Thermal Emission Microscope

# THEMOS® series

True Thermal

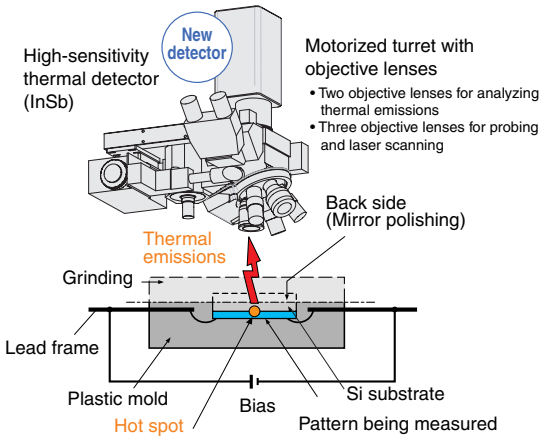

HAMAMATSU

PHOTON IS OUR BUSINESS


Thermal Emission Microscope

# THEMOS Series

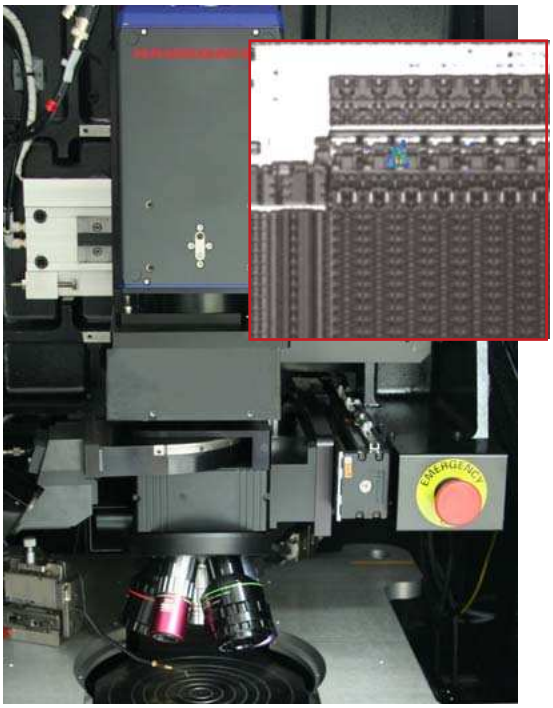
The THEMOS series thermal emission microscope is a semiconductor failure analysis system that pinpoints failures by detecting thermal emissions generated within the semiconductor device. The increasing trend toward hyperfine patterns and lower supply voltages in semiconductor devices makes the infrared rays emitted by heat generated from semiconductor failure points fainter and more difficult to detect.
The THEMOS series, which incorporates a high-sensitivity InSb camera, has a flexible product lineup from a simple stand model to an advanced system with an IR confocal laser microscope. With this flexibility, the THEMOS series can test any device from PC boards to chips.




**Thermal emission analysis imaged through the backside**

## Features

- High sensitivity is achieved by:
  - InSb camera having high sensitivity in the 3 μm to 5 μm wavelength region
  - Lens design optimized for 3 μm to 5 μm wavelengths
  - Low noise using a lock-in function (Optional)
  - High cooling performance by a Stirling cycle cooler
  - Noise equivalent temperature difference (NETD) is 20 mK.
- High resolution is achieved by:
  - InSb camera with 640 × 512 pixels (Pixel size: 15 μm)
  - Superimposing a laser pattern image from the IR confocal laser microscope
  - Thermal NanoLens is available. (Optional)
- High speed detection available by *windowing function
- Movie function
- Dynamic measurement available by tester link
- Flexible system structure for micro to macro observation
- User friendly operation identical to PHEMOS and μAMOS series
- Full lineup of optional features




*Windowing function

Possible to measure a specific area with high frame rate.

