

Development and production centers for light sensors, light sources, and application-specific products utilizing light to support a wide range of needs in medical diagnosis / treatment, chemical analysis, measurement, industrial instrumentation, and academic research



As a world leader in photonics technology, Hamamatsu Photonics is constantly researching light in all its forms. The Electron Tube Division of Hamamatsu Photonics supports progress in the most advanced photonics technologies involving low-light-level and ultra-fast measurements. The various light-related devices we develop and produce are widely used in spectrophotometry, semiconductors, biotechnology and experimental scientific research as well as in medical applications such as blood analysis and diagnostic imaging.

Based on this technology and experience in detecting low level light and ultra-fast phenomena, we have gained a high reputa-

tion for developing products that provide optimal performance even for special applications. Along with developing light sensor or photosensor products that sense light, we make ceaseless efforts to develop uniquely stable light sources that emit light. What's more, our own technical know-how, ranging from basic technology to manufacturing technologies including vacuum technology, allows us to flexibly design and develop products that meet specific needs. Those products offer a good balance of performance factors such as sensitivity, output level, stability, and operating life to fully meet your task and application requirements. This condensed catalog introduces major products available from the Electron Tube Division of Hamamatsu Photonics. For further information, please contact our sales office or visit our website.

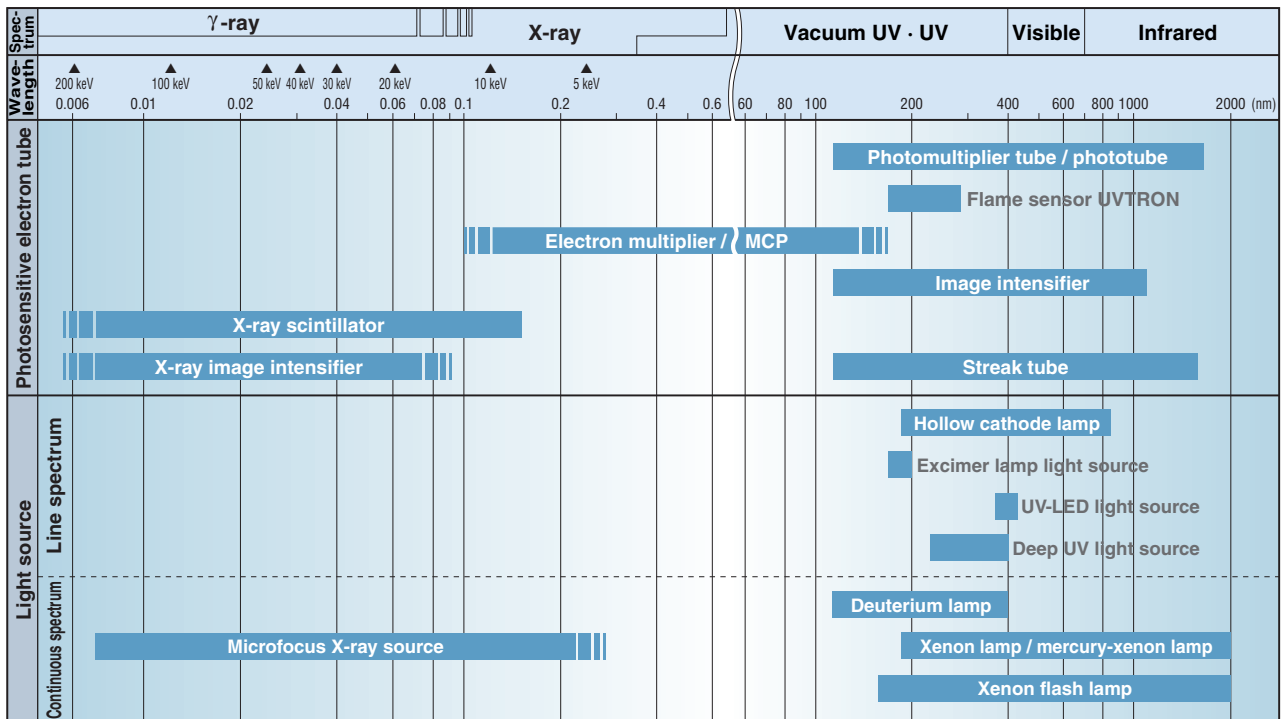
Application fields of electron tube products



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Product selection guide by wavelength



Light properties and detection technologies

Here we introduce some properties of light and give examples of our typical system products listed in this catalog using detection technology.

Wave

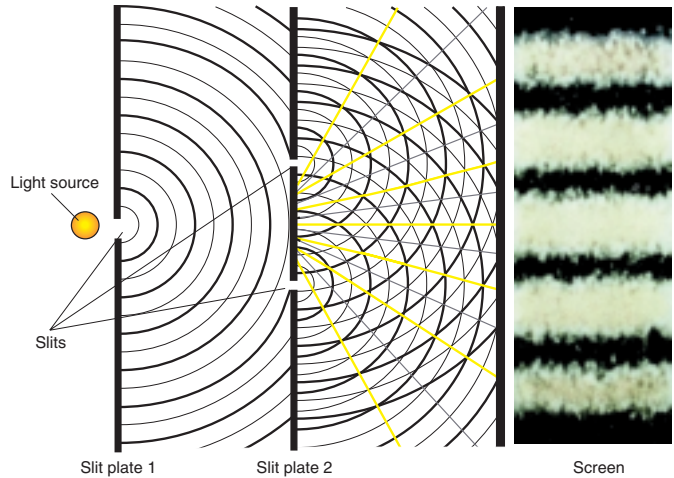
Wave nature of light

Light has the properties of a wave.

Light can be considered a type of electromagnetic wave like radio waves. These waves act just like the ripples you see on the water surface when you throw a stone in a pond.

The properties of this light "wave" can be shown in a test with Young's experiment on interference. In this experiment, light from a light source is shown on a screen after passing through the slits of 2 plates. The first plate has 1 slit for light to pass through and the second plate has 2 slits. The light coming out of the second plate with the 2 slits appears on the screen as a fringe pattern (stripe pattern). This pattern is caused by interference (waves boosting or weakening each other) with the wave property of light.

● Young's experiment on interference



Particle

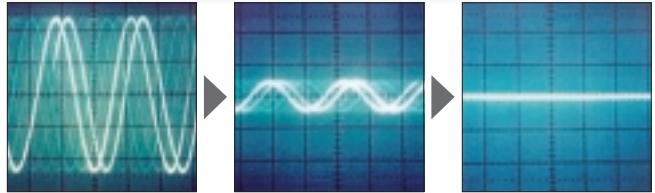
Particle nature of light

Light has the properties of a particle.

The intensity of light varies according to the number of particles. Bright light has many particles while darker light has few particles. Sound and light signals are compared in the figure on the right.

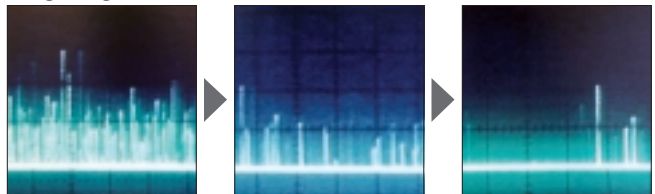
When the strength (amplitude) of a sound signal (seen on an oscilloscope) gradually weakens, the signal gets smaller and smaller and finally disappears. When the light signal on the other hand gradually weakens, the total signal quantity decreases but can still be detected as a few, discrete pulse signals. This is because one pulse is detected as one light particle. These particles of light are called "photons".

● Sound signals



▲ When sound signals become weak, they can no longer be detected. (Tuning fork resonance test)

● Light signals



▲ Light signals can be detected as pulses (particles) even after becoming very weak (very dark).

High Speed

Velocity of light

Light travels at a speed of 300,000 km per second.

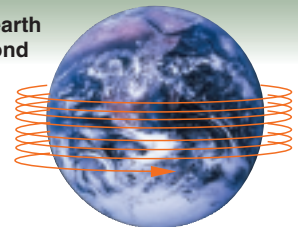
The speed of light is so fast it can travel 7 and a half times around earth in one second. This high speed is being put to work in diverse applications such as optical communications for sending large quantities of data in a short time.

A millisecond is one thousandth of a second, a microsecond is one millionth of a second, a nanosecond is one billionth of a second, and a picosecond is one trillionth of a second.

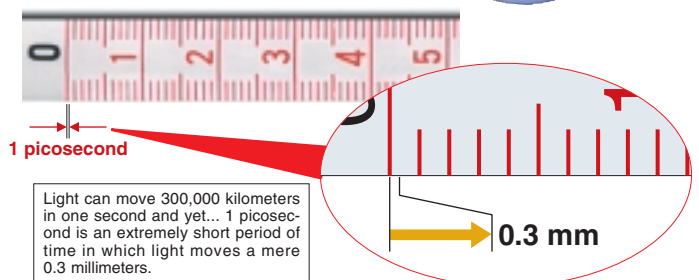
Even though light can move 7 and a half times around the Earth in one second, in a picosecond it moves only a mere 0.3 millimeters (in a vacuum).

