HAMAMATSU
PHOTON IS OUR BUSINESS

NEWS 2019 03

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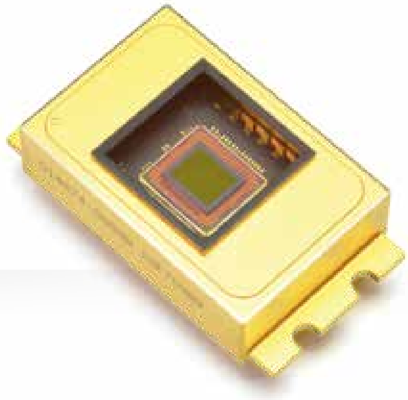


InGaAs area image sensor for hyperspectral cameras

Changing the Recycling of Plastic

Infrared image sensor capable of detecting up to 2.55 μm (world's longest*)

* InGaAs area image sensors (according to our research)

In May 2019, an amendment to the Basal Convention concerning regulations on the transporting and treatment of toxic waste across national borders was passed by an agreement among around 180 countries.

The main point of the agreement was to include the exporting and importing of plastic waste in the scope of the regulations. It drew a great deal of attention because the responsibility of developed countries, which relied on developing countries in the treatment of plastic waste, was made clear.

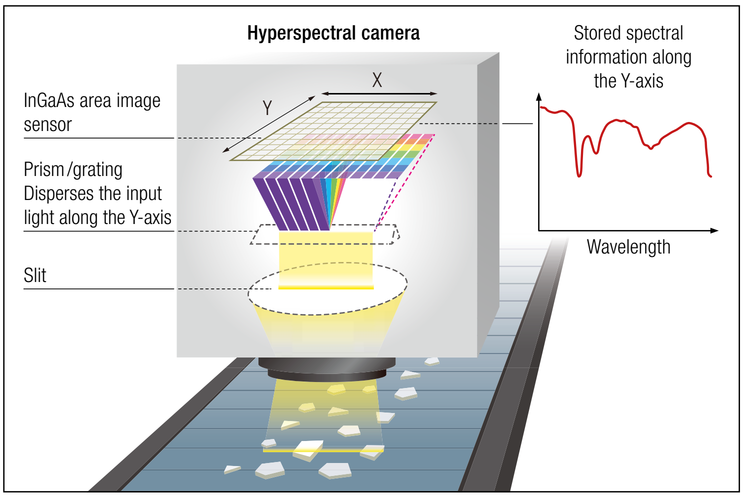
Reduction of plastic waste is a pressing issue for the entire human race. Hamamatsu infrared image sensors will be at the forefront of tackling this issue.

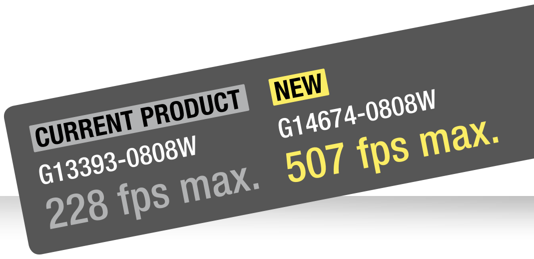
Hyperspectral imaging that improves the "screening accuracy" of plastic

In addition to China (last year's largest recipient) banning the reception of plastic waste, the enactment of a regulation on exporting recycle resources to developing countries has increased the importance of recycling plastic waste.

The key to effective plastic recycling is the identification of materials. Currently, a lot of the plastic waste is cut into little pieces with a shredder and then separated by materials. The screening method for this process that is receiving a lot of attention recently is "hyperspectral imaging", which distinguishes differences in plastics using infrared light. Hyperspectral imaging is a method by which pixel-level spectrum information is acquired simultaneously with the image of the target object. It is a useful method to identify and classify materials that are difficult to distinguish by eyesight. A hyperspectral camera is used to acquire hyperspectral images. Like normal line cameras, scanning is performed by moving the target object (or camera). The input light passes through a slit, is dispersed along the Y-axis direction by a prism/grating, and is measured by an area image sensor. Because a unique spectrum can be obtained in the infrared wavelength range, depending on the plastic material, using a hyperspectral camera with a built-in infrared area image sensor allows highly accurate identification.

Principle





Detecting infrared light up to 2.55 μm allows identification of plastics coated with flame-retardant resin

Hamamatsu has so far been producing InGaAs area image sensors that can detect infrared light up to 1.7 μm, but in this spectral range, identification of plastic that includes flame-retardant resin was difficult. Therefore, there were demands for sensors that could detect wavelengths up to about 2.4 μm, which exhibit differences in spectrum waveforms depending on the presence/absence of flame-retardant resin. To meet these market demands, Hamamatsu developed and released the G14674-0808W featuring a cutoff wavelength of 2.55 μm, which is the world's longest in InGaAs area image sensors. In addition to making the InGaAs photodiode capable of handling longer wavelengths, the readout circuit was also improved to achieve lower dark current and higher speed. The integration of this product into a hyperspectral camera expands the range of recyclable materials that can be screened and encourages recycling rate improvement.

Main features

Cutoff wavelength: 2.55 μm

Hamamatsu has successfully reduced the amount of defects that occur in the photosensitive area by optimizing the composition ratio of InAs and GaAs in the InGaAs photosensitive area and improving the process used to produce the photosensitive area. As a result, we were able to realize InGaAs area image sensors that can detect infrared light up to 2.55 μm. The product lineup also includes 1.69/1.85/2.15 μm cutoff wavelength types.

High-speed readout

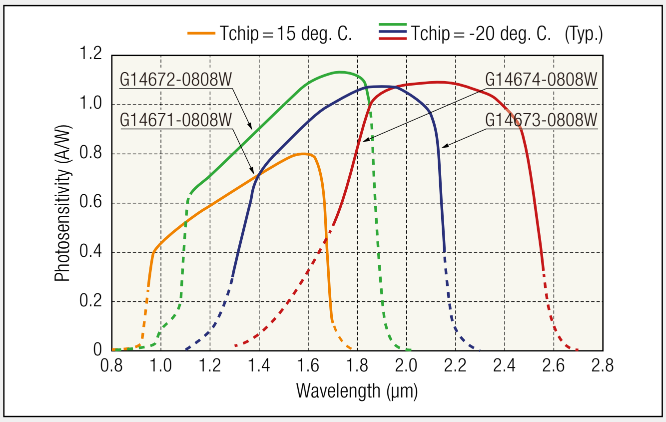
Narrower transistor gate length was achieved by designing and manufacturing original optimized circuits (ROIC*) in Hamamatsu. We were able to shorten the electrical signal transmission path. As a result, a frame rate of 507 fps max., which is more than double that of the current product, was achieved.

*Readout Integrated Circuit

Low dark current

An improved circuit that brings the voltage difference applied across the anode and cathode of the photosensitive area closer to zero was adopted to reduce the dark current that occurs in the photosensitive area.

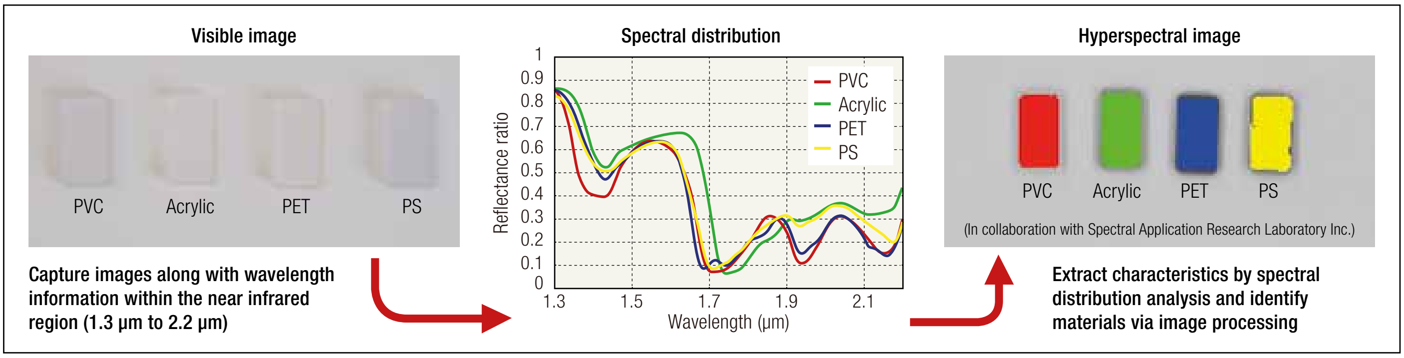
Spectral response



Additional applications expected with the capability of handling longer wavelengths

Hyperspectral imaging is used in food, pharmaceutical, chemical, and various other fields, not just in the identification of plastic. The possibilities are limitless. With the development of image sensors capable of handling longer wavelengths, there is growing expectations for this technique to be used in applications such as the degradation diagnosis of concrete structures and identification of tablets, which were difficult in the past. Hamamatsu will continue to pursue the development of long-wavelength detection and develop products that meet customer needs.

Example of plastic screening by hyperspectral imaging



Content

50 YEARS HAMAMATSU CORP.

Hamamatsu Corporation's 50th Anniversary Celebration

Akira Hiruma, President and CEO of Hamamatsu Photonics K.K., and Craig Walling, President of Hamamatsu Corporation, watch as retirees Mac Sawaki and Carol Simola, and our newest employee Brandon Gorakhnauth, break the sake barrel.

Race car competition event to benefit Bridgewater-Raritan Middle School children.

Employees as well as retirees gathered to celebrate Hamamatsu Corporation's 50th anniversary event during the company's National Business Meeting in early September 2019. There was no better way to commemorate our 50th anniversary than with the Japanese tradition of Kagami Biraki.

