HAMAMATSU
PHOTON IS OUR BUSINESS
NEWS 2019 01

PHOTON FAIR 2018

HIGHLIGHTS FROM PHOTON FAIR, NOVEMBER 2018

Cover Story

In November 2018, Hamamatsu Photonics hosted PHOTON FAIR, an exclusive exhibition to demonstrate the Company's vision for the future. The event theme was “Journey to the future of Photonics with Hamamatsu” and included the following zones.

PHOTON FAIR 2018

PHOTONICS FOR A HEALTHIER FUTURE

To live a long and healthy life. We are constantly thinking about what is needed to make this wish a reality.
Quickly discovering any and all types of diseases in the body, finding diseases in a way that is kinder to the human body, offering patients better and more potent medicines, or new surgical techniques. We believe that photonics technology can help achieve all of these needs.
'Creating a future where people stay active while improving their mental and physical health.' To achieve this goal, we showed you our vision of how photonics technology can play a major role in the future of health care.

MEDICAL & LIFE SCIENCE

MAIN EXHIBITS
MPPC modules for PET scanner
Photomultiplier tubes for laboratory testing
NanoZoomer® digital slide scanners
Scintillator plates for x-ray imaging

PHOTONICS FOR A BETTER LIFE

The Life Zone exhibition concept is the idea that photonics technology brings warm and friendly communication along with day-to-day happiness.
A world where everyone can live a pleasant and abundant life – isn't that the life we all want?
'Working for a world where everyone can live a pleasant and abundant life'
See what photonics technology can do to transform our current lives into a more plentiful future.

LIFE

MAIN EXHIBITS
Compact spectrum sensors
IR-enhanced distance image sensors
iPMSEL® (integrable Phase Modulating Surface Emitting Lasers)
UVTRON®

SAFER, MORE SECURE AND COMFORTABLE. PHOTONICS FOR THE AUTOMOTIVE FUTURE

Recent automotive technology includes sophisticated functions such as electrical motorization, self-driving vehicles and driver monitoring.
We want everyone to know and spread the word about how photonics technology is essential for bringing about improved automotive performance and reliability, as well as greater satisfaction from vehicle users.
We will continue our efforts to serve as a key enabling technology supplier for the automotive future.

AUTOMOTIVE

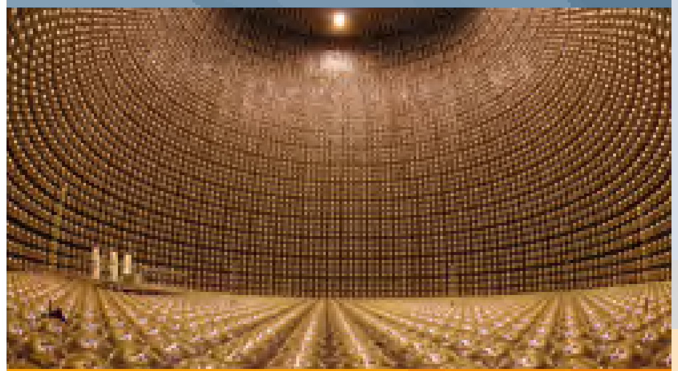
MAIN EXHIBITS
Avalanche photodiodes for LiDAR
Pulsed laser diodes for LiDAR
MEMS mirrors
Semiconductor failure analysis systems

MANUFACTURING

MAIN EXHIBITS
X-ray line scan cameras
Raman spectroscopic modules
Ultrashort pulse laser
UV-LED light sources

PHOTONICS – OPENING THE WAY TO BETTER MANUFACTURING

Ongoing advances in our society such as the IoT (Internet of Things) and AI (Artificial Intelligence), have helped create the so-called “Smart Factory”. But a true smart factory cannot be realized merely by digitalization and computerization. Manufacturing of the future will need higher efficiency, higher quality, higher accuracy and a higher degree of automation (labor-saving) and eco-engineering.
Our photonics technology, which supports craftsmanship and manufacturing, is an indispensable technology for making smart factories a reality.



SCIENCE & RESEARCH

MAIN EXHIBITS
20-inch photomultiplier tube
MPPC® for high energy physics
Spectral systems for organic EL
Scientific CMOS cameras
Laser diodes for MIR

PHOTONICS FOR CUTTING-EDGE SCIENTIFIC RESEARCH

Cutting-edge scientific research has discovered new knowledge that overturns what we know about traditional scientific laws and theories, and has opened up a new future for humanity. Photonics technology is an essential and indispensable part of these recent advances in science and technology. In the Science & Research Zone, we showed the impact photonics technology has had on three important areas: physics, chemistry and biology, and introduced the infinite possibilities of light.

ENVIRONMENT

MAIN EXHIBITS
Ion detectors for mass spectrometer
Infrared detectors for gas analysis
Image sensors for NIR
Laser diodes for MIR

PHOTONICS FOR A HEALTHIER EARTH

Based around our theme 'Monitoring Earth's Health', the Environment Zone showed how our photonics technology is contributing to the environmental field and how it will contribute in the future.
Environmental pollution, resource depletion and major natural disasters. Among the different environmental problems originating from the earth's population growth, we focused on the areas of 'water, air and soil quality, energy and resources'. As part of our work as photonics technology professionals, we showed visitors the current state-of-the-art and type of contributions we will be making in the future.

PHOTON FAIR 2018

WHAT IS PHOTON FAIR?

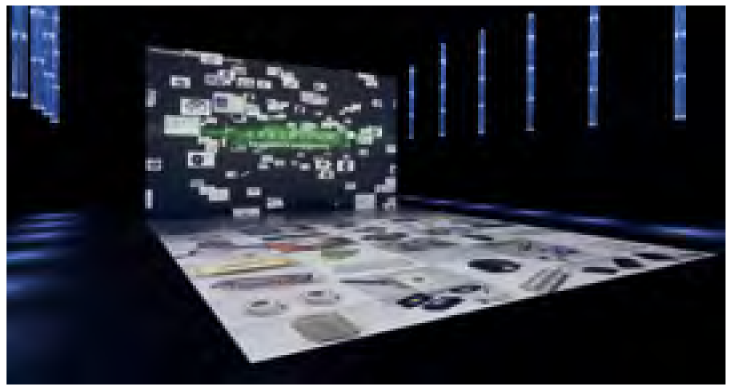
The first Hamamatsu Photonics exhibition "Photon Fair" was held in Japan in 1980. The purpose of Photon Fair was not just to exhibit the full range of products, but to introduce visitors to new technologies, provide technical consultations, lectures and workshops.

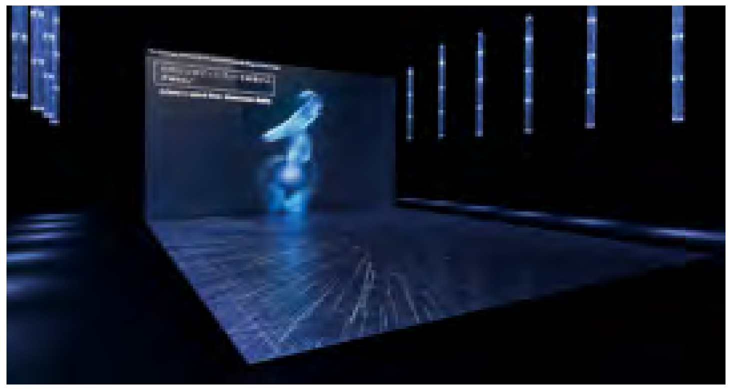
Since that first event in 1980, Photon Fair has been held every 5 years. Last year's event was held in Hamamatsu City, Japan.

This event is viewed as an ideal platform for meeting with customers to exchange ideas and information, and as an outreach to the general public. It is also an exhibition which demonstrates the Company's vision for the future, made possible with its range of cutting-edge products and technology. Visitors have the chance to experience all the possibilities that photonics technology has to offer.

Last year's event attracted more than 10,000 visitors over 3 days.

Photos from Photon Fair 2018





		Medical	Life Science	Drug Discovery	Measurement	Analytical	Semicond. Prod.	Optical Comms	Security	Industry	ND Inspection	Academic Research
	OPTO-SEMICONDUCTOR PRODUCTS											
21	Si APD S14643/S14644/S14645 Series				■	■				■		
22	CMOS Linear Image Sensor S13774				■					■		
23	CCD Image Sensor S14650/S14651/S14660/S14661 Series				■	■						
24	Infrared LED L13895-0145G				■	■						
25	InAsSb Photovoltaic Detectors P13243-122MS/-222MS				■	■				■		
	ELECTRON TUBE PRODUCTS											
26	DIUTHAME® A13331-3-1/-18-1, A14111-3-1	■	■	■		■				■		■
27	Micro PMT Module H14066	■	■	■	■	■			■	■		
28	Photosensor Module H14211-110				■	■	■					■
29	Side-on Type Photomultiplier Tube R14657		■			■						
30	UV-LED Unit LIGHTNINGCURE® LC-L5G L14012-2300									■		
31	Flame Sensor UVTRON® R14388								■	■		
32	180 kV Microfocus X-ray Source L14351-02									■	■	
	LASER PRODUCTS											
33	Pulsed Laser Diode (PLD) L11854-307-55				■				■	■		

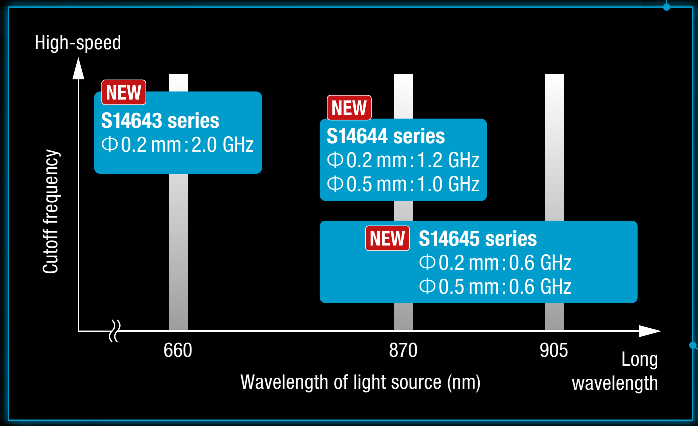
APD (avalanche photodiode)

Newly developed with boosted quality!

Our new Si APD will speed up widespread use of self-driving cars.

Si APD (silicon avalanche photodiode) is a light sensor that delivers superb sensitivity by utilizing a phenomenon called avalanche multiplication. Si APDs are used for optical fiber communications and scintillator light detection due to features such as high-speed response, high sensitivity and high signal to noise. In addition, Si APD use is now expanding to include distance measurement applications. Among these applications, LiDAR* is drawing a lot of attention as a key technology for making self-driving cars a reality and there are big expectations for developing Si APDs optimized for LiDAR.

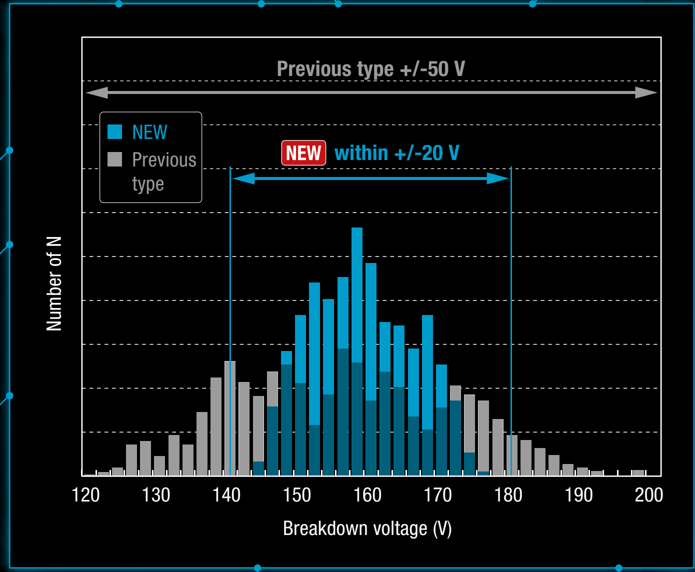
Hamamatsu Photonics has made significant improvements to Si APD and has now added a new family of Si APDs to its product lineup which offers more uniform device specifications and a wider operating temperature range. This new family will play an active role in LiDAR and in many other application fields.



Our product lineup includes near-infrared laser diodes (870 nm, 905 nm) suitable for LiDAR light sources and Si APDs suitable for 660 nm red lasers used in industrial applications.

* Light Detection and Ranging: An active remote sensing technique for measuring the distance to an object by illuminating the object with laser light and measuring the reflected light with a detector.

For more information about Si APDs, see page 21 of this issue



Stable quality

Achieved APD with minimal variations in the breakdown voltage

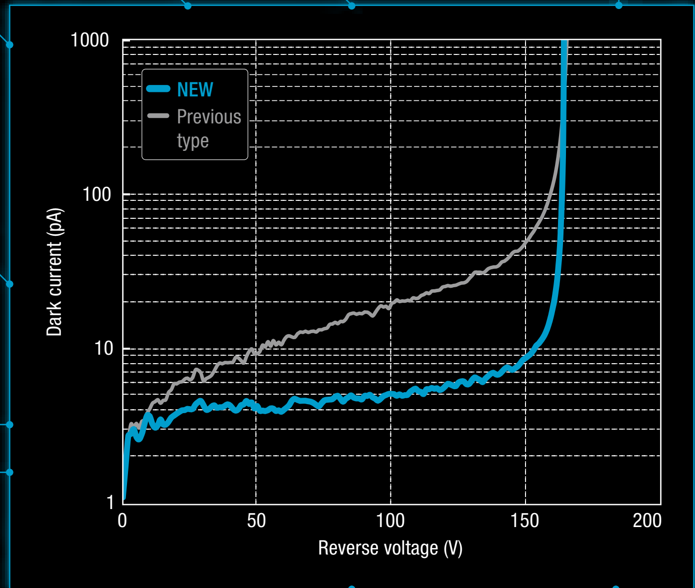
Compared to PIN photodiodes, one outstanding feature of the APD is its high signal to noise. This is achieved by an internal gain mechanism (avalanche multiplication) that multiplies low level light signals. However, the breakdown voltage (V_{BR}) related to the multiplication process varies between individual APDs. This means that the voltage needed to obtain the same gain differs from APD to APD even among the same APD type. To solve this problem, we have made improvements throughout the manufacturing process based on technical expertise accumulated over 20 years and experience in manufacturing diverse types of light sensors. We then established a production system capable of suppressing breakdown voltage variations from around ±50 V down to within ±20 V, whilst maintaining stable quality products even when coping with a large volume of product orders.

