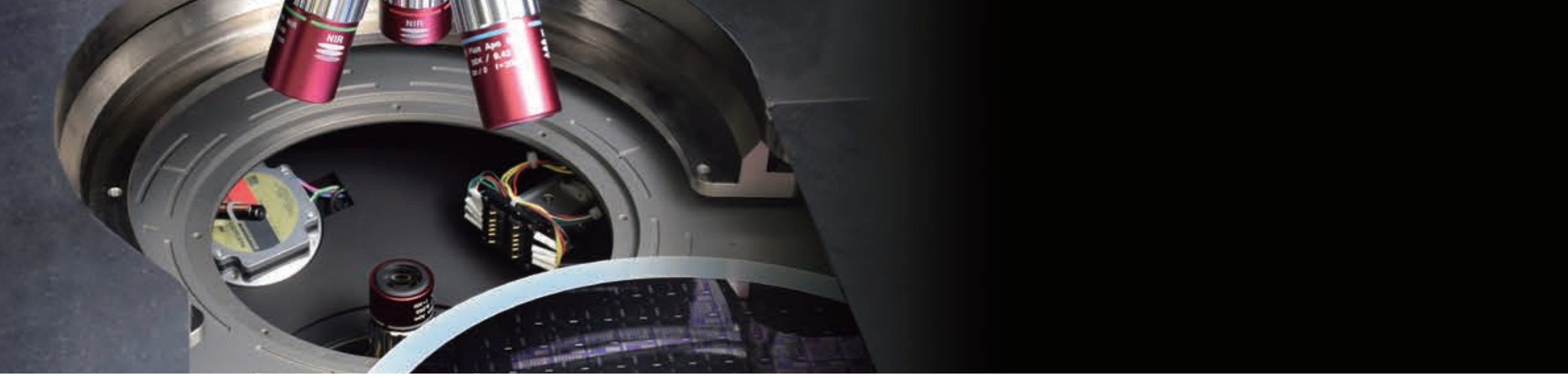
Emission microscope C16506-01

Dual PHEMOS®-X

HAMAMATSU

PHOTON IS OUR BUSINESS



Dual PHEMOS®-X

The Dual PHEMOS®-X is designed for advanced, 3D, nontransparent devices where simultaneous optical FA may be required from both side (front and back) at the wafer or die level.
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.

Features

- **Dual slide analysis**

  Easy to change between front and backside FA without moving your device to another system.

- **High accuracy stage designed for advanced devices**

  Working range of the optical stage

	X	Y	Z
Top side	40 mm	40 mm	80 mm
Bottom side	60 mm	60 mm	20 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.

- **Sample stage (Semiauto prober MPd-1000X C16688-01)**

  Main function

  - XY stage control
  - Z, Theta control

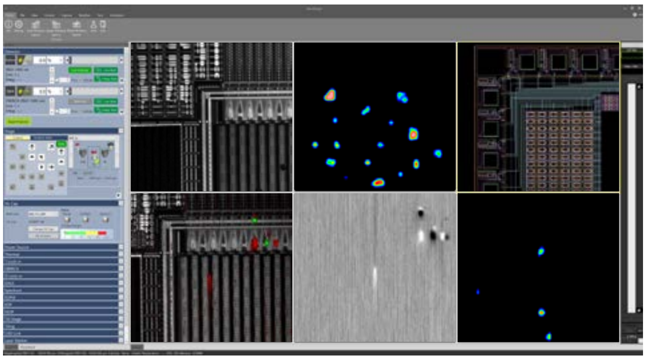
X	300 mm
Y	300 mm
Z	22.5 mm
θ	+/– 5°

  - Wafer mapping function
  - Alignment function
  - Top side PC and Bottom side PC communicate with the prober PC via LAN

Basic display functions

Superimposed display/contrast enhancement function

The Dual 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.
  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 CCD camera was developed for an emission microscope and has peltier cooling to realize low noise. It has a peak detection sensitivity in the visible light region, making it not only powerful for analysis from the surface but also suitable for backside analysis of compound semiconductors such as SiC.

Cooled CCD camera (Top side only)

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

SI-CCD (Si Intensified CCD) camera (Top side only)

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.

Application

- Backside analysis of compound semiconductor devices
- Withstand voltage failure of high voltage drive devices

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 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 backside. Combined with a laser scan system, it also enables high-resolution and high-sensitivity analysis.