It is indispensable to research of optical phenomena occurring in an extremely short period of time in new fields such as physics, chemistry, biology and so on.

● Light can circle the earth 7.5 times in one second

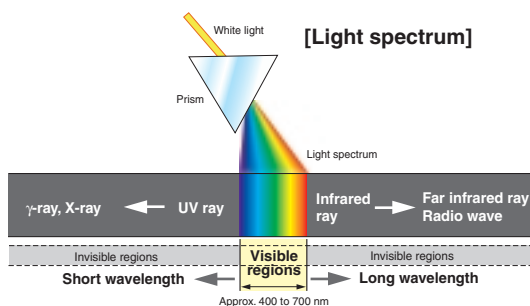


● 1 picosecond is...



Wide spectral range detection technology (including invisible light)

We can only see light within an extremely limited range. That range is about 400 nm (nanometers) to 700 nm and is called the visible light range. The other light ranges that we cannot normally see contain vast quantities of hidden information. At Hamamatsu Photonics we are developing systems capable of detecting and imaging a wide spectrum of light up to the X-ray and infrared ray ranges.



●Infrared reflectography

•Old pillar painting (Amida Hall of Hohkai Temple, Kyoto, Japan)
 (Photo courtesy of Mr. Sadatoshi Miura, National Research Institute for Cultural Properties, Tokyo)

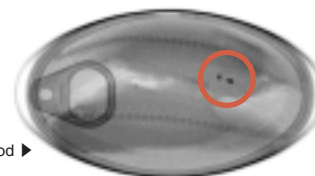


▲Normal photograph



▲Infrared reflectogram taken with IR camera
 (Enlarged view of head: A picture hidden under soot and dust appears visible.)

●X-ray image



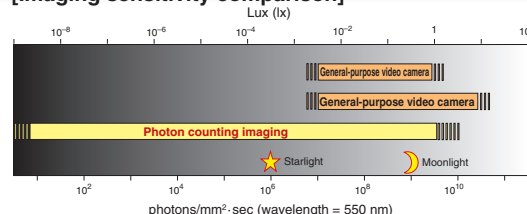
Inspection of canned food ▶
 (foreign matter in circle)

Low light level detection technology (photon counting imaging)

Light is a stream of particles called photons. Our everyday environment is filled to overflowing with photons. About 200 trillion photons rain down on us at an average indoor brightness (200 lux to 400 lux). That figure drops to 1/1000th of a lux for starlight on a moonless night and declines even further in the region called extremely low light levels where the brightness of light is less than one billionth of a lux and is completely impossible to see with the naked eye. In this region there are only a few photons each second per one square millimeter. The signal received from one photon is so small that it cannot be captured by the typical high sensitivity camera.

Photon counting imaging is a technique for visualizing an image in extremely low light levels, by detecting individual photons and their positions and then by integrating the detected signals.

[Imaging sensitivity comparison]

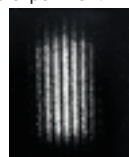


●Examples of photon counting imaging

•Young's interference experiment



▲10-second integration



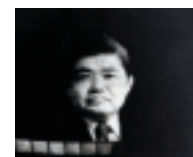
▲10-minute integration

Young's experiment was conducted in an extremely low light region. Results prove light has properties of both a wave and a particle.

•Portrait photograph



▲10-second integration



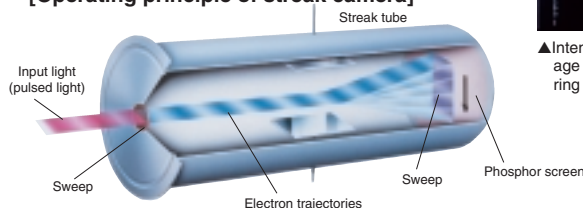
▲6.5-hour integration

Ultra high speed detection technology (streak camera)

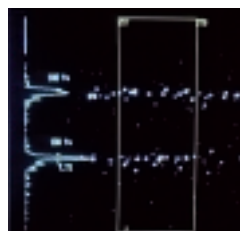
The streak camera is a device for measuring ultra high speed (ultra-short) phenomenon. Unlike the ordinary camera that captures actual images, the streak camera captures the state within the extremely short time that the light intensity changes.

The principle of the streak camera is simple. Light input in the form of a slit is converted into electrons on the photoelectric surface called "photocathode". These electrons are then swept at high speed (from top to bottom) and reconverted back into a light image on the phosphor screen. The changes in the input light intensity over time can in this way be observed as variations in image brightness that change from top to bottom. Hamamatsu Photonics developed and marketed an advanced streak camera with a time resolution down to 200 femtoseconds.

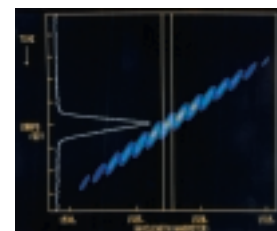
[Operating principle of streak camera]



●Images taken with streak camera



▲Intensity profile and streak image of pulsed light from a CPM ring laser



▲Optical fiber chromatic dispersion
 (Shows the difference in arrival times according to the light wavelength conveyed in the cable.)

Photomultiplier tubes

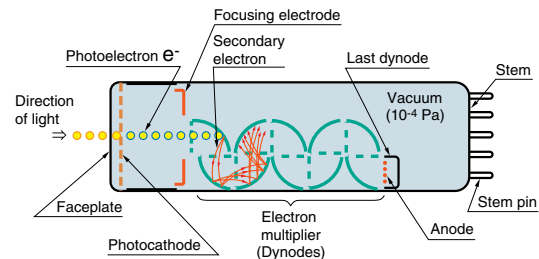


Photomultiplier tubes

Photomultiplier tubes are extremely high sensitivity photosensors having high-speed response. A typical photomultiplier tube (often abbreviated as PMT) has a vacuum envelope containing a photocathode (photoelectric surface) that converts light into electrons, focusing electrodes, an electron multiplier (dynodes) and an anode (electrode for collecting electrons).

Structure and principle

When light strikes the photocathode of a photomultiplier tube, the photocathode emits photoelectrons into the vacuum. These photoelectrons are guided by the focusing electrodes into the electron multiplier where the electrons are amplified (multiplied) by secondary emission effect. Due to this secondary emission effect, the initial photoelectrons are multiplied (one to ten million times), allowing photomultiplier tubes to offer exceptionally high sensitivity among photosensors currently available. Photomultiplier tubes also provide fast time response, a choice of photosensitive area (up to 50 cm in diameter), and many other excellent characteristics.



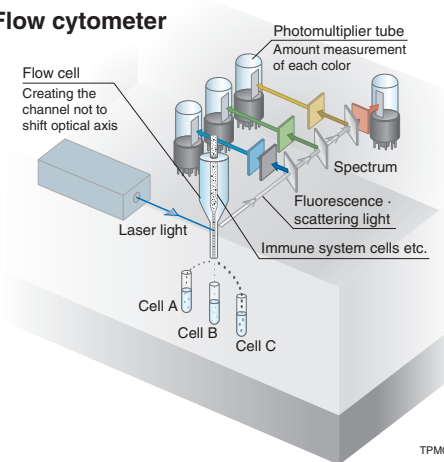
TPMHC0006EA

Applications

PMTs are widely used in high-precision photometric applications.

	Clinical testing equipment (blood test, biochemical test, etc.)
Medical	Nuclear medicine diagnostic imaging systems (PET, gamma cameras, etc.)
Analysis	Analytical instruments (spectrophotometers, environmental monitors, etc.)
Research	Academic research field (high energy physics experiments, astronomy experiments)
Measurement	Area monitoring, oil well logging, Security
Optics	Laser scanning microscopes (LSM)
Semi-conductor	Wafer surface inspection systems, plasma process monitors, ellipsometers (film thickness gauges)
Others	Agricultural crop sorters, hygiene monitors

Flow cytometer



TPMOC0266EA

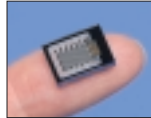
Photomultiplier tube modules

Photomultiplier tube modules are basically comprised of a photomultiplier tube, a high-voltage power supply circuit for photomultiplier tube operation, and a voltage divider circuit for distributing optimum voltage to each dynode, all assembled into a single compact case. In addition to these basic photomultiplier tube modules, Hamamatsu also provides wide variety of PMT modules having various additional functions such as a signal processing circuit, interface to PC, and cooling function. Several types with different spectral response characteristics are available to meet various application requirements.



Micro PMT modules / assemblies

Micro PMT modules and assemblies are PMT module / assembly using a newly developed μ PMT that is tinier and thinner than ever before and also easy to mass produce. These micro PMT modules and assemblies are combined with a voltage divider circuit and high-voltage power supply to allow downsizing equipment and boosting its performance.

