 A
Detectability	10 nA*2

*1 The A9187-02 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 EOP/EOFM base unit	C12323-22

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	1 kHz to 7 GHz
Number of samples	Up to approx. 500 000 points

Product name	Product number	Measurement band
EOP module 4GS/s	M14302-01	1 kHz to 1 GHz
EOP module 32GS/s	M14302-11	1 MHz to 7 GHz

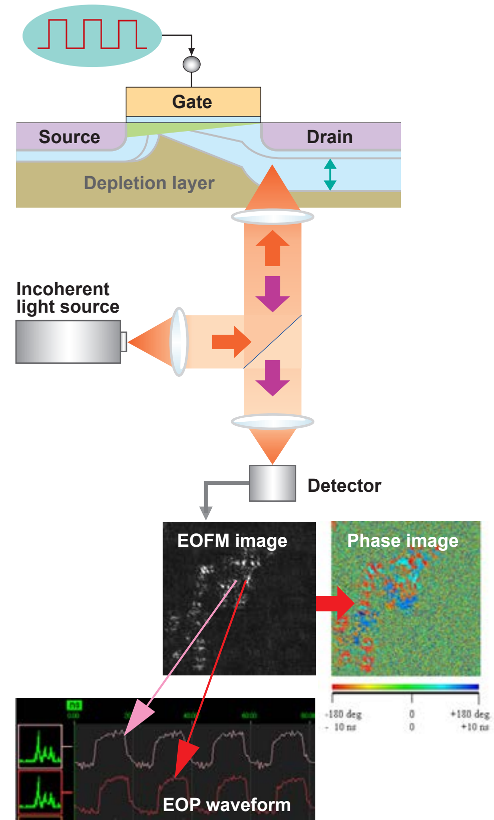
EOFM Function

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)

Selectable light source

Product name	Product number	Wavelength	Output
High power Incoherent Light source for EOP/EOFM	C13193-02	1.3 µm	60 mW
High stable light source for EOPU	C12993-01	1.3 µm	100 mW

Product name	Product number	Measurement band
EOFM module for Amplitude measurement	M14301-01	1 kHz to 1.5 GHz
EOFM module for IQ measurement	M14301-02	



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 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.

Object lens

Product name	Product number	N.A.[*1]	Magnification[*1]
Objective lens NanoLens-WR[*2]	A12913-08	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

NanoLens	Silicon thickness	Product number
NanoLens-WR	50 µm to 110 µm	A14487-01
	190 µm to 250 µm	A14487-02
	570 µm to 630 µm	A12917-56
	735 µm to 795 µm	A12917-58
	55 µm to 105 µm	A14487-31[*1]
NanoLens-HR	50 µm to 150 µm	A14487-11
	150 µm to 250 µm	A14487-12
	700 µm to 800 µm	A12917-68
Thermal NanoLens	100 µm to 400 µm	A12917-42
	500 µm to 800 µm	A12917-46

*1 NA2.7, 247×

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

The motorized turret 5 lens A13572-01 holds 5 lenses while the motorized turret 10 lens A10622-01 holds 10 lenses.

Macro lens

Product name	Product number	N.A.	WD (mm)	Analysis
Macro lens 1.35× for iPHEMOS-MP	A13573-01	0.38	16	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

	iPHEMOS-MP	iPHEMOS-DD
Main unit Dimensions(mm)/Weight	1740(W)×1150(D)×1770(H) Approx. 1400 kg	1980(W)×1270(D)×834(H) Approx. 1700 kg
Control rack Dimensions(mm)/Weight	880(W)×700(D)×1542(H) Approx. 255 kg	880(W)×700(D)×1842(H) Approx. 300 kg
Operation desk Dimensions(mm)/Weight	1000(W)×800(D)×700(H) Approx. 60 kg	1400(W)×800(D)×700(H) Approx. 60 kg

*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.

Description Label (Sample)

Caution Label

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