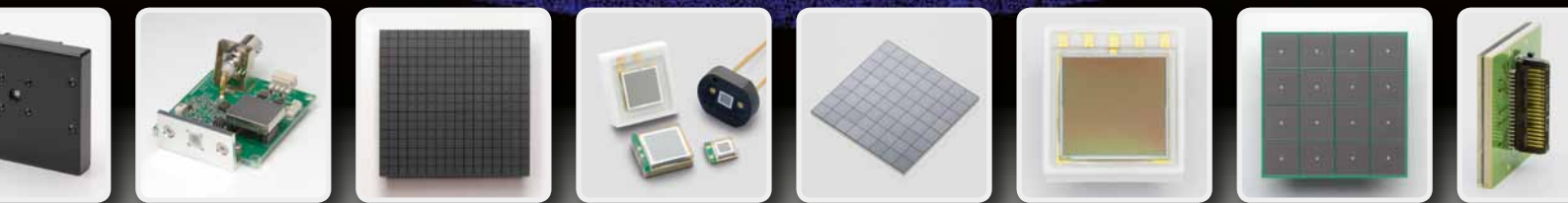


Compact Instrumentation

for Low-Light Detection



COVER STORY

PAGE 2

MPPCs[®] – Multi-Pixel Photon Counters for High Energy Physics Experiments

OPTO-SEMICONDUCTOR PRODUCTS

PAGE 11

**Fingertip size, ultra-compact
Micro-Spectrometer**

ELECTRON TUBE PRODUCTS

PAGE 17

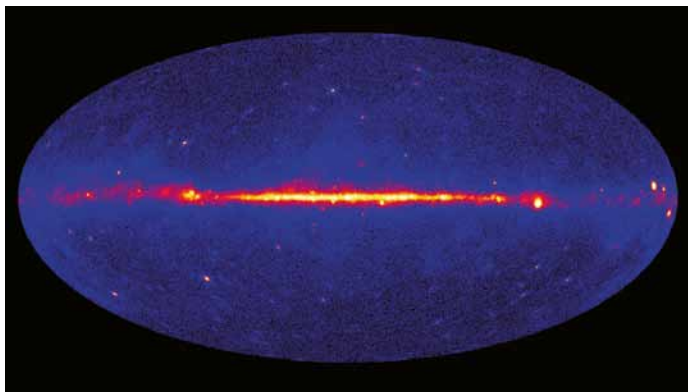
**The world's smallest, thinnest
and lightest Micro PMT Module**

SYSTEMS PRODUCTS

PAGE 24

**W-VIEW GEMINI – simultaneous
dual wavelength imaging**

Cover Story



The cover picture shows the first light map of the gamma-ray sky taken by Fermi Gamma-ray Space Telescope.

The Fermi Gamma-ray Space Telescope was equipped with Hamamatsu Photonics photomultiplier tubes and silicon strip sensors.

This is just one example where Hamamatsu Photonics worked closely with the scientists to provide technology solutions for a demanding High Energy Physics experiment.

MPPCs® – Multi-Pixel Photon Counters for High Energy Physics Experiments

Imagine – The Ultimate Detector

Once again, the HEP (High Energy Physics) community triggered a development that influenced, in this case, the whole Photonics world and eventually daily life too.

The goal of the community was to be able to count photons over a large area, under strong magnetic fields. The detector should work at room temperature and yes, it would be nice if it could be very fast too. The HEP community also made clear that to succeed we needed to offer the new technology at very challenging prices.

With the help of the HEP community, Hamamatsu Photonics accepted this challenge and together we started with the well-known Geiger-Mode effect in an avalanche diode. That meant we had to go from an active surface of some tens of microns, cooled down to -20/40 deg. C., to surfaces of square meters and of course uncooled.

We are proud to say that we succeeded in this challenge!

The result and solution are our SiPM (Silicon Photo Multipliers) called MPPC® (Multi Pixel Photon Counters). Instead of having just one active area, we covered a large surface with thousands of avalanche

pixels, each of them with its own quenching resistor. Pair this idea together with Hamamatsu's design and outstanding solid state physics knowledge and state-of-the-art in-house processing with MOEMS capabilities, and you have – **The Ultimate Detector**. The MPPCs are the result of years of work, research and hundreds of prototypes.

MPPCs enable photon counting at room temperature, with relatively high dynamic range, high speed, at low voltages and in the size of a standard photodiode, all for a reasonable cost. So the HEP community reached its goal too and they will be able to use the MPPCs for building various detectors like Calorimeters, Trackers, Triggers and cameras for Astrophysics etc. The first application to use this technology outside the HEP community has been in nuclear medicine and the first PET Scanners using our MPPC will soon be on the market. But all other fields in Photonics recognized the potential of our new technology and are catching up fast by adopting the MPPC in their new developments, like LIDAR and analytical applications. And since it is basically a "normal" photodiode, we can customize it in any active area shape desired. We can form 1D or 2D monolithic arrays or in discrete assemblies in various packages.

Imagine what you could do with the ultimate detector!

		Medical	Life Science	Drug Discovery	Measurement	Analytical	Semicond. Prod.	Optical Comms	Security	Industry	ND Inspection	Academic Research
OPTO-SEMICONDUCTOR PRODUCTS												
10	MEMS-FTIR C12606 Series											
11	Micro-Spectrometer C12666MA											
12	InGaAs Area Image Sensor G12242-0909W											
13	InAsSb Photodiode P12691-201											
14	SERS Substrate J12853											
15	CMOS Linear Image Sensor S12443											
16	Si APD S12926 Series											
ELECTRON TUBE PRODUCTS												
17	Micro PMT Module H12402/H12403 Series											
18	Head-on Type Photomultiplier Tube R12421/P											
19	Photomultiplier Tube Assembly R8874-01											
20	Photomultiplier H12445-100/-200, H12428-100/-200											
21	NIR (Near Infrared) PMT Unit H12694-25/-45/-75											
22	Amplifier Unit C6438-02											
23	Compact MCP Assembly F12395-11, F12396-11											
SYSTEMS PRODUCTS												
24	W-VIEW GEMINI A12801-01											
25	X-ray TDI Camera C12200 Series											
26	ORCA-Flash4.0 LT											
LASER PRODUCTS												
32	Quantum Cascade Laser L12004-2209H-C, L12004-2310H-C											
33	10 μ m Pulse-Type Quantum Cascade Laser L12020-0993T-C											

COVER STORY

- 2 MPPCs® – Multi-Pixel Photon Counters for High Energy Physics Experiments

COMPANY NEWS

- 4 Photon Fair 2013
- 5 SSDs and APDs helped confirm the existence of the Higgs boson
- 6 25 years supporting the Photonics Community in Northern Europe

APPLICATION REPORT

- 7 Histology and Pathophysiology of bone
- 8 Monitoring early embryogenesis via light sheet Microscopy

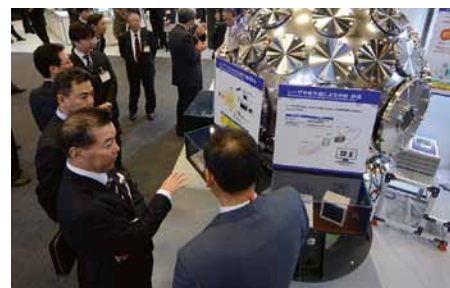
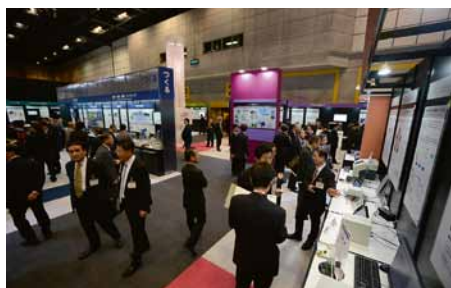
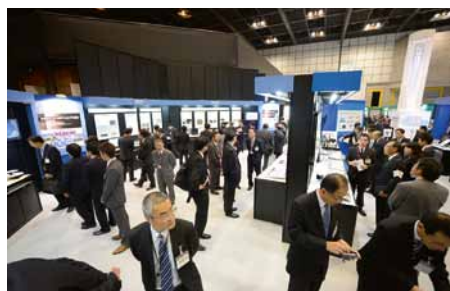
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- 28 New Methods of Plastic Welding and Soldering using Semiconductor Lasers

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Company News



PHOTON FAIR 2013

Hamamatsu Photonics K.K. Exhibition PHOTON FAIR 2013 was held from the 7th to 9th November 2013, in celebration of Hamamatsu Photonics' 60th anniversary. Through the main theme "Leading with Light," we presented our latest optical technology and products and suggested various ways in which optical technology will contribute greatly to advanced manufacturing.

The event ended on a high note. We also held lecture presentations by invited external speakers, our CEO and the executive managing director of each division.

In addition many visitors participated in the approximately 40 technical seminars held by our employees.

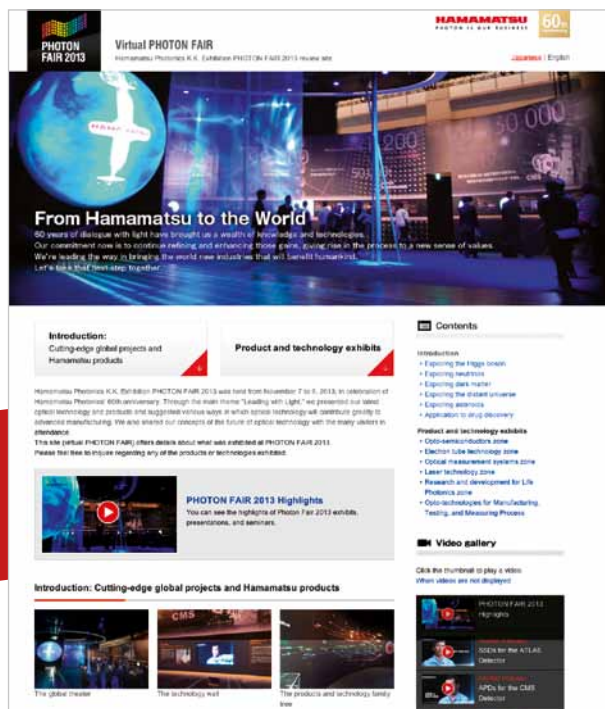


Now available
Virtual PHOTON FAIR released
www.photonfair.jp/en/

We had released virtual PHOTON FAIR which contains the essences of PHOTON FAIR 2013.

The contents include cutting-edge global projects and showcase the very latest Hamamatsu products and technologies.

Please visit the website for further information.



Virtual Photon Fair includes video interviews of the persons in charge of product development, and a live report direct from the exhibition.

SSDs and APDs helped confirm the existence of the Higgs boson

The LHC (Large Hadron Collider) project of CERN (the European Organization for Nuclear Research) stretches 27 km. For its sensors, it uses SSDs (silicon strip detectors), APDs (avalanche photodiodes), and PMTs (photomultiplier tubes).



Silicon strip detectors installed in the CMS experimental apparatus (courtesy of CERN)

APDs used as calorimeters in the CMS experiment

The APDs have a photosensitive area of 5 mm by 5 mm. They are used in combination with scintillators. To achieve optimal performance under harsh conditions in a strong magnetic field with radiation, optosemiconductors were used, which are strong in strong magnetic fields.



SSDs used in the ATLAS and CMS experimental apparatus to detect particle tracks

Approximately 14,000 SSDs are used for the ATLAS experiment, 22,000 for the CMS experiment and an SSD is a diode array in a strip shape. It detects the positions particles pass through with a resolution of several tens of μm .



What is the Higgs boson?

The Higgs boson is a particle that gives all kinds of matter mass. It is known as the "God particle," but had not been discovered until now. CERN (the European Organization for Nuclear Research) was trying to confirm the existence of the Higgs boson by continued experiments at their Large Hadron Collider (LHC), the world's largest particle accelerator, a 27 km circuit in suburban Geneva, Switzerland. In 2013, its existence was confirmed, and emeritus professors Francois Englert and Peter Higgs, who foretold its existence half a century earlier, were awarded the 2013 Nobel Prize in Physics.