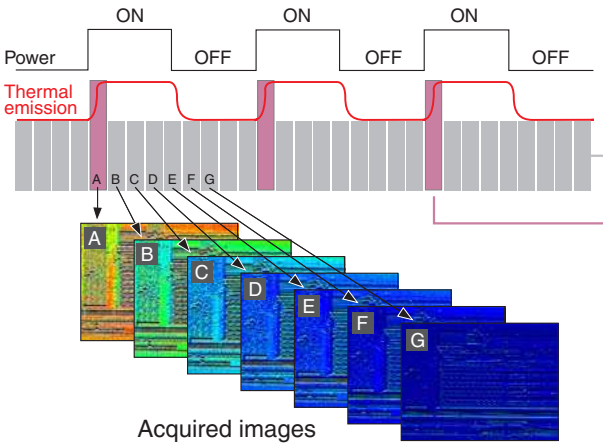
| Region of interest | Frame rate |
|---|---|
| 640 pixels × 512 pixels | 100 Hz |
| 320 pixels × 240 pixels | 200 Hz |
| 160 pixels × 120 pixels | 400 Hz |
| 64 pixels × 64 pixels | 1000 Hz |

## Applications

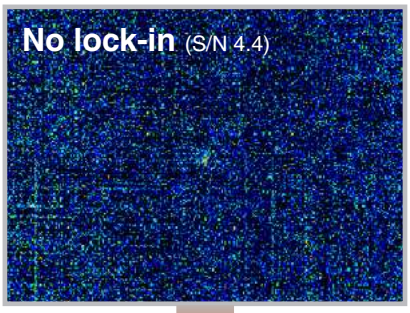
- Short-circuit of metal wirings
- Abnormality of contact holes
- Microplasma leakage in oxide layer
- Oxide layer breakdown
- TFT-LCD leakage / Organic EL leakage localization
- Observation of temperature abnormalities in devices under development process
- Temperature mapping of devices and PC boards

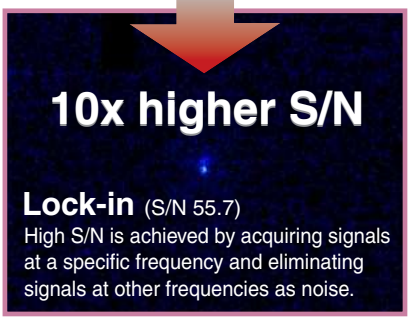
## Thermal lock-in measurement

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

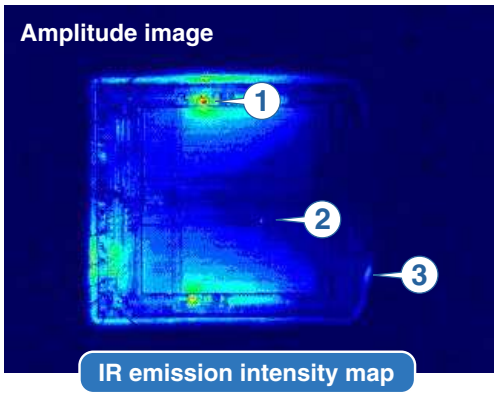


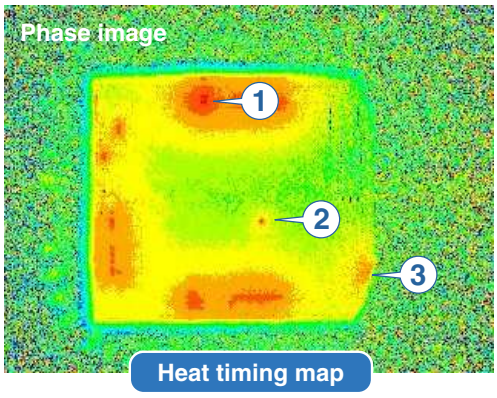




▲ Objective lens: 15x, Bias: 1.0 V, 23 mA

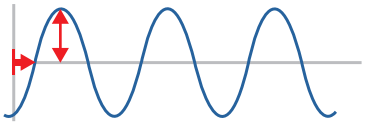
### Phase image

Possible to localize a heat source by visualizing heat timing from phase images.