InGaAs camera

The InGaAs camera has high sensitivity in the near-infrared wavelength range. Peltier cooling or LN2 cooling can be selected for the camera cooling system.

Application

- Backside analysis of Si semiconductor devices
- Junction failure of low-voltage drive devices

ThermoDynamic camera for thermal emission MIR

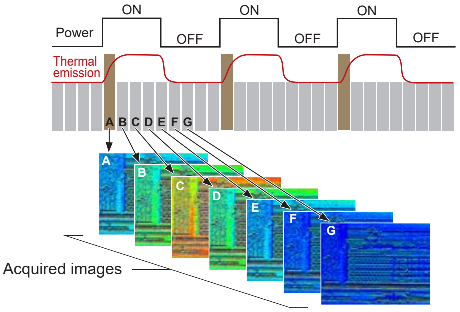
With miniaturization and low-voltage drive of semiconductor devices, infrared light originating from heat generated at failure locations is becoming weaker and difficult to detect. The ThermoDynamic camera has high sensitivity in the mid-infrared wavelength range and can capture such weak thermal signals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

Application

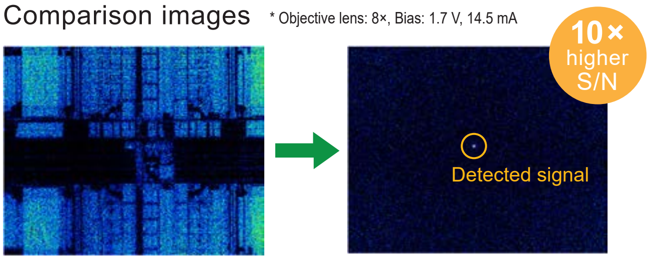
- Short-circuits in metallic layers and wiring
- Abnormal resistance at contact holes
- Insulation leakage

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

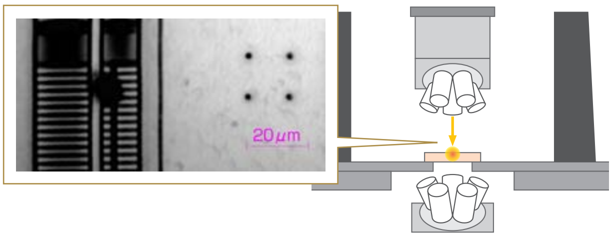
The laser scan system obtains clear, high-contrast pattern images by scanning the backside of a chip with the infrared laser (1.3 μm and/or 1.1 μm). Within 1 second, a pattern image can be acquired. By the flexible scan in 6 directions, it is possible to scan a device from different directions without 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 (Top side only)

Top side laser marking after backside analysis is useful for transfer from fault location to physical analysis.
The laser marker uses a pulse laser, and its spot size is Φ5 μm under a 100× lens.



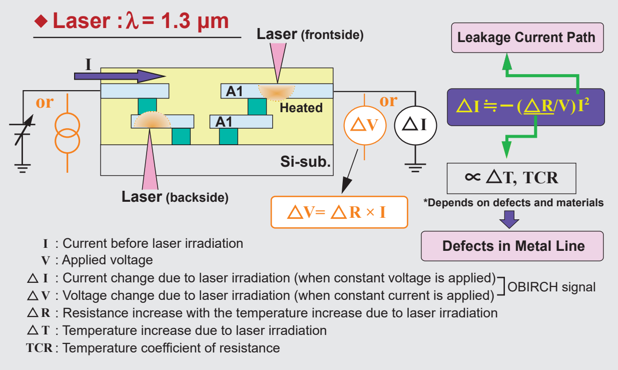
IR-OBIRCH analysis

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.

Features

- 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
- Possible to measure at four quadrants of voltage/current