When protons collide near the speed of light, the energy causes the creation of new particles. Hamamatsu Photonics' sensors are used to investigate the nature of the particles by detecting the direction (track) they fly and their energy.

In the equipment for the ATLAS and CMS experiments, SSDs have been used to detect particle tracks (supplied since 1999). PMTs are used to detect minute light for calorimeters to detect particle energy in ATLAS and CMS, and APDs are used in CMS.

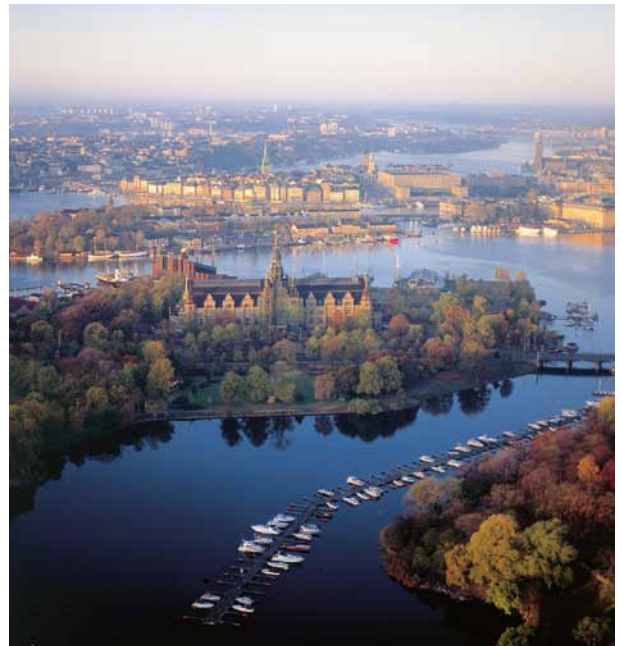


The CMS Award received from CERN in 2003 and 2005

Company News



Moscow



Stockholm

25 years supporting the Photonics Community in Northern Europe

The Northern European branch of Hamamatsu was established in Stockholm, Sweden, at the end of the eighties, with the primary goal to develop the local support of existing and potential business opportunities in Scandinavia and Finland.

Being a small scale operation with a handful of team members in the beginning, the business and the organization developed successfully over the years and today Hamamatsu Photonics Norden AB (HPN) is a well-recognized and active partner in the photonics community in the Nordic countries, supporting development of scientific and industrial projects within a wide range of technologies and application fields.

The changes in Europe during the nineties opened up exciting possibilities to develop business in Eastern Europe and as a consequence a representation office was established in Moscow at the beginning of the new millennium, offering local service and support to all our customers and partners in Russia and CIS (Commonwealth of Independent States).

Max Skoglund, Managing Director, would like to thank all customers during these 25 years for a fruitful and successful cooperation. HPN will continue aiming to be the natural choice for customers interested in photonics, striving to have a flexible organization with a qualified group of staff, co-operating with present and potential customers to develop profitable business solutions for our products and services.

Histology and Pathophysiology of bone

Pathophysiology of Bone Resorption Laboratory, INSERM UMR957, Nantes University, France

In 2011, our research laboratory acquired a digital slide scanner, the Hamamatsu NanoZoomer 2.0-RS. It converts up to 6 glass slides into digital slides by scanning them automatically and quickly at high resolutions (up to x40). The purchase was made possible thanks to INSERM (Plan Cancer 2009-2013).

Bone cancer research

We are interested in the molecular and cellular mechanisms involved in the pathogenesis of bone tumors. Our works cover the basic research, the preclinical and clinical aspects in this field.

Example A: First, this slide scanner allows us to more easily archive digital slides without worrying about sample deterioration. This is especially important in animal experimentations where hundreds of slides are typically analyzed at the same time.

Secondly, digital slides are easy to send to our collaborators in France or other countries for expertise or even diagnosis. Primary bone tumors such as osteosarcoma are rare diseases and the expert pathologists in the field are now questioned by email.

Lastly, image view, annotation and analysis can be performed “at home” on any computer, especially when using a file storage online. Researchers and students can now count, for example, bone cells (osteoblasts, osteoclasts etc) from anywhere, anytime they want.

Education, training and popular science

Using the NanoZoomer and its digital slides renders easier to explain bone histology, immunohistochemistry or in situ hybridization to students in an amphitheater, technicians at the bench or even to the public.

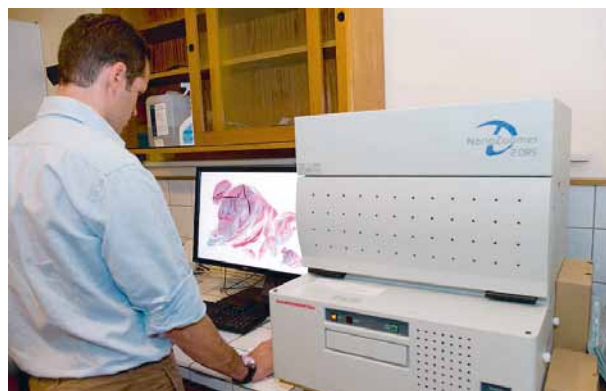
Low resolution view

Example B: In comparison to standard microscopy, the low resolution images obtained with the NanoZoomer are clearer and brighter, which is especially interesting to visualize a whole organ or tissue such as bone or primary tumor.

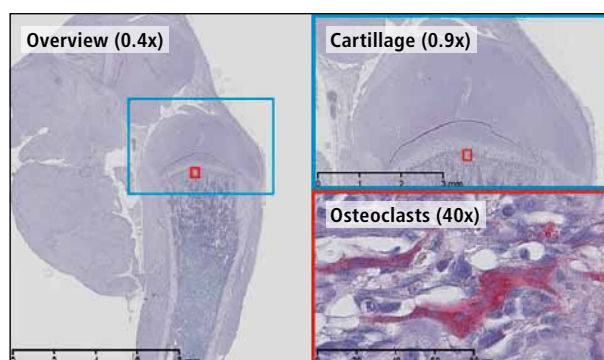
Automation of analysis

As an option (not used in the lab), combining the NanoZoomer to NDP. Analyze provides the ability to log on and analyze digital slides from anywhere. Sophisticated APPs (Application Protocol Packages) can be operated locally or via Cloud computing.

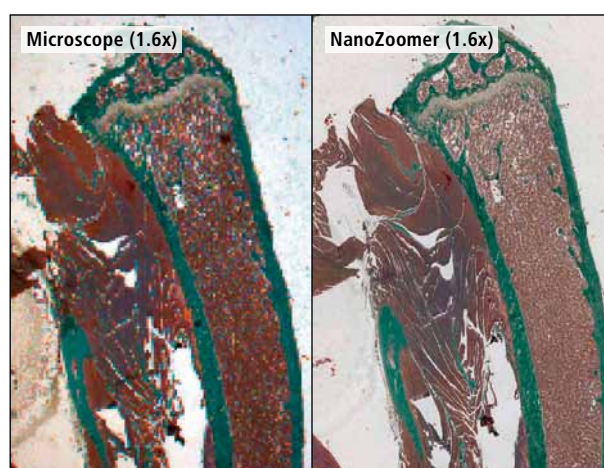
Authors: Pr D. Heymann and Dr F. Blanchard



Bone cancer research



Example A



Example B

Application Report

Monitoring early embryogenesis via light sheet Microscopy

Single-plane illumination microscopy (SPIM) is a fluorescence imaging technique that combines rapid wide-field detection with optical sectioning. By reducing phototoxicity induced by bleaching, SPIM is capable of providing a long-term, three-dimensional and time-resolved in vivo imaging of specimen.

"We have built and automated a SPIM setup specifically designed for imaging the early stages of embryogenesis of the small nematode *Caenorhabditis elegans*" explains Philipp Struntz, graduate student in the group of Prof. Matthias Weiss (Dept. of Experimental Physics I, University of Bayreuth). The setup consists of the widened beam of a 491.5 nm DPSS-laser, which is focused in one dimension by a cylindrical lens onto the back-focal plane of a water-dipping objective to form an elliptically deformed Gaussian beam that serves as light sheet (minimum waist of 2.8 mm FWHM). Fluorescence from the sample is collected perpendicular to the illumination light sheet by a second water-dipping objective. Fluorescence light is filtered and focused onto the sensor of an ORCA-Flash 4.0 sCMOS-camera (Hamamatsu Photonics). The lateral and axial extension of the setup's point-spread function was determined with FluoSpheres (diameter 20 nm) to be 460 nm and 1.4 mm in the light sheet waist.

As can be seen from figure 1, objectives are arranged in an angle of 45° degree with respect to the optical table. The sample is moved with respect to the light sheet by two motorized stages in xy-direction. A nanopositioner allows for moving the sample through the light sheet with a precision of a few nm, hence enabling the acquisition of three-dimensional image stacks of the sample.

The setup is controlled via a custom-made LabVIEW program that also has an interface to the HOKAWO imaging software (Hamamatsu Photonics) that controls the camera.

Post-processing of raw images, i.e. aligning individual sections to obtain three-dimensional data, is done with a custom-made Matlab code. With this approach, nuclei can be tracked in the developing embryo and even division axes during mitotic events can be assessed.

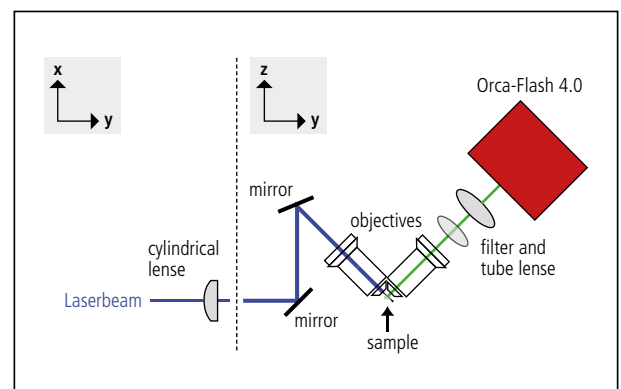


Figure 1:
SPIM-Setup: Sketch of the beam path of the custom-made SPIM. All parts left from the dashed line are shown from the top whereas all parts on the right are shown from the side.

Application Report

Philipp Struntz explains the experiment conditions: We repetitively acquired 51 optical sections (separated by a distance of 2 μm) of a *C. elegans* embryo with an exposure time of 50 ms per layer. Stack acquisition was repeated every 60 s to cover early developmental processes. Representative individual sections of this imaging are shown in figure 2a, the maximum projection obtained from the three-dimensional data is depicted in figure 2b. Since cell lineages in *C. elegans* are invariant, not only trajectories but also the type of individual cells could be identified in three dimensions over time. An example is shown in figure 2c.

Based on our data, we observed in all cases a planar cell arrangement in 4-cell embryos, and cell movements and division axes were strikingly similar between embryos, states Philipp Struntz. It is tempting to conclude on this basis that mechanical cues support the cell arrangement in early *C. elegans* embryogenesis*. The obtained time lapse images allowed us to quantitatively monitor individual cell positions and division axes within the developing embryo. These data build a valuable starting point for a deeper understanding of the spatiotemporal dynamics of developing tissues.

Prof. Matthias Weiss concentrates in his research on challenging problems at the interface of physics and biology. His group focuses on a quantitative understanding of intracellular transport processes, on elucidating interactions of proteins and membranes, and on the dynamics and self-organization of eukaryotic cells from the organelle to the organismal level.

For further information see the website of the Dept. of Experimental Physics I, University of Bayreuth, <http://www.ep1.uni-bayreuth.de/weiss/en/index.html>

*Fickentscher, Struntz and Weiss, Mechanical cues in the early embryogenesis of *Caenorhabditis elegans*, to appear in *Biophys. J.* 105(8), (2013).