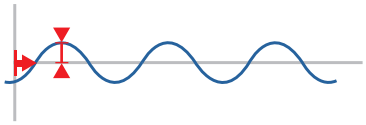


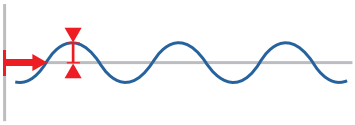

① IR emission: High
Phase shift: Small



② IR emission: Low
Phase shift: Small



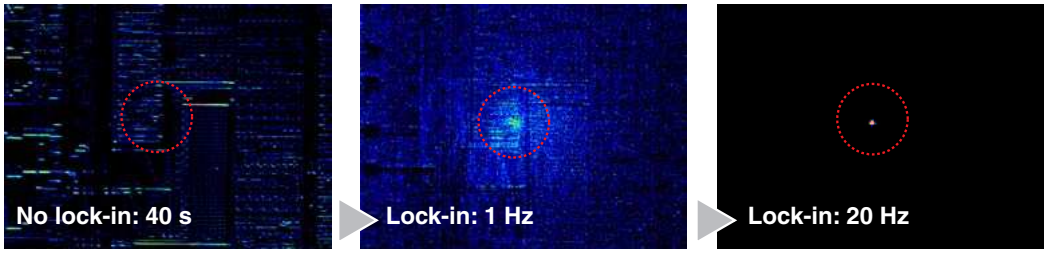
③ IR emission: Low
Phase shift: Large



**1 and 2 show small phase shift, which means fast heat timing. It indicates a heat source.**
**3 shows large phase shift, which indicates diffused heat.**

### Image difference by frequency

Possible to narrow down the heat source by increasing frequency.

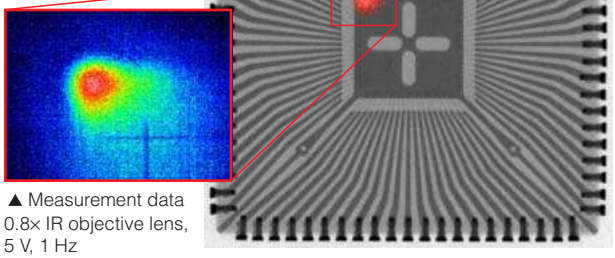


## Measurement examples

### Case study: Package device observation

◀ Microprocessor
Chip size: 30 mm × 30 mm

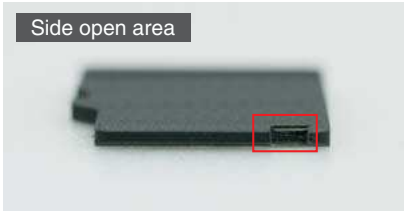
Superimposed the thermal image on an X-ray image

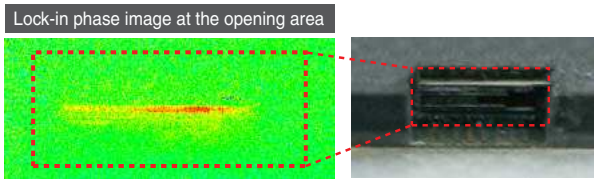


▲ Measurement data
0.8× IR objective lens,
5 V, 1 Hz

### Case study: Defect layer observation by opening a side of a device

Made a small opening at a side of mold to see a Si die.

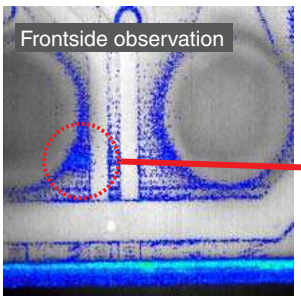


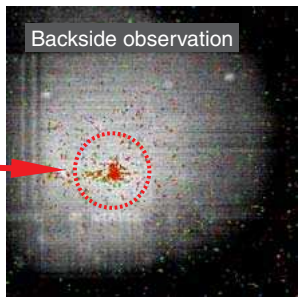

▲ Measurement data
4× IR objective lens

### Case study: CMOS observation

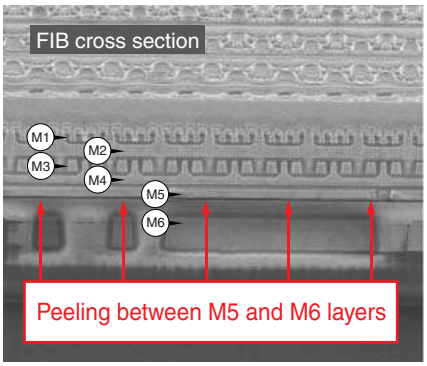
Found a defect under a bump




▲ 4× IR lens

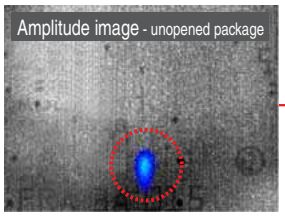



▲ Si thickness 350 µm, 0.8× IR lens

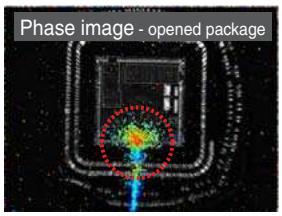



### Case study: Wiring failure between a PCB and a packaged device

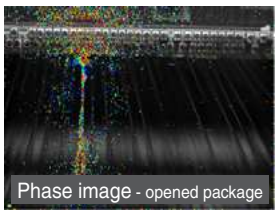
Observed a heat source before opening the package. After opening the package, took phase images to narrow down the heat source.