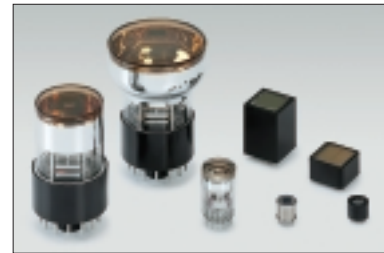


micro μ PMT[®]
HAMAMATSU



High sensitivity head-on PMTs

These head-on PMTs have drastically improved quantum efficiency (QE) and are widely used in photometric applications where high accuracy and high efficiency are required such as in particle beam detection in high energy physics experiments, radiation measurement, and molecular biology microscopes. Product lineup includes a variety of types that use ultra bialkali (UBA) photocathodes, super bialkali (SBA) photocathodes, or crystalline photocathodes (GaAs, GaAsP).



High sensitivity side-on PMTs

High sensitivity side-on PMTs were developed to meet demands for higher sensitivity arising from the increasingly high performance in modern analytical instruments. Hamamatsu offers a wide-ranging lineup of side-on PMTs with high sensitivity and high quantum efficiency over a broad spectral range from the UV to near infrared region, which are installed in most models of analytical instruments such as spectrophotometers.



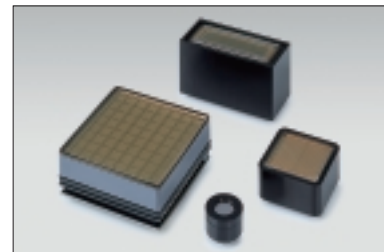
Ruggedized high temperature PMTs

These ruggedized PMTs are designed for oil well logging applications to offer superior resistance to high temperature, vibration, and shock. We also developed new PMTs with longer product service life even during continuous high temperature use. This amounts to a service life about 8 times longer than our existing high temperature PMTs when used at 175 °C and about 6 times longer at 200 °C. This feature makes them ideal for long-term use and drilling into a deeper stratum at higher temperatures, to help procure a stable oil supply.



Metal package PMTs

Metal package PMTs are very compact PMTs with excellent time response characteristics. These PMTs contain an electron multiplier of 8 to 12-stage dynodes (metal channel dynode) and are sealed in a TO-8 type metal package, 30 mm or 50 mm square metal package suitable for multianode assemblies. The 52 mm square package type has an effective area ratio of nearly 90% and are available in a flat panel configuration with 64-channel or 256-channel multianodes.



Thermoelectric cooled NIR-PMT units

These PMT units utilize a high sensitivity compact near infrared PMT we developed in-house here at Hamamatsu. We assembled them to precision specifications in a sealed off housing evacuated to a high vacuum. The built-in thermoelectric cooler eliminates the need for liquid nitrogen and cooling water.



Photomultiplier tube accessories

To extract maximum performance from photomultiplier tubes, Hamamatsu provides a variety of accessories and options designed with our accumulated technology as a leading photomultiplier tube manufacturer.

High voltage power supplies

PMT output is very sensitive to variations in supply voltage, so high voltage power supply stability directly affects measurement accuracy. Hamamatsu high voltage power supplies are designed and manufactured for precision photometry using PMTs, by taking into account all characteristics including output stability and ripple. Various models are available, ranging from on-board mounting types to general-purpose bench-top types.



Socket assemblies

A variety of socket assemblies are available to help users to quickly and easily use PMTs. Besides basic types that contain a PMT socket and a voltage divider circuit in a compact case, we have a lineup of socket assemblies with added functions such as current-to-voltage conversion amplifiers and/or high-voltage power supply circuits.



Amplifier units

These amplifier units convert low level, high impedance current signals from a PMT into low impedance voltage signals. We have a lineup of various types that cover a wide frequency band from DC to 1.5 GHz.



Thermoelectric coolers

Thermoelectric coolers efficiently reduce thermoelectrons emitted from the photocathode of a PMT. Hamamatsu thermoelectric coolers also contain an electrostatic and magnetic shield to minimize adverse effects from ambient environments, and greatly improve the signal-to-noise ratio (S/N ratio).



Optical blocks

Optical blocks contain or are designed to include optical components such as bandpass filters and dichroic mirrors optimized for low-light-level measurement using photomultiplier modules or high-sensitivity cameras. Optical blocks allow accurate arrangement of optical components and provide excellent light-shielding, making it easy to set up the desired measurement system by simply combining blocks.

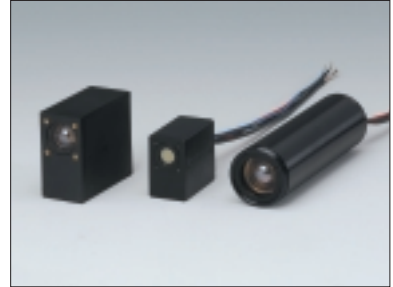


Photon counting products

Demands for low-light-level measurement using photon counting are recently increasing in many fields such as biology, chemistry, and medical applications. To meet these demands, Hamamatsu provides a full line of photon counting products.

Photon counting heads

Photon counting heads contain a low-noise PMT, a high-speed photon counting circuit, and a high-voltage power supply. Since the discrimination level and PMT supply voltage are preset to optimal values, the unit can easily be operated by just connecting a +5 V power supply and counting the photons on a pulse counter. Types with a built-in counter allow direct input of measurement results into a PC via USB.



Stabilized light sources

This LED light source was developed for adjusting the sensitivity of PMT and PMT modules. The LED light level is monitored and controlled by its internal photodiode to emit constant, stable, low-level light. This LED light source is ideal for ensuring sensitivity of photomultiplier tubes assembled into blood test equipment, etc.



Photon counting unit

The C9744 photon counting unit contains an amplifier and discriminator to convert single photoelectron pulses from a PMT into a 5 V digital signal. By inputting the output of this photon counting unit to a counting unit or counting board, the count data can be loaded and processed on a PC.



Counting unit

The C8855-01 is a counter with a USB interface and can be used as a photon counter when combined with a photon counting head and PC. The counter section has two counter circuits (double counter method) capable of counting input signals with no dead time.



Counting board

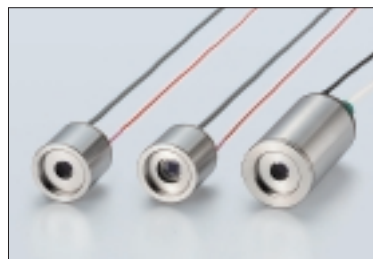
The M9003-01 counting board is a PCI bus add-in board type counter. The M9003-01 functions as a photon counter when combined with a photon counting head, etc. The counter section includes two counting circuits (double counter method) capable of counting input signals with no dead time. The counter can operate in either gate mode or in reciprocal mode.



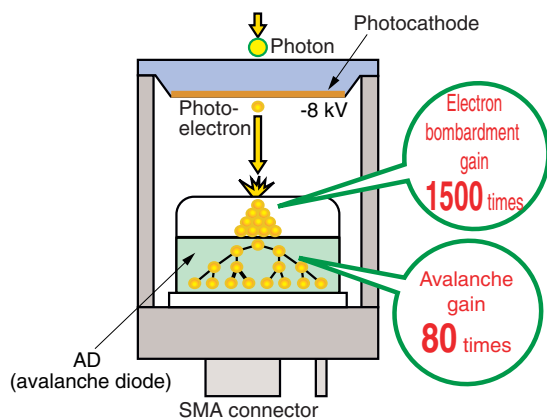
Other photosensors

HPD (hybrid photo detectors)

The HPD (hybrid photo detectors) are completely new PMTs that contain a semiconductor device within an electron tube (vacuum tube). Photoelectrons emitted from the photocathode are directly bombarded onto the semiconductor to multiply the photoelectrons. This method allows efficient electron multiplication with less noise.



Structure and principle



Applications

- Confocal microscopy
- Multiphoton microscopy
- Fluorescence correlation spectroscopy (FCS)
- Light detection and ranging (LIDAR)
- Time-correlated single photon counting (TCSPC)

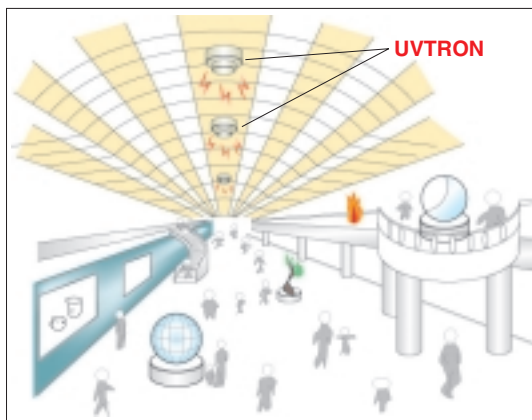
Flame sensors UVTRON®

UVTRON flame sensors are UV detectors utilizing the photoelectric effect obtained from metal and gas amplification. The spectral response of UVTRON flame sensors only covers a narrow UV region between 185 nm and 260 nm. This eliminates the need for optical visible-cut filters and makes UVTRON flame sensors easy to use for UV detection. UVTRON flame sensors can quickly and reliably detect the weak UV rays emitted from flames and so are ideal for applications such as fire alarms, arson monitors, and burner combustion monitors.