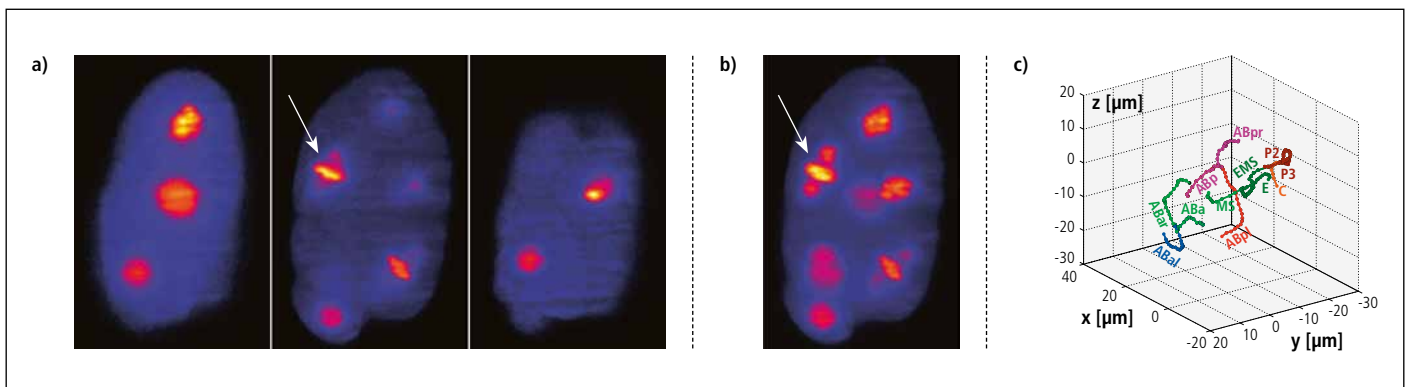


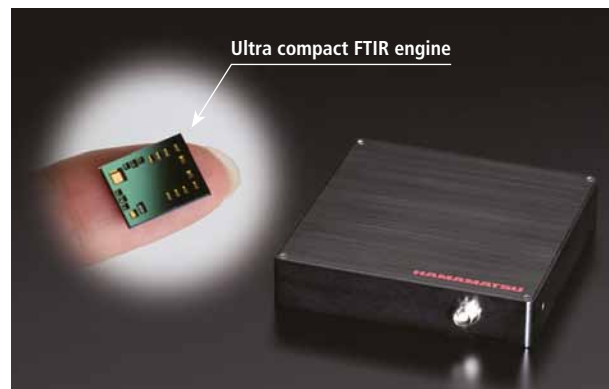
Figure 2:
a) Different layers of a *C. elegans* embryo (long axis 50 μm) in the 8-cell stage.
b) Maximum projection of all 51 sections of the embryo in (a), showing all 8 nuclei positions with a high contrast.
c) Example of three-dimensional cell trajectories. Cells are color-coded and named. Cell divisions are visible as branching points of trajectories.

MEMS-FTIR C12606 Series

NEW

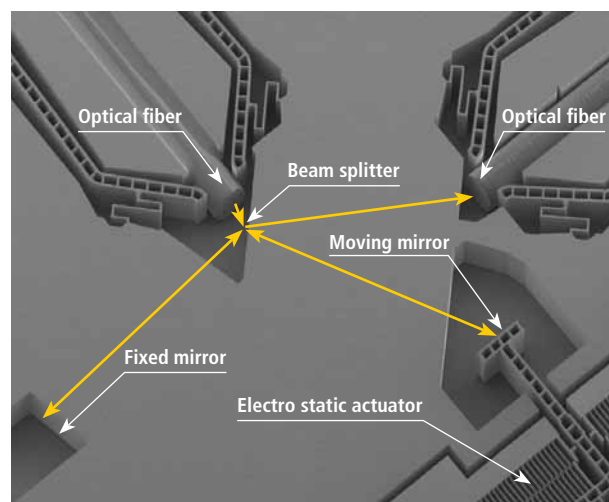
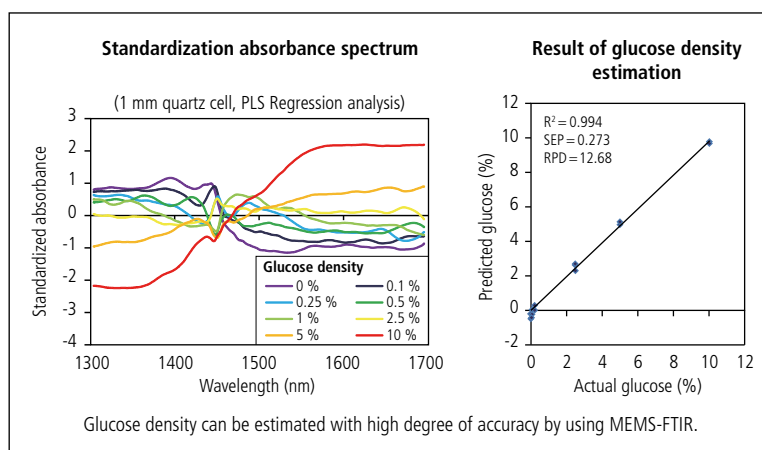
Compact NIR spectrometer with a built-in fingertip size MEMS-FTIR engine

MEMS-FTIR (Fourier Transform Infrared) spectrometer is a compact and low-cost Fourier transform infrared spectrometer, where a Michelson Interferometer and infrared detector are packaged in a small housing. Connecting it to a PC via a USB cable allows spectrum measurement and absorbance measurement.



C12606 series

Glucose solution measurement



SEM image of MEMS interferometer

Specifications

Parameter	Symbol	C12606-01	C12606-02	Unit
Spectral response range	λ	1.15 to 1.65	1.15 to 2.05	μm
Spectral resolution (FWHM) *1	$\Delta\lambda$	8 ($\lambda=1.65 \mu\text{m}$)	12 ($\lambda=2.05 \mu\text{m}$)	nm
SNR *2	25 deg. C.	30	29	dB
	40 deg. C.	29	25	
Scan rate *3	-	5		ms
Dimensions (W x D x H)	-	100 x 75 x 27		mm

*1 About 29 cm^{-1} in wavenumber

*2 On a condition of about 600 μW white light input at a fiber ($\phi 200 \mu\text{m}$, $\text{NA}=0.2$), 1 s integration time

*3 The minimum time to acquire an optical spectrum, cutoff frequency: 200 Hz

Micro-Spectrometer C12666MA

NEW

Fingertip size, ultra-compact spectrometer head integrating MEMS and image sensor technologies

A micro-spectrometer is an ultra-compact spectrometer head developed utilizing MEMS and image sensor technologies. The adoption of a newly designed optical system has achieved a remarkably small size, less than half the volume of the previous mini-spectrometer MS series (C10988MA-01). Its package is hermetically sealed for high reliability versus humidity. The spectral response range is from 340 to 780 nm and so is used to measure light in the visible region. Micro-spectrometers are ideal for assembly into portable equipment requiring color control such as handheld color monitors and printers.

Features

- Fingertip size: 20.1 × 12.5 × 10.1 mm
- Weight: 5 g
- Hermetic package: high reliability against humidity
- Installation into mobile measurement equipment
- Designed for use in combination with portable devices such as smartphones and tablets

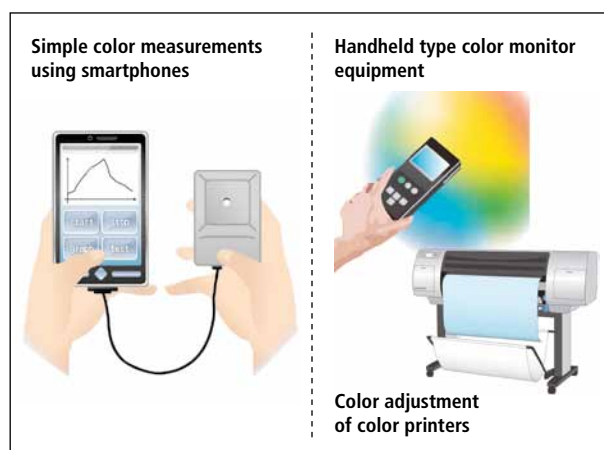
Applications

- Color monitoring for printers and printing machines
- Testers for lights and LEDs
- Color adjustment of various large size displays
- Water quality control monitors and other environment measuring instruments



C12666MA

Application examples



Specifications

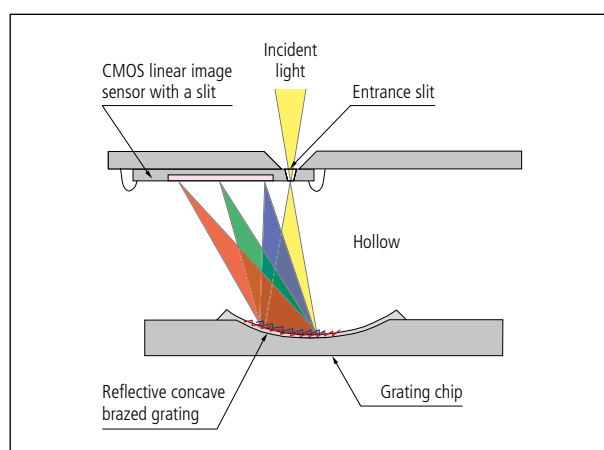
Parameter	Value	Unit
Spectral response range	340 to 780	nm
Spectral resolution (FWHM)	15 max.	nm
Spectral stray light *1	-25	dB
Slit (H x V)	50 x 750	μm
NA	0.22	-
Number of pixels	256	pixels
Pixel size (H x V)	12.5 x 1,000	μm
Dimensions (W x D x H)	20.1 x 12.5 x 10.1	mm

*1 Spectral stray light = 10 × log (TI/Th)

Th: count measured when light at a certain wavelength is input

TI: count measured at a wavelength 40 nm longer or shorter than the input light wavelength

Structure



InGaAs Area Image Sensor G12242-0909W

NEW

2-D InGaAs image sensor for easily capturing a near infrared image

The two-dimensional InGaAs image sensor G12242-0909W is a sensor for easily capturing a near infrared image. An InGaAs photodiode chip is connected with ROIC, and then each channel is read out from a shift-register. The ROIC incorporates a timing generator, so video output can be obtained by simple digital input. The temperature of the InGaAs photodiodes in the package can be controlled constantly with a built-in TE-cooler and a thermistor.

Features

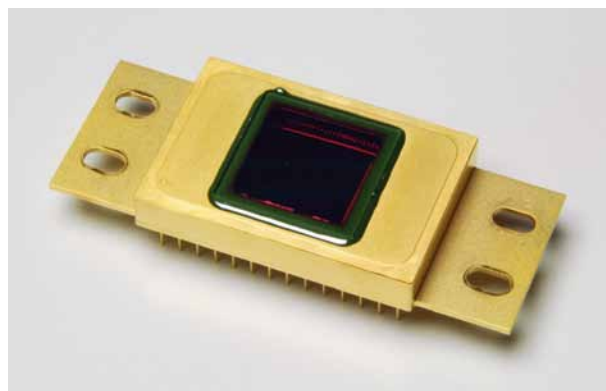
- Spectral response range: 0.95 to 1.7 μm
- 640 x 512 pixels
- Two-stage TE-cooled type
- Preparing a multichannel detector head (C12376)

Applications

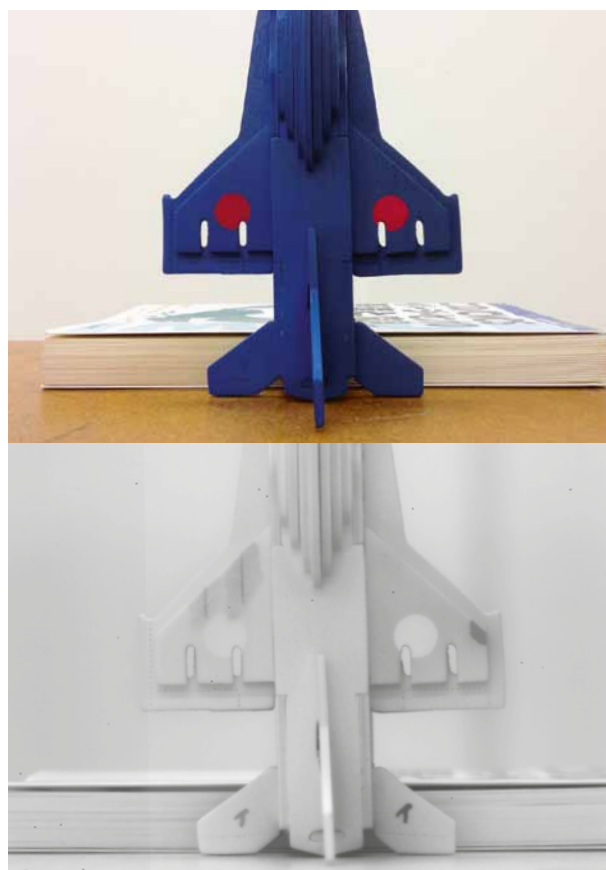
- Semiconductor wafer defect analysis
- Person recognition in low visibility environment
- Near infrared imaging

Specifications

Parameter	Symbol	Value	Unit
Number of pixels	-	640 x 512	pixels
Pixel pitch	-	20	μm
Peak sensitivity wavelength	λ_p	1.55	μm
Frame rate	-	30	frames/s
Conversion efficiency	CE	2	$\mu\text{V}/\text{e}^-$
Saturation charge	Qsat	500	ke^-
Saturation output voltage	Vsat	1	V
Photoresponse nonuniformity	PRNU	± 10	%
Dark output	Vd	6.25	V/s



G12242-0909W



Near-infrared imaging of a color-painted wooden airplane toy makes visible the cracks, traces of resin, and characters underneath the paint layer, etc.