Parameter	Previous type	NEW
Operating temperature	-20 ~ +60 deg. C.	-30 ~ +100 deg. C.
Storage temperature	-40 ~ +80 deg. C.	-40 ~ +100 deg. C.

Wide operating temperature range

Wide operating temperature range suitable for in-vehicle applications

The wide operating and storage temperature range is a huge advantage offered by our new Si APDs. As with other sensors, APDs used in a wide variety of applications and environments must operate accurately and reliably over a wide temperature range. We reviewed the materials and assembly process and developed new Si APDs capable of operating in a temperature range from -30 deg. C. to +100 deg. C., which is much wider than the ordinary APD temperature range of -20 deg. C. to +60 deg. C. We are also developing products that meet automotive standards.

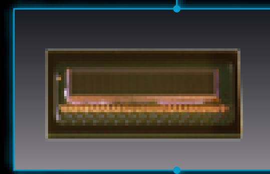


Reduced dark current

Reducing the dark current causing noise to less than one half

To develop our new Si APDs, we also reviewed and optimized the semiconductor process that determines light sensor performance. As a result, we succeeded in reducing the dark current causing noise to less than half that of ordinary products. This new Si APD is also suitable for high precision measurement at very low light levels.

Multichannel arrays and other custom products with long or large photosensitive areas are also available.
We now offer multichannel APD arrays with extremely uniform characteristics between sensor elements due to minimal variations in breakdown voltage. For LiDAR applications requiring various shapes and sizes, we welcome custom requests for specific characteristics, shapes and package materials. In addition to APD, we also provide a wide range of light sensors (MPPC, PIN Photodiodes, etc.) and laser diodes allowing us to propose products optimized for customer applications.



Ellipsometry from the Inside

Introduction

At MIRell Photonics we have created the most versatile and flexible laser ellipsometer on the market. With such a device, thin film thicknesses and refractive indices are measured in single or multiple surface layers.

Compactness, measurement speed and reliability are paramount for our ellipsometers. For a detector in the wavelength range around the border from near to far infrared, an InAsSb photodiode from Hamamatsu is used. Incidentally, it is the one component that was onboard from the very beginning of product design until today.

The following article describes the inner workings of an ellipsometer and some infrared applications. In other words, the **Why**, the **How** and the **What.**

Why is the measuring of optical parameters so important?
Both in research and industrial applications, the knowledge of optical parameters of surface layers is vital. Quality monitoring and defect analysis are the natural application fields.

The refractive index is a simple number which subsumes a lot of condensed matter effects. It is directly related to the bandgap of the material and thus susceptible to influences of doping, stoichiometry and even temperature. The exact monitoring of the refractive index is therefore vital. Furthermore, in the optical measurement of layer thicknesses, the optical path (= geometric path times refractive index) depends again upon said influences.

Most of all, the refractive index changes with wavelength. Surface coatings always have to be measured at the wavelength of each application, for example in the visible range for CCD cameras, in the near infrared for telecommunication applications or in the mid infrared for thermal and spectroscopic applications.

Ellipsometry is the only available non-destructive technology that can determine the thickness of a surface layer and its refractive index independently.

Thus in the past when we were working on devices on the AlGaAsSb Material system, we noticed that there is no suitable ellipsometer on the market for measuring doped multilayer structures in the mid-infrared. That was when we founded MIRell Photonics to build a suitable laser ellipsometer ourselves.

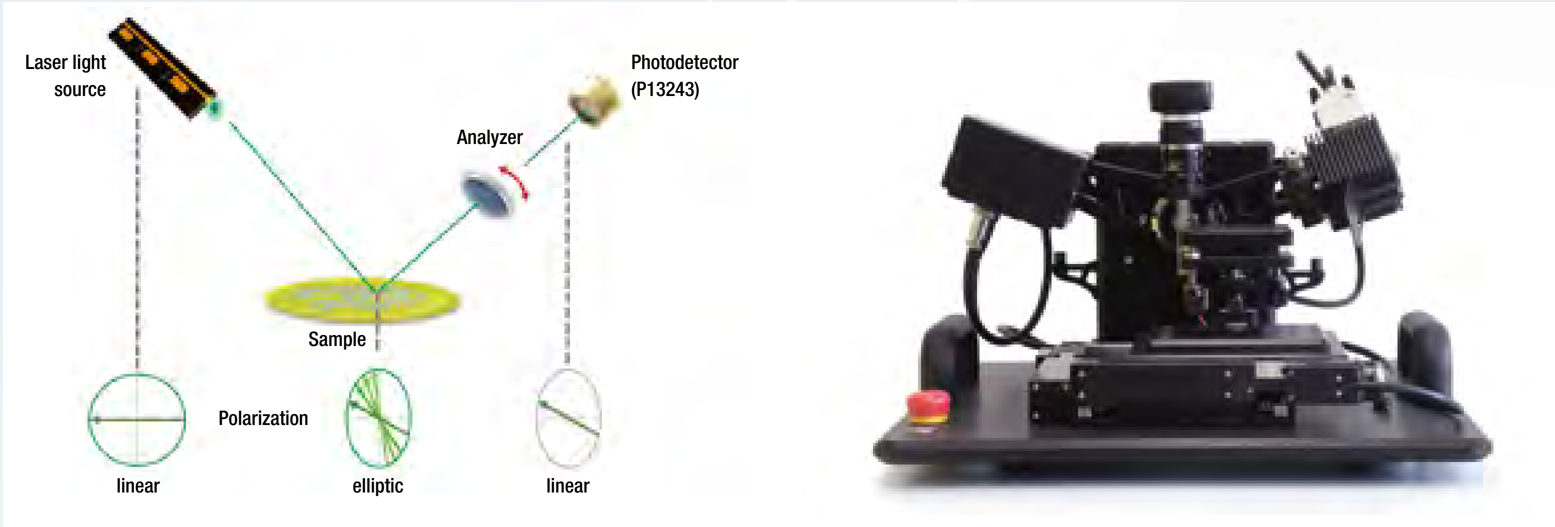


Figure 1: (above) optical components and (right) real-world laser ellipsometer.

How does an ellipsometer work?
The amount of light reflection and transmission of light at the border of materials (and air) depend upon the polarization of the light. According to Brewster's Law, light polarized perpendicular to the axis of incidence behaves different from light in parallel.

The ellipsometer makes use of this by shining light under defined polarization onto a sample and measuring the change in polarization invoked by the sample. A numeric model of the sample is then simulated iteratively until it reproduces the measured data, yielding the best values for the optical parameters of the sample.

A general ellipsometer as shown in figure 1 consists of a (monochromatic) light source, polarizer and analyzer optics and a photodetector.

At MIRell Photonics we created a flexible and compact device using semiconductor lasers as light sources. Thus measurements can be taken at any wavelength where there are lasers available. This allows each customer to measure at the desired target wavelength, be that at 400 nm or 20 µm.

Using laser light sources, we can offer faster and more precise measurements at a fraction of the device costs compared to conventional monochromated white-light ellipsometers.

Singlemode lasers offer an enormous spectral power density within an emission linewidth of $< 10^{-5}$ nm. Compared to devices with broadband light sources, the measurement time per spot decreases to a fraction of a second, which is up to 200 times faster. Furthermore, the spot size can approach the diffraction limit of the laser in use.

Stable, linear and low-noise detectors are important and thus we were very happy to have Hamamatsu's P13243 InAsSb photodiodes for the near and mid infrared wavelength range.

During the development of the device, we changed our choice of optics, electronics and mechanics. But the InAsSb photodiode was on board all the time.

What can be done with ellipsometry?
From monitoring coating processes on glass or polymer substrates to semiconductor production lines, ellipsometers have a wide range of applications.

In a coating, the refractive index depends upon the material composition. Using ellipsometry, you can measure both the layer thickness and its material composition by tracing the refractive index. For example if a titanium oxide layer is deposited on a substrate, using ellipsometry, you can at the same time monitor the layer thickness and the oxide to titanium ratio.

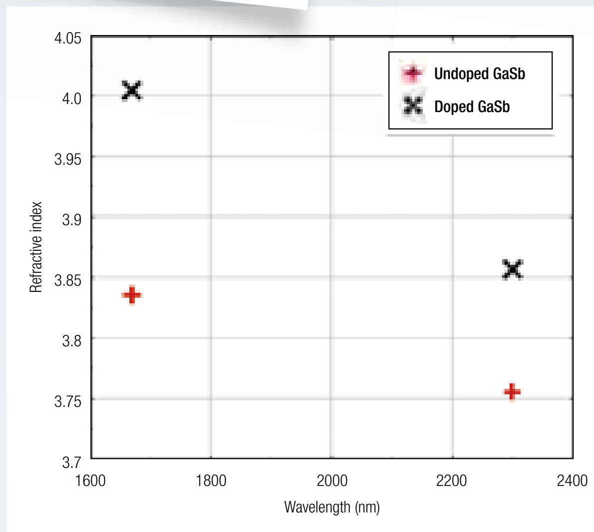


Figure 2: significant effect of a high doping concentration upon the refractive index. Shown here for a pure GaSb layer with tellurium doping.

Another example is shown in the following figure 2, where the refractive index of an GaSb layer is shown, once undoped and once with relatively high doping.

The impact on the refractive index is in the region of 20 %, which is quite noticeable in optical applications, like in the design of lasers, photodiodes or photonic integrated circuits.

For many optical applications like wave guiding, it is vital to be able to define carefully the refractive indices of photonic circuits. Ellipsometry helps to monitor the optical parameters in situ and in quality control.

Conclusion

Using laser light sources, ellipsometers become a lot faster and more precise at a significantly lower cost compared to devices using a broadband light source. Laser ellipsometers are compact, lightweight and reliable.

Over the last years, longer wavelengths were made accessible with new suitable laser sources like Hamamatsu's Quantum Cascade Lasers and suitable photodetectors such as the P13243 InAsSb photodiode. This enables us to offer laser ellipsometers all across the spectrum from ultraviolet to mid-infrared. Taking the precision measurement to the user's operating point.

Eight markers, multiplex immunofluorescent staining with the NanoZoomer S60

(Multiple of 4 immunostains, DAPI and autofluorescence subtraction)

Maddalena M Bolognesi and Giorgio Cattoretti, Department of Pathology, Università di Milano-Bicocca, Milan, Italy.

Today's pathology practice calls for an ever-shrinking size of tissue samples and an expanding need for immunostains. Fine needle biopsies are becoming the norm for diagnosis, staging and therapy. Cell block preparation is required to optimize the cytological diagnosis from fine needle aspirations. In solid tumors, such as lung cancer, there is a need to balance the necessity to save precious material for extractive molecular tests (EGFR) and the assessment of in-situ protein targets for advanced, personalized therapy aimed at activated oncogenes (ALK, BRAF, ROS), checkpoint inhibitors (PD-1, VISTA, PD-L1), etc.

The cancer-driven impulse at immunomodulatory therapy has already impacted on the evaluation of biopsies obtained for autoimmune, inflammatory conditions such as systemic lupus erythematosus (SLE), chronic liver, intestinal and skin diseases, transplant rejection etc. These biopsies are traditionally minute, often unique tissue samples. Single cell analysis by cell suspension is not feasible and a relatively limited number of sections can be obtained in expert hands.

Furthermore, formalin-fixed, paraffin-embedded (FFPE) material is almost invariably the only tissue available.

A solution to overcome these constraints is to do multiple stains on the very same section.

Current protocols in IHC allow two-three stains on non-overlapping cellular/subcellular targets [1]. There are more choices by using immunofluorescence (IF) stains.

Most IF microscopes are equipped with three IF channels, conventionally named after the prototype fluorochrome DAPI, FITC, TRITC. A fourth channel may be added, Cy5. Traditional microscopes however do not record whole slide images (WSI), limiting the documentation to selected fields, after which the fluorescence on the section fades out and no additional fields can be examined. On the contrary, IF slide scanners record the WSI in multiple channels, allowing a dynamic, complete and retrospective evaluation of any tissue area of choice.

In 2015, Hamamatsu Photonics introduced the NanoZoomer S60 brightfield and IF scanner, which can accommodate up to 60 slides. The S60 scanner has two six-filter wheels, one for excitation, the other for emission filters, a three-cube turret and is equipped with a Planapo lambda 20x NA 0.75. Objective (Nikon), a Fluorescence Imaging Module equipped with a L11600 mercury lamp (Hamamatsu Photonics), and a linear ORCA-Flash 4.0 digital CMOS camera (Hamamatsu Photonics).

Choices for multiple IF stains are complicated by several limitations:

- Spectral unmixing of multiple excitation/emission wavelengths within the 350-750 nm span [2] requires ad hoc spectral IF microscopy apparatuses and software and can accomodate no more than 7 colors (including DAPI).
- DNA-barcode or directly fluorochrome conjugated antibody applications [3-5] require custom antibody conjugation, dedicated high NA, high sensitivity optics, multiple cycles of staining and quenching with only two fluorochromes at a time.
- Ion-tagged custom antibodies and in situ MALDI-type instruments can accomodate ~40 markers at 1µm/pixel resolution with a high cost of hardware investment [6].

Most of these techniques i) allow the staining of a single section per round, ii) do not support WSI, iii) reagents and instruments are so costly and time-consuming that staining of multiple single sections is discouraged, or one or all of these combined. Another property of FFPE material is tissue autofluorescence (AF), which has restrained the application of IF for diagnosis or research.