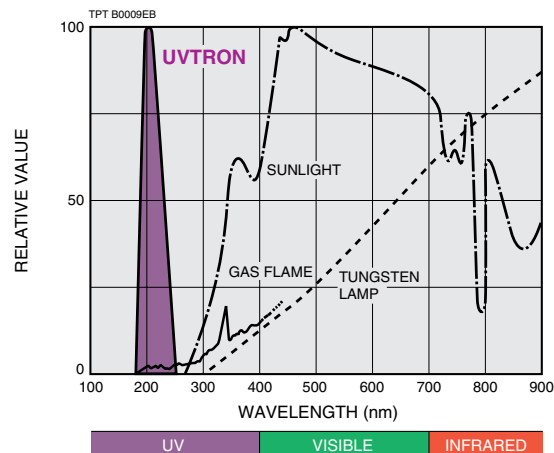


Applications

- Fire detection in a building with large space



Spectral response range only covers from 185 nm to 260 nm !



Phototubes

Phototubes are widely used in chemical/medical analytical instruments and laser measurement units. Phototubes deliver a stable output even when the ambient temperature fluctuates and also offer a large photosensitive area compared to semiconductor detectors. In particular, phototubes using a single metal photocathode exhibit less deterioration in sensitivity even after long, continued exposure to UV radiation, and are ideal for monitoring high-intensity UV radiation such as from mercury sterilizer lamps.

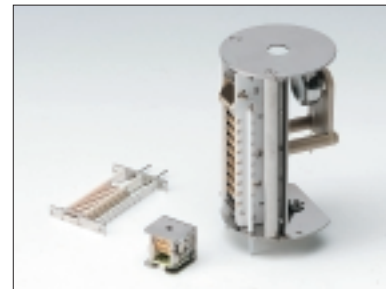


Applications

UV detectors, laser measurement, analytical instruments, etc.

Electron multipliers

Electron multipliers are used for the detection and measurement of electrons, ions, charged particles, vacuum UV radiation and soft X-rays. Hamamatsu electron multipliers offer high gain and low dark current, making them suitable for measurement of very small quantities of input particles by using the photon counting method.



Applications

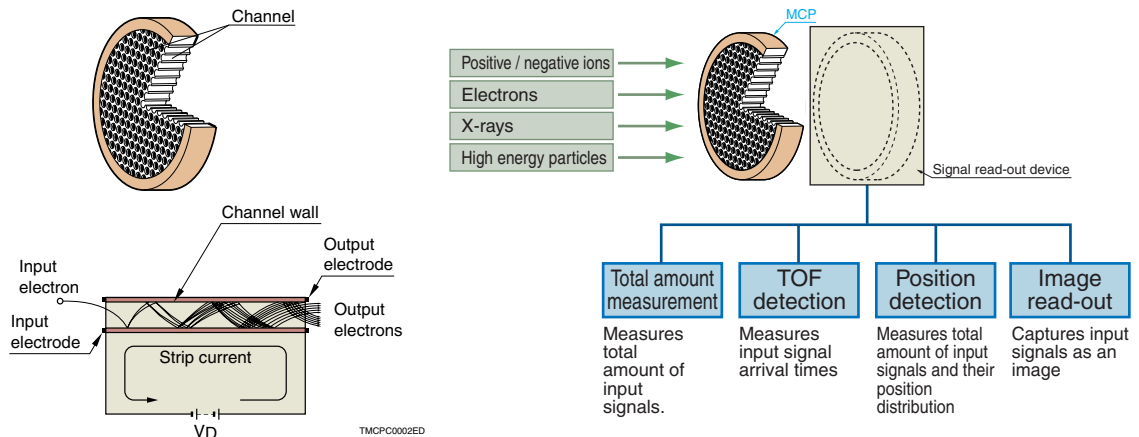
Mass spectrometry (TOF-MS, LC-MS, GC-MS, ICP-MS, SIMS, etc.)
Electron spectroscopy
Vacuum UV spectroscopy

MCP (microchannel plates) / MCP assemblies

MCP (microchannel plates) are electron multipliers capable of 2-dimensional detection and amplification of electrons in a vacuum. The MCP are sensitive not only to electrons but also to ions, vacuum UV rays, X-rays and gamma-rays, making it a versatile detector for those particles and rays. The MCP are available in easy-to-use assemblies mounted with electrode leads and also with various types of read-out devices according to applications.



Structure and principle



Products using photosensors

Photon detection units

The photon detection units are single photon counting units designed to make low-light measurements without a time-consuming setup for the measurement system. All that needed to do is prepare a sample to be measured and a personal computer (PC). The USB interface allows anyone to make the setup without difficulty by plug & play when connecting to the PC.

■Applications

Bioluminescence / chemiluminescence measurement, food oxidation and antioxidant activity luminescence measurement, activated cell luminescence measurement, delayed fluorescence measurement using excitation light source (UV-LED), other low-light-level measurements

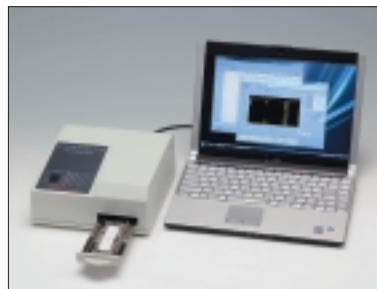


Immunochromato-readers

The Immunochromato-reader system supports R&D and quality control of immunochromatographic reagents. This system acquires highly reliable data with high measurement reproducibility even in low light level where visual inspection are extremely difficult. In addition to models capable of measuring dye concentrations in the two colors red and blue, we also provide a model that can measure the light emission level of fluorescent particles. OEM models are also available on request.

■Applications

R&D and quality control of immunochromatography reagent kits



UV power meter

This UV power meter is designed to monitor and control absolute optical power of UV light. Its flat spectral response over a wide UV wavelength region allows this UV power meter to measure the optical power independent of the spectral emission distribution of the light source being measured.









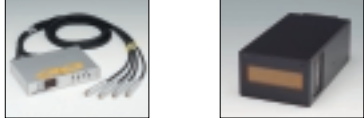

This UV power meter is recommended by JIS (Japanese Industrial Standard) R1709 for monitoring the optical power of photocatalytic light sources.

■Applications

UV power monitoring: Black light, UV-LED, UV (UV-A), etc.



Lamps / light sources lineup

Lamps / light sources	Features	Applications	Light source products
<p>Xenon lamps Mercury-xenon lamps</p> 	<ul style="list-style-type: none"> · Broad spectrum from UV to infrared · High stability · Long life · High brightness · No arc point shift · High color rendering (xenon lamps) · High UV intensity (mercury-xenon lamps) 	<p>Semiconductor wafer surface inspection system Film thickness gauge Fluorescence microscope Flow cytometer Fluorophotometer SOx/NOx analyzer Color analyzer (colorimeter)</p>	<p>Standard light sources Spot light sources LIGHTNINGCURE[®] LCB Opto-Spectrum Generator</p> 
<p>Xenon flash lamps</p> 	<ul style="list-style-type: none"> · Broad spectrum from UV to infrared · Instantaneously high peak output · High stability · Long life 	<p>Semiconductor wafer surface inspection system Strobe light source for factory automation Color analyzer (colorimeter) Laboratory testing equipment Blood test equipment Air/water analyzer High-performance liquid chromatograph Spectrophotometer</p>	<p>Flash light sources Flash light sources LIGHTNINGFLASH[®] LF1 LIGHTNINGFLASH[®] LF2</p> 
<p>Deuterium lamps</p> 	<ul style="list-style-type: none"> · Broad UV spectrum · High stability · Long life · Less variation of intensity · High UV intensity 	<p>High-performance liquid chromatograph Semiconductor wafer surface inspection system Thickness gauge Spectrophotometer Air/water analyzer Electrostatic charge remover Photoionization source</p>	<p>X2D2 UV-VIS fiber light source Compact S2D2 UV-VIS fiber light source H2D2 light source units</p> 
<p>Hollow cathode lamps</p> 	<ul style="list-style-type: none"> · Line spectra unique to each element · Lineup includes 66 types of single element lamps and 11 types of multi-element lamps 	<p>Atomic absorption spectrophotometer Atomic fluorescence spectrophotometer Water analyzer Wavelength calibration light source</p>	
<p>Deep UV light sources</p>	<ul style="list-style-type: none"> · High output · Mercury free · Long life 	<p>Labratory testing equipment Blood test equipment Air / water / soil analyzer UV bonding UV curing Material resistance evaluation Sterilization</p>	<p>Deep UV light sources UVCL</p> 
<p>UV-LED light sources</p>	<ul style="list-style-type: none"> · High stability · High output · Long life · Low power consumption 	<p>UV bonding UV ink drying UV coating agent drying UV tape peeling Fluorescence excitation/scratch & flaw inspection lighting High output UV irradiation</p>	<p>UV-LED spot light sources Linear irradiation UV-LED units LIGHTNINGCURE[®] LC-L1V3 LIGHTNINGCURE[®] LC-L5G</p> 
<p>Excimer lamp light sources</p>	<ul style="list-style-type: none"> · Single wavelength of 172 nm allows highly efficient processing · Uniformly irradiates a large area by using a long flat lamp · Gives stable output with minimal flicker by using RF (radio frequency) discharge 	<p>Surface modification Dry cleaning</p>	<p>Excimer lamp light sources FLAT EXCIMER EX-400 EX-86U EX-mini</p> 

Lamps / light sources

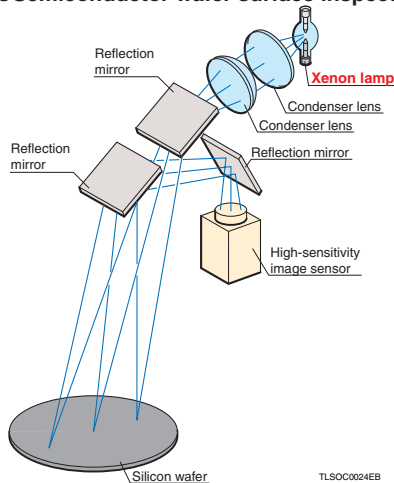
Xenon lamps / mercury-xenon lamps

These lamps emit a continuous spectrum with high brightness from the UV to infrared region, and so are highly ideal as light sources for various types of photometric equipment such as spectrophotometers. All these lamps employ a high-performance BI cathode that has eliminated the problems with conventional lamps. These lamps are widely used in applications where high-precision measurement light sources are needed.