InAsSb Photodiode P12691-201

NEW

InAsSb photodiode with high-speed response and high sensitivity in the 8 μm spectral band

The P12691-201 is an infrared detector that provides high sensitivity in the 8 μm spectral band by integrating a lens using our unique crystal growth technology and back-illuminated structure. The InAsSb photodiode has a PN junction that ensures high-speed response and high reliability. Typical applications include gas analysis such as NO, NO₂, and N₂O. The P12691-201 is easy to use as it uses a compact TE-cooled package (TO-8) not requiring liquid nitrogen.

Features

- High speed response
- High sensitivity
- High reliability
- Compact, thermoelectrically cooled TO-8 package
- RoHS compliant
- Can be assembled in a module with QCL

Applications

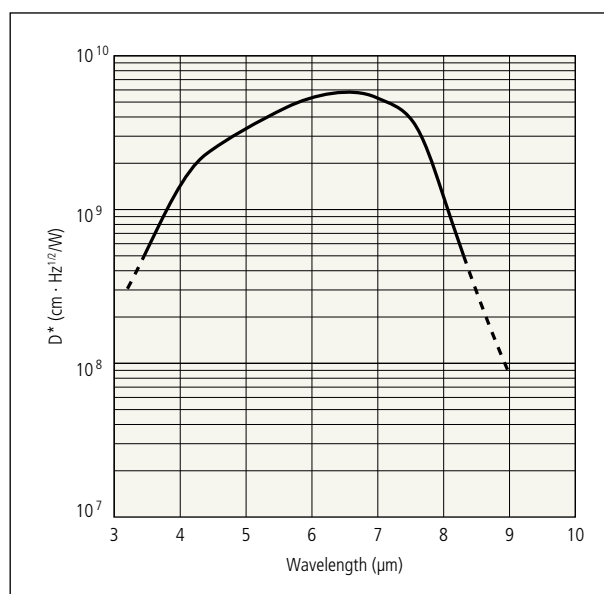
- Gas analysis
- Radiation thermometers
- Thermal imaging
- Remote sensing
- FTIR
- Spectrophotometers



P12691-201

Spectral response

(Typ. Td = -30 deg. C.)



Specifications

Parameter	Condition	Min.	Typ.	Max.	Unit
Photosensitive area	-	$\phi 1.0$			mm
Peak sensitivity wavelength	-	-	6.7	-	μm
Cutoff wavelength	-	8.2	8.3	-	μm
Photosensitivity	$\lambda = \lambda_p$	0.8	1.2	-	A/W
Shunt resistance	$V_R = 10 \text{ mV}$	13	40	-	Ω
Detectivity	$(\lambda_p, 600, 1)$	4.0×10^9	6.0×10^9	-	$\text{cm} \cdot \text{Hz}^{1/2}/\text{W}$
Noise equivalent power (NEP)	$\lambda = \lambda_p$	-	1.5×10^{-11}	2.3×10^{-11}	$\text{W}/\text{Hz}^{1/2}$
Rise time	$V_R = 0 \text{ V}, R_L = 50 \Omega$ 0 to 63 %	-	-	10	ns

SERS Substrate J12853

NEW

SERS substrate suitable for high-sensitivity Raman spectroscopic analysis

The SERS* substrate is a disposable substrate using nanoimprint technology, and can be used to enhance Raman scattering light for molecular measurement. It facilitates high-sensitivity Raman spectroscopic analysis.

Features

■ Uniform activated surface structure

The activated surface structure that enhances Raman scattering light (active area) is made of gold. Nanoimprint technology is used to form a fine pattern to produce a uniform structure.

■ Structure for protecting the active area

To effectively produce the performance of the SERS substrate, adsorption of contamination of the activated structure (active area) on the SERS chip must be prevented.

■ Easy measurement of solution samples

SERS substrate J12853 has a well structure, making it convenient for measuring solution samples. In addition, to allow measurements of a wide variety of samples, the handling plate is made of polypropylene, which has high chemical resistance among commodity plastics.



J12853

*SERS: Surface Enhanced Raman Spectroscopy

Specifications

Parameter	Specification	Unit
SERS substrate size	76 x 26 x 3.6	mm
SERS chip size	4 x 4	mm
Active area	2.7 x 2.7	mm
Well structure capacity	6	μL
Activated surface structure	Gold nano-structure	-
Handling plate material	Polypropylene	-
Raman excitation wavelength (recommended)	785	nm

CMOS Linear Image Sensor S12443

NEW

Small package type CMOS linear image sensor (2,496 pixels)

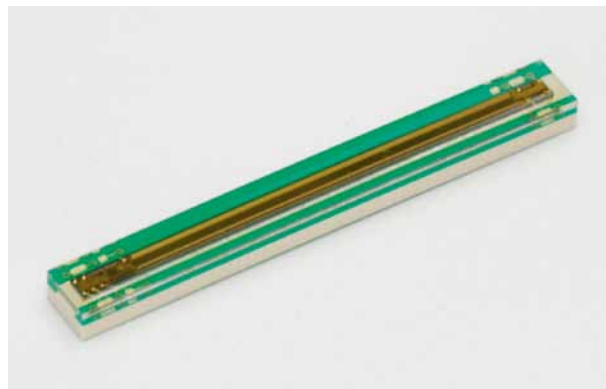
The S12443 is a compact CMOS linear image sensor designed for barcode readers, encoders, and image input applications. The CMOS process allows sensor operation with two digital signals of CLK and ST. The input terminal capacitance is as small as 5 pF, so the digital signal drive IC exhibits low power consumption and the operating speed is enhanced.

Features

- Small package: 2.7 x 22.9 x 1.6 mm
- 3.3 V single power supply operation
- High sensitivity: 500 V/(lx·s)
- Video data rate: 10 MHz max.

Applications

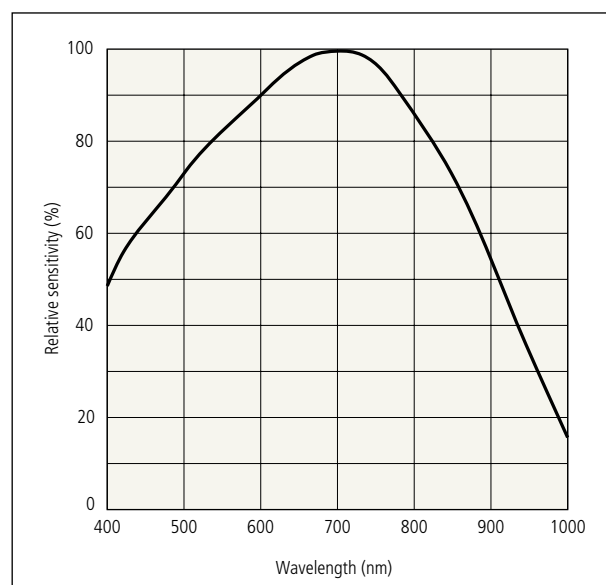
- Barcode reader
- Position detection
- Encoders
- Image reading



S12443

Spectral response (typical example)

(Ta = 25 deg. C.)



Specifications

Parameter	Value	Unit
Number of pixels	2,496	pixels
Pixel pitch	7	μm
Pixel height	125	μm
Photosensitive area length	17.472	mm
Spectral response range	400 to 1,000	nm

Si APD S12926 Series

NEW

Si APD with a bandpass filter for 900 nm band for optical rangefinder

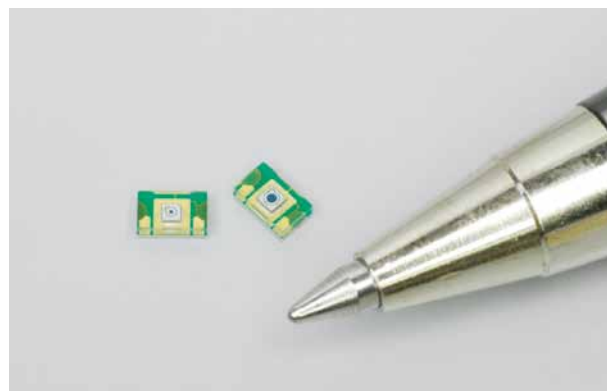
The S12926 series is a Si APD with a bandpass filter suitable for detection of light sources in the 900 nm band widely used for optical rangefinders. The S12926 series is available in a small surface-mount package and operates at low bias voltage, making it ideal for handheld distance meters.

Features

- Miniature and thin package: 1.8 x 3.1 x 1.0 mm
- Stable operation at low bias (Breakdown voltage = 200 V max.)
- High-speed response: cutoff frequency = 700 MHz (S12926-02/-02F)
- Low price
- With 900 nm bandpass filter (S12926-02F/-05F)

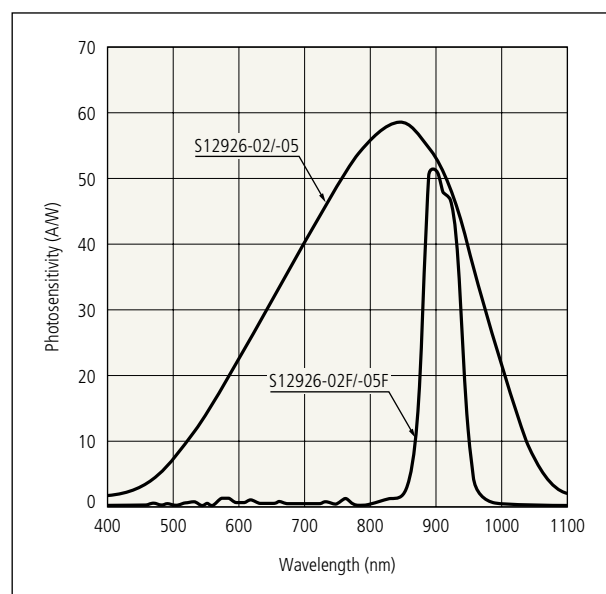
Application

- Optical rangefinders



S12926-02, S12926-05

Spectral response (Typ. Ta = 25 deg. C., M = 100, at 900 nm)



Specifications

(Ta = 25 deg. C.)

Parameter	Condition	S12926-02/-02F	S12926-05/-05F	Unit
Effective photosensitive area size	-	φ 0.2	φ 0.5	mm
Spectral response range	M = 1 S12926-02/-05	400 to 1,100		nm
Photosensitivity	M = 100, λ = 900 nm	50		A/W
Breakdown voltage max.	I _b = 100 μA	200		V
Temp. coefficient of V _{BR}		1.1		V/deg. C.
Cutoff frequency	R _L = 50 Ω, -3 dB M = 100, λ = 900 nm	700	600	MHz
Terminal capacitance	M = 100, f = 1 MHz	0.7	1.3	pF
Center wavelength of filter	S12926-02F/-05F	905		nm
FWHM of filter		60		

Micro PMT Module H12402/H12403 Series

NEW

The first PMT modules containing the world's smallest, thinnest and lightest micro PMT*

The H12402/H12403 series are micro PMT modules with an output cable. They include a micro PMT, a voltage divider circuit, and a high-voltage power supply circuit. Both series are available in two photocathode types (bialkali or multialkali) and in two module shapes (H12402 or H12403).