A method to sequentially stain and strip an FFPE routinely processed section has been published [7]. This method employs widely available primary unconjugated and secondary IF antibodies, double indirect IF staining and digital tissue AF subtraction [7]. By carefully selecting primary antibodies produced in various species and/or of different immunoglobulin isotypes (e.g. Rabbit Ig + Mouse IgG1 + IgG2a/b + IgG3 or Rabbit + Mouse + Rat + Goat Ig) the full extent of the IF span of the S60 can be exploited.

Four primary antibodies from one of the above mentioned selections can be visualized and acquired, in addition to the acquisition of the DAPI nuclear counterstain and the tissue AF for background subtraction. One single FFPE section is all that is required, different from a spectral unmixing acquisition, where for every desired wavelength a corresponding section is necessary for spectral identification and AF subtraction. To attain this goal, the standard S60 setting was modified to accomodate DAPI, BV480, FITC, TRITC, Cy5 and AF, as shown in Figure 1.

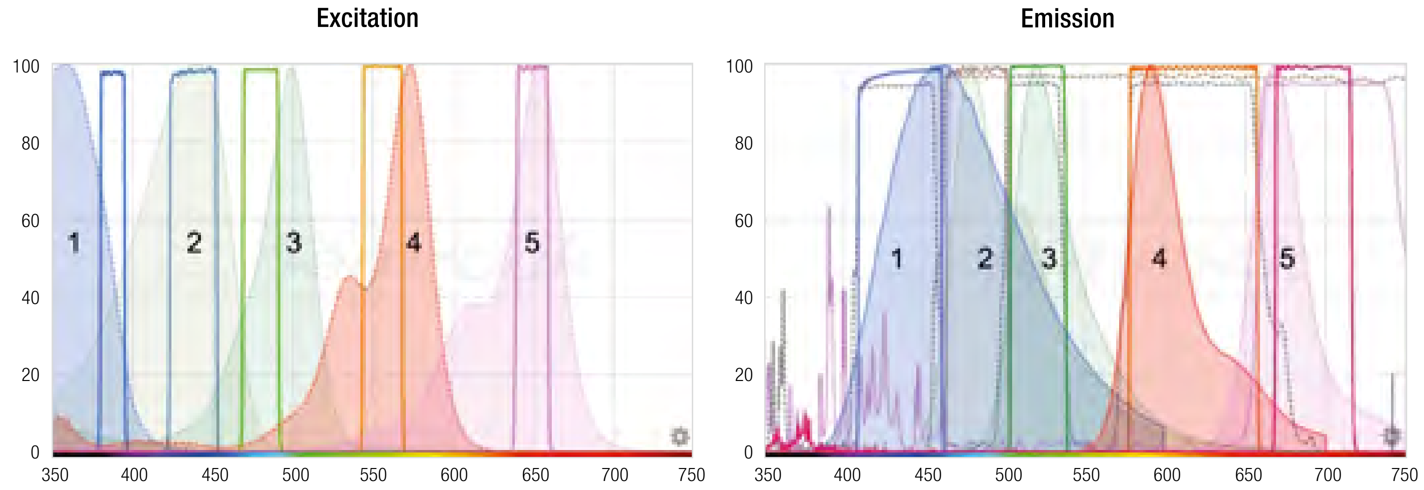


Figure 1: The composite panel represents the excitation filters and fluorochrome spectra (left) and the emission filters, dichroic mirrors and fluorochrome spectra (right). Excitation spectra are represented by a dashed profile, emission spectra by a solid profile. The filter profiles are represented by solid lines, the dichroic ones by a dashed line. 1: DAPI (359/461) [exc/em]; 2: BV480 (437/478); 3: Alexa 488 (499/519); 4: Rhodamine RedX (570/590); 5: Alexa 647 (652/668).

The filter combination depicted are DAPI: 387/11 – 435/40 [exc/em], BV480: 438/24 – 483/32; FITC: 480/17 – 520/28; TRITC: 556/20 – 617/73; Cy5: 650/13 – 694/44; AF: 438/24 – 617/73.
The dichroic mirrors are: FF403/497/574-Di01 (triband), 458-Di02 and FF655-Di01. Alexa® dyes are a Life Technologies patent. BV480 dye is a BD Biosciences patent. The spectra images are obtained with the Searchlight Semrock web application.

To address the immune environment and the tissue architecture of SLE nephritis on FFPE renal biopsies, we set up an 8-marker panel in IF, inclusive of T cells (CD3), B cells (CD20), monocyte/macrophages (CD68, CD163), plasmacytoid dendritic cells (pDC) (IRF8), endothelium (CD34), interstitial or glomerular fibroblasts (CD248) and interferon response genes (MX1). The antibody clone, the Ig specific and the secondary IF reagent are shown in Table 1. This panel was divided into two four-marker rounds, with one stripping cycle in between. For stripping we used the beta Mercaptoethanol/SDS protocol [7]; however, a friendlier protocol has been published [7], based on non-toxic compounds. CD34 and CD248 stain non-overlapping stromal components in the interstitium and define the fine architecture of the glomerulus (Fig 2). In the presence of an autoimmune inflammation, MX1 is induced upon interferon signaling.

The immune infiltrate, both inside and outside the glomerulus is defined in its components (T, B, pDC, Mono/Mac) and the distribution relative to each other and the kidney structure (Fig 2). A complete 8-marker panel can be accomplished in three day staining and stripping cycles; up to 40 individual cases can be processed for this multiplex panel in a working week. The ability to perform 8 established stainings, on multiple individual single sections, with a turnaround time compatible with clinical needs, brings this technique close to a clinical application of the multiplex IF staining with the Nanozoomer S60. No other instrument/reagent combination available today can accomplish this task.

For research, sections stained with the 8-marker panel can be safely stored at -20 deg. C. in buffered glycerol [7] and sequentially stained and stripped in excess of 10 times (> 44 markers), bringing this technique up to high-plex IF staining ([7] and Bolognesi MM et al, in preparation).

References

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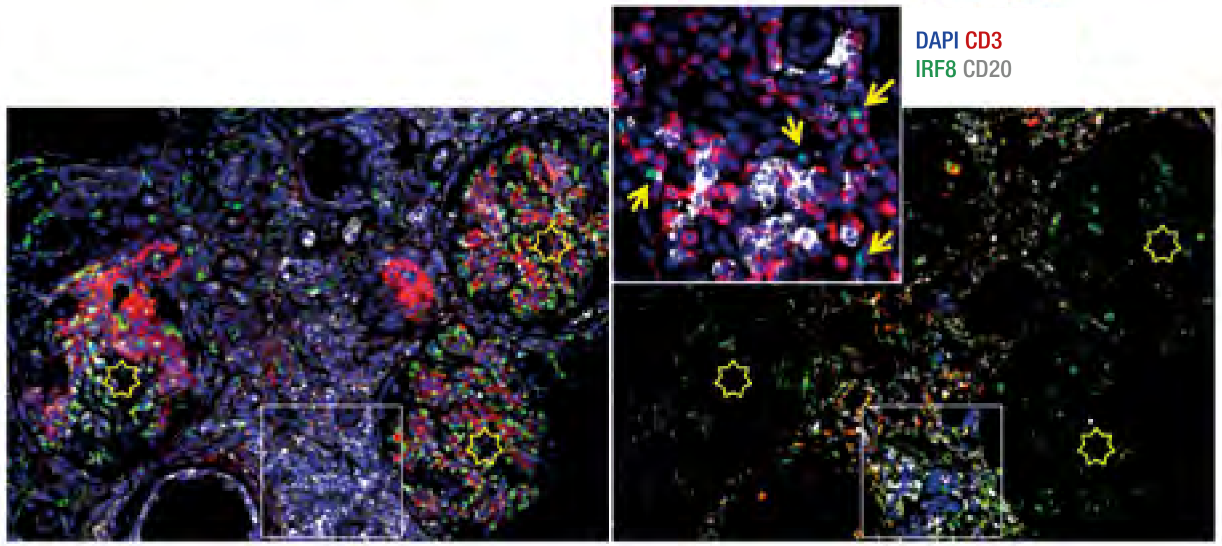


Table 1: Primary and secondary antibodies used*

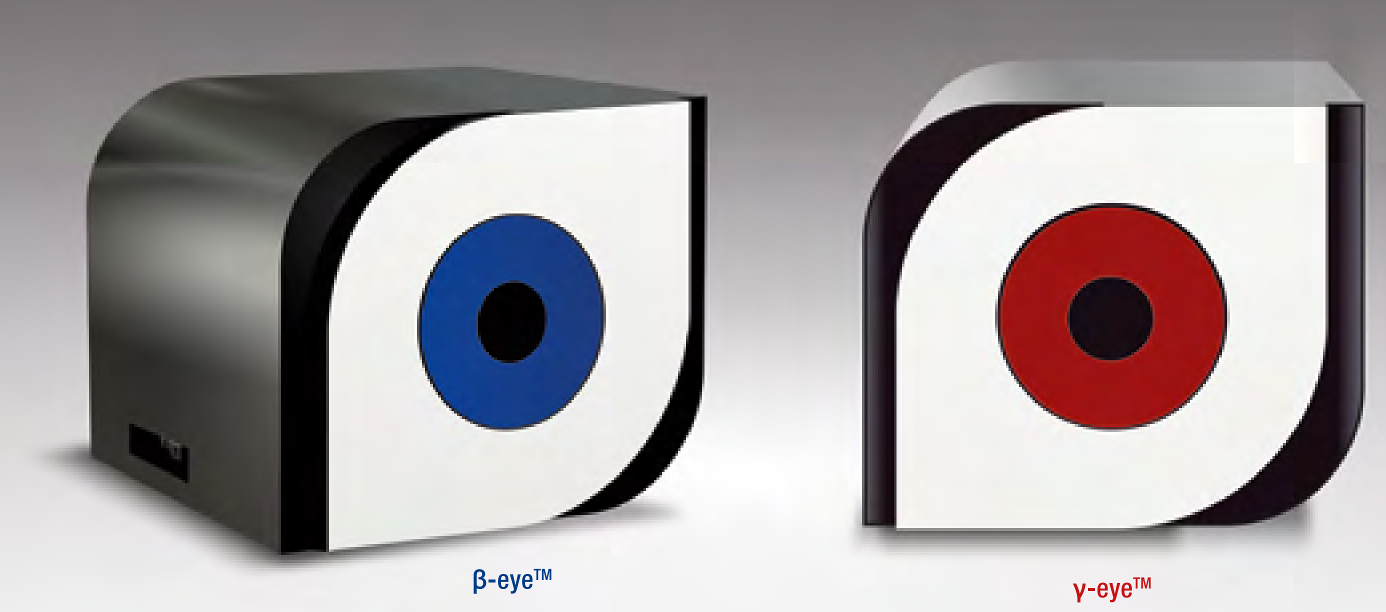
Antibody	Clone	Species	Isotype	Secondary Ab	Fluorochrome
CD3	-	Rabbit	Ig	Gt a Rb	Rhodamine RedX
CD20	L26	Mouse	IgG2a	Gta Mo IgG2a	BV480
CD163	10D6	Mouse	IgG1	Gt a Mo IgG1	Alexa 488
CD68	PGM1	Mouse	IgG3	Gt a Mo IgG3	Alexa 647
MX1	-	Rabbit	Ig	Gt a Rb	Alexa 488
CD248	B1/35	Mouse	IgG1	Gt a Mo IgG1	Alexa 647
IRF8	E9	Mouse	IgG2b	Gta Mo IgG2b	BV480
CD34	3A1	Mouse	IgG3	Gt a Mo IgG3	Rhodamine RedX

* Secondary antibodies are from Jackson Immunoresearch

Figure 2: Eight markers (+ DAPI) immunostaining of a renal biopsy with SLE. A selected field from a WSI is imaged as RGB+white composites. Left: the image depicts three glomeruli (stars) containing CD248 mesangium (red) and CD34 endothelium (green). Sparse interstitial fibroblasts (red) and capillaries (green) are seen. MX1 (white) is induced in tubules, interstitial inflammatory cells and the endothelium of a vessel (lower center). Right: the image shows macrophages (CD68, green) and histiocytes (CD163, red), admixed with CD20+ B cells (blue) and CD3+ T cells (white). CD68+ CD163- phagocytes predominate inside the glomeruli. The inflammation area in the white square, enlarged in the inset, shows IRF8+ plasmacytoid dendritic cells (green, arrowed) admixed with T cells (CD3, red) and B cells (CD20, white). DAPI (blue) counterstain. AF has been subtracted from individual grey level images before RGB merging.

H12700A flat panel multianode PSPMT as photon detector in small animal nuclear imaging

Eleftherios Fysikopoulos, Maria Georgiou, Maritina Rouchota and George Loudos
BioEmission Technology Solutions, Athens, Greece



Abstract

Small animal imaging, using nuclear medicine techniques, is a valuable tool in preclinical research. Several multimodal imaging systems are commercially available for preclinical research, but their purchase and maintenance costs make them unaffordable for the majority of small and medium research groups. Taking into account the average end user needs we have recently introduced the “eye-series”, currently including two unique, low cost, benchtop systems for in-vivo imaging of radio-labeled biomolecules with SPECT and PET isotopes. Integrated into these systems is the new generation of the Hamamatsu flat panel type multianode position sensitive photomultiplier tube (PSPMT).

The H12700A large effective area of 48.5 mm^2 and typical quantum efficiency of 33 % at about 380 nm, makes it the ideal solution for photon detection in small animal nuclear imaging systems.

Introduction

Molecular imaging is one of the frontiers in modern medical imaging [1]. Molecular imaging modalities can assess biologic processes at the molecular and cellular level providing important information in biologic studies of disease and non-disease states, as well as in drug design and evaluation. Nuclear medicine techniques such as positron emission tomography (PET) and/or single photon emission computed tomography (SPECT) are robust tools to study non-invasively the biodistribution of various biomolecules. Preclinical research in small mammals using nuclear medicine imaging techniques has also the potential to drastically enhance the efficiency and accuracy of drug target selection and drug safety or efficacy [2].