Kagami Biraki is a ceremony which literally translates to "opening the mirror", and serves as a symbol for opening or breaking into the future. This 300-year-old traditional ceremony is still performed in Japan at significant events worthy of being celebrated to wish good health and fortune in the future.

After the breaking of the sake barrel, employees toasted with sake, marking the transition to a new stage as we forge our path to the next 50 years to remain a leader in photonics technology and contributor to the well-being of society.

> "Instead of being taught by someone, see it with your own eyes, listen to it with your own ears, understand it with your own heart. What we do not know and what we cannot do is an infinite dimension we must now explore."
>
> *Teruo Hiruma, Former Chairman and CEO of Hamamatsu Photonics K.K.*

In keeping with our corporate mission to benefit society, the afternoon began with a team building activity designed to give back to the local Bridgewater, New Jersey community. Our 260 attendees were divided into 36 groups of 7-8 and provided materials and instructions to build solar and recycled cars. Teams used creativity and ingenuity to build solar and recycled cars in preparation for an exciting, competitive team car race. All solar cars along with material kits including hand-written messages of encouragement were donated to Bridgewater-Raritan Middle School to encourage children to develop STEM skills. The event culminated with a representative from the school thanking Hamamatsu for the meaningful donation and raising awareness for STEM with local students.

As our 50th anniversary celebration ended, we look forward to continuing our research and development through collaborations with colleagues and universities to create cutting edge technologies and innovations that will provide exceptional quality and service to our customers.

At Hamamatsu Photonics, we not only dream of contributing to our society through the use of light; we have the technical background, including the necessary device manufacturing technology, to make that dream a reality.

How are visions transformed into reality? It can only happen because each and every employee is dedicated to exploring the unknown within the realm of creating devices that will contribute to our lives in countless ways.

Here's to another 50 years of light-powered innovations in photonics.

Company News

CEO Debbie Gustafson cuts the ribbon surrounded by the leadership team of Energetiq. From left to right: Don McDaniel (VP R&D), Cristina Chu (VP Product Marketing), Yasuyuki Horiuchi (Board Member), Debbie Gustafson, Naofumi Toriyama (Board Member), Claire Brown (COO), Kenneth Kaufmann (Board Member), Smith Utubor (Controller)

Energetiq Celebrates Grand Opening of New Manufacturing Facility and Corporate Headquarters

Energetiq Technology, a subsidiary of Hamamatsu Photonics, recently hosted a ribbon cutting at its facility north of Boston, MA in the United States. Energetiq is known for its broadband Laser-Driven Light Source (LDLS™) products as well as the Electrodeless Z-Pinch™ EUV systems.

Energetiq's products are used to measure and test virtually every semiconductor chip manufactured in the world today and leading consumer electronics companies use Energetiq's technology to test their most advanced optical sensors.

Energetiq's continuous revenue growth over the last several years is driving the relocation of office space and the expansion of clean manufacturing. The new location includes indoor and outdoor experiences including collaboration areas and quiet spaces strengthening the culture of innovation. The new facility will support Energetiq's growing customer base by increasing the footprint available for manufacturing, research and development, customer support and administrative functions.

There is a new customer showroom as well as larger logistics and clean manufacturing areas and improved R&D laboratories.

Environmental building objectives drove the selection of many design elements, such as repurposed furniture, recycled carpeting and ceiling tiles, automatic on/off lighting and a high efficiency HVAC system.

Company News

Application spotlight

Laser-Driven Light Sources for Ellipsometry

Energetiq Technology, a wholly-owned subsidiary of Hamamatsu Photonics, is known for their innovative Laser-Driven Light Sources (LDLS™).

LDLS products are used in many semiconductor applications including spectroscopic ellipsometry.

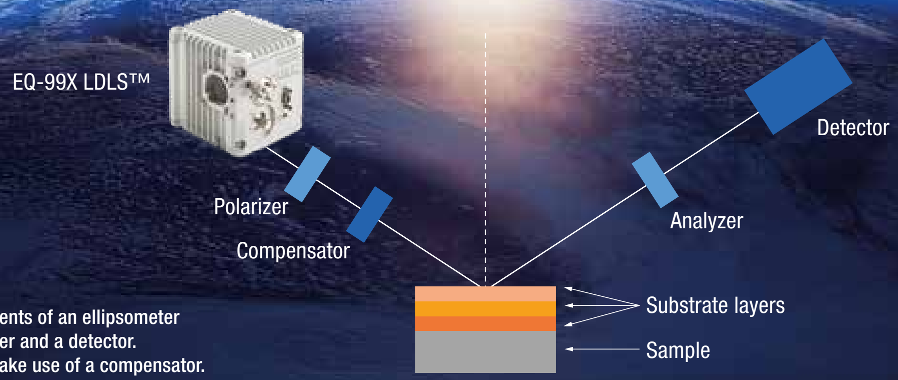


Figure 1: The main components of an ellipsometer are a light source, a polarizer and a detector. Some ellipsometers also make use of a compensator.

Introduction to ellipsometry

Spectroscopic ellipsometry is a non-destructive metrology method used to examine nanoscale materials and is especially useful to determine the thickness of thin film substrates as well as quality monitoring and defect analysis. The technique dates to at least 1886 when the German physicist Paul Drude developed the fundamental equations, and it was first referred to by the term “ellipsometry” in 1945. An ellipsometer measures the interaction of light with a sample material by measuring the change in polarization of reflected light. This technology can be used to measure multilayer film thickness, refractive index and absorption. The main components of an ellipsometer are a collimated broadband light source such as Energetiq’s EQ-99X LDLS, a polarizer and an analyzer and detector pair as shown in Figure 1. Some ellipsometers also make use of a compensator to modify the polarization of the collimated light.

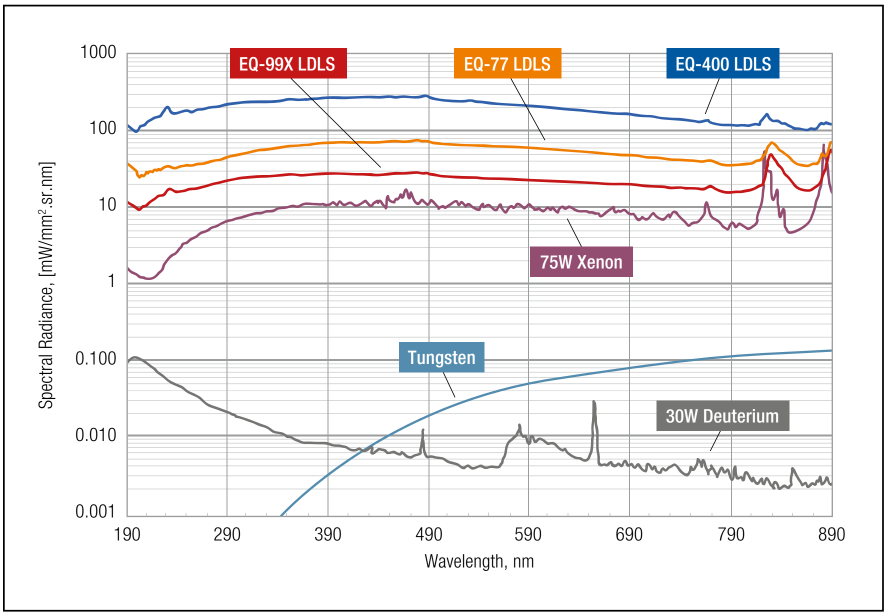
Ellipsometry applications

Energetiq’s light sources are often used in spectroscopic ellipsometry for thin film characterization for the semiconductor industry. Ellipsometry has several other applications from research in physical sciences, to data storage solutions, flat panel display, biosensing, and optical coating on eyeglasses. More recently, researchers in the medical field are beginning to use ellipsometry to examine biological samples.

A superior light source

Energetiq’s Laser-Driven Light Sources are ideal for ellipsometry because of their extremely high brightness, broad emission spectrum and very small spot size. Other commonly used ellipsometer light sources include solid state lasers and traditional xenon or mercury arc lamps. For a high-volume production application that calls for maximum

LDLS spectral radiance performance composite



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

throughput like many processes in the semiconductor supply chain, brightness becomes a very important factor in selecting a light source. Brightness describes the ability of a light source to efficiently couple power into a small area.

The LDLS offers an advantage in brightness across a broad spectral range and is ideal for nanoscale applications because it offers an unparalleled number of photons from a xenon plasma spot as small as 100 μm in diameter. Because the light is coming from such a small spot, the broadband output can be very efficiently coupled into many optical systems with small étendues.

The LDLS becomes even more appealing when you consider its broad wavelength range. The LDLS offers extremely high brightness across the UV-Vis-NIR range of the electromagnetic spectrum from 170 nm to 2,400 nm. This is relevant because the material properties of the sample being examined often vary when measured at different wavelengths. Using an LDLS, an ellipsometer can simultaneously provide information about multiple material properties at once. For ellipsometers using a laser light source, the user is limited to the given wavelength band and may have to acquire multiple sources to unlock such a broad wavelength range. It also means that one ellipsometer can be marketed for multiple applications. For instance, semiconductor lithography requires ultraviolet wavelengths, but flat panel display quality control requires visible light.

LDLS 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 as shown in Figure 2. In traditional approaches such as with xenon arc and deuterium lamps, the brightness, spatial stability, 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 lamp's life because the electrodes are used only during ignition and are not used, and therefore degrading, during operation.