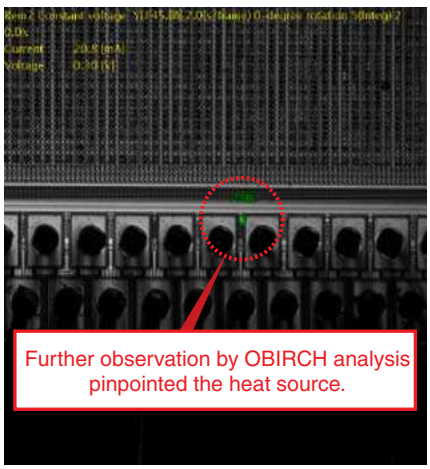

▲ 0.8× Lock-in 5 Hz




▲ 0.8× Lock-in 5 Hz




▲ 4× Lock-in 20 Hz




▲ OBIRCH 20×


THEMOS-1000


THEMOS mini

Flexible system structure corresponding to customer needs and application

Micro / Macro type

Simple and wide view type

Prober type

## System configurations

| Type | THEMOS-1000 | THEMOS mini | Micro / Macro type*1 | Simple and wide view type*1 | Prober type*1 |
|---|---|---|---|---|---|
| C9985-04 InSb camera | ✓ | ✓ | ✓ | ✓ | ✓ |
| IR confocal laser microscope | ✓ | - | ✓ | - | - |
| Auto stage control | XYZ | Manual | XYZ | Z | Manual |
| Standard lens | 0.8×, 4×, 15× | 0.8×, 4×, 15× | 25 mm*2, 0.8×, 4×, 15× | 25 mm*2 | 0.8×, 4×, 15× |
| Sample stage*3 | PM8, PM8DSP | HPK stage (8-inch) | PM8, PM8DSP | - | PM8, PM8DSP |
| Eyepiece for probing | ✓ | ✓ | ✓ | - | ✓ |
| Lens for probing | NIR 5× | 5× | NIR 5× | - | 5× |
| Anti-vibration table | ✓ | ✓ | ✓ | - | - |
| Dark box | ✓ | - | ✓ | - | - |
| THEMOS analysis software | ✓ | ✓ | ✓ | ✓ | ✓ |
| FOV (unit: mm) | 12 × 9.6 to 0.64 × 0.51 | 12 × 9.6 to 0.64 × 0.51 | 125 × 100, 12 × 9.6 to 0.64 × 0.51 | <428 × 342 | 12 × 9.6 to 0.64 × 0.51 |
| Object | Wafer (up to 12-inch) Si die, Package | PCB*4, Wafer (up to 8-inch) Si die, Package | PCB*4, Wafer (up to 8-inch) Si die, Package | PCB*4, PV, LCD | PCB*4, Wafer (up to 8-inch) Si die, Package |

✓: Standard - : Not available
*1 : The systems are special order products. *2 : The lens for macro observation *3 : Please ask Hamamatsu for more details. *4 : In the case of integrating 0.29× objective lens