Several imaging systems are commercially available, but their purchase and maintenance costs make them unaffordable for the majority of small and medium teams. For this reason, we recently introduced in the market two unique, low cost, benchtop systems for in-vivo imaging of radiolabeled biomolecules and nanoparticles. "γ-eye" is a scintigraphic system that allows the in-vivo imaging of biomolecules labelled with SPECT isotopes, while "β-eye" is a coincidence camera suitable for in-vivo molecular imaging of PET isotopes. Filling the gap between ex-vivo biodistributions and advanced imaging systems, the "eye-series" are the only truly portable molecular imaging systems in the market that allow static and fast dynamic whole-body mice studies, giving the opportunity to turn your desk into a lab.

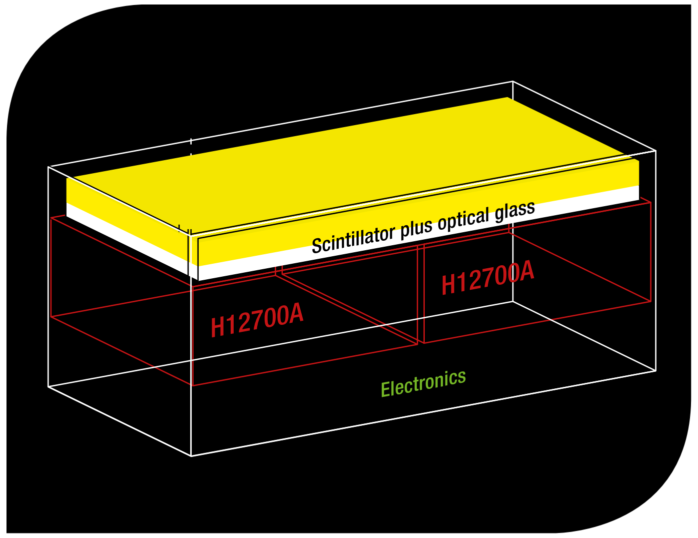


Figure 1: The "eye-series" detectors general assembly.

The detectors

General assembly

Practically, "γ-eye" and "β-eye" detectors are based in a common design architecture involving 3 parts (figure 1):

- Scintillator plus optical glass
- Photodetector
- Electronics

"β-eye" is structured using two detectors placed one physically opposed to the other, at a distance of 60 mm, allowing coincidence imaging of photons produced using PET isotopes. On the other hand, "γ-eye" is structured using one detector along with a parallel hole collimator, which is located above the scintillator, in order to allow only photons travelling in a direction perpendicular to the detector head to interact with the crystal.

Scintillation detection

In β-eye a pixellated (2 × 2 × 5 mm^3, pitch: 0.25 mm) bismuth germanate (BGO) crystal is used for scintillation detection, while in γ-eye a pixelated (1.45 × 1.45 × 5 mm^3, pitch: 0.25 mm) sodium activated cesium iodide (CsI:Na). BGO was selected since it combines low cost, good detection ability and large probability detection efficiency (~ 40 %) for 511 keV quanta. The scintillation emission maximum of BGO is situated at 480 nm. CsI:Na has high density, high γ-ray stopping power, high light output and a wavelength of emission peak at 420 nm. A borosilicate glass window, 2 mm thick, covered with optical grease, provides the best coupling scheme with the photodetector, in terms of intrinsic performance, in both systems.

Photon detection

For photon detection, in both systems, we use the Hamamatsu H12700A multianode position sensitive photomultiplier tube (PSPMT), due to its large effective area 48.5 × 48.5 mm^2. In order to obtain whole body mice images, two H12700A PMTs shall be used in a 1 × 2 arrangement for each detector, forming a ~ 48 × 98 mm^2 field of view (FOV), ideal for mice imaging. H12700A is sensitive in the range of 300 nm to 650 nm, with a typical quantum efficiency of 33 % at about 380 nm providing a good matching factor with the emission spectrum of BGO and CsI:Na. Among the multichannel photodetectors, the H12700A stands out for the very small inactive border around the device and the PSPMT square cross-sectional geometry which allows for a close packing ratio (~ 87 %), making it ideal for use in multiple tube detector schemes by minimizing the dead area corresponding to gaps between the tubes. These features, together with the nominal low dark counts contribution and the moderate cross-talk between neighbouring pixels, make the H12700A particularly suitable for applications in nuclear medicine where relatively large FOV is required.

Electronics

The output signals of the 2 PSPMTs of each detector are reduced to 4 position signals using a symmetric resistive charge division circuit [3]. Field programmable gate arrays (FPGA) based data acquisition systems along with high speed analog to digital converters (ADCs) are used for digitization, processing and transmission of the acquired data to the computer for post processing [4], [5].

Performance evaluation

The "γ-eye" and "β-eye" novel imagers have been fully characterized with their performance quantified for energy resolution, spatial system response and sensitivity using ^{68}Ga (PET isotope) and ^{99m}Tc (SPECT isotope) radioisotopes, respectively. These measurements are collated in Figure 2. Both systems have been evaluated in proof-of-concept animal studies using normal Webster Swiss Albino mice with average weight of 25 g. All applicable institutional and/or national guidelines for the care and use of animals were followed.

Performance Specifications

	β-eye	γ-eye
Useful Field of View (UFOV)	48 mm × 98 mm	48 mm × 98 mm
Sensitivity within energy window	14 kcps/MBq	56 cps/MBq
Spatial resolution	1.5 mm @ 30 mm	1.7 mm @ 0 mm
Energy resolution	19 % @ 511 keV	19 % @ 140 keV

Figure 2: Performance specifications of the "eye-series" products.

A static image of the mouse injected with the [^{99m}Tc]-MDP tracer, acquired for 15 min, at 4 hours post injection, with the "γ-eye" scintigraphic imager, is presented in Figure 3. The spine and the bones of the mouse are clearly distinguished and even the ribs.

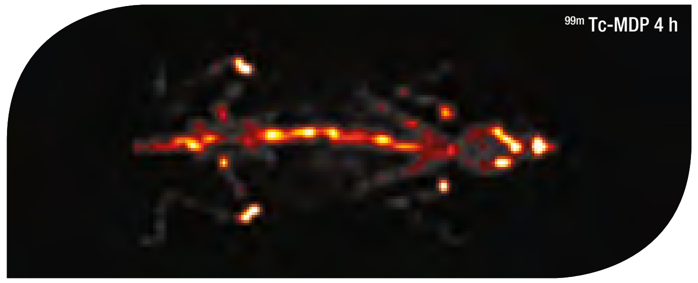


Figure 3: Mouse injected with [^{99m}Tc]-MDP at 4 hours pi (15-min acquisition time).

A static image of a mouse injected with the [^{18}F]-FDG tracer, acquired for 10 min, at 1 hour post injection, with the "β-eye" coincidence imager, is illustrated in Figure 4. The biodistribution of the tracer is clearly given and several intermediate time points can be derived. Both systems sensitivity allows several intermediate time points to be derived even down to 10 sec frames.

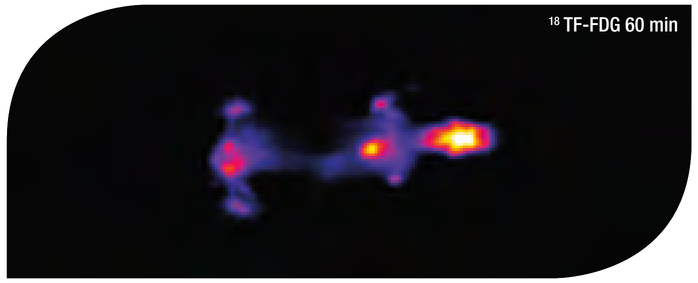


Figure 4: Mouse injected with [^{18}F]-FDG at 1 hour pi (15-min acquisition time).

Conclusion

Performance metrics demonstrate the ability of the "eye-series" products to be used as efficient standard screening tools for daily research, supporting the imaging needs of research groups that have access to radioactivity, to animals with radiolabelled compounds, but then use ex-vivo biodistributions. While multimodal systems can fully validate a new probe, the performance of "β-eye" and "γ-eye" supports the argument that coincidence and scintigraphic imaging of PET and SPECT isotopes, respectively, can provide in a cost effective and accurate way, a very good indication of the in-vivo biodistribution, boosting research in drugs and biomolecules development. An essential component in the "eye-series" products is the new generation of Hamamatsu flat panel type multianode, large effective area PSPMT, the H12700A.

References

[1] R. Weissleder and U. Mahmood, "Molecular imaging", Radiology, vol. 219, no. 2, pp. 316–333, 2001.
[2] T. E. Peterson and S. Shokouhi, Advances in preclinical SPECT instrumentation, J. Nucl. Med., vol. 53, 2012.
[3] P. Olcottetal.,"Compact readout electronics for position sensitive photomultiplier tubes", IEEE Trans. Nucl. Sci., vol. 52, 2005.
[4] E. Fysikopoulos et al., "A Spartan 6 FPGA-based data acquisition system for dedicated imagers in nuclear medicine", Meas. Sci. Tech., vol. 23, 2012.
[5] E. Fysikopoulos et al., "Fully digital FPGA-Based data acquisition system for dual head PET detectors", IEEE Trans. Nucl. Sci. vol. 61, 2014

Company News

Dr. Reinhold Guth, Managing Director, Hamamatsu Photonics Germany GmbH

New Managing Director for Hamamatsu Photonics Germany GmbH

Hamamatsu Photonics Deutschland GmbH (HPD) is pleased to announce the appointment of Dr. Reinhold Guth as their new Managing Director.

Now in his 26th year with the company, Dr. Guth started as a Sales Engineer for Optoelectronic Components in 1992 and since 2000, held the position of Sales Director for Optoelectronic Components.

Dr. Guth gained a diploma in Physics at Ludwig Maximilian University in Munich and a PhD from the University of Karlsruhe, now Karlsruhe Institute of Technology. His specialty was High Energy Physics.

Speaking of his appointment, Dr. Guth said "I had a chance to grow with HPD not only through sales activities but also by contributing to the implementation of Lotus Notes, Customer Relationship Management Systems (CRM) and the Website. I look forward to shaping the structures and workflows of HPD as necessary for the continued growth of the company".

Dr. Guth succeeds Dr. Peter Eggl, who resigned from his position after 25 years. Dr. Eggl will remain with the company in the future as a strategic consultant and member of the Supervisory Board of Hamamatsu Photonics Germany and Hamamatsu Photonics Europe for a period of two years.

Dr. Eggl also resigns from his role as Managing Director of Hamamatsu Photonics Europe and Mr. Max Skoglund, Managing Director of Hamamatsu Photonics Norden AB, has been appointed as his successor.

SPIE Photonics West 2019 Preview

Photonics West/BIOS is the world's largest photonics technologies event consisting of three conferences and two world-class exhibitions.

It will be held from 2 – 7 February 2019 at The Moscone Center, San Francisco, California, USA.

Visit Hamamatsu Corporation's booth number 941 at Photonics West to see the latest products and technology from Hamamatsu Photonics, such as MPPC/MPPC Modules, IR detectors, light sources, devices for LiDAR, scientific CMOS cameras, the recently-launched ORCA-Fusion camera, and more. You can also attend live demonstrations of many Hamamatsu products, including demos for the new SMD series mini-spectrometer, the world's smallest grating-based spectrometer and a Prism Award finalist.

Hamamatsu Corporation will also have these additional activities and highlights at Photonics West.

SPIE. PHOTONICS WEST
Visit us at booth 941

Product Demonstrations
Introducing the SMD series mini-spectrometer which is the world's smallest grating-based spectrometer.

SMD series mini-spectrometers are grating-based SWNIR spectral sensor heads fabricated through MOEMS.

Presenter: Dana Hinckley
Date: Saturday, 2 Feb 2019
Time: 1:30 PM – 2:00 PM
Location: PW19B BIOS Demo Area (Hall A South)

Date: Tuesday 5 Feb 2019
Time: 12:30 PM – 1:00 PM
Location: Demo Area 1 (Hall ABCD South)

One Day Workshop
Hosted by Hamamatsu Corporation

Instructors: Slawomir Piatek, Koei Yamamoto

Title:
Introduction to Photodetectors, Spectroscopy + Spectrometers, PMT, SiPM + SPAD

Date: Wednesday 6 Feb 2019
Time: 8:10 AM - 5:00 PM

Part 1
Time: 8:10 AM – 10:00 AM
Introduction to Photodetectors

Part 2
Time: 10:15 AM to 11:45 AM
Spectroscopy and Spectrometers

Part 3
Time: 1:10 PM – 3:00 PM
PMT, SiPM and SPAD: Technology Progress, Characteristics, Performance, and Applications

Part 4
Time: 3:15 PM – 5:00 PM
Automotive LiDAR: Design Concepts, Light Sources, and Photodetectors

Conference Papers/ Presentations
Hamamatsu Corporation has submitted the following to the SPIE conference on MOEMS and Miniaturized Systems XVIII, part of SPIE OPTO:

Title:
Grating-based ultra-compact SWNIR spectral sensor head developed through MOEMS technology

Presenter: Takafumi Yokino, Katsuhiko Kato, Anna Yoshida, Shinichi Nakata, Toshiteru Suzuki, Ryosuke Abe, Shigeru Suzuki, Yoshihisa Warashina, Katsumi Shibayama, Koei Yamamoto
Session 2: Spectrometers I
Date: Saturday 2 Feb 2019
Time: 10:50 PM – 12:20 PM

Title:
Compact FTIR engine made through MOEMS technology

Presenter: Tomofumi Suzuki, Tatsuya Sugimoto, Kyosuke Kotani, Yutaka Kuramoto, Katsumi Shibayama
Session 7: Spectrometers II
Date: Sunday 3 Feb 2019
Time: 1:50 PM – 3:40 PM

Best Paper Awards
Hamamatsu Corporation is delighted to sponsor two Best Paper Awards for High-Speed Biomedical Imaging and Spectroscopy VI Conference BO508.

Prism Award
The Prism Awards for Photonics Innovation is a leading international competition that honors the best new optics and photonics products on the market.