Application example

● Semiconductor wafer surface inspection system



Xenon lamps

Xenon lamps are point light sources with high brightness and high color rendering. These lamps emit a continuous spectrum from the UV to the infrared region, and so are widely used as light sources for various types of photometric equipment such as spectrophotometers. By using our proprietary-developed high-performance BI cathode, these lamps also offer highly stable light output and long lifetime.

Mercury-xenon lamps

Mercury-xenon lamps produce high radiant power especially in the UV region. An optimal mix of mercury and xenon gas gives these lamps a spectral distribution including a continuous spectrum ranging from UV to infrared light and strong mercury line spectra in the UV to visible region. As with high-stability xenon lamps, these mercury-xenon lamps also use a high-performance BI cathode, and therefore feature high stability and long operating life.

Applications

Semiconductor wafer surface inspection systems, film thickness gauges, fluorescence microscopes, flow cytometers, fluorescence spectrophotometers, SOx/NOx analyzers, color analyzers (colorimeters), etc.

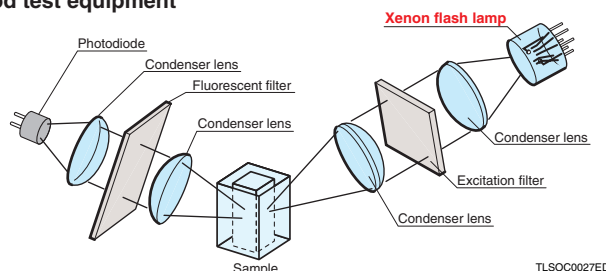
Xenon flash lamps

Compared to DC operation lamps, xenon flash lamps are more compact, generate less heat, and also emit a high-intensity continuous spectrum from the UV to the infrared region. Hamamatsu xenon flash lamps are especially ideal as light sources in precision photometry because of their highly stable light output and long lifetime achieved by improving the electrode structure and materials. Various types are available including normal glass bulb types, high output built-in reflector types that delivers a light intensity about 4 times higher than conventional lamps by using a reflecting mirror, and 60 W types that provide even higher light output by applying metal can. Our product lineup also includes lamp modules integrated with a trigger socket and power supply.



Application example

● Blood test equipment



Applications

- Semiconductor wafer surface inspection systems
- Strobe light sources for factory automation
- Color analyzers (colorimeters)
- Laboratory testing equipment
- Blood test equipment
- Air/water analyzers
- High-performance liquid chromatographs
- Spectrophotometry

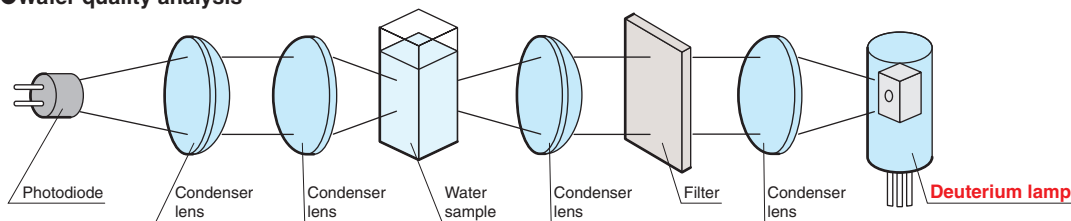
Deuterium lamps

Deuterium lamps are high stability and long life lamps utilizing the arc discharge in deuterium (D₂) gas. Deuterium lamps mainly emit UV light at wavelengths shorter than 400 nm and are widely used as a continuous UV spectrum light source for analysis instruments. We have a lineup of four types: long life L2D2 series, high-brightness X2D2 series, compact S2D2 series and ultra high-brightness H2D2 series. Our unique electrode (ceramic electrode) production technology ensures lamps with high stability and minimal fluctuations in light output.



Application example

Wafer quality analysis



TLSOC0051EA

Applications

High-performance liquid chromatography, semiconductor wafer surface inspection systems, film thickness gauges, spectrophotometers, air/water analyzers, electrostatic charge removers, and photoionization sources, etc.

Hollow cathode lamps

Hollow cathode lamps are metal-vapor discharge lamps specifically developed for atomic absorption spectroscopy. We have a lineup of single-element lamps in 66 types including silver, aluminum and arsenic, and multi-element lamps in 11 types such as Na-K and Ca-Mg. To support various models of spectrophotometers and analysis techniques, Hamamatsu provides standard hollow cathode lamps, and giant-pulse hollow cathode lamps using S-H background correction designed for absorption spectroscopy.



Applications

Atomic absorption spectrophotometers, atomic fluorescence photometers, water analyzers, wavelength calibration light sources

Deep UV light sources UVCL

This is the mercury-free deep UV light source which has peak wavelength of 265 nm and 305 nm. Its features of low power consumption and long life contributes to the total cost reduction. This lamp is compact but designed as an all-in-one device which contains lamp power supply. Therefore it is easy to assembly into various types of equipment.

Applications

Laboratory testing equipment, blood test equipment, air / water / soil analyzer, UV bonding, UV curing, material resistance evaluation, sterilization



Products using light sources

Spot light sources LIGHTNINGCURE LC8

These spot light sources are UV light sources optimized for UV adhesive curing. Using a highly stable mercury-xenon lamp and an optical system with minimum loss, these light sources produce high-intensity UV light. A quartz light guide with high UV transmittance is used to irradiate UV light only onto the target area. These spot light sources are ideal for UV adhesive curing for bonding micro components and optical components which require high precision.

UV-LED light sources LIGHTNINGCURE LC-L1V3 / LC-L5

The LC-L1V3 and LC-L5 are light sources using a UV-LED. These are monochromatic light sources and cause no thermal damage or harmful DUV (deep UV) effects on the objects being irradiated. Their low power consumption makes them an eco-friendly light source. The LED lifetime may be as long as 20000 hours and so reduces costly downtime from having shut down the production line to replace lamps. These light sources contribute to improving productivity.

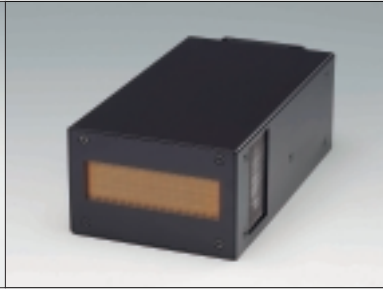
LIGHTNINGCURE® LC8



LIGHTNINGCURE® LC-L1V3

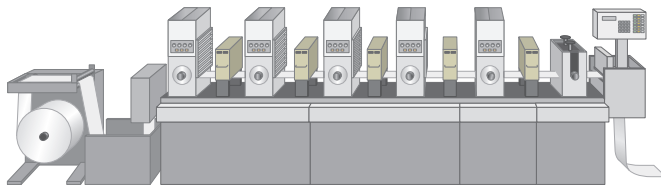


LIGHTNINGCURE® LC-L5



Application examples

Various printers



UV ink drying

Smartphone



Touch display bonding
Camera module fixation

Camera



Camera lens fixation

Applications

- UV bonding
- UV ink drying
- UV coating agent drying
- UV tape peeling
- Fluorescence excitation / scratch and flaw inspection lighting
- High output irradiation

Flash light sources LIGHTNINGFLASH LF1 / LF2

These flash light sources contain a xenon flash lamp and a power supply/control circuit in the same housing. They emit a variety of different types of light by selecting the optical system such as light guides. The light emission is highly intense for a period of microseconds making them an ideal strobe light source. These light sources are also easy to handle due to the useful functions such as programmable light emission, flash count setting, and control from a PC.