## Functions

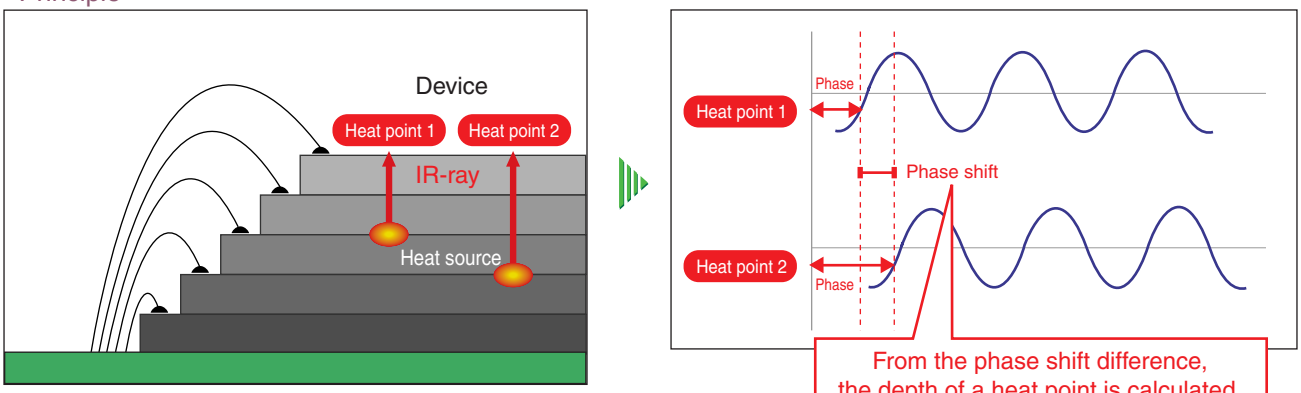
| Function | THEMOS-1000 | THEMOS mini | Micro / Macro type*1 | Simple and wide view type*1 | Prober type*1 |
|---|---|---|---|---|---|
| Thermal lock-in measurement | Optional | Optional | Optional | Optional | Optional |
| 3D-IC measurement | Optional | Optional | Optional | Optional | Optional |
| Temperature measurement function | Optional | Optional | Optional | - | Optional |
| Thermal NanoLens | Optional | Optional | Optional | - | Optional |
| Movie function | ✓ | ✓ | ✓ | ✓ | ✓ |
| Windowing function | ✓ | ✓ | ✓ | ✓ | ✓ |
| External triggering | ✓ | ✓ | ✓ | ✓ | ✓ |
| IR-OBIRCH analysis function | Optional | - | Optional | - | - |
| DALS | Optional | - | Optional | - | - |
| Photoemission analysis | Optional | - | - | - | - |

✓: Standard - : Not available
*1 : The systems are special order products.

## 3D-IC measurement function A12319

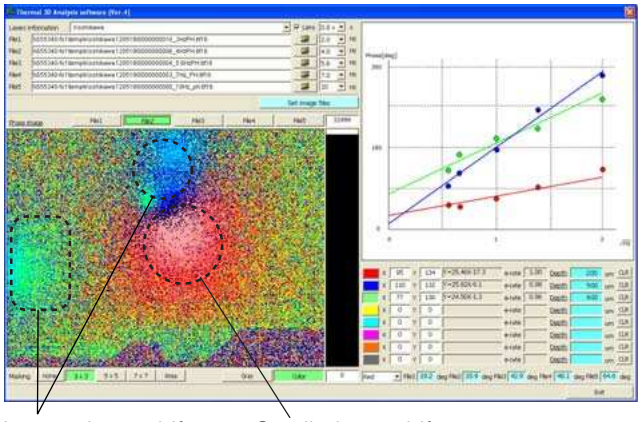
Possible to detect a heat point and its point of origin within stacked IC layers by using phase images taken by lock-in measurement and calculating them with thermal property information of each layer. If a layer's material information is unknown, it is possible to obtain the information by using a pulse heater. Even with the obtained material information, depth can be measured within a few % error.

### Principle




▲ Heat generated from failure points

### 3D-IC measurement software



Large phase shift
(A heat spot is deep.)

Small phase shift
(A heat spot is close to the surface.)

Indicate the depth of a heat point by the heat conductance algorithm and thermal property information of a device material

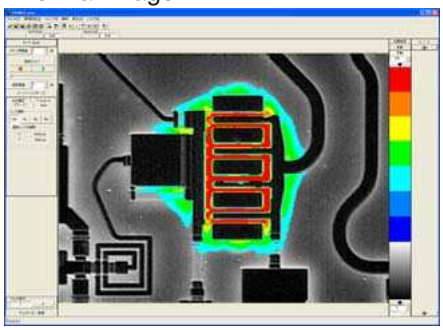

- Obtain thermal property information using a pulse heater.

  It is important to input the correct material information to get an accurate result. When you do not have the thermal property information of a material used in a device, it is possible to obtain that data by measuring the material with a pulse heater.