Hamamatsu Photonics are proud to be a finalist this year for our Mini-spectrometer, SMD series C14384-MA01, a grating-based SWNIR spectral sensor head through MOEMS technology.

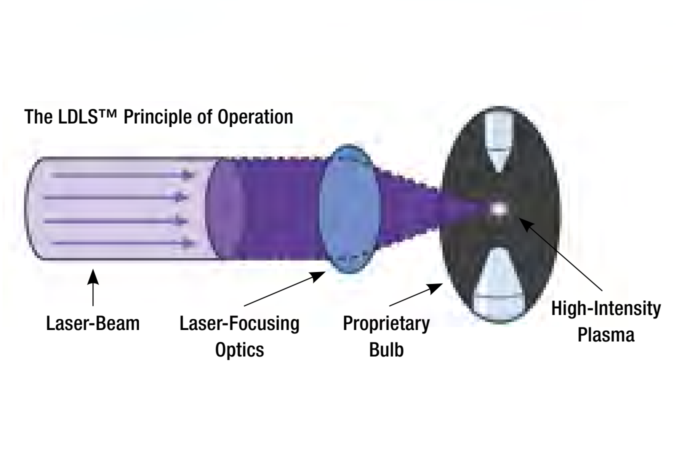
The award ceremony will be held at Photonics West.

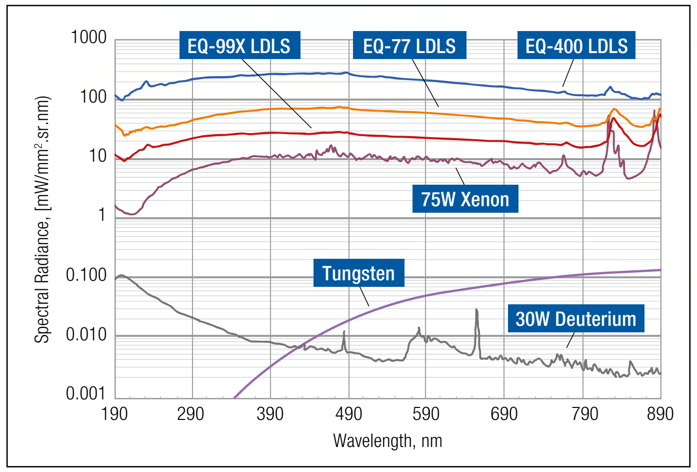
Company News

Laser-Driven Light Sources from Energetiq Technology

Hamamatsu Photonics KK of Japan acquired Energetiq Technology of the United States in 2017. Energetiq is a world leader in high brightness light sources for advanced technology applications. Hamamatsu subsidiaries around the world are pleased to now distribute Energetiq's Laser-Driven Light Source (LDLS™) products.

Energetiq has developed a revolutionary single-light source technology called the Laser-Driven Light Source (LDLS™) that enables extreme high brightness over a broad spectral range, from 170 nm to 2 µm, combined with lifetimes an order of magnitude longer than traditional lamps.





Principle of Operation

Energetiq's innovative LDLS technology uses a CW laser to excite and sustain a xenon plasma thereby creating extremely bright, broadband light. In traditional approaches the brightness, UV power, and lamp lifetime are limited by the use of electrodes to couple power to the plasma. Energetiq's LDLS technology allows for extremely stable light production for the duration of the bulb's life because the electrodes are used only during ignition and are not used during operation.

The proprietary bulbs used in Laser-Driven Light Sources can be used continuously for up to one year without a significant drop in output. This is ideal for high throughput applications, fits in well with scheduled maintenance for semiconductor labs and leads to a low overall cost of ownership.

Spectral Radiance of LDLS™

Energetiq's Laser-Driven Light Sources produce extremely bright light from 170 nm to 2 µm. This broad range is a key benefit for applications that may have previously required the use of multiple light sources. Additionally, LDLS are significantly brighter than competing sources such as xenon arc, tungsten or deuterium lamps.

Brighter Together

ENERGETIQ

HAMAMATSU PHOTON IS OUR BUSINESS

Laser-Driven Light Sources (LDLS™)

Energetiq's Laser-Driven Light Sources are preferred by the semiconductor industry because of their extremely high brightness, stability and long maintenance cycle. However, with broadband output emitting from a xenon plasma that is just 100 µm to 300 µm in diameter, the LDLS™ product line also enables many other OEM and end-user applications.

The LDLS product line offers options suitable for varying radiance requirements and preferred light delivery. For any application that calls for extremely bright and stable broadband light, Laser-Driven Light Sources are in a class of their own.

Features:
- Broadband emission (170 nm to 2 µm)
- Free space or fiber coupled output
- Ultra-high brightness source
- High temporal and spatial stability
- Long bulb lifetime (> 9,000 hours)

Applications:
- UV-VIS spectroscopy
- Optics testing
- Analytical instrumentation
- Monochromator source
- Thin-film measurement
- Semiconductor metrology
- Advanced imaging
- Materials characterization
- Life science / biological imaging

Laser-Driven Tunable Light Sources (LDTLS™)

The Laser-Driven Tunable Light Source (LDTLS™) is a compact, fully-integrated, wavelength tunable source that allows users to rapidly step from one band to another. LDTLS systems utilize the EQ-77, EQ-9 or EQ-400 LDLS to meet the requirements of a variety of applications.

Designed with high throughput applications in mind, the LDTLS can be run continuously and has an extremely long lifetime of more than 9,000 hours. It has high stability, very low noise and is coupled with a precision high-performance monochromator for accurate wavelength selection and repeatable light output across the broad range of 350 nm to 1,100 nm.

Features:
- Fully integrated, etendue matched monochromator
- Broad emission from 350 to 1,100 nm
- Fiber coupled output

Applications:
- Optical sensor testing
- Process monitoring and control
- VIS/NIR spectroscopy
- Thin-film measurements
- Materials characterization

For additional information about Energetiq's innovative light sources please visit www.energetiq.com.

Company News

30th Anniversary

Hamamatsu Photonics UK Limited

“HPUK” was founded in 1988 and in September 2018 reached its 30th anniversary.

HPUK began with just 5 employees, under the leadership of Mr Kenji Yoshida, working from a small office in Enfield, North London, with a turnover of less than 1M GBP.

Today, we have grown the business substantially and now employ 48 people. To mark this milestone in our history HPUK will hold an official anniversary celebration in April 2019.

Tim Stokes, Managing Director, comments:
“Our company has expanded substantially since our humble beginnings back in 1988. Our sales have grown continuously year on year and the number of employees increased to almost 50.

We are proud of our many achievements over our 30 year history. Our success has been due to the hard work and dedication of all of our employees, doing their best to provide the highest levels of service and support to all of our customers, big and small, with everyone working together to achieve our common goals.

Our vision for HPUK today and in the future, is to form collaborative relationships with all of our customers; HPUK should always be viewed as a trusted and valued business partner, not just a distributor of Hamamatsu Photonics' products, so that we can continue to be a leading contributor to the future success of Hamamatsu Photonics.

The continuous support of our customers and from the global Hamamatsu team is critical for us to achieve our future success as we look to building ever closer relationships, enabling us to achieve sustainable and profitable business in the future.”

Hamamatsu Photonics Sweden

In 2018, it was 30 years since Hamamatsu Photonics established its Swedish subsidiary in Stockholm, with the goal of developing business opportunities and improving customer support in the Nordic countries.

In the beginning, operations were handled by a small team, but over the years, operations have developed successfully and the company currently has close to thirty employees, with its headquarter in Kista, northern Stockholm.

The changes in Eastern Europe during the early nineties opened up new opportunities for the Swedish subsidiary to also expand the business activities in the Baltic countries. The next natural step was then to establish a branch office in Moscow in 2002 to improve the local support for customers in Russia and other countries in the Commonwealth of Independent States (CIS).

Hamamatsu in Sweden is today an established supplier and partner in northern Europe within a broad spectra of cross-scientific disciplines including biotechnology, analytics, environmental, medical, life sciences, industrial automation, communication and many more. In close collaboration with the other Hamamatsu companies in Europe and with the parent company in Japan, the goal is to constantly strive at improving service and support as well as offering continuity and stability to our customers.

Max Skoglund, Managing Director of Hamamatsu Photonics Norden AB, wishes to thank all customers and partners for these years and looks forward to fruitful collaboration also in the future.

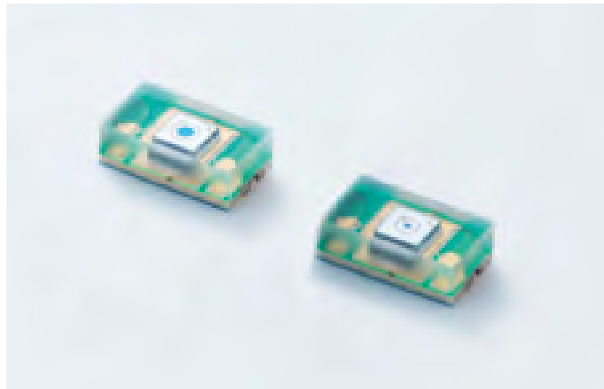
NEW

Si APD S14643/S14644/S14645 Series

New APD with improved individual differences in breakdown voltage characteristics

This new Si APD minimizes the breakdown voltage to within ±20 V, where until now there was ±50 V of variation, and further improves the dark current characteristics. Less variation in characteristics means it is easier to design devices for incorporation with Si APDs.

We offer a lineup of Si APD that match near infrared laser diode wavelengths (870 nm, 905 nm) used in light sources for LiDAR, as well as for red laser wavelengths (660 nm) used for industrial purposes.



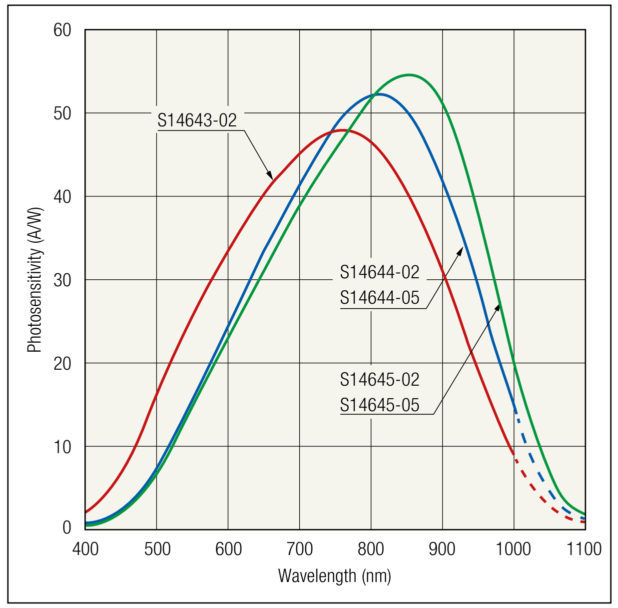
S14643/S14644/S14645 series

Specifications (Typ, Ta = 25 deg. C., plastic package)

Parameter	Symbol	S14643-02	S14644-02/-05	S14645-02/-05	Unit
Photosensitive area	–	Φ0.2/Φ0.5			mm
Operating temperature	Topr	-30 to +100			deg. C.
Storage temperature	Tstg	-40 to +100			deg. C.
Spectral response range	λ	400 to 1,000		400 to 1,100	nm
Peak sensitivity wavelength	λp	760	800	840	nm
Breakdown voltage	V_{BR}	100	160	175	V
Cutoff frequency	fc	2.0	1.2/1.0	0.60	GHz
Terminal capacitance	Ct	0.7	0.6/1.6	0.5/1.0	pF
Gain	M	100			–

S14645 series: On-chip band-pass filter type (sensitive from 850 to 950 nm) is available upon request.

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

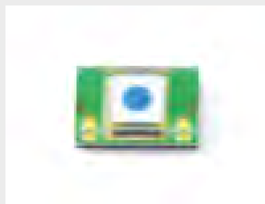


Related products

Devices for automotive LiDAR

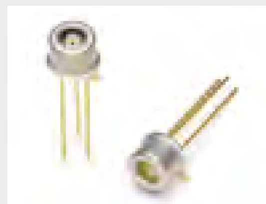
Hamamatsu offers a variety of products with light emitters and detectors for LiDAR. Custom products are also available.

Pulsed laser diode



Si PIN photodiode

MPPC®



InGaAs APD

APD with front-end IC

CMOS Linear Image Sensor S13774

NEW

High-speed readout (100 klines/s)

The S13774 is a CMOS linear image sensor developed for industrial cameras that require high-speed scanning. The column-parallel readout method, which has a readout amplifier and an A/D converter for each pixel, allows high-speed readout. For the A/D converter resolution, either 10-bit (high-speed mode: 100 klines/s max.) or 12-bit (low-speed mode: 25 klines/s max.) can be selected. Video signal is output serially in 180 MHz LVDS format.

Differences from previous products

Equipped with an A/D converter for high-speed readout at a max. 100 klines/s (previous products: 2.5 klines/s).