Principle

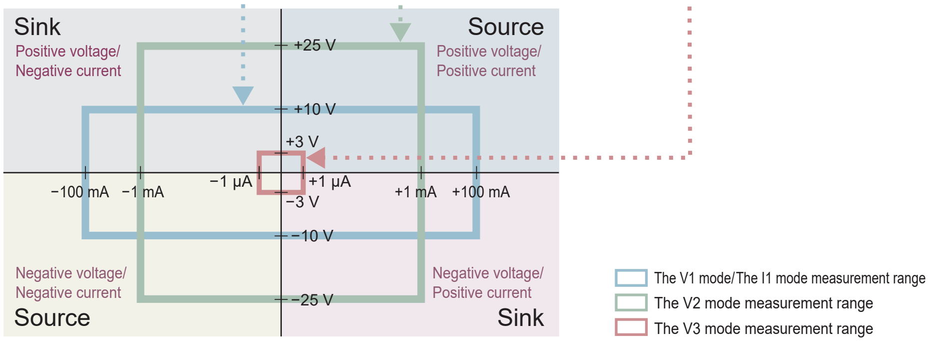


I : Current before laser irradiation
V : Applied voltage
ΔI : Current change due to laser irradiation (when constant voltage is applied)
ΔV : Voltage change due to laser irradiation (when constant current is applied)
ΔR : Resistance increase with the temperature increase due to laser irradiation
ΔT : Temperature increase due to laser irradiation
TCR : Temperature coefficient of resistance

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.

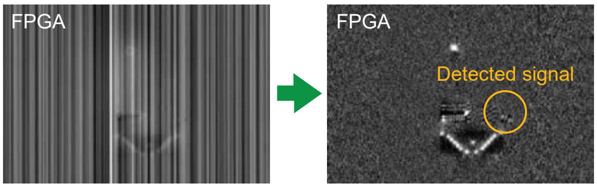
	V1 mode	I1 mode	V2 mode	V3 mode
Voltage range	−10 V to +10 V		−25 V to +25 V	−3 V to +3 V
Current range	−100 mA to +100 mA		−1 mA to +1 mA *1	−1 μA to +1 μA
Detectability	1 nA *2	1 μV *3	3 pA *2	1 pA *2

*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.



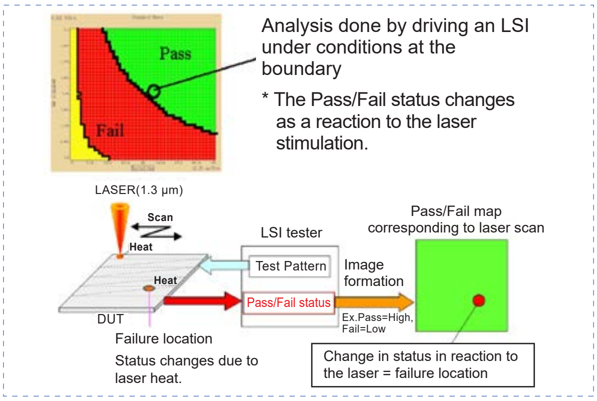
No digital lock-in Digital lock-in

Analysis using the current detection head

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

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 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.

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.

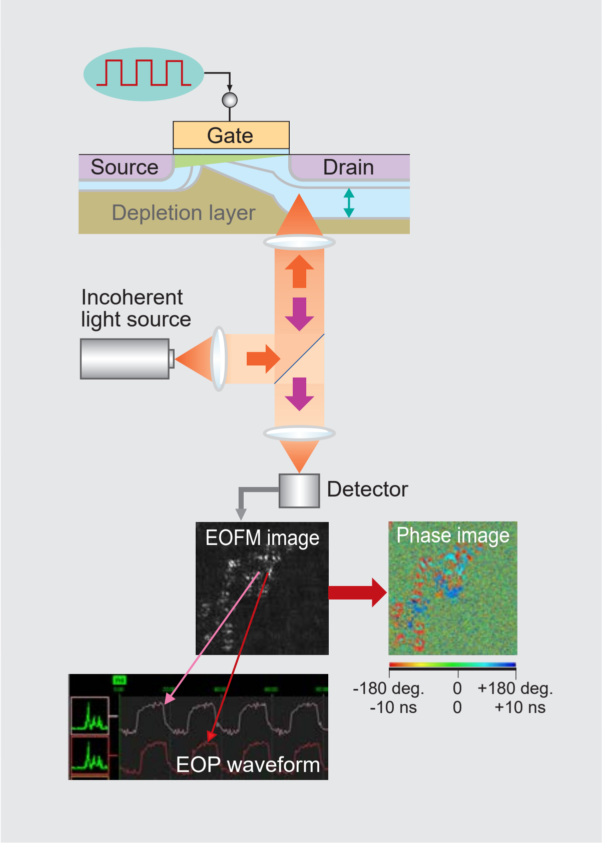
Bandwidth	1 kHz to 7 GHz

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	Top side	Bottom side
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	Top side	Bottom side
Macro lens 1.35× for PHEMOS®-X	A7909-16	0.4	25	Emission/OBIRCH	✓	-
Macro lens 1× for InSb camera	A10159-10	0.33	52	Thermal emission	✓	-
Macro lens 1.35× for iPHEMOS™-MP	A13573-01	0.38	15	Emission	-	✓

Macro lens

The 1.35× macro lens has a high numerical aperture (N.A.) of 0.4 (for Macro lens 1.35× for iPHEMOS™-MP: 0.38) 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 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-WR (N.A. 3.1) 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. And the Thermal NanoLens (N.A. 2.6) is appliable to thermal analysis.