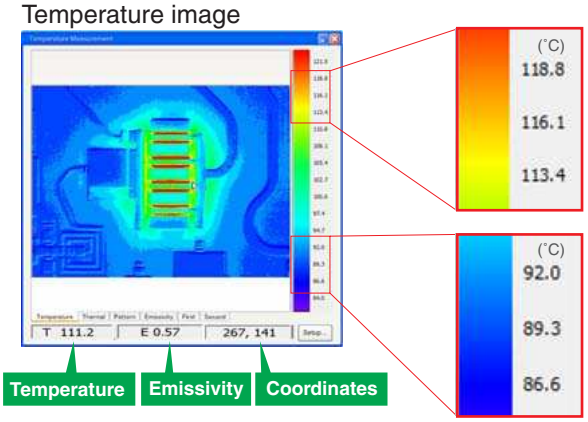
## Temperature measurement function U11389

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 U11389 temperature measurement function.

Thermal image



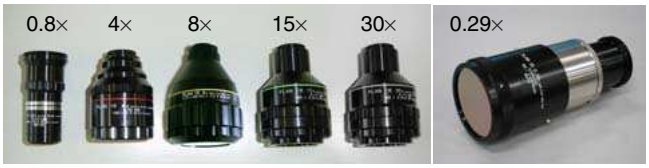
Temperature image



## Optics

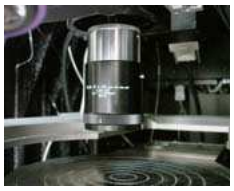
| Objective lens<br>Macro lens | N.A. | WD (mm) | FOV (mm) | Standard development |
|---|---|---|---|---|
| MWIR 0.29× | 0.048 | 12 | 33 × 26 | Optional (THEMOS mini) |
| MWIR 0.8× | 0.13 | 22 | 12 × 9.6 | ✓ |
| MWIR 4× | 0.52 | 25 | 2.4 × 1.9 | ✓ |
| MWIR 8× | 0.75 | 15 | 1.2 × 0.96 | Optional |
| MWIR 15× | 0.71 | 15 | 0.64 × 0.51 | ✓ |
| MWIR 30× | 0.71 | 13 | 0.32 × 0.26 | Optional |
| M-Plan-NIR 5× : A11315-01 | 0.14 | 37.5 | 2.6 × 2.6 | ✓ |
| M-Plan-NIR 20× : A11315-03 | 0.4 | 20 | 0.65 × 0.65 | ✓ (THEMOS-1000) |
| M-Plan-NIR 100× : A11315-05 | 0.5 | 12 | 0.13 × 0.13 | ✓ (THEMOS-1000) |

✓ : Standard

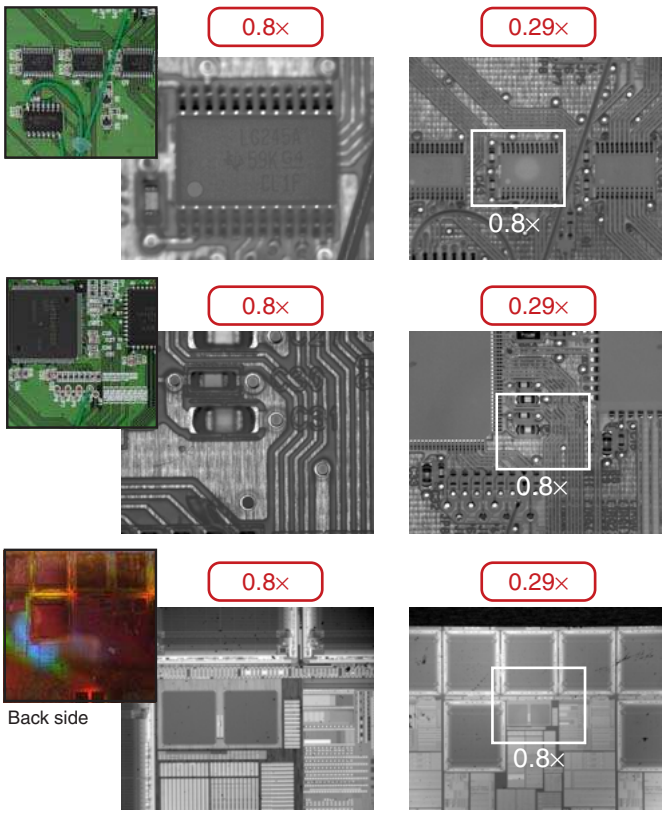



## Macro analysis

Newly developed 0.29× IR lens provides a clear wide view image without a narcissus phenomenon and shading.



View size comparison




## IR confocal laser scan microscope

THEMOS-1000 provides high resolution pattern images by integrating an IR confocal laser scan microscope. By overlaying a laser pattern image on a thermal image, heat point can be localized accurately.