Applications

Strobe light sources

LIGHTNINGFLASH™ LF1 LIGHTNINGFLASH™ LF2



X2D2® UV-VIS fiber light source

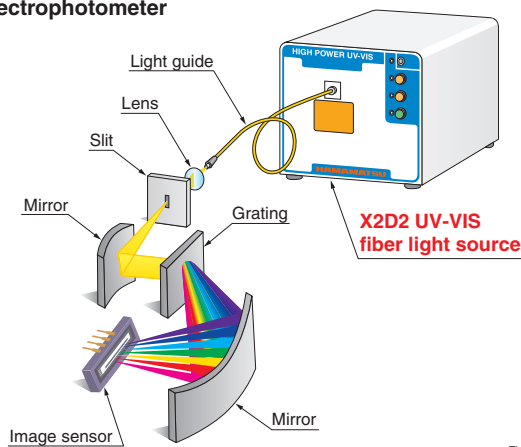
This UV-visible light source incorporates a high-brightness deuterium lamp (X2D2 lamps) and a tungsten-halogen lamp into a single housing, and emits a broad light spectrum from 200 to 1100 nm through a light guide. It also offers highly stable light output with high intensity which is about twice that of conventional products. Along with a compact size and light weight that makes it easy to carry, this light source is available with useful functions such as a shutter mechanism and external control, making it ideal for various portable devices.



(Light guide is sold separately.)

Application examples

● **Spectrophotometer**



TLSOC0048EA

Applications

- Portable spectrophotometers
- Film thickness gauges
- Environment measurement
- Absorption spectrum measurement
- Drug inspection
- Semiconductor inspection
- Analytical equipment

S2D2® compact UV-VIS fiber light source

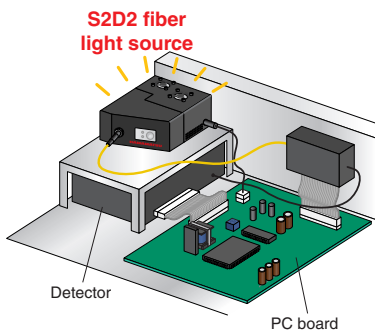
This is a very compact UV-visible fiber light source using a compact deuterium lamp (S2D2 lamp). This is the light source that provides high radiant power and high stability despite its compact size. Besides being compact and easy to carry, this light source operates on a low voltage, making it ideal for various types of portable instruments.



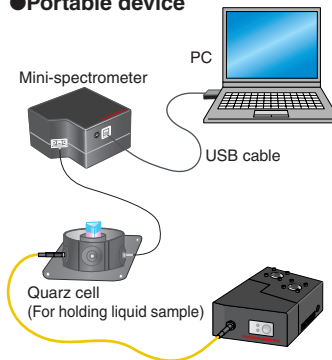
(Light guide is sold separately.)

Application examples

● **Assemble into equipment**



● **Portable device**



Applications

- Portable spectrophotometers
- Environment measurement
- Absorption spectrum measurement
- Drug inspection
- High-performance liquid chromatography
- Biological measurement
- Semiconductor inspection
- Optical component inspection
- Film thickness gauges

Products using light sources

Standard light sources

These light sources deliver the extremely high levels of stability and repeatability essential to a calibrated light source. They are available in a convenient set including a lamp, lamp housing and power supply so that anyone can easily reproduce a highly stable light output as needed. The xenon lamp light source is calibrated over a wide spectral range from 200 nm to 800 nm, and the deuterium lamp light source is calibrated in the UV range from 200 nm to 400 nm. A JCSS (Japan Calibration Service System) calibration certificate logo mark comes attached to these light sources when purchased.



Applications

Light level control of light sources, sensitivity control of photosensors, light intensity measurement and studies of photoreactions, quality control of photometric equipment (analysis equipment, semiconductor inspection systems, imaging devices, etc)

H2D2[®] light source units

The H2D2 light source units emit light at a luminance 6 times higher than our long life deuterium lamps (L2D2 lamps). Despite its high brightness, the H2D2 light source units are highly stable, has a long lifetime, and allow air-cooled operation by the use of a specially designed housing. This feature makes it much more convenient and easier to use than ordinary water-cooled lamps.



Applications

- Semiconductor inspection
- Film thickness measurement
- Photoionization
- Electrostatic removal (vacuum condition)
- Spectrophotometry
- Environmental measurement
- Optical component inspection

S2D2[®] VUV light source unit

The S2D2 VUV light source unit is a vacuum UV light source unit that incorporates a compact deuterium lamp with an MgF₂ window. Equipped with a SUS flexible tube with a vacuum flange and a unique cooling mechanism, this light source unit allows irradiating objects or samples at a very close distance, and can be installed and operated under depressurized conditions.



Applications

- Electrostatic removal (vacuum condition)
- VUV spectrophotometer
- Photoionization
- UV resistance testing of various material
- Excitation light source

Opto-Spectrum Generator

The Opto-Spectrum Generator is a wavelength-tunable light source capable of emitting light at any desired wavelength and selectable in 1 nm steps over the UV to near infrared range. Our unique optical systems make the Opto-Spectrum Generator more compact than currently available wavelength-tunable light sources yet offer higher stability and higher output power. This light source is possible to generate a desired wavelength light with high reproductivity and allows highly accurate evaluation / test.

Opto-Spectrum Generator



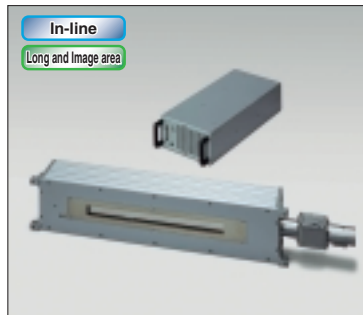
Applications

- Light stimulus to living body
 - Plant photosynthesis activity, plant culture, light stimulus to living cells
- Spectral characteristic evaluation of devices
 - Evaluations of solar cell devices, camera spectral characteristics, optical system deflection characteristics and CCD/CMOS
- Optical property evaluation of materials
 - Evaluations of photocatalyst, fluorescent materials and solar cell materials
- Illumination
 - Light source for microscopes and endoscopes

Excimer lamp light sources FLAT EXCIMER

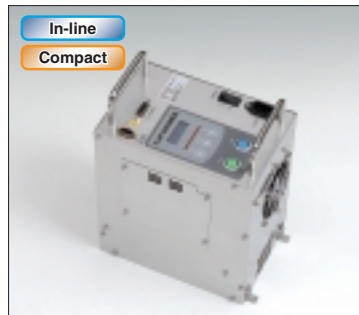
Vacuum UV light at 172 nm emitted from the excimer lamps generates ozone and a large amount of active oxygen, and at the same time breaks up the molecular bonds of organic matter adhering to a material surface to perform surface modification and dry cleaning. These light sources provide a stable light output with uniform irradiation and very little flicker through the use of a flat lamp bulb and RF (radio frequency) discharge.

EX-400



Delivering stable output with uniform irradiation over a large area and less flickering.

EX-86U



The EX-86U can be installed anywhere and easily set up in a production process with little time and task.

EX-mini



(Ozone decomposition unit is sold separately.)

Amazingly handy and easy to use design allows simple yet highly accurate testing and evaluation in any place needed.

Applications

- Surface modification
 - Bonding pre-processing(Improve adhesiveness)
 - Adhesion improvement during printing
 - Adhesion improvement during coating
- Dry cleaning
 - Silicon wafer cleaning
 - Glass substrate cleaning
 - Organic contamination removal

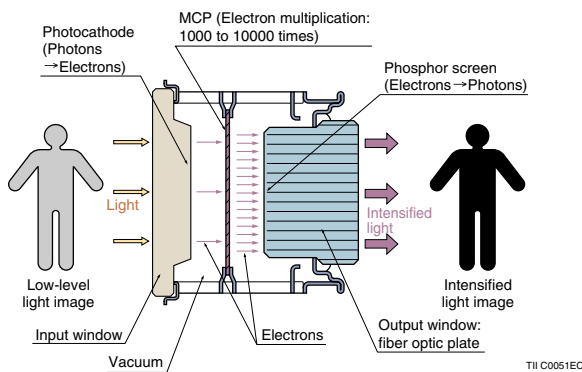
Image sensors

Image intensifiers

Image intensifiers were primarily developed for nighttime viewing and surveillance under moonlight or starlight. They are capable of detecting and amplifying low-level light (light emitted or reflected from objects) for bringing it into view as a sharp contrast image. Major applications include nighttime viewing and surveillance, ICCD (intensified CCD) cameras, and scientific research.



Structure and principle



Applications

- High-speed emission analysis:
 - Observation of internal combustion engine operation, plasma emission, and discharge
- Low-light-level imaging:
 - Microscope imaging, bioluminescence imaging, etc.
- Observation of high-speed moving objects:
 - Observation of turbine blade motion, high-speed photography of explosion, etc.

Streak tubes

Streak tubes are ultra-high speed imaging tubes capable of capturing changes in light intensity over time that occur in an ultra-short time duration in the picosecond region; and at the same time provide spatial information in a one-dimensional direction. When used in combination with a spectroscope, streak tubes allow measuring light intensity versus wavelength versus time in the picosecond region.