The LDLS™ principle of operation

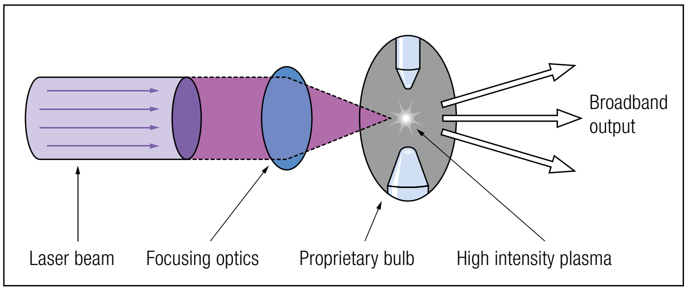


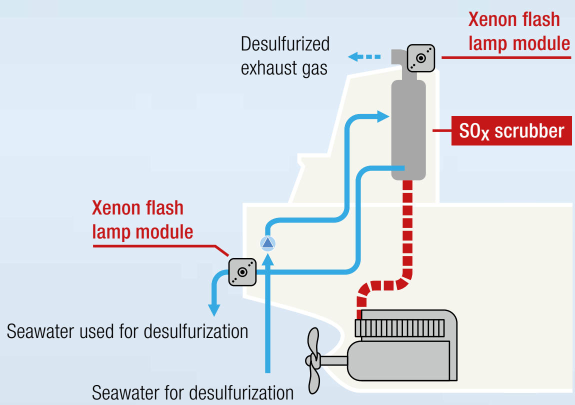
Figure 2: LDLS technology utilizes a laser to create an extremely small, high brightness plasma as small as 100 μm in diameter that produces ultraviolet, visible and near infrared radiation from 170 nm to 2,400 nm.

In Focus

Xenon flash lamp modules

High Stability, Long Life, High Intensity Pulsed Light Source Support Solutions to the 2020 SO_X Regulation Problem Faced by the Maritime Shipping Industry

Hamamatsu Photonics offers xenon flash lamp modules that deliver high stability and long life, yet provide high output power covering a broad spectrum of light from the UV to infrared region. These xenon flash lamp modules have been used in wide-ranging applications and fields such as environmental monitoring, including atmospheric and water quality analysis, medical research and treatment such as blood analysis, and industrial uses such as product inspection.



Now, applications of xenon flash lamp modules are expanding even further to include the maritime shipping industry.

SO_X (sulphur oxides)
emission regulations (general sea area)

2012		2020
3.5 %	→	0.5 %

SO_X scrubbers for washing away SO_X with seawater are the key to dealing with the SO_X regulations that will become tougher in 2020

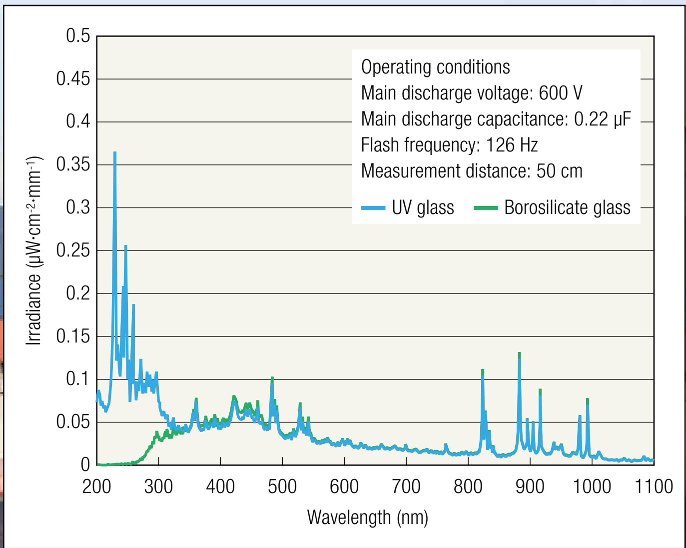
The maritime shipping industry has been promoting the reduction of SO_X (sulphur oxides) emissions mainly in areas where maritime traffic is concentrated such as the oceans near Europe and North American coasts. In 2020, the global regulations to reduce SO_X emissions will be set forth according to the International Convention for the Prevention of Pollution from Ships (MARPOL) that will strengthen and expand the regulations to include general sea areas in addition to the currently designated sea areas. To cope with these new regulations an exhaust gas cleaning system called the "SO_X scrubber" is being installed on ships.

A SO_X scrubber, as the name implies, is a system that scrubs out or washes away SO_X in exhaust gas by using seawater. Installing this system along the exhaust gas path helps reduce the amount of SO_X emitted from ship engines and allows ship owners to continuously use their existing ship engines and fuels that might exceed the upper sulphur concentration limit if not improved. This method proves very effective in reducing SO_X emissions quickly, cheaply and in a short time period, so is likely to become the future mainstream approach. When using a SO_X scrubber, it is essential to keep monitoring exhaust gas as well as wastewater used for cleaning to ensure that the SO_X concentration is not higher than the specified level. The monitor devices for this purpose require a light source and Hamamatsu Photonics manufactures xenon flash lamp modules to meet that need.

Excellent luminous efficiency and instantaneously high optical output support measurements of even low pollutant concentrations in exhaust gas and wastewater

Currently, one technique called the “fluorometer method” for monitoring residual SO_X discharged from scrubbers is becoming the mainstream that determines the concentration of pollutants called PAHs (polycyclic aromatic hydrocarbons) by measuring their fluorescence. In this method, PAHs in exhaust gas and wastewater constantly discharged from a scrubber are excited by light to generate fluorescence. Xenon flash lamps were selected as a light source ideal for efficiently exciting PAHs. Our xenon flash lamps are designed to instantaneously emit highly intense light over a broad wavelength range from 160 nm to 7,500 nm. This allows measuring even low-concentration PAHs in exhaust gas and wastewater. We also provide compact lamp modules integrated with a power supply and trigger socket that easily install into equipment.

Spectral distribution (5 W xenon flash lamp module L9455 series)



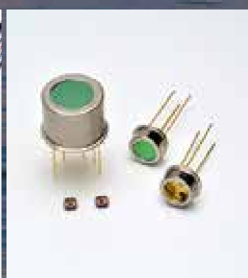
Bringing together our know-how from manufacturing electron tubes and discharge control technology to deliver the high stability and long service life needed to withstand long ocean cruises

There are even more reasons why our xenon flash lamps are selected for SO_X scrubber monitors used on ships. In modern maritime transport, containers are transshipped from one port to another to streamline transportation so it often takes more than a whole year for a ship to return to its home port. This makes it essential that the SO_X scrubber work both correctly and non-stop while the ship is at sea. These conditions mean that the SO_X scrubber and peripheral devices must have high stability and long service life and also be maintenance-free. Our xenon flash lamps are highly rated for their high stability and long service life achieved by electron tube manufacturing knowledge and discharge control technology we have accumulated since our company was first founded. We will further extend these characteristics and continue to develop even more compact and cost-saving products.

Responding to diverse analysis needs with our wide variety of light emitting and sensing technologies

Besides SO_X emission reduction described above, the maritime shipping industry is engaged in various environmental protection activities such as reducing NOx emissions and deterring environmental pollution caused by ballast water. A wide variety of optical sensing technologies are applied to support those technologies. At Hamamatsu Photonics we have a wide ranging product lineup including light detectors such as photomultiplier tubes and InAsSb (indium arsenide antimonide) photovoltaic detectors and light sources such as xenon flash lamps and quantum cascade lasers (QCLs).

Photomultiplier tubes



InAsSb photovoltaic detectors

Quantum cascade lasers

Applications of High Resolution Digital Cameras in Solar Tower Plants

Solar Tower Plants (STPs) rely on a conceptually simple method of energy generation. However, maximizing their performance and thereby providing an efficient method of energy generation requires knowledge of important parameters such as solar extinction. Let us show you an example of how scientific cameras have been used during the design and operation of STPs, in order to enhance the efficiency of indirect solar power collection.

Figure 3: Solar extinction is routinely measured at PSA.

Figure 1: Aerial view of the experimental CESA 1 facility at Plataforma Solar de Almería

Collection of solar energy

Solar irradiation serves as a major energy source for renewable electrical energy. This solar energy can be collected either by direct or indirect methods.

Direct methods convert radiation energy directly into electrical energy, most commonly through photovoltaic effects. Photovoltaic modules consist of a semiconductor material, which generates voltage and current when light is absorbed in its bulk material.

Indirect methods instead use solar-thermal technologies, where sunlight is focussed onto an absorbing material that transforms the radiation energy into thermal energy. The thermal energy is then used to power steam turbines, in the same way as fossil-fuel or nuclear power plants.

Solar tower plants

In STPs, solar irradiation is reflected and focussed by an array of mirrors, called ‘heliostats’, onto a receiver installed on an elevated structure, the power tower. The heliostats feature a tracking system in order to focus solar irradiation onto the receiver throughout the day. The receiver absorbs the concentrated solar irradiation and the resulting heat is passed to a heat transfer fluid, which is used for consecutive power generation [Zhang 2013]. Figure 1 shows the layout of an experimental STP at Plataforma Solar de Almería (PSA) in Spain.

Solar extinction measurements

Upscaling the power of STP is conceptually straightforward but a couple of pitfalls have to be avoided. In a best-case scenario, all of the direct irradiation from sunlight captured by the heliostats would be utilized for power generation. A complication of increasing the size of STPs is a comparative increase in solar extinction between the heliostats and the receiver, which limits the efficiency of energy collection. In modern, high power STPs, the heliostat-receiver distance may exceed 1 kilometer, so the solar extinction caused by local parameters such as humidity or particle concentration (i.e. dust) has to be considered when assessing STP performance.