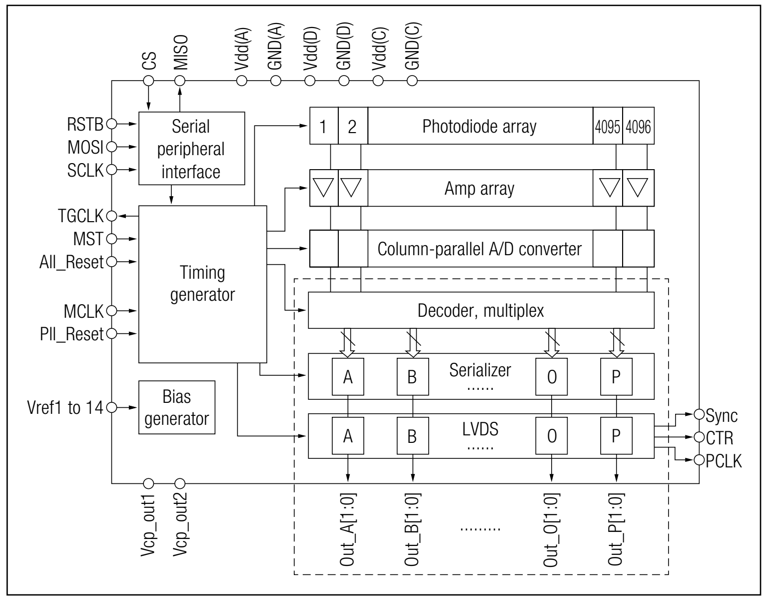
Features

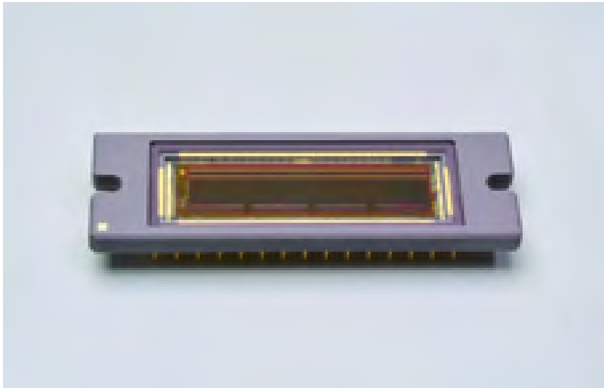
- High-speed readout: 100 klines/s
- Simultaneous integration of all pixels
- 3.3 V power supply operation
- SPI communication function
- Built-in 10-bit/12-bit A/D converters

Applications

- Machine vision
- Film inspection
- Printed circuit board appearance inspection
- Print inspection

Block diagram





S13774

Specifications

Parameter	Specifications	Unit
Number of pixels	4,096	pixels
Pixel size (H x V)	7 × 7	μm
Effective photosensitive area length	28.672	mm
Spectral response range	400 to 1,000	nm
Line rate* max.	100	klines/s

*High-speed mode

NEW

CCD Image Sensor S14650/S14651/S14660/S14661 Series

Photosensitive area structure suitable for spectrometers (1,024 × 192 pixels, 2,048 × 192 pixels)

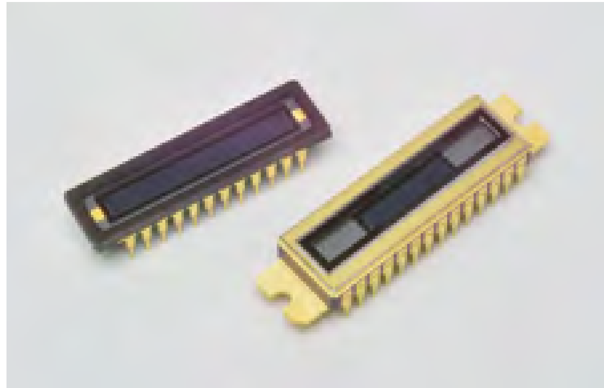
These are back-thinned CCD image sensors designed for spectrometers. Low-noise type (S14650/S14651 series) and high-speed type (S14660/S14661 series) are available. They offer nearly flat spectral response characteristics with high quantum efficiency from the UV to near infrared region.

Differences from previous products

Provides 3 times the number of vertical pixels (192 pixels) than conventional products.

Features

- Low etaloning
- High sensitivity over a wide spectral range, nearly flat spectral response characteristics
- 3 times the number of vertical pixels than conventional products: 192 pixels
- C11860 driver circuit (sold separately) available for the S14651 series



S14650/S14651/S14660/S14661 series

Specifications

Parameter		S14650 series	S14651 series	S14660 series	S14661 series	Unit
Type		Low-noise type		High-speed type		–
Cooling		Non-cooled	One-stage TE-cooled	Non-cooled	One-stage TE-cooled	–
Number of effective pixels	-1024	1024 × 192				pixels
	-2048	2048 × 192				
Pixel size (H × V)		14 × 14				μm
Image size (H × V)	-1024	14.336 × 2.688				mm
	-2048	28.672 × 2.688				
Spectral response range		200 to 1,100				nm
Line rate*1	-1024	95		305		lines/s
	-2048	68		153		
Conversion effciency		6.5*2		8*3		μV/e-
Readout noise		6*4		30*5		e- rms

*1 Full line binning
*2 $R_L = 100$ kΩ, $V_{OD} = 24$ V
*3 $R_L = 2.2$ kΩ, $V_{OD} = 15$ V
*4 fc = 20 kHz (Ta = -40 deg. C.)
*5 fc = 5 MHz (Ta = 25 deg. C.)

Infrared LED L13895-0145G

NEW

Surface mount type, peak emission wavelength: 1.45 μm

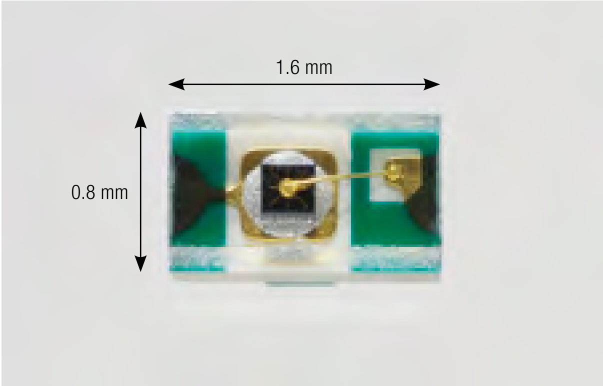
The L13895-0145G is a high-power LED that emits infrared light at a peak of 1.45 μm. A surface mount type (L13895-0145G) is newly added with a previous bullet-shaped package (L13895-0145P). It offers high output power, high reliability and low cost.

Features

- Low cost
- High reliability
- Small and surface mount type (1.6 × 0.8 × 0.7t mm)
- Suitable for lead-free reflow

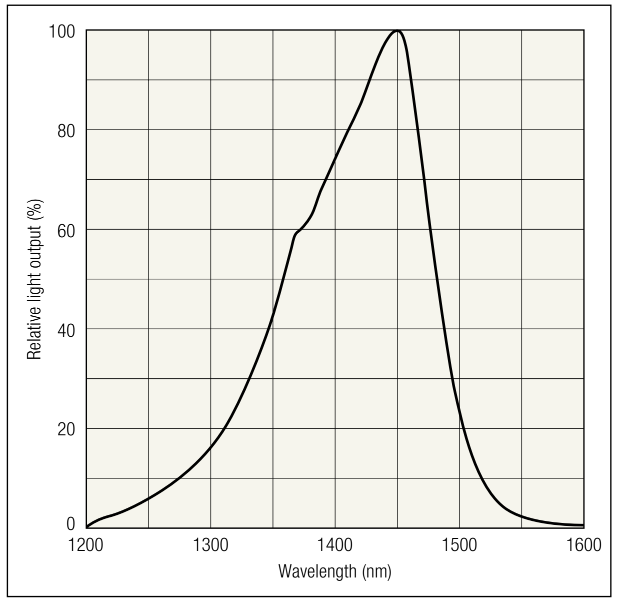
Applications

- Light sources for foreign object sorting
- Light sources for moisture meters



L13895-0145G

Emission spectrum (Typ, Ta = 25 deg. C., I_F = 50 mA)



Specifications

Parameter	Specification	Unit
Peak emission wavelength*1	1,450	nm
Spectral half width*1	120	nm
Radiant flux*1	4	mW
Forward voltage*1	0.9	V
Reverse current max.*2	10	μA
Cutoff frequency*3	10	MHz

*1 $I_F = 50$ mA
*2 $V_R = 1$ V
*3 $I_F = 50$ mA ± 10 mAp-p

InAsSb Photovoltaic Detectors P13243-122MS/-222MS

NEW

High-speed response and high sensitivity in the spectral band up to 5 μm, TE-cooled type

The P13243 series are photovoltaic type infrared detectors that have achieved high sensitivity in the spectral band up to 5 μm using Hamamatsu unique crystal growth and process technologies.

Differences from previous products

The photosensitive area is larger than that of previous products (P13243-011MA/-013CA), so it is easy to incorporate with optical systems. It is also equipped with a thermoelectric cooling device to provide less noise.

Features

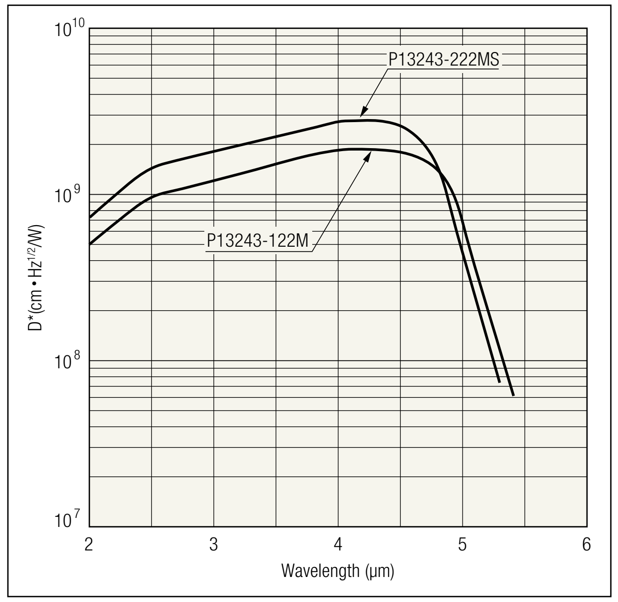
- High sensitivity
- High-speed response
- High shunt resistance

Applications

- Gas detection (CH_4, CO_2, CO, etc.)
- Radiation thermometers

P13243-122MS/-222MS

Spectral response (Typ, Ta = 25 deg. C.)



Specifications

Parameter	P13243-122MS	P13243-222MS	Unit
Cooling	One-stage TE-cooled	Two-stage TE-cooled	–
Photosensitive area	2 × 2		mm
Cutoff wavelength	5.2	5.1	μm
Peak sensitivity wavelength	4.1		μm
Photosensitivity*1	8.6	8.8	mA/W
Shunt resistance*2	19	33	kΩ
Detectivity*3	1.9×10^9	2.8×10^9	cm · $Hz^{1/2}$/W
Rise time*4	0.1		μs

*1 λ = λp
*2 $V_R = 10$ mV
*3 λ = λp, fc = 1,200 Hz, Δf = 1 Hz
*4 10 % to 90 %, λ = 1.55 μm

Ionization-Assisting Substrates DIUTHAME®
A13331-3-1/-18-1, A14111-3-1

NEW

Significantly reduces pretreatment time for imaging mass spectrometry and delivers high resolution imaging

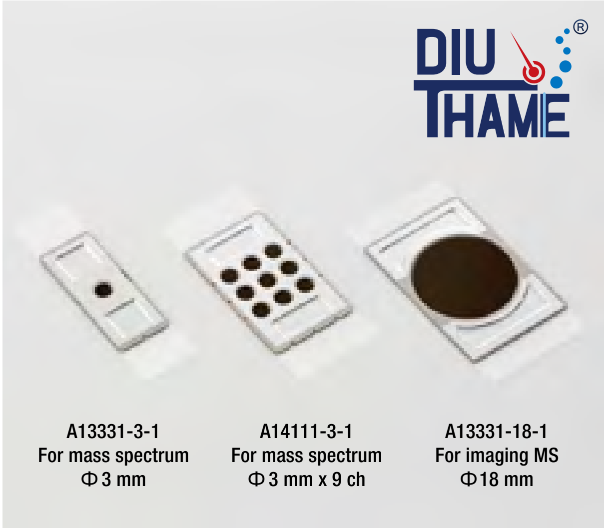
Matrix-Assisted Laser Desorption/Ionization (MALDI) used as a major ionizing method for imaging mass spectrometry requires cumbersome pretreatment for mixing matrix with a sample to ionize it. This pretreatment includes matrix preparation, coating and drying, and so takes a lot of time. DIUTHAME gives accurate results through simple pretreatment for imaging mass spectrometry by just placing a DIUTHAME substrate on a sample instead of using any matrix.

Features

- NO matrix background noise
- NO sample pretreatment needed: Pretreatment time for imaging mass spectrometry is 1/10 of the time needed for ordinary sample pretreatment
- High reproducibility with minimal variation no matter who does the experiments
- High spatial resolution in imaging mass spectrometry ensured by nanometer-order structure

Applications

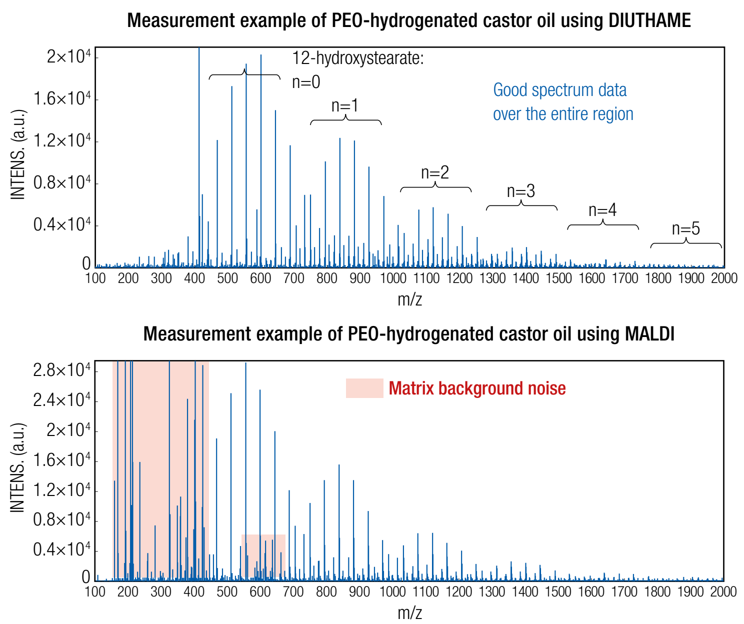
- Mass spectrometry: MALDI-TOF MS



A13331-3-1/-18-1, A14111-3-1

Mass spectrum measurement example: PEO-hydrogenated castor oil*1

Measurement sample: Cosmetic raw material (Hydrogenated castor oil)

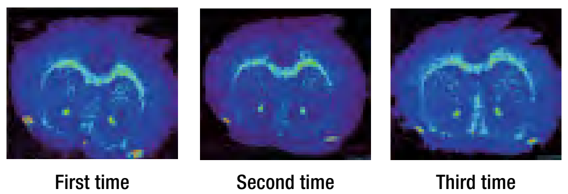


Measurement method: The mixed sample was dropped from above the DIUTHAME.
Measurement sample details: The sample was dissolved in THF at a concentration of 1 mg/mL.
NaTFA was used as the cationizing agent and dissolved in THF at a concentration of 1 mg/mL.
The sample was mixed with the cationizing agent at a ratio of 1:10 (v/v).