Applications

High-speed time-resolved spectrophotometry



Products using image sensors

Image intensifier units

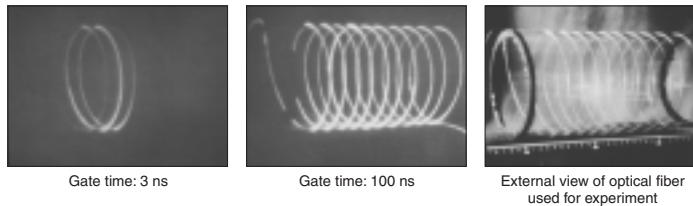
These are high-sensitivity imaging units consisting of a compact image intensifier head and its remote controller. The head also contains a high-speed gate circuit for image intensifier operation. Built-in image intensifiers are available with three standard photocathodes, which are GaAsP, GaAs and multialkali photocathodes. These photocathodes provide a wide spectral response range from UV to near infrared. Image intensifier units can capture "instantaneous images" of high-speed phenomena occurring in extremely short time durations.



Imaging example

Pulsed laser light passing through optical fiber

Photos show a laser light pulse passing through an optical fiber. Distance that the light travels within each gate time can be observed.



Gate time: 3 ns

Gate time: 100 ns

External view of optical fiber used for experiment

Applications

Analysis of engine combustion state
 Observation of gaseous and liquid bodies moving at high speed
 Observation of plasma emission changes over time
 Observation of high-speed moving objects
 Observation of turbine blade motion
 Fluorescence lifetime observation
 Observation of explosion phenomena
 Imaging of low-level bioluminescence and chemiluminescence

ICCD cameras

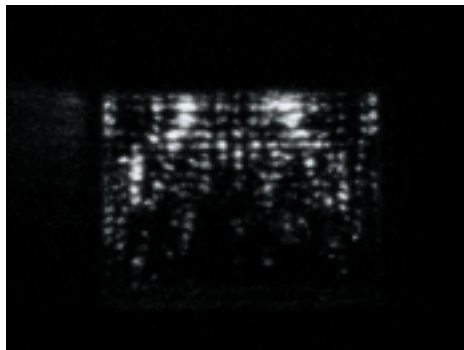
ICCD cameras use an image intensifier with a high-speed electronic shutter, and allow imaging and measuring various high-speed phenomena with high sensitivity and excellent time resolution.



Application example

Observation of low-level luminescence (sonoluminescence) in ultrasonic cleaning tank

Photo shows low-level luminescence (sonoluminescence) caused by cavitations in an ultrasonic cleaning tank.



Applications

Analysis of engine combustion state
 Observation of gaseous and liquid bodies moving at high speed
 Observation of plasma emission changes over time
 Observation of high-speed moving objects
 Observation of turbine blade motion
 Fluorescence lifetime observation
 Observation of explosion phenomena
 Imaging of low-level bioluminescence and chemiluminescence

X-ray products

Microfocus X-ray sources

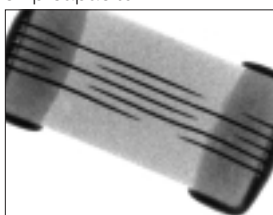
Microfocus X-ray sources are widely used for X-ray non-destructive inspection. A small focal point prevents blurring of X-ray images and delivers sharp, clear enlarged X-ray images even when observing a three-dimensional shape. An RS-232C interface is provided as a standard feature for easy control from a PC, etc.



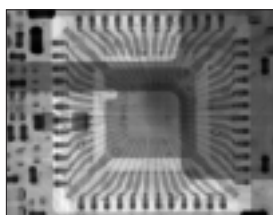
Imaging examples

Capacitor

0402 (0.4 mm x 0.2 mm) size chip capacitor



Printed circuit board



Applications

X-ray fluoroscopic equipment
 X-ray CT equipment
 In-line X-ray inspection systems
 Applicable objects:
 Electronic components, PC boards, lithium ion battery, plastic components, metal components, foods, beverages, drugs and medicines, bioproducts, etc.

X-ray scintillators FOS®, ACS®, GPXS®, and ALS®

These are optical plates for converting an X-ray image to a visible image. A columnar structure CsI(Tl) scintillator is used as the conversion film to ensure high quality images with high resolution. These plates can be coupled to a two-dimensional imaging device and their applications are expanding ever wider in fields such as X-ray testing in medical diagnosis and industrial inspection.



FOS (FOP coated with X-ray scintillator)

FOS is basically a "fiber optic plate" which bundles tens of millions of glass fibers each having a diameter of several micrometers, coated with X-ray scintillator material and then covered with a protective film.

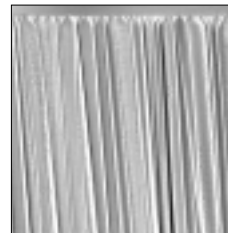
ACS (amorphous carbon plate coated with X-ray scintillator)

GPXS (high reflection aluminum plate coated with X-ray scintillator)

ALS (aluminum plate coated with X-ray scintillator)

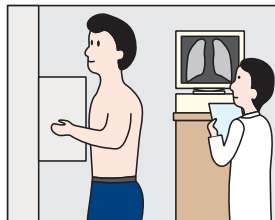
These are large-area, high-resolution, thin X-ray detection plates fabricated by evaporating CsI scintillator over an amorphous carbon plate (ACS), high reflection aluminum plate (GPXS) or aluminum plate (ALS) and then coating the surface with a protective film. The amorphous carbon substrate has high transmittance even for low-energy X-rays, so X-ray images can be captured at a high S/N ratio.

CsI(Tl) columnar structure

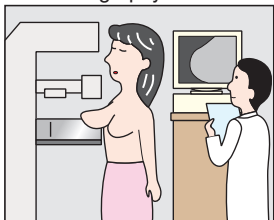


Application examples

Chest examination



Mammography



Dental intra oral imaging



Dental panoramic imaging



X-ray image intensifier camera units

These are X-ray camera units those contain an X-ray image intensifier and a CCD camera. The X-ray input window is made of aluminum or beryllium that allows X-ray imaging in a low energy region above a few keV that transmits through light-element materials such as plastic (PET: polyethylene terephthalate).

Applications

X-ray non-destructive inspection systems

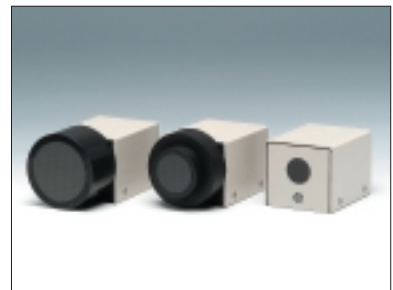


Compact X-ray CCD cameras X-CUBE™

The X-CUBE are compact X-ray CCD cameras using a commercial CCD chip and are designed for non-destructive inspection. The X-CUBE allow X-ray imaging much the same as when handling a typical CCD camera. Its compact and lightweight design supports a new level of X-ray non-destructive inspection and testing.

Applications

X-ray non-destructive inspection systems



Energy differentiation type radiation line sensor (64-ch CdTe)

This radiation line sensor simultaneously measures the number of radiation photons in 5 different energy regions to acquire their images. Utilizing information on the radiation energy passing through a substance allows identifying the substance material and measuring the material quantities that include the substance thickness, density, and concentration. This radiation line detector uses a cadmium telluride (CdTe) detector.

Imaging example

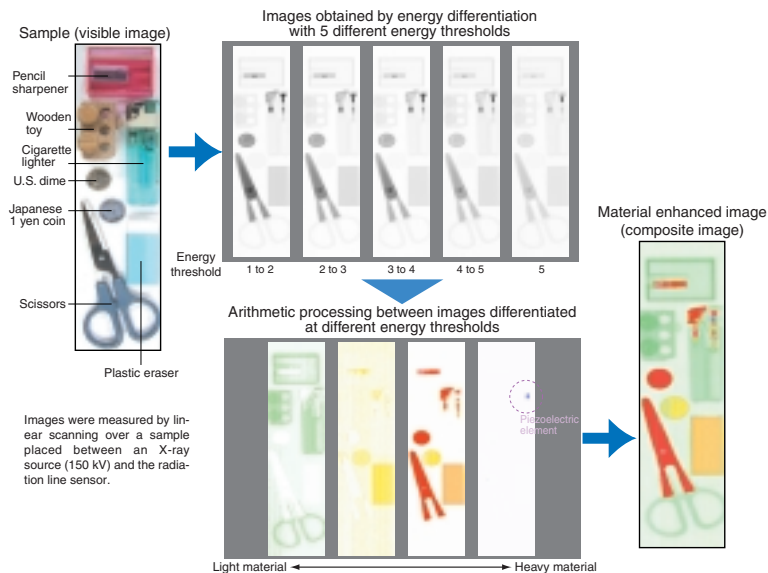
Simultaneous measurement of different X-ray energy levels

Images were measured by linear scanning over a sample placed between an X-ray source (150 kV) and the radiation line sensor.