Established methods to analyze solar extinction aim to determine the transmission or scattering coefficients at the local site. There are significant drawbacks to using these methods, including the comparably small measurement volume, or the requirement to use monochrome light sources. Deriving the solar extinction, as it is occurring in STPs, from such measurements would therefore require extrapolation in spatial and spectral dimensions, which can create large errors.

A new method proposed by Ballestrin et al. employs scientific cameras (ORCA-Flash4.0) as detectors to measure solar extinction. By using the solar signal and a broadband detector, spectral extrapolation can be avoided, yielding more accurate measurements of solar extinction. A simplified diagram of the measurement setup is shown in figure 2.

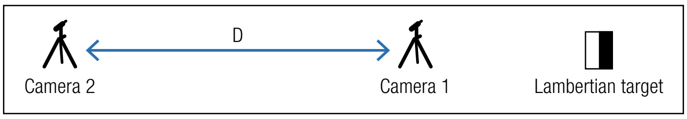


Figure 2: A Lambertian target, consisting of a white part of high solar reflectance and a black part of high solar absorbance is observed by 2 cameras simultaneously from different distances. The white part of the target serves as the signal source, while the black part serves as a dark reference to consider the effect of scattered light into the measurement distance. Both cameras observe the same area on the target.

Taking simultaneous images of a Lambertian target (a target with uniform scattering properties, as determined in [Ballestrin 2018]) with two cameras at different distances, the solar extinction can be derived by the following formula:

$$\text{Extinction}(\%) = 100(1-\frac{I_2}{I_1})$$

With I_2 being the intensity observed by camera 2 and I_1 by camera 1, the areas observed on the target are identical for both cameras. By knowing the distance 'D' between both cameras, the extinction coefficient can be determined using the Beer-Lambert law. From this coefficient, solar extinction can be obtained for each particular heliostat receiver distance applying the law.

In the system developed at PSA, the distance 'D' is 742 m which is representative in a low extinction environment such as PSA.

Experimental preconditions for employing this method are the availability of Lambertian targets of high homogeneity and diffusivity, as well as highly linear cameras.

It is desirable to use this method in the process of determining appropriate locations for STPs, as well as during operation, to include the effect of solar extinction into the routine assessment of efficiency (see figure 3).

The method has been applied over one year at Plataforma Solar de Almería, Spain. The results in figure 4 indicate that the solar extinction reached its minimum value and minimum variability during the winter months, while the absolute extinction and its variability peaked during the summer months [Ballestrin 2019].

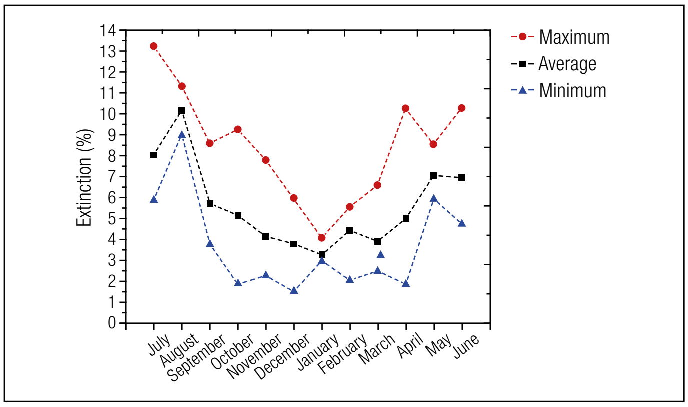


Figure 4: Solar extinction measured using the described method at Plataforma Solar de Almería over one year

Conclusion

Solar tower plants rely on a conceptually simple method of energy generation. However, maximizing their performance and thereby providing an efficient method of energy generation is contingent upon having knowledge of important parameters. In this report, two studies by Ballestrin et al., were presented which involve the determination of solar attenuation in STPs. In another study, Ballestrin et al., showed how scientific cameras can be employed to monitor the solar irradiation on the receiver during operation [Ballestrin 2019]. Both methods employed ORCA-Flash4.0 cameras as spatially resolved light detectors, thereby mitigating geometric effects present in commonly employed point detectors. The ORCA-Flash4.0 was the camera of choice for these experiments, as it delivers good linearity and uniformity.

References

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Real-time Monitoring of Thermal Laser Processes

The SPOLD and LD-Heater laser processing systems from Hamamatsu, which were recently released in Europe, feature real-time integrated temperature measurement. This enables simpler and more precise thermal laser processes, e.g. for plastic welding, laser-sintering or the curing of adhesives.

With its new laser laboratory, Hamamatsu is able to support its customers with their applications.

“Photon is our Business” is the corporate slogan of the Japanese company Hamamatsu. Whilst photon detectors were historically their main focus, the company now also offers a wide range of laser products. The SPOLD and LD-Heater laser systems, which were recently introduced to the European market, will soon attract more attention to Hamamatsu's laser business. They have an interesting technical feature, the integrated real-time process monitoring.

“These two systems are each based on a diode laser that can be used for thermal processing”, says Hamamatsu sales engineer Alexander Görk, while describing the basic function of the SPOLD and LD-Heater. “There are numerous applications for this technology, including plastic welding, laser-sintering, adhesive curing and soldering. It is also suitable for the waterproof sealing of plastics, such as those used in the manufacture of mobile phones, for the hermetic sealing of glass products, which are required in medical technology, and for many other applications.”

According to Görk, Hamamatsu is particularly focused on three application fields: plastic welding, laser-sintering and thermal curing. “In plastic welding, we can already draw on many years of experience on the part of the Japanese parent company and envision very good application possibilities for these two systems in this area. From our point of view, laser-sintering is a technology with an extremely promising future market, and SPOLD and LD-Heaters are perfectly suited for this as well.” Applications for the thermal curing of thermosetting adhesives are the third field on which Hamamatsu is concentrating in the first phase.

Real-time process monitoring

The basic function of both the SPOLD and LD-Heater laser systems is to heat the materials to be processed with laser energy, thereby initiating the desired thermal processing. Diode lasers are used in both products, which mostly operate with a wavelength of 940 nm and an output power of up to 360 W. Laser diodes allow both systems to produce a wide range of laser signals. Spot sizes from 0.1 to 6.4 mm in diameter and, if required, line optics are available to adapt the laser properties to the task at hand. Hamamatsu uses a special process to optimize the shape of the laser beam and achieve a so-called top hat beam profile. The resulting energy distribution allows an optimal and homogeneous heat input to the objects to be processed.

But the greatest unique aspect of both systems is the integrated process monitoring: both SPOLD and LD-Heaters make it possible to monitor the heat-emission process in real time during treatment by the laser and in this way control parameters such as laser power or traversing speed to optimize results. The only difference between the two systems is the type of process monitoring integrated in the system: SPOLD allows a relative temperature measurement of the processed object surfaces, while LD-Heaters allow for an absolute one.

With SPOLD, the temperature measurement is realized coaxially via the same optical fiber that is used to transmit the laser energy to the object to be processed. LD-Heaters, on the other hand, use a second optical fiber to measure the temperature. Here, 2-color pyrometry is used, where the detectors record two filtered wavelengths, compare the results, and thus measure the absolute temperature.

Precise temperature control for optimum results

Görk uses an example to explain why the monitoring of process parameters during temperature exposure by the laser is so important: “When two plastics are welded together, the temperatures must be kept exactly within very narrow limits in order to achieve the desired strength of the joint. If the traversing speed or the laser power is not set optimally, the welding process will not achieve the desired result.”

Equally important is the adherence to the exact process parameters during laser-sintering. One area this process is used is to make printed conductors conductive. If the laser power is too low or the traversing speed is too high, the particles of the printed circuit paths do not melt. If the laser power is too high or the traversing speed is too slow, the circuit paths burn. The result is the same in both cases: The desired activation of the conductivity is not achieved.

Comprehensive service

In order to enable its customers to get started as effectively as possible and to quickly apply the two laser systems, Hamamatsu's sales location in Germany has its own laser laboratory. It meets all requirements for working with the class 4 lasers used in SPOLD and LD-Heaters. “In this laboratory we actively support our customers in the evaluation and advise them on, among other things, which spot sizes and laser heads are best suited for their respective applications”, explains Görk. “The wide range of options for spot sizes and laser heads makes the SPOLD and LD-Heater systems very variable and can be tailored precisely to customer requirements. With our experience, we make a significant contribution to ensuring that users can implement their systems as quickly as possible.”

During the course of such a consultation, it usually becomes clear very quickly which product is the right one for the respective customer: If temperature monitoring of the process is required, an LD-Heater is the right choice during the development phase of a laser system and for individual tests. With its real-time monitoring of absolute temperatures, it accelerates the determination of optimum process parameters.

If the results from the development phase are to be used in later mass production, LD-Heaters remain the preferred systems as they can shorten the development time and the user can expand their knowledge of the plant by collecting the absolute process data.
For plants in which temperature monitoring is necessary but the data from the development phase is no longer needed, Görk recommends the SPOLD system, which also has integrated process monitoring. With a guaranteed lifetime of over 10,000 operating hours, both systems are suitable for continuous use in industrial applications.

External pyrometers become obsolete

The use of Hamamatsu's SPOLD and LD-Heater systems brings a further technical and economic advantage. In order to reduce waste in thermal laser processes, external pyrometers are frequently used today to measure object temperature. The main disadvantage of this method is that it requires significant effort to position the temperature measurement exactly at the point where the machining takes place.

In certain applications, measurement errors occur due to the use of external pyrometers, emphasizes Görk: “Here, our SPOLD and LD-Heater systems are much easier to use and lead to highly accurate results, since the measuring system is directly coupled with the processing laser. SPOLD and LD-Heater are exactly calibrated in our production facility in Japan, so that the user can completely dispense with external pyrometers."