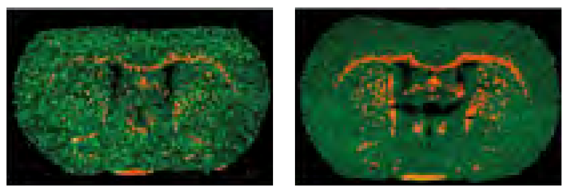
Imaging mass spectrometry measurement example*2

Reproducibility of serial slices of mouse brain (near m/z 850)

Good reproducibility » DIUTHAME — Mouse brain slice thickness: 50 µm, Laser pitch: 50 µm



Comparison between MALDI and DIUTHAME using mouse brain (m/z 848)



MALDI	DIUTHAME
Tissue section has contracted somewhat	» Good spatial resolution » Maintains shape of tissue section
Conditions: Mouse brain slice thickness: 10 µm Matrix conditions DHB 50 mg/ml, 50 % ACN Spray coating Measurement conditions: Reflectron, positive ion mode Laser pitch: 50 µm	Conditions: Mouse brain slice thickness: 50 µm DIUTHAME size Effective diameter: 18 mm Measurement conditions: Reflectron, positive ion mode Laser pitch: 50 µm

*1 Measurements were carried out in cooperation with Dr. Hiroaki Sato, Polymer Chemistry Group of the Research Institute for Sustainable Chemistry, National Institute of Advanced Industrial Science and Technology (AIST).

*2 Measurements were carried out in cooperation with Designated Assistant Professor Keiko Kuwata, The Institute of Transformative Bio-Molecules Nagoya University

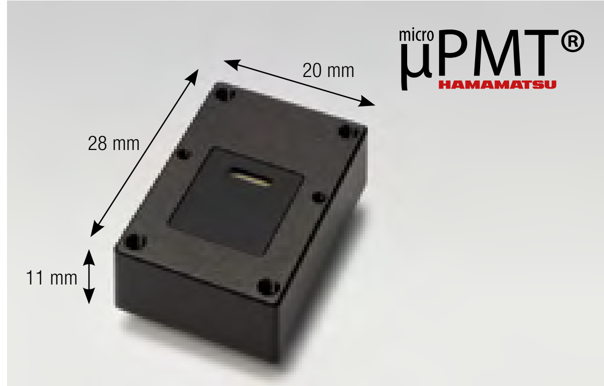
Micro PMT Module
H14066

NEW

Finger-tip size micro PMT module

The H14066 is a current output micro PMT module that incorporates the world's smallest micro PMT* and a high-voltage power supply circuit. Its input and output pins allow direct mounting on a PC board. Its compact size helps create portable high-sensitivity testing/measuring devices that have been difficult to design with ordinary photomultiplier tubes.

The cubic volume has shrunk to 45 % and the weight slashed to 25 % of the previously available micro PMT modules.



H14066

Features

- Compact
- Light weight: 10 g
- Low voltage (+5 V) operation
- Highly resistant to vibration and shock

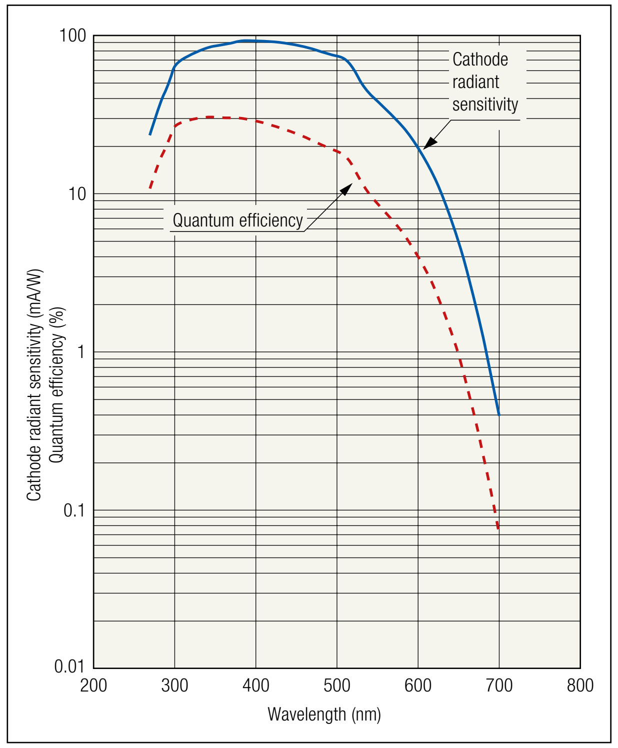
Applications

- Portable high-sensitivity photometric devices
- Portable environmental measurement devices
- Point-of-care medical devices

Specifications

Parameter	Specifications	Unit
Spectral response range	300 to 650	nm
Effective photocathode area (X × Y)	4 × 1	mm
Input voltage	+4.75 to +5.25	V
Maximum input current	5	mA
Maximum output current	5	µA
Ripple noise (p-p)	0.3	mV
Setting time	10	s

Spectral response



* As of Oct. 2018, based on our research.

Photosensor Module H14211-110

NEW

Photomultiplier tube module usable in a vacuum or depressurized environment

The H14211-110 is a current output photomultiplier tube module incorporating a TO-8 package photomultiplier tube and a high-voltage power supply circuit. Custom design is available with different photomultiplier tubes, shapes, cables and connectors.

Features

- Usable in a vacuum or depressurized environment
- Compact and lightweight
- Low power consumption

Applications

- Low-level light measurement in a vacuum or depressurized environment
  - VUV measurement
  - Experiments using balloons
  - Measurement in high-altitude environments

H14211-110

Specifications

Parameter	Specification	Unit
Spectral response range	300 to 700	nm
Input voltage	+3 to +5	V
Input current (at dark)	2.7	mA
Effective area	ϕ8	mm
Operation environment	Atmospheric to 0.001 Pa	–
Case material	Alminium alloy	–

Side-on Type Photomultiplier Tube R14657

NEW

High sensitivity from visible to NIR region

The R14657 is a 13 mm (1/2 inch) diameter side-on photomultiplier with high near-infrared sensitivity that is approximately 2.5 times greater than that of our current product (R6357).

Features

- Compact
- High sensitivity from visible to NIR region

Applications

- Flow cytometer
- Spectrophotometer
- Microscope

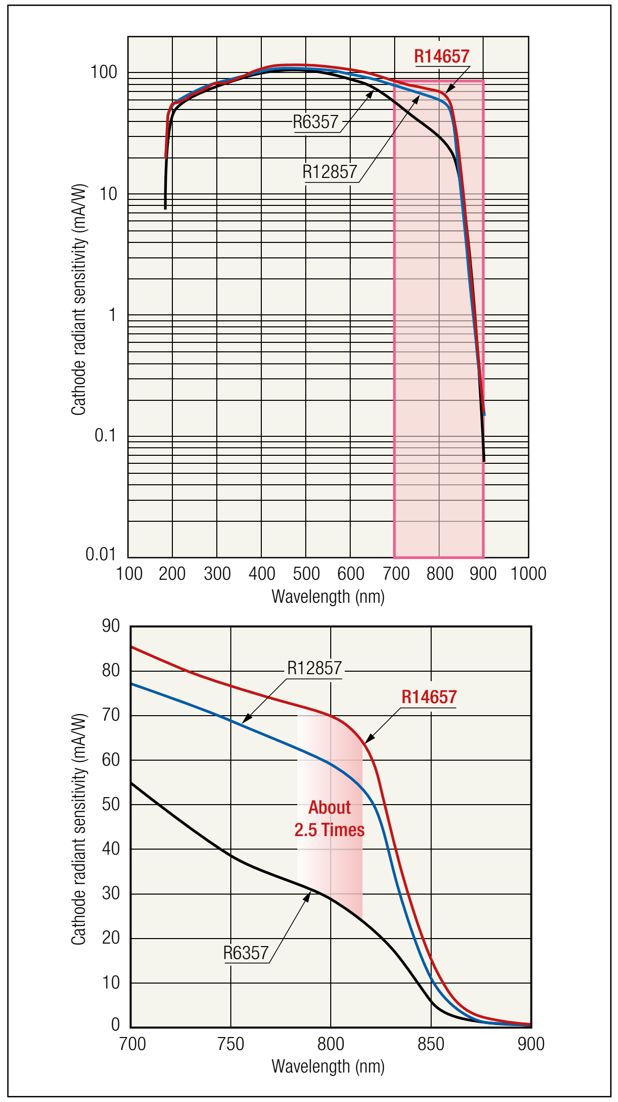
R14657

Specifications

Parameter	Specifications	Unit
Spectral response range	185 to 900	nm
Cathode luminous sensitivity	750	μA/lm
Anode luminous sensitivity*1	1,800	A/lm
Anode dark current*1, 2	4	nA
Gain*1	2.4×10^6	-
Red / white ratio	0.45	-

*1 Supply voltage 1,000 V, at 25 deg. C.
*2 After 30 min storage in darkness

Spectral response



Linear Irradiation Type UV-LED Unit LIGHTNINGCURE® LC-L5G L14012-2300

NEW

Palm sized UV-LED unit

The L14012-2300 is a UV light source ideal for UV ink drying and UV adhesive curing. The size is reduced while maintaining the peak illuminance at a level equal to our current products, making the L14012-2300 ideal for small printing machines that can be installed in a narrow space.

L14012-2300

Features

- High output
- Small installation space
- Fan air cooling

Applications

- UV ink drying
- UV coating drying
- UV tape peeling
- UV adhesive bonding/temporary bonding
- Light source for fluorescence excitation and flaw inspections

Specifications

Parameter		Specification	Unit
Irradiation area		10 × 15	mm
Irradiation window size		11 × 26	mm
UV irradiance (WD = 0 mm)		10	W/cm²
UV irradiance (WD = 2 mm)		8	W/cm²
Input voltage (DC)	LED	48	V
	Fan	12	
Peak wavelength		385	nm
LED design life		20,000	h

ELECTRON TUBE PRODUCTS ■

Flame Sensor UVTRON® R14388

NEW

Can detect a flame from a distance of 100 meters

The UVTRON ultraviolet ON/OFF detector makes use of the photoelectric effect of metal and the gas multiplication effect. It has a narrow spectral sensitivity of 185 nm to 260 nm, being completely insensitive to visible light. It does not require optical visible-cut filters, thus making it easy to use.

R14388

Features

- Detects weak UV light emitted from a flame
- Solar blind characteristic – sensitive only in the UV region
- Long-distance flame detection

Applications

- Fire alarm apparatus
- Arson watch monitor
- Discharge/spark detection

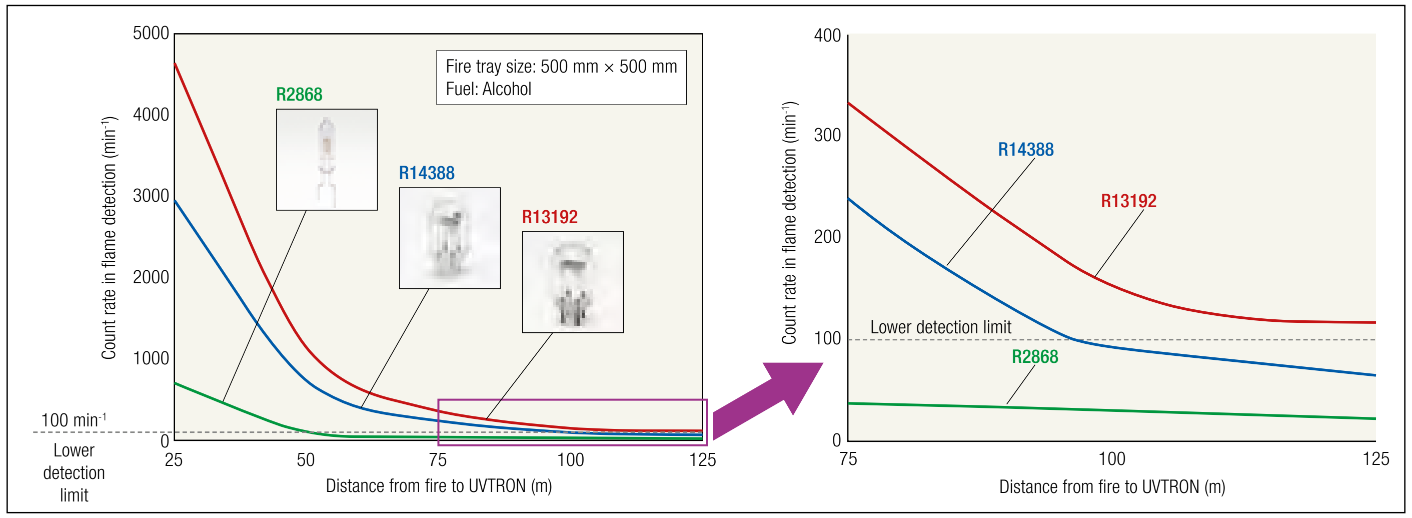
Specifications

Parameter	Specifications	Unit
Spectral response range	185 to 260	nm
Operation ambient temperature (maximum rating)	-20/+125	deg. C.
Recommended operating voltage	325±25	V
Sensitivity (typ.)*1	10,000	min^{-1}
Background (max.)*2	5	min^{-1}

*1 Count rate measured at 25 deg. C. using UV light at 200 nm wavelength and 10 pW/cm² power. Sensitivity varies depending on the wavelength of the incident UV light and the driving circuit.