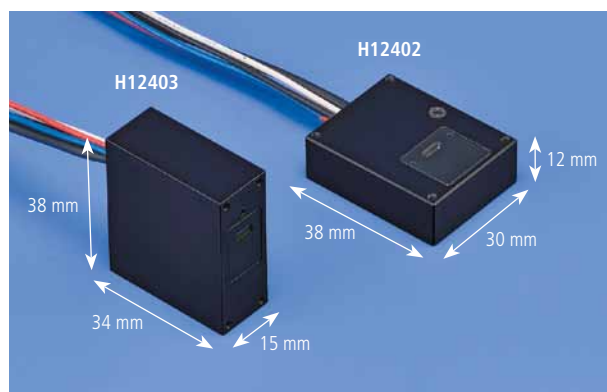
Features

- Compact
- Low voltage (+5 V) operation

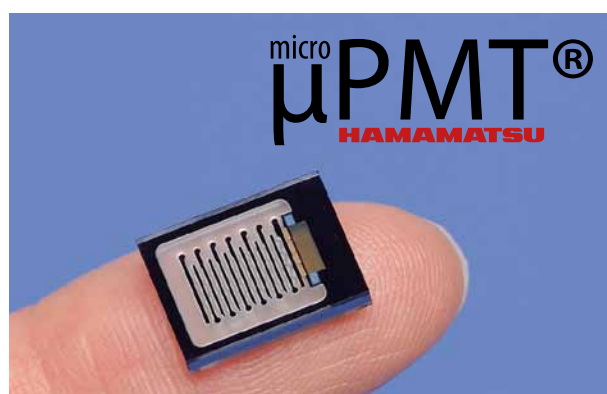
Applications

- Compact, high sensitivity instruments
 - Portable medical diagnostic devices
 - Portable environmental measurement devices
 - Medical monitors, etc.

*As of Dec. 2012, based on our research



H12402/H12403 series



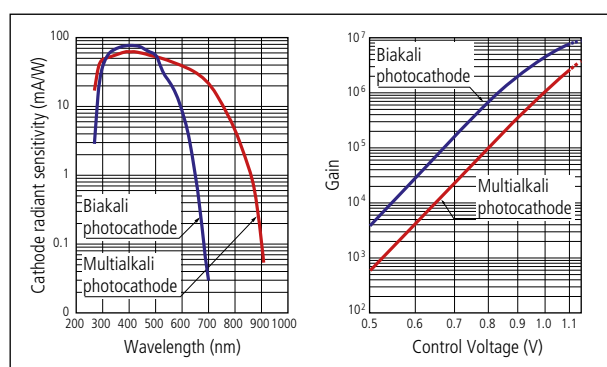
Specifications

Parameter	Specification		Unit
Suffix	none	-01	-
Spectral response range	300 to 650	300 to 850	nm
Photocathode type	Bialkali	Multialkali	-
Effective photocathode area (X x Y)	3 x 1		mm
Input voltage	+4.5 to +5.5		V
Recommended control voltage adjustment range	+0.5 to +1.0	+0.5 to +1.1	V
Cathode radiant sensitivity (typ.)	80	200	μA/lm
Anode dark current (typ.) *1 *2	0.3		nA
Rise time *1	1.2		ns

*1 Control voltage +0.9 V, at 25 deg. C.

*2 After 30 min storage in darkness

Spectral response – Gain



Head-on Type Photomultiplier Tube R12421/P

NEW

Compact PMT with low dark counts

The R12421/P are 13 mm (1/2 inch) diameter head-on photomultiplier tubes. Due to the newly designed electrodes, the electron collection efficiency is improved and the overall length is reduced from 71 mm to 43 mm when compared to the conventional product (R647). This helps improve the performance of the instruments and reduce their size and weight. The R12421P comes with a magnetic shield and HA treatment, and has lower dark count than the R12421.

Features

- Compact
- Low dark counts
- Good PHD and plateau characteristics

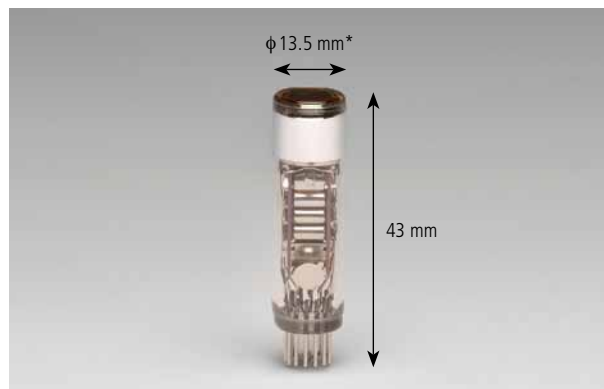
Applications

- Photon counting
 - Hygiene monitoring
 - Clinical testing
 - Fluorescence/bioluminescence observation
- Scintillation counting
 - Survey meters
 - PM2.5 monitors

Specifications

Parameter	Specification	Unit
Spectral response range	300 to 650	nm
Photocathode type	Bialkali	-
Effective photocathode area	$\phi 10$	mm
Gain (typ.) *1	2×10^6	-
Dark counts (typ.) *1	80 (R12421) 40 (R12421P)	s ⁻¹

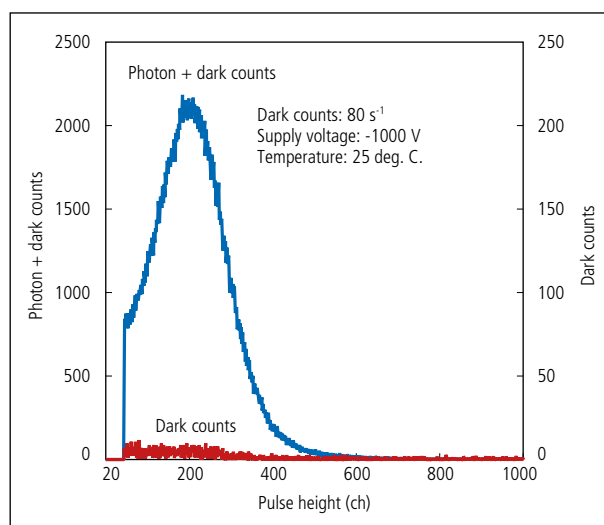
*1 Supply voltage 1,000 V, at 25 deg. C.



R12421

*R12421P is $\phi 14.3$ mm

Single photoelectron PHD



NEW

Ruggedized High Temperature Photomultiplier Tube Assembly R8874-01

High vibration resistance for use in oil well logging, with 500 m/s² operation at a rated voltage of 1,500 V

The R8874-01 uses a ceramic tube and conventional electrodes usually used in glass bulb PMT. This combination provides high vibration resistance and high gain to enhance reliability, yet offers low power consumption. The conventional highly ruggedized PMT assembly (R5473-02) has been limited in use because its rated voltage is as high as 2,000 V and so requires a higher voltage rated power supply. The R8874-01 can be operated at a lower voltage of 1,500 V, which is equal to the voltage required to operate the conventional glass bulb PMT.

Features

- High temperature operation: +175 deg. C. maximum
- High vibration resistant: 500 m/s² (50 G)
- High gain

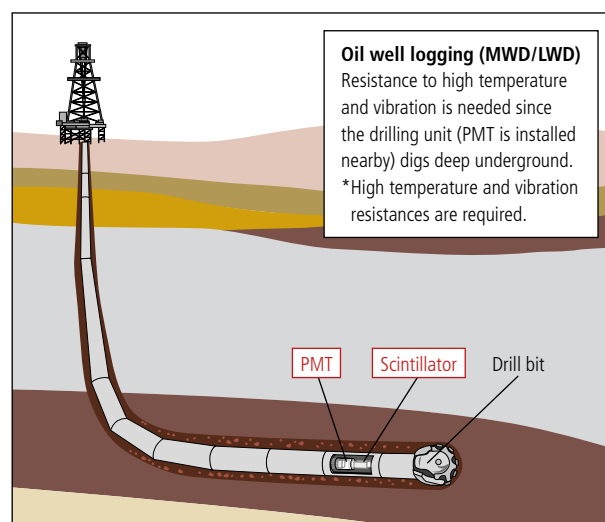
Applications

- Resource exploration
 - Oil, natural gas, etc.



R8874-01

Application example



Specifications

Parameter	Specification	Unit
Operating/storage ambient temperature	-30 to +175	deg. C.
Sine vibration	500	m/s ²
Shock	10,000	m/s ²
Gain (typ.) *1	5.0 x 10 ⁵	-
Supply voltage	1,500	V
Effective photocathode area	φ14	mm
Outer size	φ19 x 50	mm

*1 Supply voltage 1,500 V, at 25 deg. C.

Multianode Photomultiplier Tube Assembly

H12445-100/-200, H12428-100/-200

NEW

Wide effective area, high collection efficiency, compact size

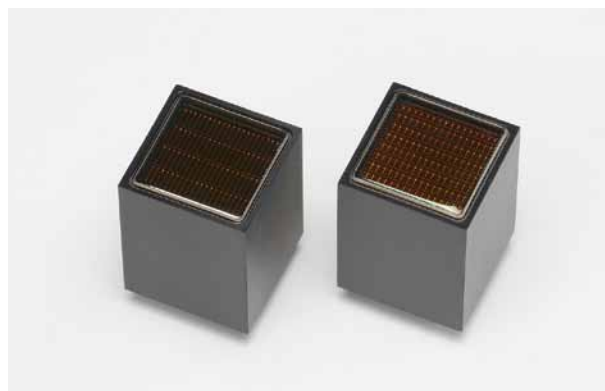
These PMT assemblies use a 1-inch square metal-package PMT with metal channel dynodes. Due to the newly designed electrodes, the effective area is increased approximately 1.6 times and the electron collection efficiency is enhanced from 75 % to 85 % (based on electron trajectory simulation) when compared to the conventional product (H8711, H7546). The overall length is also reduced from 45 mm to 39 mm. These features help improve the performance of photometric instruments and reduce their size and weight.

Features

- Wide effective photocathode area: 23 mm x 23 mm
- High quantum efficiency and collection efficiency
- High speed response

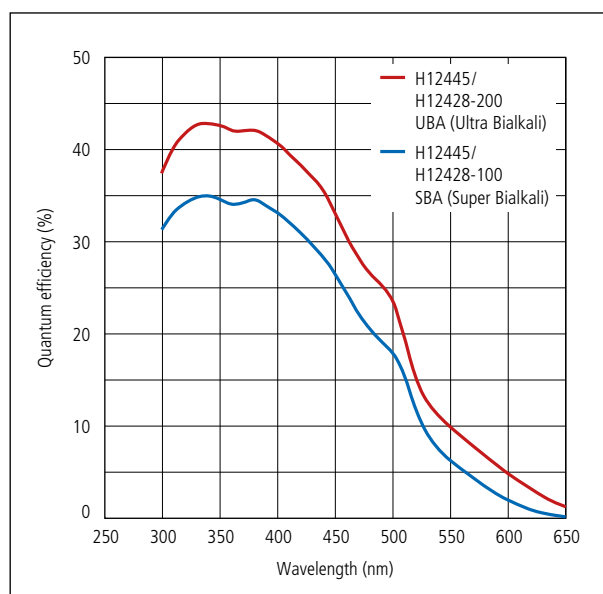
Applications

- High energy physics experiments
- Medical image diagnostic equipment (PET, gamma camera, etc.)
- Radiation measurement



H12445-100/-200, H12428-100/-200

Quantum efficiency



Specifications

Parameter	H12445	H12428	Unit
Effective photocathode area	23 x 23		mm
Spectral response range	300 to 650 *1		nm
Photocathode type	SBA (Suffix: -100) UBA (Suffix: -200)		-
Anode type	Matrix 4 x 4 (16 ch)	Matrix 8 x 8 (64 ch)	-
TTS (FWHM) (typ.) *2	0.34	0.35	ns
Outer size (W x H x D)	30 x 39 x 30		mm

*1 UV glass type is also available. Suffix: SBA -103, UBA -203 Spectral response range: 185 nm to 650 nm

*2 Per channel

NIR (Near Infrared) PMT Unit H12694-25/-45/-75

NEW

Air-cooled thermoelectric cooling, gate function

The detector unit contains a compact near-infrared PMT in a vacuum sealed-off housing. The built-in air-cooled thermoelectric cooler ensures low dark current. The high-speed gate function enables accurate measurement by eliminating influence of the background light and extracting only the necessary signals.