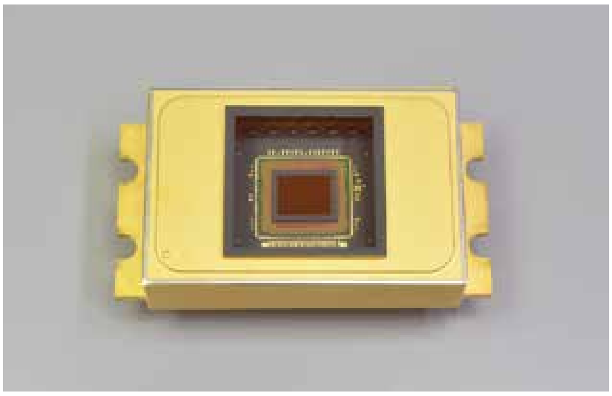
Görk is convinced that SPOLD and LD-Heaters, with their integrated real-time process monitoring, will provide the user with completely new possibilities for laser machining processes with sound thermal specifications. “In combination with our experience in this field and the newly created laser laboratory, we can offer our customers in Europe real added value in the evaluation and implementation of their solutions.”

InGaAs Area Image Sensors G14671 to G14674-0808W

NEW

Two-dimensional image sensor with 320 × 256 pixels developed for near infrared imaging

The G14671 to G14674-0808W have a hybrid structure consisting of a CMOS readout circuit (ROIC: readout integrated circuit) and back-illuminated InGaAs photodiodes. Each pixel is made up of an InGaAs photodiode and a ROIC electrically connected by indium bump. The timing generator in the ROIC provides an analog video output which is obtained by just supplying digital inputs. The products are hermetically sealed in a metal package together with a two-stage thermoelectric cooler to deliver stable operation. The frame rate is at least twice as fast as the previous product, and a partial readout function is now available.



G14671 to G14674-0808W

Features

- High frame rate: 507 fps
- High sensitivity: 3.5 μV/e⁻
- Low dark current
- Global shutter mode
- Partial readout function
- Simple operation (built-in timing generator)
- Two-stage TE-cooled type

Lineup

Type no.	Condition Chip temperature (deg. C.)	Spectral response range (μm)	Number of pixels	Frame rate (fps) max.	Conversion efficiency (μV/e⁻)	Dark current (pA)
G14671-0808W	15	0.95 to 1.69	320 x 256 [20 μm pitch]	507	3.5	0.03
G14672-0808W	-20	1.12 to 1.85	320 x 256 [20 μm pitch]	507	3.5	0.3
G14673-0808W	-20	1.3 to 2.15	320 x 256 [20 μm pitch]	507	3.5	3
G14674-0808W	-20	1.7 to 2.55	320 x 256 [20 μm pitch]	507	3.5	30

Multichannel detector head

A multichannel detector head that can easily evaluate and test InGaAs area image sensors is available. It consists of a driver circuit, temperature controller, and high-speed communication controller. It outputs analog video signals from an InGaAs area image sensor as digital output. Contact us for more detailed information.

NEW

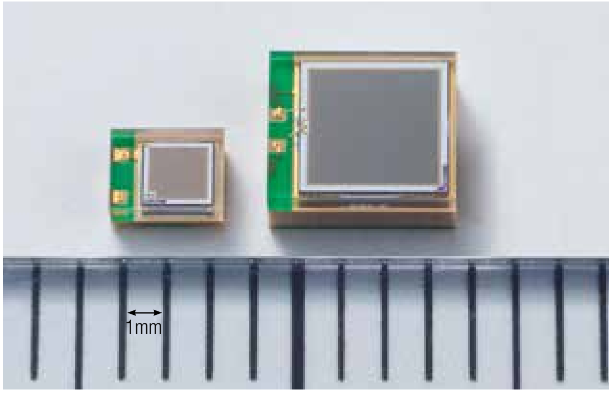
MPPC® (Multi-Pixel Photon Counter) S14160 Series

Wide dynamic range MPPC

These are MPPCs with a small pixel size and are suitable for light measurement with a wide dynamic range.

Differences from previous products

In comparison with the previous product, crosstalk and dark count have been reduced while maintaining the same level of fill factor by using narrower pixel pitches (10 µm, 15 µm).



S14160 series

MPPC modules

C15524 series C15522 series

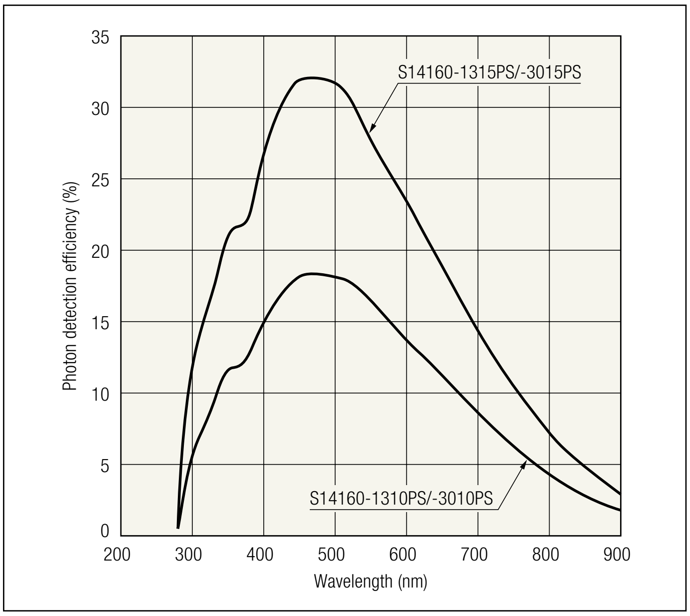
Wide dynamic range type

Module products with a built-in MPPC that can detect low-level light are available. The modules contain an amplifier, a temperature-compensation circuit, a high-voltage power supply circuit, and other components needed for MPPC operation. These modules operate simply by supplying power from an external source (±5 V). There are two types of modules: the C15522 series, which has an MPPC mounted directly on the circuit board, and the C15524 series, which has an MPPC with a flexible cable.

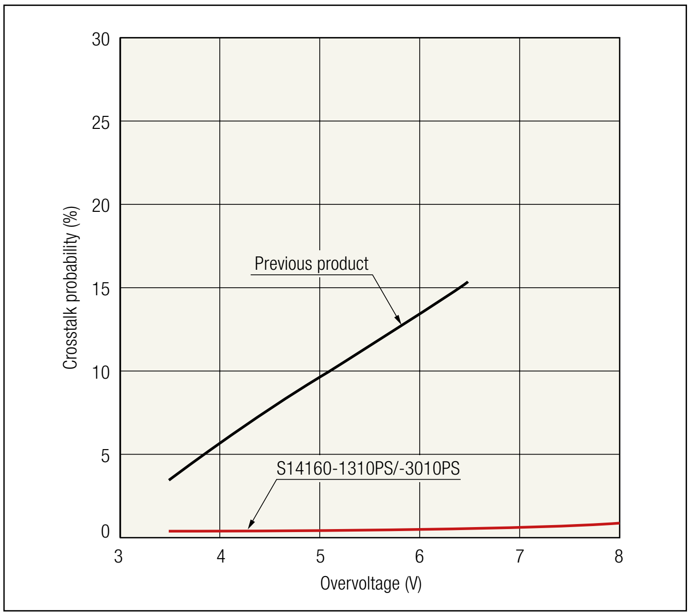
Specifications

Parameter	S14160 series				Unit
	-1310PS	-3010PS	-1315PS	-3015PS	
Effective photosensitive area	1.3 × 1.3	3 × 3	1.3 × 1.3	3 × 3	mm
Pixel pitch	10		15		µm
Number of pixels	16675	90000	7296	40000	–
Fill factor	31		49		%
Photon detection efficiency (λ = 460 nm)	18		32		%
Breakdown voltage	38 ± 3				V
Dark count rate	120	700	120	700	kcps

Photon detection efficiency vs. wavelength (Typ. Ta = 25 deg. C., V_R = Vop)



Crosstalk probability vs. overvoltage (Typ. Ta = 25 deg. C.)



Si Photodiodes
S12915 Series

NEW

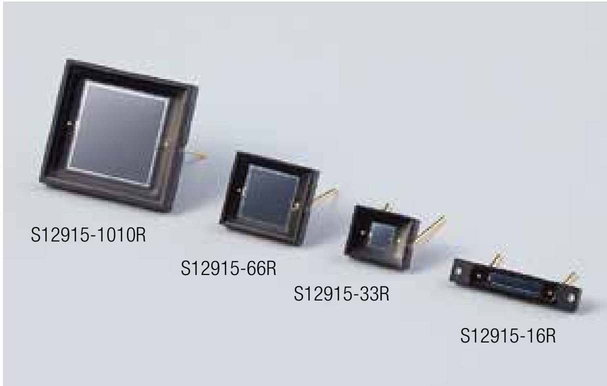
Photodiodes for general light measurement from visible to infrared region

These Si photodiodes have high sensitivity in the visible range to near IR. Four types with different photosensitive areas are available.

Differences from previous products

While keeping the price, shape, and pin connections the same as the previous product (S2387 series*), improved characteristics such as high sensitivity, low dark current, and high humidity resistance have been achieved.

* The sales of the S2387 series will continue for the time being.