*2 Measured under room lighting (approximately 500 lux) and recommended operating conditions. Background may increase due to external factors when used outdoors.

Sensitivity and distance from fire



180 kV Microfocus X-ray Source L14351-02

NEW

Sealed type microfocus X-ray source that delivers a maximum output of 90 W

The L14351-02 is a sealed type microfocus X-ray source with a maximum tube voltage of 180 kV. It allows inspection of even thicker materials and the inspection tact time will be one-third compared to our current product (150 kV L12161-07).

L14351-02

Features

- High output: 90 W Max.
- No high voltage cable connection required
- High voltage power supply is integrated with the main unit
- External control via RS-232C interface

Applications

- Non-destructive inspection
  - Dimension measurement
  - Failure analysis
  - Quality management
  - Automatic inspection
- Applicable objects:
  - Metal component
  - Battery
  - Printed circuit board
  - Electronic component
  - Plastic component

Specifications

Parameter	Specification	Unit
X-ray tube voltage operational range	40 to 180	kV
X-ray tube current operational range	10 to 500	µA
Maximum output	90	W
X-ray focal spot size (nominal value)*1	200 (20 at 4 W)	µm
X-ray beam angle*2	Approx. 62	degrees
FOD (Focus to object distance)	Approx. 19.8	mm
Weight*3	Approx. 38	kg

*1 This focal spot size changes depending on the output
*2 Reference value: with 50 % of maximum X-ray emission
*3 This weight includes the accessories of approx. 0.3 kg

Pulsed Laser Diode (PLD) L11854-307-55

NEW

Improved spatial resolution with sharp NFP pattern

This product is a multimode laser that emits a high power beam from a emitting area of 70 µm × 10 µm. Applications include light sources for LiDAR, security, laser ranging, monitoring and surveillance. This product comes in a standard TO-5.6 can package but is also available in other can packages.

L11854-307-55

Differences from conventional products

High heat dissipation by excellent internal component design; can be driven with a simple circuit making usage easy.

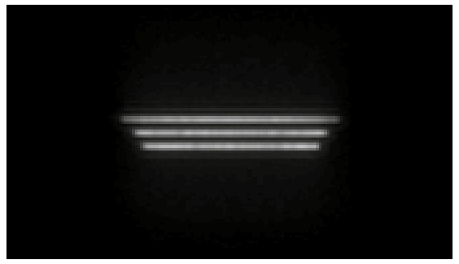
Features

- 3 stack PLD
- Peak output power ≥21 W
- Peak emission wavelength: 905 nm
- Emitting area size: 70 µm × 10 µm

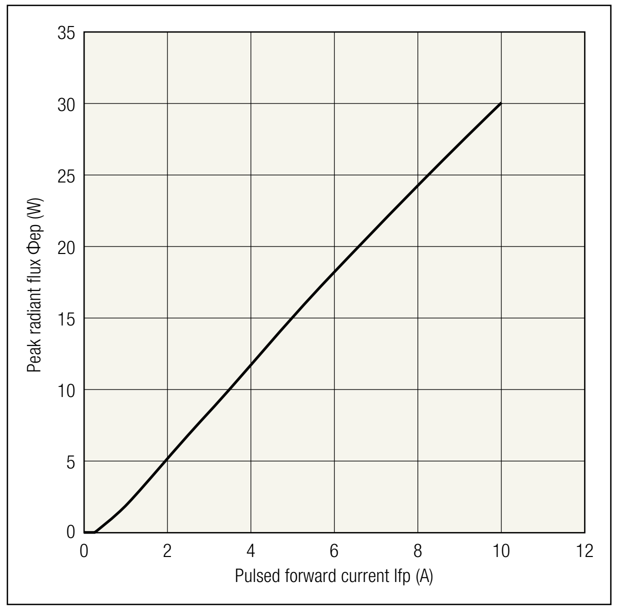
Applications

- LiDAR (autonomous cars, robot, drone)
- Security (human detection, collision prevention)
- Laser ranging (surveying, golfing)

Emitting image of near field pattern (NFP)



Radiant flux vs. forward current (Typ, $T_{op(C)}$ = 25 deg. C.)



Lineup: Single emitter PLDs*1

Type number	Wavelength*2	Peak output power	Operating current	Emitting width	Case polarity	Package*3
L11649-120-05	870 nm	22 W	20 A	200 µm × 1 µm	Anode	Φ5.6 CD

Lineup: 3 stack PLDs*1

Type number	Wavelength*1	Peak output power	Operating current	Emitting width	Case polarity	Package*2
L11348-307-05	870 nm	21 W	7A	70 µm × 10 µm	Anode	Φ5.6 CD
L12169-336-51		100 W	35 A	360 µm × 10 µm	Cathode	
L11854-307-55*4 NEW	905 nm	21 W	7A	70 µm × 10 µm		
L11854-307-05*4					Anode	
L11854-323-51		75 W	25 A	230 µm × 10 µm	Cathode	
L11854-336-05		100 W	35 A	360 µm × 10 µm		

*1 General operating conditions: pulse width 50 ns, frequency 1 kHz.
*2 Tolerance of emission wavelength is +/-10 nm.
*3 Contact our Hamamatsu sales office for specifications and package info.
*4 It is the same LD chips which are different in polarity.

Global Exhibitions 2019

USA

January 2019

CES
Jan 8-11 2019, Las Vegas, NV

February 2019

BIOS
Feb 2-3 2019, San Francisco, CA
SLAS
Feb 2-6 2019, Washington, D.C.
SPIE Photonics West
Feb 2-7 2019, San Francisco, CA
Autonomous Vehicles Silicon Valley (IQPC)
Feb 25-27 2019, Santa Clara, CA

March 2019

Biophysical
March 2-6 2019, Baltimore, MD
USCAP
March 16-21 2019, National Harbor, MD
Pittcon
March 17-21 2019, Philadelphia, PA
ADAS Sensors
March 20-21 2019, Detroit, MI
AACR
March 30-April 3 2019, Atlanta, GA

April 2019

InPrint
April 9-11 2019, Louisville, KY
Defense & Commercial Sensing
April 14-18 2019, Baltimore, Maryland

May 2019

Pathology Informatics Summit
May 6-9 2019, Pittsburgh, PA
CLEO
May 7-9 2019, San Jose, CA

June 2019

ASMS
June 2-6 2019, Atlanta, GA
Digital Pathology and AI Congress
June 13-14 2019, New York City, NY
CYTO
June 22-26 2019, Vancouver, Canada
Sensors Expo
June 25-27 2019, San Jose, CA

Europe

January 2019

LM Facility Managers Meeting
Jan 2-4 2019, Liverpool, UK
Quantitative Bioimaging Conference (QBI)
Jan 9-11 2019, Rennes, France
Bamberger Morphologietage
Jan 25-27 2019, Bamberg, Germany

February 2019

iCT (9th International Conference on Industrial Computed Tomography)
Feb 13-15 2019, Padova, Italy
A&T 2019
Feb 13-15 2019, Torino, Italy
Techinnov
Feb 14 2019, Paris, France
VCI
Feb 18-22 2019, Vienna, Austria
ECR
Feb 27-March 3 2019, Vienna, Austria

March 2019

Photonics
March 4-7 2019, Moscow, Russia
XVIII International Workshop on Neutrino Telescopes
March 18-22 2019, Venezia, Italia
13th Goetting Meeting of GNS
March 20-23 2019, Goettingen, Germany
Automaticon
March 26-29 2019, Warsaw, Poland
Elektronik
March 27-28 2019, Gothenburg, Sweden

April 2019

Oasis
April 1-2 2019, Tel Aviv, Israel
ENOVA
April 3-4 2019, Nantes, France
FYSICA
April 5 2019, Amsterdam, Netherlands
Industry 4.0
April 10 2019, Warsaw, Poland
Focus on Microscopy
April 14-17 2019, London, UK
8th Conference of PET/MR and SPECT/MR
April 15-17 2019, Munich, Germany
Analitika
April 23-26 2019, Moscow, Russia

May 2019

EOT
May 7-9 2019, Herning, Denmark
TEC PL
May 16 2019, Warsaw, Poland
Optics & Photonics Days 2019
May 27-29 2019, Espoo, Finland
SmartAuto
May 28 2019, Warsaw, Poland
SPS IPC Drivers Italia 2019
May 28-30 2019, Parma, Italy

June 2019

ECC – European Congress of Cytology
June 16-19 2019, Malmö, Sweden
Laser World of Photonics
June 24-27 2019, Munich, Germany
Hamamatsu Photonics FDSS Symposium
June 25 2019, Barcelona, Spain
Sensor und Test
June 25-27 2019, Nuremberg, Germany
Agri Food Innovation Event
June 26-27 2019, Venlo, Netherlands
SLAS Europe
June 26-28 2019, Barcelona, Spain

July 2019

Microscience Microscopy Congress
July 3-6 2019, Manchester, UK

September 2019

ECP (European Congress of Pathology)
Sep 7-11 2019, Nice, France,
MipTec
Sep 9-12 2019, Basel, Switzerland
IAA
Sep 9-13 2019, Frankfurt, Germany
ESREF
Sep 23-26 2019, Toulouse, France
Measurement World
Sep 24-26 2019, Paris, France
Ilmac
Sep 24-27 2019, Basel, Switzerland
Labelexpo
Sep 24-27 2019, Brussels, Belgium

Hamamatsu Photonics K.K. Sales Offices

Japan:
HAMAMATSU PHOTONICS K.K.
325-6, Sunayama-cho, Naka-ku
Hamamatsu City, Shizuoka Pref. 430-8587, Japan
Telephone: (81)53 452 2141, Fax: (81)53 456 7889

China:
HAMAMATSU PHOTONICS (CHINA) Co., Ltd
1201 Tower B, Jiaming Center, 27 Dongsanhuan
Beilu, Chaoyang District, Beijing 100020, China
Telephone: (86)10 6586 6006, Fax: (86)10 6586 2866
E-mail: hpc@hamamatsu.com.cn

USA:
HAMAMATSU CORPORATION
Main Office:
360 Foothill Road
Bridgewater, NJ 08807, U.S.A.
Telephone: (1)908 231 0960, Fax: (1)908 231 1218
E-mail: usa@hamamatsu.com

California Office:
2875 Moorpark Avenue
San Jose, CA 95128, U.S.A.
Telephone: (1)408 261 2022, Fax: (1)408 261 2522
E-mail: usa@hamamatsu.com

United Kingdom, South Africa:
HAMAMATSU PHOTONICS UK LIMITED
Main Office:
2 Howard Court, 10 Tewin Road, Welwyn Garden City,
Hertfordshire, AL7 1BW, United Kingdom
Telephone: (44)1707 294888, Fax: (44)1707 325777
E-mail: info@hamamatsu.co.uk

South Africa Office:
9 Beukes Avenue
Highway Gardens
Edenvale 1609
Johannesburg, South Africa
Telephone/Fax: (27)11 6090367

France, Belgium, Switzerland, Spain, Portugal:
HAMAMATSU PHOTONICS FRANCE S.A.R.L.
Main Office:
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

Swiss Office:
Dornacherplatz 7
4500 Solothurn, Switzerland
Telephone: (41)32 625 60 60, Fax: (41)32 625 60 61
E-mail: swiss@hamamatsu.ch

Belgian Office:
Axisparc Technology,
7, Rue Andre Dumont
B-1435 Mont-Saint-Guibert, Belgium
Telephone: (32)10 45 63 34, Fax: (32)10 45 63 67
E-mail: info@hamamatsu.be

Spanish Office:
C. Argenters, 4 edif 2
Parque Tecnológico del Vallés
E-08290 Cerdanyola, (Barcelona) Spain
Telephone: (34)93 582 44 30, Fax: (34)93 582 44 31
E-mail: infospain@hamamatsu.es

Germany, Denmark, Netherlands, Poland:
HAMAMATSU PHOTONICS DEUTSCHLAND GmbH
Main Office:
Arzbergerstr. 10,
D-82211 Herrsching am Ammersee, Germany
Telephone: (49)8152 375 0, Fax: (49)8152 265 8
E-mail: info@hamamatsu.de

Danish Office:
Lautruphoj 1-3
DK-2750 Ballerup, Denmark
Telephone: (45)70 20 93 69, Fax: (45)44 20 99 10
E-mail: info@hamamatsu.dk

Netherlands Office:
Transistorstraat 7
NL-1322 CJ Almere, The Netherlands
Telephone: (31)36 5405384, Fax: (31)36 5244948
E-mail: info@hamamatsu.nl

Poland Office:
8 St. A. Boboli Str.
PL-02-525 Warsaw, Poland
Telephone: (48)22 646 0016, Fax: (48)22 646 0018
E-mail: poland@hamamatsu.de

North Europe and CIS:
HAMAMATSU PHOTONICS NORDEN AB
Main Office:
Torshamnsgatan 35
SE-16440 Kista, Sweden
Telephone: (46)8 509 031 00, Fax: (46)8 509 031 01
E-mail: info@hamamatsu.se

Russian Office:
11, Chistoprudny Boulevard, Building 1,
RU-101000, Moscow, Russia
Telephone: (7)495 258 85 18, Fax: (7)495 258 85 19
E-mail: info@hamamatsu.ru

Italy:
HAMAMATSU PHOTONICS ITALIA S.R.L.
Main Office:
Strada della Moia, 1 int. 6
20020 Arese, (Milano), Italy
Telephone: (39)02 93581733, Fax: (39)02 93581741
E-mail: info@hamamatsu.it

Rome Office:
Viale Cesare Pavese, 435,
00144 Roma, Italy
Telephone: (39)06 50513454, Fax: (39)02 93581741
E-mail: inforoma@hamamatsu.it

Impressum

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HAMAMATSU PHOTONICS K.K.
325-6, Sunayama-cho, Naka-ku
Hamamatsu City
Shizuoka Pref. 430-8587, Japan
Telephone: (81)53 452 2141
Fax: (81)53 456 7889
http://www.hamamatsu.com
kikaku2@hq.hpk.co.jp

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