External connection

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	1900 mm (W) × 2130 mm (H) × 1350 mm (D) Approx. 2200 kg
System rack	1060 mm (W) × 1841.5 mm (H) × 715 mm (D) Approx. 300 kg
Prober rack	1000 mm (W) × 1800 mm (H) × 650 mm (D) Approx. 400 kg

Utility

Line voltage	Single phase 200 V, 220 V 50 Hz/60 Hz
Power consumption	Approx. 3300 VA (system rack) / 6600 VA (prober rack)
Vacuum	80 kPa or more
Compressed air [*1]	0.5 MPa to 0.7 MPa

[*1] Including a regulator

LASER SAFETY

The Dual 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

- PHEMOS is a registered trademark of Hamamatsu Photonics K.K.(China, EU, Japan, Korea, Taiwan, UK, USA).
- Dual PHEMOS is a trademark of Hamamatsu Photonics K.K.
- The product and software package names noted in this brochure are trademarks or registered trademarks of their respective manufacturers.
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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.
- The measurement examples in this brochure are not guaranteed.
- Specifications and external appearance are subject to change without notice.

HAMAMATSU PHOTONICS K.K. **www.hamamatsu.com**

Systems Division
812 Joko-cho, Higashi-ku, Hamamatsu City, 431-3196, Japan, Telephone: (81)53-431-0124, Fax: (81)53-433-8031, E-mail: export@sys.hpk.co.jp
U.S.A.: HAMAMATSU CORPORATION: 360 Foothill Road, Bridgewater, NJ 08807, U.S.A., Telephone: (1)908-231-0960, Fax: (1)908-231-1218
Germany: HAMAMATSU PHOTONICS DEUTSCHLAND GMBH.: Arzbergerstr. 10, 82211 Herrsching am Ammersee, Germany, Telephone: (49)8152-375-0, Fax: (49)8152-265-8 E-mail: info@hamamatsu.de
France: HAMAMATSU PHOTONICS FRANCE S.A.R.L.: 19 Rue du Saule Trapu, Parc du Moulin de Massy, 91882 Massy Cedex, France, Telephone: (33)1 69 53 71 00, Fax: (33)1 69 53 71 10 E-mail: infos@hamamatsu.fr
United Kingdom: HAMAMATSU PHOTONICS UK LIMITED: 2 Howard Court,10 Tewin Road, Welwyn Garden City, Hertfordshire, AL7 1BW, UK, Telephone: (44)1707-294888, Fax: (44)1707-325777 E-mail: info@hamamatsu.co.uk
North Europe: HAMAMATSU PHOTONICS NORDEN AB: Torshamnsgatan 35 16440 Kista, Sweden, Telephone: (46)8-509 031 00, Fax: (46)8-509 031 01 E-mail: info@hamamatsu.se
Italy: HAMAMATSU PHOTONICS ITALIA S.R.L.: Strada della Moia, 1 int. 6, 20044 Arese (Milano), Italy, Telephone: (39)02-93 58 17 33, Fax: (39)02-93 58 17 41 E-mail: info@hamamatsu.it
China: HAMAMATSU PHOTONICS (CHINA) CO., LTD.: 1201 Tower B, Jiaming Center, 27 Dongsanhuan Beilu, Chaoyang District, 100020 Beijing, P.R. China, Telephone: (86)10-6586-6006, Fax: (86)10-6586-2866 E-mail: hpc@hamamatsu.com.cn
Taiwan: HAMAMATSU PHOTONICS TAIWAN CO., LTD.: 13F-1, No.101, Section 2, Gongdao 5th Road, East Dist., Hsinchu City, 300046, Taiwan(R.O.C), Telephone: (886)3-659-0080, Fax: (886)3-659-0081 E-mail: info@hamamatsu.com.tw

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