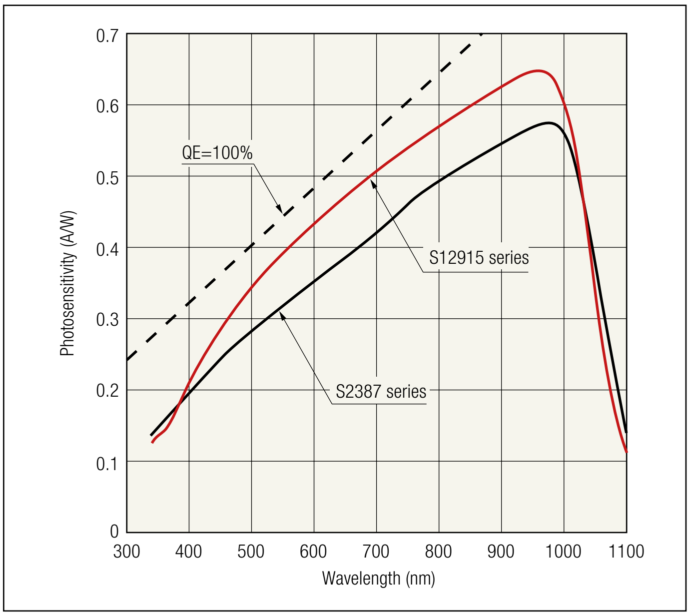


S12915 series

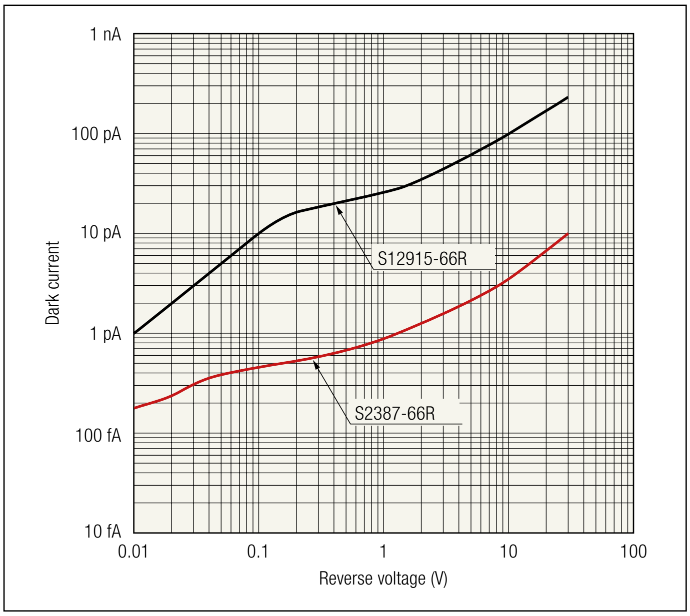
Features

- High sensitivity: 0.64 A/W
- Low dark current: 5 pA max. (S12915-16R/-33R)
- High humidity resistance

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



Dark current vs. reverse voltage (typical example) (Typ. Ta = 25 deg. C.)



NEW

Si Photodiodes S12742-220/-254/-275

Monochromatic light (220, 254, 275 nm) detection photodiode with filter

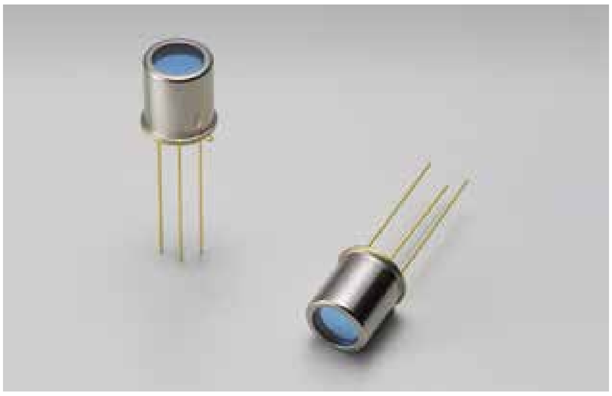
These Si photodiodes use an interference filter for its window and is sensitive only to monochromatic light. Three types are available with the center sensitivity wavelengths at 220 nm (S12742-220), 254 nm (S12742-254), and 275 nm (S12742-275). The spectral response half width (FWHM) is extremely narrow at 10 nm typ., allowing accurate photometry with little stray light.
These Si photodiodes can be customized to have peak sensitivities at other wavelengths such as 340 nm and 560 nm.

Features

- Narrow spectral response half width (FWHM): 10 nm typ.
- With monochromatic light filter

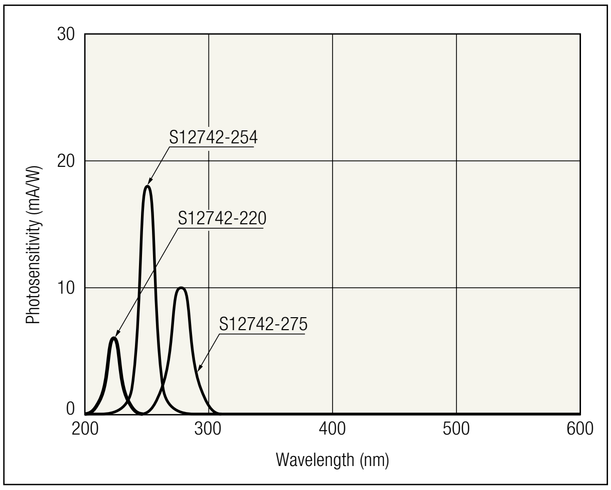
Applications

- Water quality and atmosphere analysis
- UV monitor (Hg lamp or the like)



S12742-220/-254/-275

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



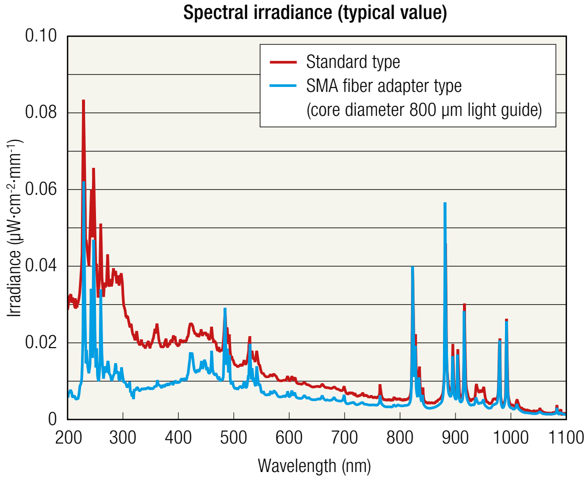
Related product

Xenon flash lamp module L13651 series

Can be used in conjunction with a Si photodiode for water quality analysis.

Standard type (left), SMA fiber adapter type (right)

Spectral irradiance (typical value)



Main discharge voltage: 600 V

Main discharge capacitance: 0.141 μF

Lamp light emission repetition frequency: 79 Hz

Measurement distance: 50 cm

InAsSb Photovoltaic Detector P13894-011CN

NEW

High-speed response and high sensitivity in the spectral band up to 11 μm have been achieved

The P13894-011CN is a photovoltaic type infrared detector that has achieved high sensitivity in the spectral band up to 11 μm using Hamamatsu's unique crystal growth technology and process technology.

Differences from previous products

In addition to the previous metal package products, we have now added ceramic package types to the lineup.

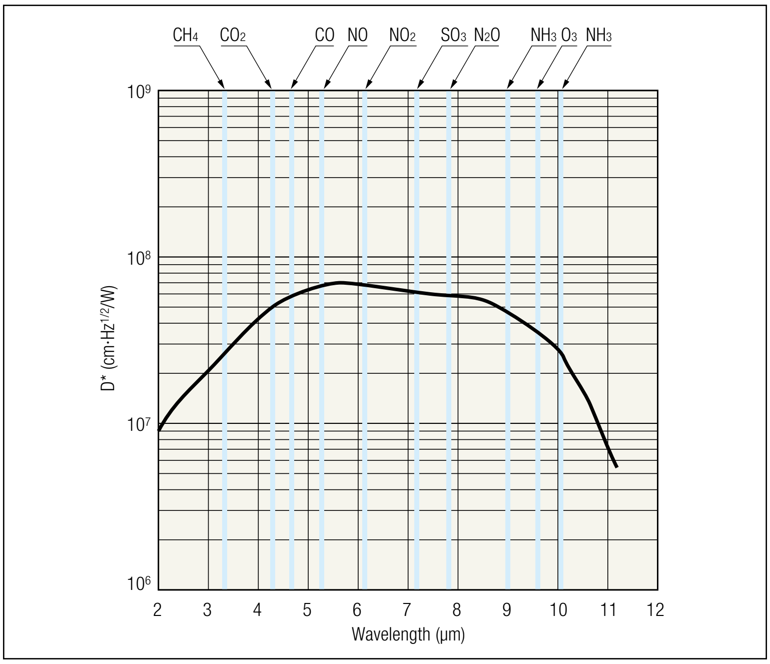
Features

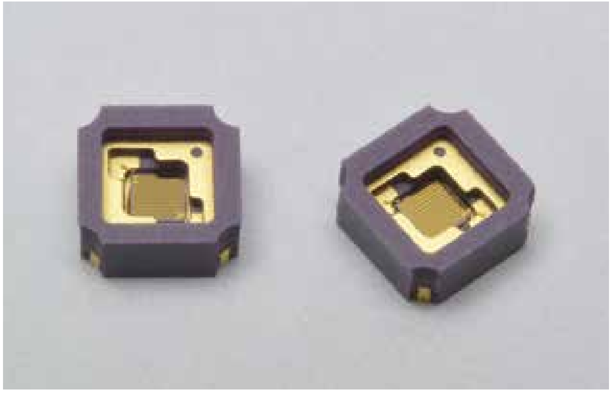
- High sensitivity
- High-speed response
- High shunt resistance
- No window type
- Compact: 2.6 mm × 2.6 mm × 1.5 mmt
- Compatible with lead-free reflow soldering

Applications

- Gas detection (CH_4, CO_2, CO, NH_3, O_3, etc.)
- Radiation thermometers

Spectral response (D*) (Typ. Ta = 25 deg. C.)