Features

- High sensitivity by high gain
- Gate function (normally OFF)
- High speed response
- Low noise by air-cooled thermoelectric cooling

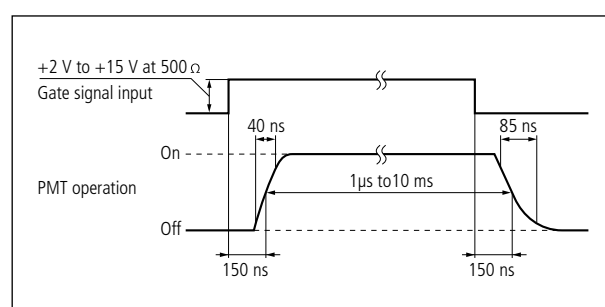
Applications

- LIDAR for atmospheric research
- Excitation singlet oxygen measurement
- Delayed fluorescence measurement



H12694-25/-45/-75

Gate timing chart



Specifications

Parameter	H12694-25	H12694-45	H12694-75	Unit
Spectral response range	950 to 1,200	950 to 1,400	950 to 1,700	nm
Photocathode type	InP/InGaAsP	InP/InGaAsP	InP/InGaAs	-
Gate width	1 μs to 10 ms			-
TTS (FWHM) (typ.)	0.4			ns
Repetition rate (max.)	10			kHz
Gain (typ.) *1	1 x 10 ⁶			-

*1 Supply voltage 800 V, at 25 deg. C.

Amplifier Unit C6438-02

NEW

Switchable output signal polarity, Frequency bandwidth DC to 50 MHz

The C6438-02 is a current-to-voltage conversion amplifier unit that amplifies input signals in inverted or non-inverted mode. The output signal polarity can be selected with a switch.

Features

- Non-inverting/inverting output switchable
- Frequency bandwidth: DC to 50 MHz
- Current-to-voltage conversion factor: 5 mV/μA

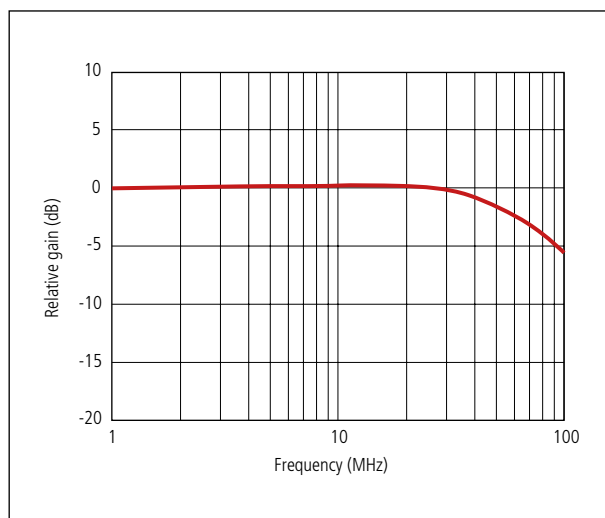
Applications

- Output signal readout from photomultiplier tube and photodiode



C6438-02

Frequency response



Specifications

Parameter	Specification	Unit
Supply voltage	±5	V
Frequency bandwidth (-3 dB)	DC to 50 MHz	-
Current-to-voltage conversion factor	5	mV/μA
Input polarity	Positive/Negative	-
Amplifying method	Non-inverting/Inverting output (switchable)	-
Maximum output signal voltage (at 50 Ω load resistance)	±1.3	V
Maximum output noise voltage	2	mV rms

Compact MCP Assembly F12395-11, F12396-11

NEW

Compact and thin assembly with easy maintenance

These are compact MCP assemblies usable in various applications ranging from general-purpose measurements to ion detection in TOF-MS (time-of-flight mass spectrometry). Its thin and flat shape permits installation in minimum spaces as add-on parts. Maintenance and servicing of this MCP assembly are quite easy since there are only 2 wiring connections.

Features

- Easy maintenance since there are only 2 wiring connections
- Robust MCP
- Compact and thin
- Output terminal: SMA connector

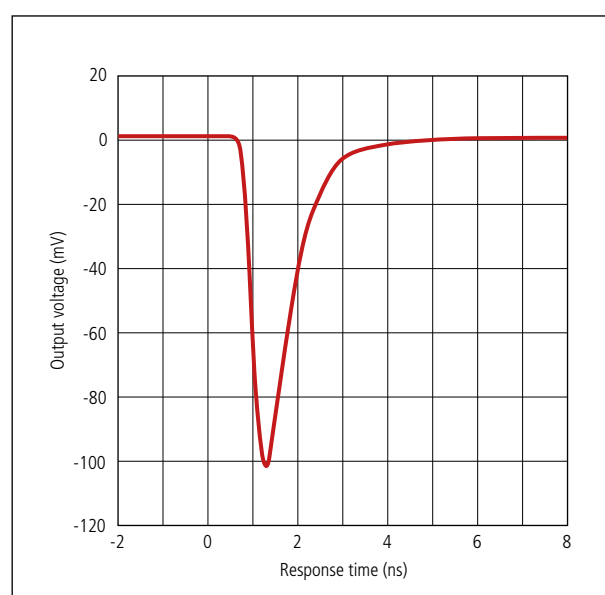
Applications

- Ion detection (TOF)
- Electron beam detection
- X-ray detection
- Vacuum UV light detection

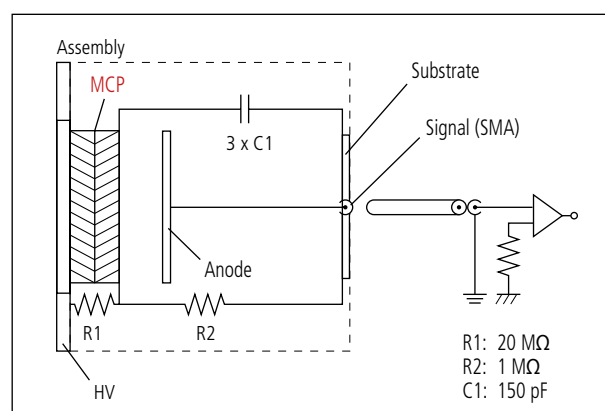


F12395-11, F12396-11

Output wavelength



Block diagram



Specifications

Parameter	F12395-11	F12369-11	Unit
Outer size (W x H x D)	41 x 61 x 15.1	52 x 72 x 15.1	mm
Effective area	φ 27	φ 42	mm
Gain (min.) *1	1 x 10 ⁶		-
Pulse width (FWHM)	1.5		ns

*1 At HV: -2.1 kV

W-VIEW GEMINI A12801-01

NEW

Simultaneous dual wavelength imaging

The W-VIEW GEMINI is an image splitting optics which provides one pair of dual wavelength images separated by a dichroic mirror onto a single camera.

Features

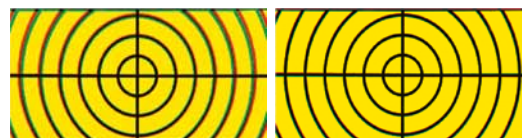
- High transmittance
- Wide field of view
- Compatible with commercially available filters
- Chromatic aberration correction mechanism
- Designed for stability on both inverted and upright microscopes



A12801-01

Chromatic aberration correction mechanism

The chromatic aberration correction mechanism improves the magnification difference of two wavelength images caused by chromatic aberration.

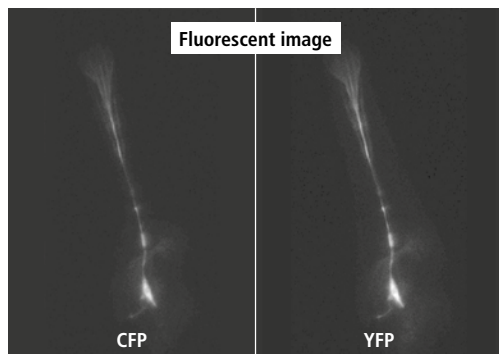


Without correction

With correction

Application example

Wide field of view and high speed Ca²⁺ imaging of YC3.60 expressing ASER neuron in *C. elegans*



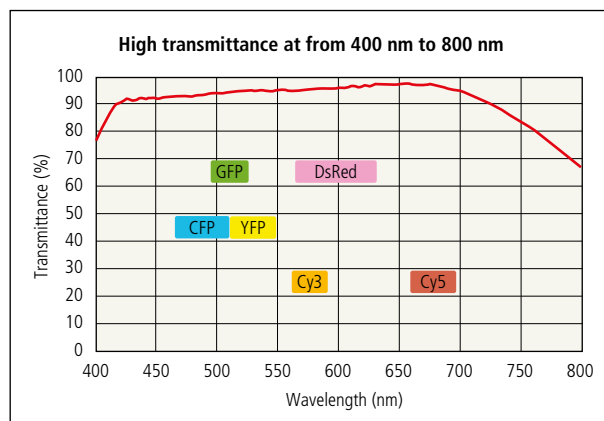
The combination of W-VIEW GEMINI and the ORCA-Flash4.0 V2 Gen II sCMOS camera realizes wide field of view dual wavelength imaging.

Sample:
C. elegans

Camera:
ORCA-Flash4.0 V2

Sample and Image courtesy of Takayuki Teramoto, Ph.D. and Takeshi Ishihara, Ph.D., Dept. of Biology, Faculty of Sciences Graduate School of Systems Life Sciences, Kyushu University

W-VIEW GEMINI transmittance in Bypass mode



X-ray TDI Camera C12200 Series

NEW

High speed imaging camera for in-line inspection

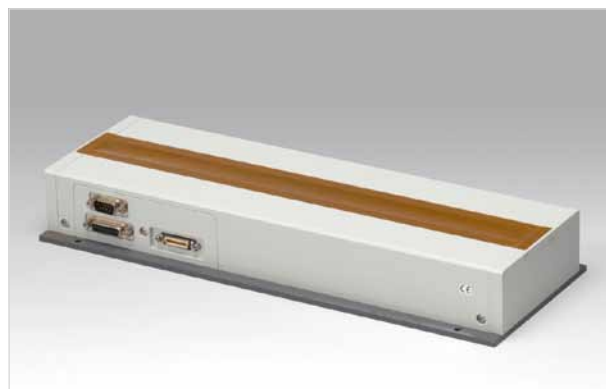
The X-ray TDI camera C12200 series is useful for in-line applications requiring high-speed operation with high sensitivity. The C12200 series has around three times the readout speed of the standard model x-ray TDI camera C10650. The C12200-461 can detect wide area with no dead areas.