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

* Can't use 2 lasers of the same wavelength.

## IR-OBIRCH analysis function A8755

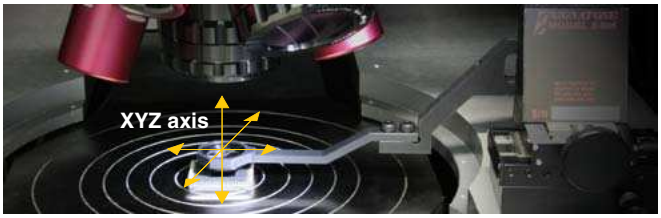
Adding the OBIRCH function for failure analysis allows pinpointing current leakage paths and defective interconnections in LSI devices. This function is expandable to include lock-in OBIRCH analysis and laser-irradiated dynamic analysis by connecting to an LSI tester.

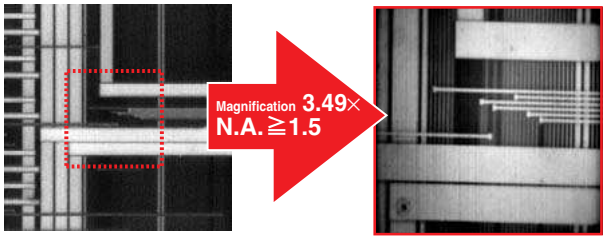
### Dynamic analysis by laser stimulation kit (DALS) A9771

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.

## Thermal NanoLens System A11079

The Thermal NanoLens System provides drastic improvements in light correction efficiency and resolution by high N.A.. Microscope immersion oil applied between the sample and lens achieves high N.A. even on samples with poor surface flatness. A manipulator simplifies the NanoLens system design, making it easy to retrofit into your working equipment.




▲ Standard objective lens ▲ Thermal NanoLens

## LSI tester docking

Semiconductor devices are becoming ever more complicated, which makes it essential to interface with LSI testers to initialize sampling measurement and to set special conditions. Installing a dedicated probe card adapter allows cable docking with LSI testers to perform analysis.

## Camera selection for photoemission observation

A full lineup of optional cameras that detect faint photoemission from visible to near infrared light is available. Dual stage structure of THEMOS-1000 allows two-image acquisition (photoemission and thermal emission) without changing sample setting. It saves you time and lab space.

| Type No. | Cooling type | Effective number of pixels | Spectral sensitivity |
|---|---|---|---|
| InGaAs camera C8250-21 | Liquid nitrogen cooling | 640 (H) × 512 (V) | 900 nm to 1550 nm |
| InGaAs camera C8250-27 | Peltier cooling | 640 (H) × 512 (V) | 900 nm to 1550 nm |
| InGaAs camera C8250-31 | Liquid nitrogen cooling | 1000 (H) × 1000 (V) | 900 nm to 1550 nm |
| Cooled CCD camera C4880-59 | Peltier cooling | 1024 (H) × 1024 (V) | 300 nm to 1100 nm |
| Si-CCD camera C11231-01 | Peltier cooling | 1024 (H) × 1024 (V) | 400 nm to 1100 nm |

## Laser marker C7638

Marking the vicinity of a localized failure point or four points around the failure point makes it easy to transfer position information on that failure point to other analysis equipment.


## Utility

| | THEMOS-1000 | THEMOS mini |
|---|---|---|
| Line voltage | AC 220 V (50 Hz/60 Hz) | AC 220 V (50 Hz/60 Hz) |
| Power consumption | 3000 VA | 700 VA |
| Vacuum | Approx. 80 kPa or more | Approx. 80 kPa or more |
| Compressed air | 0.5 MPa to 0.7 MPa | 0.5 MPa to 0.7 MPa |

## Dimensions/Weight (Including option)

| | Dimensions/Weight |
|---|---|
| THEMOS-1000 main unit | 1360 mm (W) × 1410 mm (D) × 2120 mm (H), Approx. 900 kg |
| THEMOS 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 |

| | Dimensions/Weight |
|---|---|
| THEMOS mini main unit | 880 mm (W) × 840 mm (D) × 1993 mm (H), Approx. 450 kg |
| PC desk | 700 mm (W) × 700 mm (D) × 700 mm (H), Approx. 45 kg |

### LASER SAFETY (THEMOS-1000)

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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