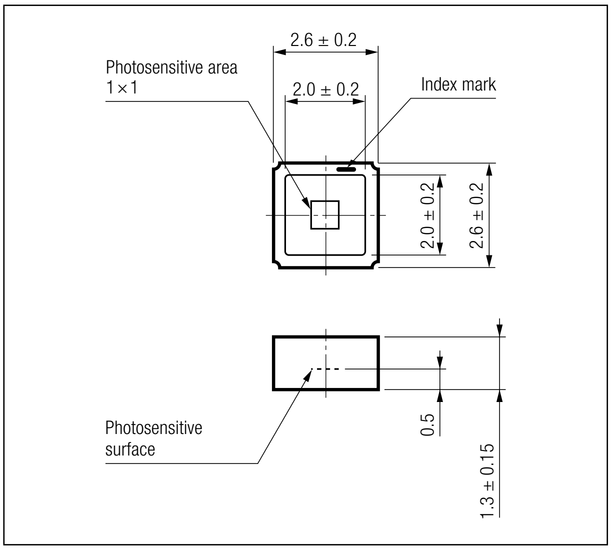
P13894-011CN

Specifications

Parameter	Specification	Unit
Package	Ceramic	–
Cooling	Non-cooled	–
Photosensitive area	1 × 1	mm
Peak sensitivity wavelength	5.6	μm
Cutoff wavelength	11.0	μm
Photosensitivity*1	2	mA/W
Shunt resistance*2	2.0	kΩ
Detectivity*3	7.0×10^7	cm·Hz$^{1/2}$/W
Rise time*4	3	ns

*1 λ = λp
*2 V_R = 10 mV
*3 λ = λp, fc = 1200 Hz, Δf = 1 Hz
*4 10 to 90 %, no window, λ = 1.55 μm

Dimensional outline (unit: mm)



NEW

Infrared Detector Module with Preamp C12494-011LH

Compact, easy-to-handle InAsSb module with a high-speed amplifier

This is a module with an integrated amplifier that can detect infrared light simply by connecting a DC power supply. Because its spectral response range is wide, it is suitable for detecting numerous gases. It supports 100 MHz, and high-speed spectroscopic measurement in combination with a QCL is possible.

Differences from previous products

In comparison with the previous product (C12494-210M/-210S), long-wavelength light detection and high-speed response have been achieved.

Features

- With a built-in 11 µm band InAsSb photovoltaic detector (P13894-011NA)
- Compact: 65 (W) × 20 (D) × 50 (H) mm
- High-speed response: 100 MHz max.
- Easy handling

Applications

- Gas analysis
- CO_2 laser monitor

C12494-011LH

Specifications

Parameter	Specification	Unit
Detector	InAsSb (P13894-011NA)	–
Photosensitive area	1 × 1	mm
Peak sensitivity wavelength	5.6	µm
Cutoff wavelength	11.0	µm
Photosensitivity*1	40	V/W
Noise equivalent power*2	4.0×10^{-9}	$W/Hz^{1/2}$
Frequency characteristics (FcH)*3	0 to 100	MHz
Current consumption max.*4	+35, -35	mA

*1 λ = λp, f = 1200 Hz
*2 λ = λp
*3 -3 dB
*4 Vin = ±2.5 V

Soft X-ray Source L13050

NEW

Low energy X-ray source that can be easily operated by a PC

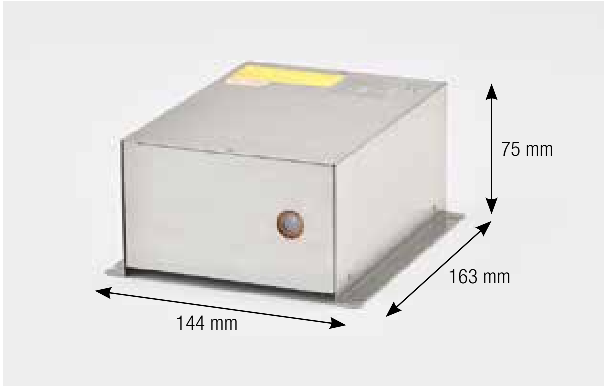
The L13050 is a high-stability soft X-ray source assembled with a power supply in a compact module. It can be easily controlled by a PC, so it is ideal for research and experiments using soft X-rays.

Features

- High stability: X-ray output stability is ±0.5 %
- Variable tube voltage and tube current
- Compact size
- Easy to use: Can be controlled via RS-232C

Applications

- Film thickness measurement
- Low energy non-destructive inspection

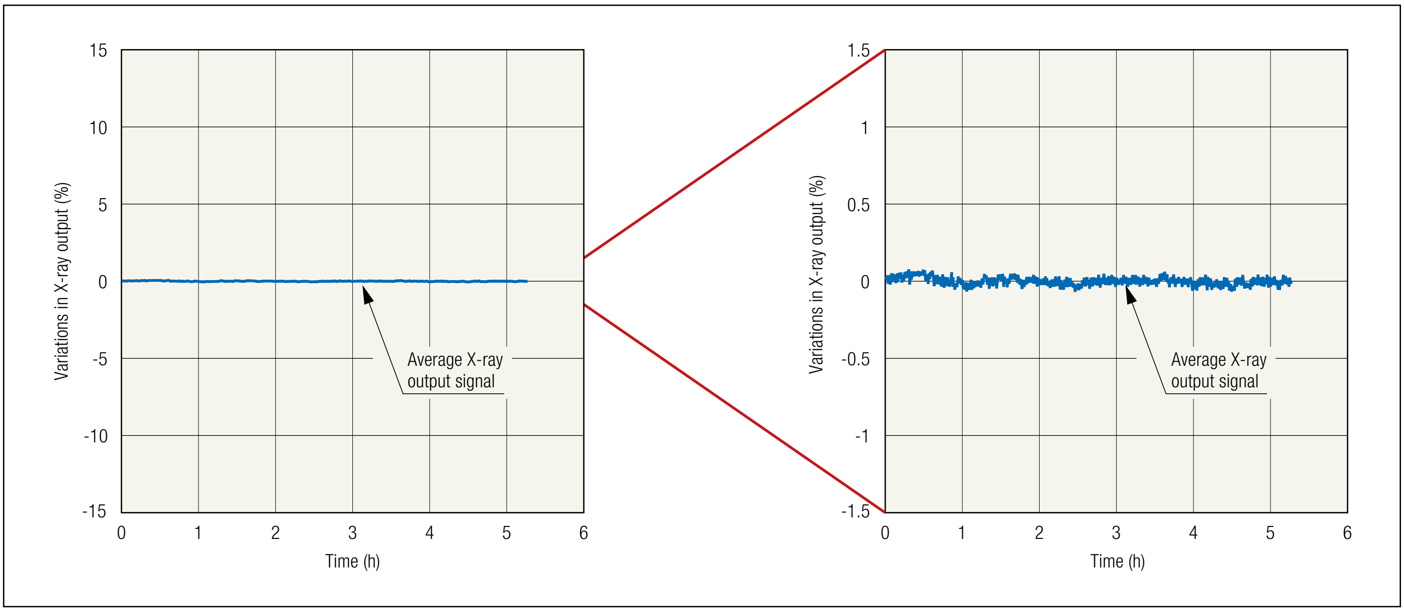


L13050

Specifications

Parameter	Specification	Unit
Variable tube voltage range	10 to 15	kV
Variable tube current range	100 to 150	μA
Maximum output	1.5	W
Maximum rated voltage	26.4	V
X-ray output stability	±0.5	%

X-ray output stability



NEW

ORCA®-Lightning Digital CMOS Camera C14120-20P

Wide-field imaging realized at high speed and low noise

The ORCA-Lightning is a digital CMOS camera that captures a wide field of view with high resolution. In addition, while maintaining low noise as the conventional CMOS cameras, the readout speed is about 3 times faster than them.

C14120-20P

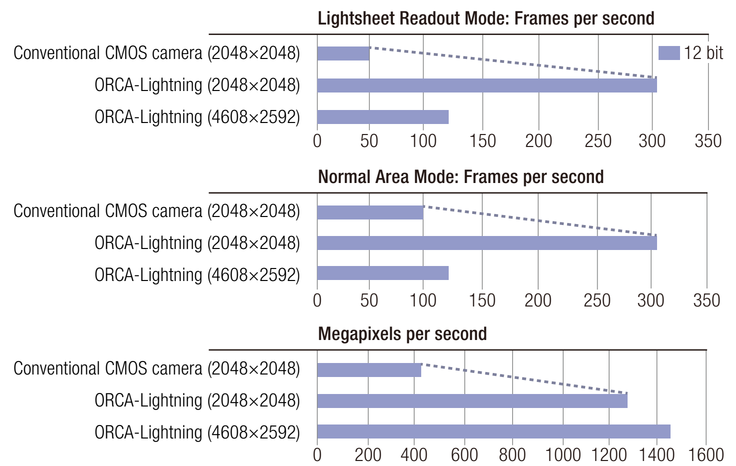
Features

- Large field of view: 4608 × 2592 pixels (12M pixels), sensor with a diagonal dimension of 29.078 mm
- High-speed readout: 121 frames/s (4608 × 2592), 307 frames/s (2048 × 2048)
- Low readout noise: 2.0 electrons rms
- High resolution: pixel size 5.5 µm × 5.5 µm
- High dynamic range: 17 000:1 (high full well capacity mode)

Applications

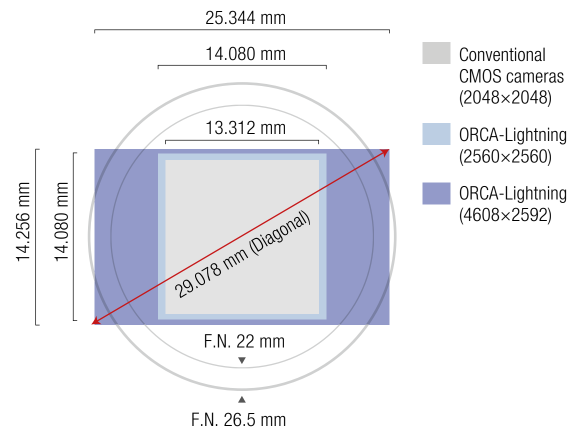
- Lightsheet microscopy
- Super-resolution microscopy
- High-speed Ca^{2+} imaging
- Brightfield microscopy
- Synchrotron radiation research
- TEM image readout

Speed comparison with conventional CMOS cameras



The ORCA-Lightning can capture images at about 6 times the readout speed of conventional CMOS cameras by the "Lightsheet Readout Mode" while maintaining the same readout noise as them.