Features

- High S/N ratio with 12 bit (-321)/16 bit (-461) output
- Camera Link interface (Base configuration)
- Single power supply (+15 V) operation
- Real time dark current/shading correction function
- Frame readout mode for easy installation alignment

Applications

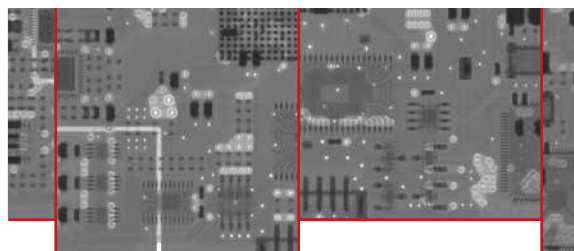
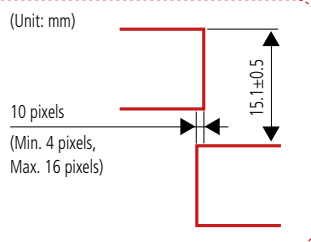
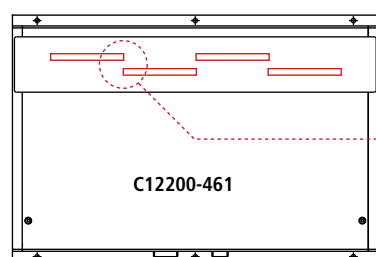
- Printed circuit board (PCB) inspection
- Surface-mounted component inspection
- Battery inspection
- High-resolution in-line non-destructive inspection



C12200-321

Wide detection area with no dead areas

The C12200-461 offers a wide detection area with no dead areas due to its staggered sensors.





Gen II scientific CMOS camera Bigger, faster images with the exceptional new ORCA-Flash4.0 LT

ORCA®-Flash4.0LT

Hamamatsu Photonics introduces a new addition to their ORCA-Flash4.0 family, the ORCA-Flash4.0 LT Gen II scientific CMOS camera.

The ORCA-Flash4.0 LT makes it easy to be brilliant – delivering excellent image quality and high reliability. It delivers 2x the speed, 3x the field of view and up to 5x the signal-to-noise of even the best interline CCD cameras.

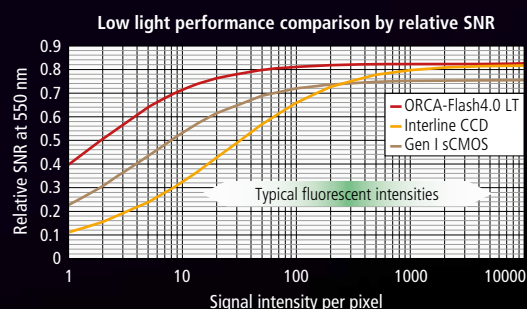
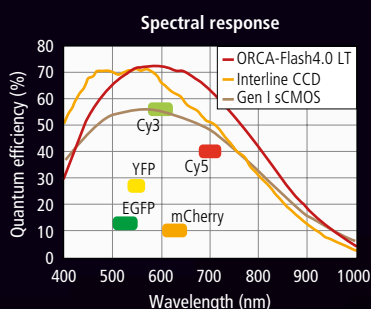
The ORCA-Flash4.0 LT brings research-grade performance to every imaging project, from bright field to fluorescence, from live cell to fixed tissue and from routine to ground-breaking. It is designed to be an ideal workhorse digital camera and a cost-effective solution for all routine imaging applications.

The ORCA-Flash4.0 LT delivers the high performance of sCMOS technology, at the price of a scientific CCD.

Performance beyond interline CCD

The combination of high quantum efficiency and low noise allows the ORCA-Flash4.0 LT to produce images of superb quality. It has a larger field of view, compared to commonly-used interline CCDs, which is ideally suited to modern research microscopes.

The superb frame rate, at full resolution, enables high-speed image acquisition with a wide field of view.



NEW

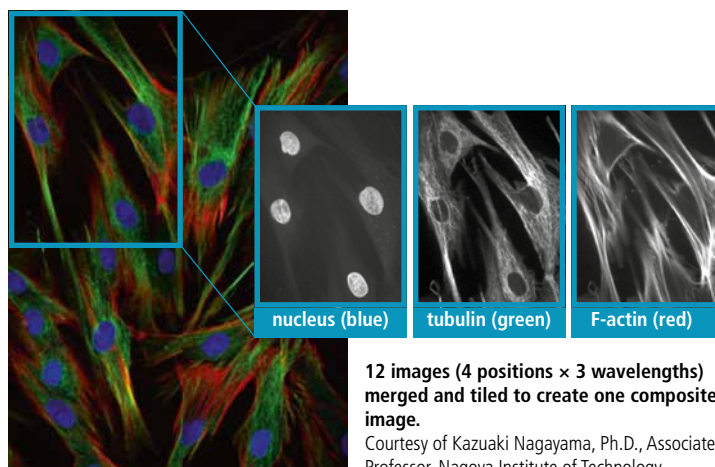
ORCA-Flash4.0 LT

Applications where ORCA-Flash4.0 LT shines

Multi-dimensional imaging

Collect large data sets from x, y or z with multiple wavelengths more efficiently. The combined features of large field of view, low light performance and speed means less time at the scope and more time finding the answers.

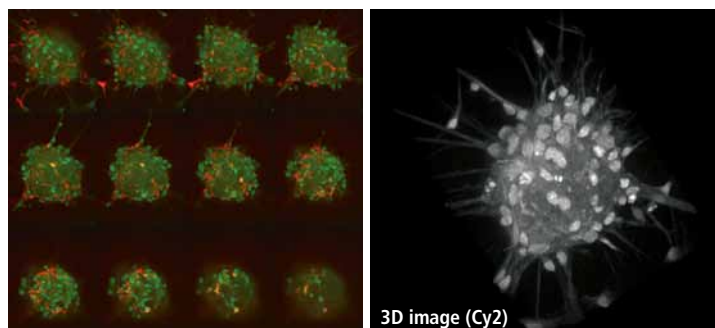
Sample:	Porcine Aortic Smooth Muscle Cells
Fluorescent Probe:	nucleus (Hoechst 33342), tubulin (Alexa Fluor 488), F-actin (Alexa Fluor 546)
Objective Lens:	60× oil
Confocal Scanner:	Yokogawa CSU-X1
Light source:	Light Engine Spectra X



3D imaging

Multi-wavelength Z-series with resulting 3D reconstruction.

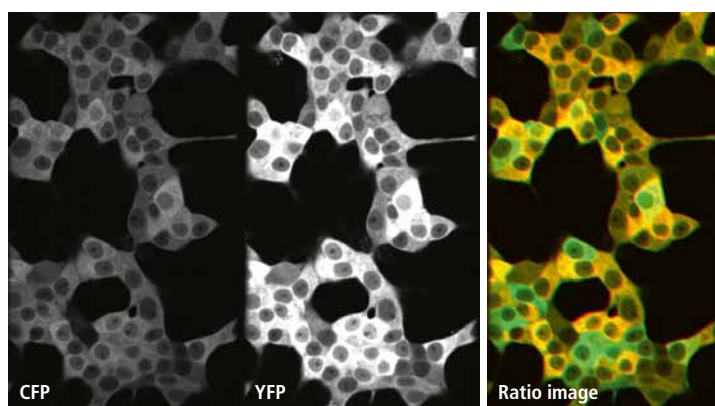
Sample:	Mouse Neural Stem Cells
Fluorescent Probe:	DAPI, Cy2, Cy3
Objective Lens:	60× oil
Z step:	0.6 μm
Confocal Scanner:	Yokogawa CSU-X1
Light source:	Light Engine Spectra X



Ratiometric Ca²⁺ imaging

Spontaneous calcium oscillations in Ins-1 cells acquired through simultaneous imaging of CFP/YFP. The large field of view of the ORCA-Flash4.0 LT makes it possible to capture meaningful data even when using split image optics.

Sample:	Ins-1 Cells
Fluorescent Probe:	Yellow Cameleon3.60
Objective Lens:	60× water
Confocal Scanner:	Yokogawa CSU-W1 SplitView
Light source:	Laser 440 nm



R&D Interview

New Methods of Plastic Welding and Soldering using Semiconductor Lasers



LD Heating Light Source / LD Irradiation Light Source

Real-time temperature monitoring vastly improves development speed and makes in-process laser control possible

Twenty years ago, no one believed that plastic welding and soldering using laser would expand to manufacturing. It was at that time that a top-down project started, centered at Hamamatsu's Central Research Laboratory. The theme of the project was "Applications for High-output Semiconductor Lasers being used for Nuclear Fusion". Among the broad range of elusive applications, the research started with a focus on laser plastic welding technology, which maximizes the advantages of semiconductor lasers (LD). Hamamatsu Photonics not only develops light sources, but also light sensors. It has been predicted that in-process temperature monitoring will become an important factor in laser processing in the future. This is because temperature information will be a parameter that provides in-process guidelines, like shortening the period to find the best process conditions.

A separate group from the Central Research Laboratory (currently the Laser Commercialization Division) also began to search for ways to expand the industrial use of high-output LD technology for laser fusion.

The combination of these two led in 2006 to the creation of the LD heating light source (LD-HEATER), which monitors temperature during laser processing. Now, in 2014, LD plastic welding and soldering are no longer rare methods. We spoke with five young members currently involved in the commercialization of monitoring equipment and LD light sources aimed at LD processing applications and mass production.



Interviewees (from the left)

Kazuya Takahashi (*Manufacture group*)
Takenori Omiya (*Development group*)
Masaki Watanabe (*Development group*)
Satoru Ooishi (*Sales group*)
Hironobu Kurino (*Sales group*)

R&D Interview

Hamamatsu Photonics: Pursuing the Possibilities of Light

Real-time temperature monitoring allows laser processing to be "visualized"

Could you explain about the difficulties of temperature monitoring during laser processing?

Omiya: The only way to obtain temperature information during the laser processing was to measure the amount of infrared light from the laser processor. At first, we simply thought that we could measure the infrared light with a radiation thermometer, but the measurements were not accurate. We had to measure very weak infrared light among extremely powerful laser light, so there's no way the measurements could have been accurate. The intensity ratio of laser light to infrared light is about one hundred million to one. Hamamatsu Photonics thankfully excels at capturing weak light, so we were able to overcome the difficulties.

Please explain in simple terms why temperature monitoring is important for laser processing.

Omiya: There are a wide variety of colors and thicknesses of plastics to be processed. For example, if you focus light through a magnifying glass on to a piece of paper, it will be burnt if the paper is black, but it's harder to burn it if it's white. Similarly, even if the light output is the same, it's impossible to determine if processing is being done properly without measuring the temperature of the irradiated surface. The temperature increase will be different even if the thickness of the target object differs.

Takahashi: It is only temperature monitoring which allows us to determine that the temperature has increased to a certain point so the processing is successful. Just ensuring that the laser power output meets the specifications is not a guarantee of correct processing. On the other hand, the irradiated surface reaching the specified temperature is evidence that the processing is successfully done. Previously, laser processing was often carried out by experienced workers, but seeing temperature information as processing information allows laser processing to be "visualized".

Watanabe: That's right. By mixing in pigments to add color to plastics, the processing condition changes. This can also be found only with temperature monitoring.

Omiya: A lot of unexpected things happened at the actual production sites. Without even realizing, robots are getting faster and/or the state of molds are

changing, these may results in the surfaces of plastic materials changing from time to time. These changed conditions are often detected by the difference of temperature during processing.

Watanabe: Temperature monitoring is also helpful to shortening the time to find the optimal processing conditions for plastic welding etc. Some customers say that it is around one third of the time they previously spent. Without a temperature monitoring function, finding the right conditions takes time. It can take half a year until production starts, including the time for mold revisions. Adding monitoring significantly reduces this time. That is what makes the device so highly acclaimed.

The first enquiries didn't come from end users, but from material manufacturers

That means that you would be able to discover the various condition changes that happen on site. Was this anticipated from the beginning?

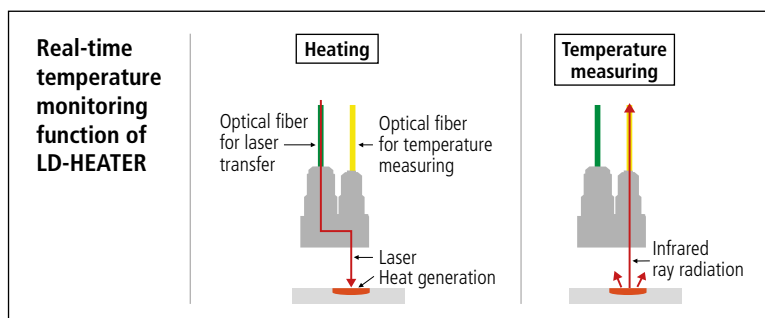
Omiya: To some degree, however, at first, we were surprised to see more feedback from material manufacturers than from end users. They wanted to perform in-house material stability measurements. We are also proud of the fact that these developments made together with the material manufacturers have contributed to the spread of laser welding plastics.