Sensor size comparison with conventional CMOS cameras



The ORCA-Lightning's sensor size is 4608 pixels (horizontal) × 2592 pixels (vertical), which makes it possible to effectively use a microscope with a field size of 26.5 mm.

LD Irradiation Light Source SPOLD® L14140-21M

NEW

Spot laser light source helps “visualize” thermal information

The L14140-21M is a laser irradiation light source with a monitoring function. It is suitable for installation into a mass production process because the laser processing quality can be monitored by reliably acquiring thermal information from the laser irradiation point.

Differences from conventional products

Compliance with CE standard.

Features

- Simultaneous transmission of laser and thermal information using single fiber
- Thermal information of laser irradiation point can be acquired reliably without any adjustment
- Compatible with galvano mirror system
- High-speed, 1-millisecond sampling to detect instantaneous changes
- Simplified processing (peripheral components combined into a compact irradiation unit)

Applications

- Plastic welding
- Thermal curing of adhesives, etc.
- Soldering
- Processing and treatment using laser as a heat source

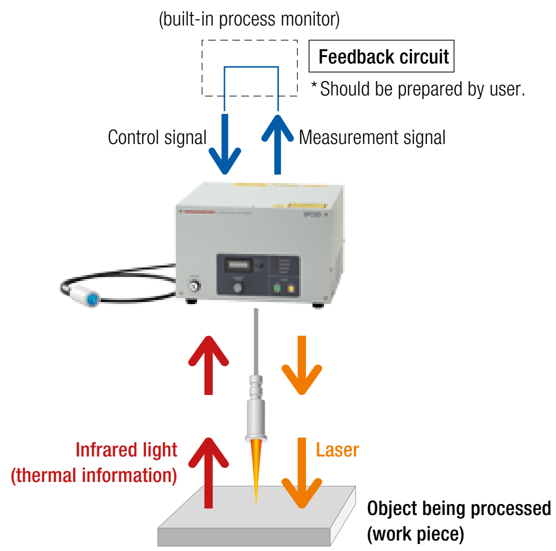
L14140-21M

Specifications

Parameter	Specification
Type No.	L14140-21M
Light output (with maximum current setting, at the focal spot of irradiation unit)	8.5 W (min.)
Peak oscillation wavelength (25 deg. C.)	915 nm ± 20 nm
Cooling method	Air-cooling
Dimensions (W × H × D)	Approx. 280 mm × 180 mm × 300 mm (excluding protruding parts)
Light condensing spot diameter	ϕ0.2 mm ~ ϕ3.2 mm*1

*1 Depending on the fiber core diameter and condensing magnification.

System diagram



NEW

LD Irradiation Light Source SPOLD®
L14140-11/-21/-31

Lightweight & compact spot laser light source suitable for embedding into equipment

Air-cooled/fiber-output spot laser light source used for various thermal processing applications. Compact and lightweight. By selecting the appropriate fiber-core diameter and irradiation unit, laser irradiation with the desired beam diameter is possible.

Differences from conventional products

Compliance with CE standard.

Features

- High reliability (no individual differences)
- Wide product selection by output
- Especially for embedded applications

Applications

- Plastic welding
- Thermal curing of adhesives, etc.
- Soldering
- Processing and treatment using laser as a heat source

L14140-11/-21/-31

Specifications

Parameter		Specification		
Type No.		L14140-11	L14140-21	L14140-31
Light output (with maximum current setting)	Output end of laser transmitting optical fiber	9.5 W (min.)		15 W (min.)
	Output end of irradiation unit	9 W (min.)		13.5 W (min.)
Laser type		Laser diode (LD)		
Oscillation type		CW		
Peak oscillation wavelength (25 deg. C.)		915 nm ± 20 nm		
Cooling method		Air-cooling		
Dimensions (W × H × D)		Approx. 280 mm × 100 mm × 300 mm (excluding protruding parts)		
Light condensing spot diameter		ϕ0.1 mm ~ ϕ0.8 mm*1	ϕ0.2 mm ~ ϕ3.2 mm*1	ϕ0.4 mm ~ ϕ3.2 mm*1

*1 Depending on the fiber core diameter and condensing magnification.

Global Exhibitions 2019 and 2020

USA

November 2019

ASNT
Nov 18-21 2019, Las Vegas, NV

Printed Electronics
Nov 20-21 2019, Santa Clara, CA

December 2019

RSNA
Dec 1-6 2019, Chicago, IL

MRS Fall Meeting
Dec 3-5 2019, Boston, MA

Cell Biology
Dec 7-11 2019, Washington, DC

January 2020

CES
Jan 7-10 2020, Las Vegas, NV

SLAS
Jan 25-29 2020, San Diego, CA

February 2020

BIOS
Feb 1-2 2020, San Francisco, CA

Photonics West
Feb 4-6 2020, San Francisco, CA

Biophysical
Feb 15-19 2020, San Diego, CA

USCAP
Feb 29-March 6 2020, Los Angeles, CA

March 2020

Pittcon
March 3-5 2020, Chicago, IL

April 2020

WQA Convention and Expo
April 1-3 2020, Orlando, FL

AACR
April 24-29 2020, San Diego, CA

Defense & Commercial Sensing
April 28-30 2020, Anaheim, CA

May 2020

CLEO
May 12-14 2020, San Jose, CA

June 2020

ASMS
June 1-4 2020, Houston, TX

The Vision Show
June 9-11 2020, Boston, MA

Sensors Expo
June 22-24 2020, San Jose, CA

Europe

November 2019

CompaMed
Nov 18-21 2019, Düsseldorf, Germany

Technology Days
Nov 18-29 2019, Solothurn, Switzerland | London, UK | Paris, France | Stockholm, Sweden | Munich, Germany | Milan, Italy

Colloque Rayons X Et Matière
Nov 19-22 2019, Nancy, France

MECSPE 2019
Nov 28-29 2019, Bari, Italy

MIC Symposium
Nov 29 2019, Bern, Switzerland

December 2019

Digital Pathology Congress
Dec 5-6 2019, London, UK

Annual Meeting of the Biomedical Photonics Network (BMPN)
Dec 10 2019, Bern, Switzerland

Optogen 2019
Dec 12-13 2019, Venezia, Italy

January 2020

22. Bamberger Morphologietage
Jan 24-26 2020, Bamberg, Germany

B2B Meetings – Industrie Grand Ouest 2020
Jan 28-30 2020, Nantes, France

OPTRO2020
Jan 28-30 2020, Paris, France

February 2020

Southern Manufacturing
Feb 11-13 2020, Farnborough, UK

AERO'NOV
Feb 13-14 2020, Toulouse, France

A&T 2020 (Automation & Testing)
Feb 12-14 2020, Torino, Italy

Techinnov – B2B Meetings
Feb 27 2020, Paris, France

NEUBIAS Conference
Feb 29-March 6 2020, Bordeaux, France

March 2020

Barcelona Breast Meeting
March 10-13 2020, Barcelona, Spain

ECR
March 11-14 2020, Vienna, Austria

DPG-Frühjahrestagung – SKM
March 15-20 2020, Dresden, Germany

MED'INOV – B2B Meetings
March 25-26 2020, Lyon, France

International Meeting on Optical Biosensors
March 28-29 2020, Paris, France

Analytica
March 31-April 3 2020, Munich, Germany

April 2020

Salon Analyse Industrielle
April 1-2 2020, Paris, France

LAL 2020
April 2-5 2020, Nancy, France

Standard Model @ LHC 2020
April 27-30 2020, Roma, Italy

May 2020

IFAT2020 – Messe für Wasser-, Abwasser-, Abfall- und Rostoffwirtschaft
May 4-8 2020, Munich, Germany

AKL 2020
May 6-8 2020, Aachen, Germany

Optatec
May 12-14 2020, Frankfurt, Germany

Advanced Engineering
May 27-28 2020, Antwerp, Belgium

June 2020

LASYS
June 16-18 2020, Stuttgart, Germany

Drupa
June 16-26 2020, Dusseldorf, Germany

Sensor + Test
June 23-25 2020, Nuernberg, Germany

NANOTECH 2020
June 24-26 2020, Paris, France

July 2020

LALS2020
July 7-10 2020, Dijon, France

Asia

December 2019

68th Annual National Conference of Indian Association of Pathologists and Microbiologists (IAPM) and International Academy of Pathology-Indian Division (IAP-ID) – APCON 2019
Dec 5-8 2019, Chandigarh, India

Africa

November 2019

Bacterial Morphogenesis, Survival and Virulence (BMSV)
Nov 24-28 2019, Cape Town, South Africa

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