Watanabe: About 30 % of the enquiries we received from customers were about uses we had never expected. This was extremely interesting for me as a developer. Unfortunately I cannot go into more detail due to Non-disclosure agreements.

Ooishi: We were able to increase our capabilities by listening to the broad range of requirements that our customers had and then searching for solutions.

Takahashi: Our starting point was laser plastic welding users, therefore we can understand and share our customer's problems. That is one of our strengths.

R&D Interview



Both the LD-HEATER and an LD irradiation light source (SPOLD) are available on the plastic welding market. Please describe what makes each one unique.

Takahashi: The LD-HEATER is multi-functional, and is best suited for finding of processing conditions and analyzing problems. It was developed using concepts that even those who don't thoroughly understand lasers can use, so safety was also taken into consideration. On the other hand, the SPOLD was made to be less expensive, lighter, and smaller, so it is easy to use at mass production sites. It is a light source that has been simplified as much as possible, anticipating that it will be incorporated into the other equipment.

Omiya: As laser plastic welding is becoming more wide spread, the need for light sources that can handle mass production has increased. The design concept for a UV spot light source from the Electron Tube Division was incorporated into the design.

Ooishi: At the beginning, we envisioned the LD-HEATER as a device for laboratories, but there are many cases in which the same customer uses both the LD-HEATER and SPOLD.

Omiya: After the processing conditions are given by the LD-HEATER, the SPOLD can be used to devise a mass production system, which allows the established processing conditions to be used as they are. That way, if a problem arises during actual production, the customer can revert back to the processing condition settings if they have an LD-HEATER.

The laser process monitor (LPM) provides a monitoring function that detects temperature abnormalities

Now that the LD-HEATER and SPOLD are on the market, what other products do you want to introduce?

Watanabe: We plan on releasing a SPOLD coupling with LPM (laser process monitor) in April 2014. The product was first unveiled at the Photon Fair in November 2013.

Kurino: The idea of mass production with a SPOLD using the optimal conditions output by the LD-HEATER has been welcomed by our customers, just as we had expected. However, these customers have then gone on to tell us that they want to monitor processing from a quality control perspective and at a low cost. We thought about developing something with a simple function for providing information on whether or not processing is being stably carried out. That's where the LPM comes in.

Omiya: Infrared light is output from the area heated by the laser. The LD-HEATER calculates the temperature with the information from a highly precise detection method known as the "two-color method". In contrast, the LPM outputs correlated analog information after picking up the infrared light created by the heat. For example, if there is a processing fault, the amount of infrared light changes, and the value output by the LPM will be different. If stable processing is performed with stable equipment and stable materials, the output signal should also be stable. An unusual signal can be used to determine that something is wrong.

How was it introduced at the Photon Fair?

Watanabe: We combined the LPM with a Galvano scanner*. The LPM sends processing laser light through a fiber, and infrared light information is obtained with the same fiber.



R&D Interview

Even if the fiber is moved, the location irradiated by the laser and the location that produces the infrared light remain completely consistent. Since the light source fiber and the measurement fiber are one in the same, axis adjustment is not necessary. Thanks to this, even a compact Galvano scanner can be used.

Kurino: The number of customers who want to use a Galvano scanner is increasing, but there has never been a product with a temperature monitoring function until now.

Ooishi: Even our competitors and customers who already use other lasers want the LPM. But, we will supply LPM only as an optional device of SPOLD because this potential cannot be realized without a SPOLD.

Did the development of the LPM go as scheduled?

Watanabe: Since we also envisioned the LPM for laser soldering, there were some challenging issues: a minimum temperature of 150 deg. C. (the blackbody furnace value) and a measurement cycle of 1msec. Not only are these ranges problematic for light-receiving technology, but optimized electronic circuit designs are also important. On a mechanical level, it also took time to figure out a construction that would resist vibration and impact.

What market do you think the LPM is suited for?

Ooishi: Generally the tact time for laser processing is short, it is important to detect any problems in-line and to react as early as possible. We believe that using an LPM for in-line monitoring during mass production will contribute to an improvement in laser processing productivity. We think it will be useful in many production facilities including the automotive, electrical, and electronic sectors.

Watanabe: Light can be shaped into a variety of forms, but if infrared light information in an irradiated region has to be measured accurately, the viewpoint shape should be exactly the same as the light. With the LPM, the irradiated light and monitoring information travels the same optical path in the same lens, so the same form is always viewed. Regardless of whether big or small, near or far, square or triangular, it is always the same.

Ooishi: Until now, a round beam was the mainstream in plastic welding. Recently, some customers wanted to use a square beam, or have created unique demand to start with a small irradiation region and then enlarge partway through. It is difficult to satisfy these demands with just a lens or some additional optics.

Omiya: We hope that uniting the processing area and the infrared light information acquisition area will contribute to stable production control.

The continued progress of automation for soldering also makes parts smaller and contributes to a decrease in labor costs

Are there any other fields you think LPM can be applied to?

Ooishi: We think the field of soldering is promising, since soldering irons are still used in some manufacturing sites. The disadvantage of using a soldering iron is that reliability drops as the tip of the iron wears out and the conditions change. There are also demands to shorten the tact time. Since the conventional technology is soldering irons, it is very difficult to compare in cost. However, the SPOLD L11785 series has the advantage of being a light source that was made with lower costs in mind.

Watanabe: It is possible for LPM to monitor the temperature in a short time and/or small spot such as that for laser soldering.

Omiya: Manual processing is becoming increasingly difficult particularly in the electrical and electronic fields as products such as smartphones continue to get smaller. We think the SPOLD with an LPM shows potential to contribute toward the advancement of automation.

Please tell us about your future sales strategies for laser plastic welding technology and soldering.

Kurino: As semiconductor laser light sources continue to become easier to use and their ability to reduce processing costs appreciated, we feel laser welding technology will continue to spread. Foreign manufacturers, particularly those in Germany, are ahead of the game in LD technology. However, Hamamatsu Photonics is focused on all aspects of optical technology, and we feel our products that combine both light-emitting and light-receiving technologies, can compete in this market.

Ooishi: Since the LD-HEATER was released in 2006 and the SPOLD in 2011, Hamamatsu Photonics' products have gradually made their way into the market. Thanks to our expanded product lineup and steady promotional efforts, we received twice as many orders in 2013 than we had expected.

Omiya: We think that more sites will adopt laser processing to replace existing methods as their equipment is updated. Using efficient LD processing also contributes to energy-saving.

CW-Type Quantum Cascade Laser L12004-2209H-C, L12004-2310H-C

An optimum mid-infrared CW laser diode for molecular gas analysis

Quantum Cascade Lasers are semiconductor lasers that offer peak emission in the mid-IR range (4 μm to 10 μm). They have gained considerable attention as a new light source for mid-IR applications such as molecular gas analysis.

Difference from conventional product

There is a short wavelength laser in the DFB-CW type.

Features

L12004-2209H-C **NEW**

- Emission wavelength 4.53 μm (typ.)
- Output power 20 mW (min.)
- Threshold current 1.0 A (max.)

L12004-2310H-C **PRELIMINARY**

- Emission wavelength 4.33 μm (typ.)
- Output power 20 mW (min.)
- Threshold current 1.0 A (max.)

Applications

L12004-2209H-C

- IR molecular spectroscopy (N_2O)

L12004-2310H-C

- IR molecular spectroscopy (CO_2 , CO_2 isotope)



Specifications

Parameter	Specification		Unit
	L12004-2209H-C	L12004-2310H-C	
Wavelength	4.53 (typ.)	4.33 (typ.)	μm
Wave number	2,209	2,310	cm^{-1}
Output power	20 (min.)	20 (min.)	mW
Threshold current	1.0 (max.)	1.0 (max.)	A

PRELIMINARY

10 μm Pulse-Type Quantum Cascade Laser L12020-0993T-C

Mid-infrared pulsed laser diode for molecular gas analysis

Quantum Cascade Lasers are semiconductor lasers that offer peak emission in the mid-IR range (4 μm to 10 μm). They have gained considerable attention as a new light source for mid-IR applications such as molecular gas analysis. L12020-0993T-C is a pulsed type 10 μm laser.

Difference from conventional product

There is longer wavelength in the DFB-pulsed type.

Features

- Emission wavelength 4.33 μm (typ.)
- Output power 20 mW (min.)
- Threshold current 1.0 A (max.)

Applications

- IR molecular spectroscopy (CO_2 , CO_2 isotope)



L12020-0993T-C

Specifications

Parameter	Specification	Unit
Wavelength	4.33 (typ.)	μm
Wave number	2310	cm^{-1}
Output power	20 (min.)	mW
Threshold current	1.0 (max.)	A

Global Exhibitions 2014



USA

March 2014

Phosphor Global Summit

March 26-28 2014, San Diego, CA

APEX

March 25-27 2014, Las Vegas, NV

April 2014

AACR

April 5-9 2014, San Diego, CA

May 2014

SPIE Defense, Security & Sensing

May 6-8 2014, Baltimore, MD

RadTech

May 12-14 2014, Rosemont, IL

Pathology Informatics

May 13-16 2014, Pittsburgh, PA

CYTO

May 17-21 2014, Ft. Lauderdale, FL

June 2014

CLEO

June 10-12 2014, San Jose, CA

ASMS

June 15-19 2014, Baltimore, MD

August 2014

SPIE Optics and Photonics

Aug 17-21 2014, San Diego, CA

September 2014

CAP '14

Sept 7-10 2014, Chicago, IL

October 2014

MDM Minneapolis

Oct 29-30 2014, Minneapolis, MN

microTAS

Oct 26-30 2014, San Antonio, TX

Pathology Visions

Oct 19-22 2014, San Francisco, CA

November 2014

ISFTA

Nov 9-13 2014, Houston, TX

Nuclear Science Symposium

Nov 11-13 2014, Seattle, WA

Neuroscience

Nov 15-19 2014, Washington, DC

RSNA

Nov 30-4 2014, Chicago, IL

December 2014

MRS Fall Meeting

Dec 2-4 2014, Boston, MA

ASCB Annual Meeting

Dec 6-10 2014, Philadelphia, PA

EUROPE

April 2014

Analytica

April 1-4 2014, Munich, Germany

PHOTONICS EUROPE

April 15-16 2014, Bruxelles, Belgium

May 2014

SPS-IPC DRIVES

May 20-22 2014, Parma, Italy

Optatec

May 20-22 2014, Frankfurt, Germany

ELMI

May 20-23 2014, Oslo, Norway

June 2014

International Workshop on Position Sensitive Neutron Detectors

June 2-4 2014, Juelich, Germany

Sensor + Test

June 3-5 2014, Nurnberg, Germany

Photonex Scotland Roadshow

June 4 2014, Edinburgh, Scotland

FDSS USERS MEETING

June 12 2014, Alschwill, Switzerland

Photonex Cambridge Roadshow

June 18 2014, Cambridge, England

12th European Congress Digital Pathology

June 18-21 2014, Paris, France

July 2014

Microscience Microscopy Congress (MMC)

July 1-3 2014, Manchester, England

August 2014

European Congress of Pathology

Aug 30-Sept 3 2014, London, England

September 2014

Photon14

Sept 1-4 2014, London, England

ELRIG: Drug Discovery

Sept. 2-3 2014, Manchester, England

E-14

Sept 11-13 2014, Odense, Denmark

OPTO

Sept 16-18 2014, Paris, France

World of Technology & Science

Sept 30-Oct 3 2014, Utrecht, Netherlands

October 2014

Photonex

Oct 15-16 2014, Coventry, England

November 2014

Vision

Nov 4-6. 2014, Stuttgart, Germany

Electronica

Nov 11-14 2014, Munich, Germany

Carrefour Pathologie

Nov 17-21 2014, Paris, France

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