Applications

Inspection of foreign matter in food
 Baggage inspection/screening
 Industrial non-destructive inspection such as for piping, structures, and containers
 Medical radiation diagnostic equipment such as X-ray CT and bone-density measuring devices



Other products and technologies

Optical elements and function materials

Flow cells

Hamamatsu provides flow cells and a variety of glass products which are manufactured by applying our glass processing technology gained from over 50 years of experience in the production of vacuum tube devices such as photomultiplier tubes. We also welcome requests for custom products.

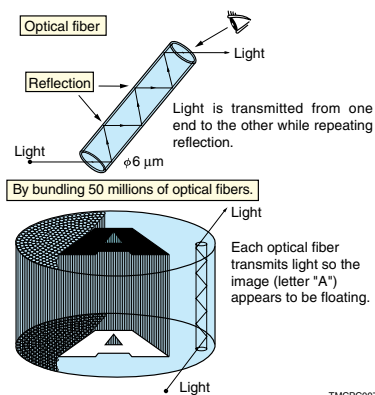


FOP (fiber optic plates)

FOP (fiber optic plates) are optical devices bundling optical fibers having several micrometers in diameter. They will transmit the light and image with high efficiency and low distortion, which allows them as the better replacement of optical lens. In addition, it has no necessity to consider the focal point like optical lens, which can make the optical design simple and compact. Hamamatsu will offer the variation in the high definition type having minimum fiber size of 3 micrometers and in the magnification or reduction size of 5: 1 maximum for tapered type.



Structure and principle



Applications

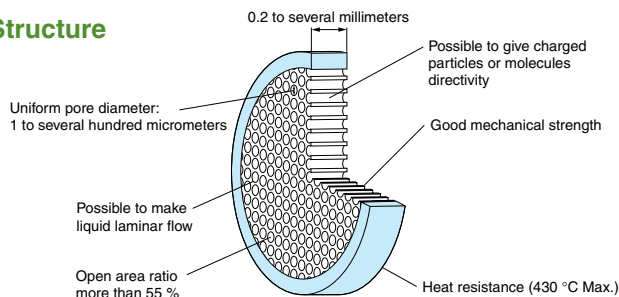
Finger print identification, etc.
Input window for CCD image sensor

TMCP0079EA

Capillary plates

The capillary plate is a glass plate with a thickness of 0.2 to several millimeters. It is comprised of a two-dimensional regular array of glass tubes with pore diameters ranging from 1 to several hundred micrometers. Each glass tube has excellent linearity and accuracy, thus being useful in a wide range of applications including use in optical guide and flow control. An typical open area ratio of 55 % or more is provided.

Structure



Applications

Fluid/gas flow control
Differential-pumping window
Soft X-ray collimator
X-ray/neutron guide

●Static electricity removal products

Hamamatsu ionizers remove static electricity by photoionization that generates ions in a clean way. Photoionization directly ionizes atoms/molecules in the air (residual atoms/molecules in a vacuum) to generate ions that neutralize electrostatic charges very efficiently without needing air flow and causing no overshoot (generation of oppositely charged ions). This allows instantly removing electrostatic charges even from objects or in environments where electrostatic charges have been difficult to remove up to now by conventional methods.

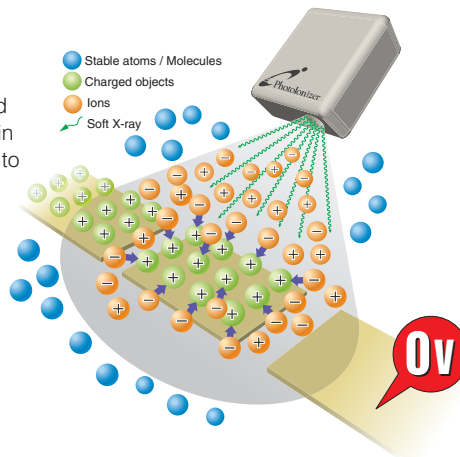
Electrostatic charge removers PhotoIonizer / PhotoIonBar

Removing static charges in air

PhotoIonizer and PhotoIonBar remove static charges by making use of soft X-rays. Unlike conventional corona discharge methods, photoionizers need no maintenance such as electrode cleaning yet have a high capacity for removing static charges. Their compact size has a narrow footprint for installation even in narrow spaces.

■Principle

The PhotoIonizer and PhotoIonBar ionizes molecules near charged objects and these ions in turn effectively function to remove electrostatic charges from objects. Even electrostatic charges on high-speed moving objects or powders that have so far been difficult to remove can now be eliminated instantly.



■Applications

- Semiconductor manufacturing equipment
- Liquid crystal manufacturing equipment
- Organic EL manufacturing equipment
- Film manufacturing equipment
- Printing machine
- Surface moulder / chip moulder
- Plastic parts manufacturing equipment



Standard ionizer which is able to neutralize in short time.



The ionizer which can change neutralization area by connecting.

Electrostatic charge removers VUV Ionizer

Removing static charges in a vacuum

The VUV Ionizer remove static charges by making use of VUV (vacuum UV) light. Its superb ability to remove static charges under depressurized conditions makes this ionizer ideal for improving the yield ratio and throughput in various production processes. It can also remove static charges even in an inert gas atmosphere.

■Applications

- Dechucking of electrostatic chucks
- Semiconductor manufacturing equipment (vacuum process)
- Liquid crystal manufacturing equipment
- Organic EL manufacturing equipment
- Hard disk manufacturing equipment
- Film manufacturing equipment
- Equipment utilizing electron beam (SEM, etc.)

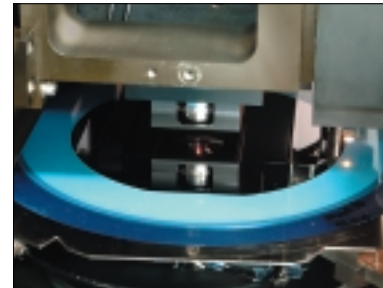


Other products and technologies

●Dicing technology

Stealth dicing technology

Stealth dicing is a completely new wafer dicing technology using laser. Stealth dicing is an integration of optoelectronics and laser technology including laser machining equipment and IC thin film stripping devices produced for the world's semiconductor markets based on long accumulated technology from Hamamatsu Photonics. This technology is available in unit modules called stealth dicing engine that can be installed in the wafer dicing equipment.

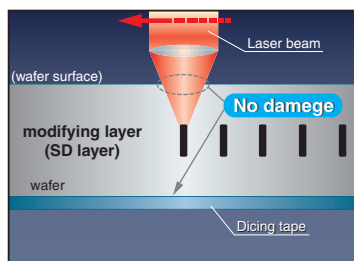


<Materials>

- Si
- Chemical strength-
- Glass
- Sapphire
- SiC
- LiTaO₃
- InP
- Crystalline
- GaAs
- LiNbO₃

■Principle

Stealth dicing technology includes two processes. One is a "laser process" that forms a cleaving start point (SD layer) on the interior of a wafer for separating it into chips, while the other is a "separation process" that divides the wafer into small chips.



●Laser process

A laser beam focuses on points inside the wafer to form a modifying layer (SD layer) for cutting the wafer. Here, "cracks" are also formed on this modifying layer (SD layer) in the interior of the wafer which extend towards both surfaces of the wafer. These cracks are indispensable for dividing the wafer into chips.

●Separation process

Expanding a tape-mounted wafer already formed with a modifying layer (SD layer) towards the periphery of the wafer applies a tensile stress to the internal cracks in the wafer. This stress causes the internal cracks to develop towards both surfaces of the wafer and separates the wafer into small chip shapes.

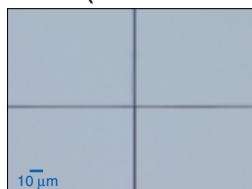
■Comparison with conventional dicing methods

	■Blade dicing	■Laser ablation dicing	■Stealth dicing
Processing method	Grinding cutting and process	Surface absorption laser process (melting, evaporation)	Internal absorption laser process (locally selective)
Water (cooling / cleaning)	Required	Required	Not required
Chipping	Occurs	Occurs	Does not occur
Debris generation	Generates	Generates	Does not generate
High-speed ultra-thin wafer dicing	Might be possible in certain cases	Possible in certain cases	Possible
Chip yield	Not so good	Not so good	Good
Processing speed	Not so good	Not so good	Good
Thermal effect on device	Affected (including residual stress)	Affected (HAZ*)	Not affected

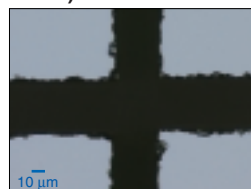
* HAZ: Heat Affected Zone

■Processing examples

●Wafer (cross section on surface)



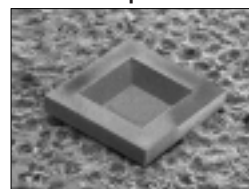
Stealth dicing



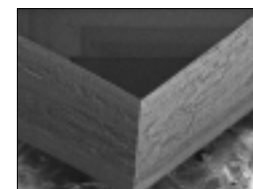
Conventional blade dicing

Stealth dicing offers high-quality dicing (no chipping or micro cracking) with zero kerf loss.

●MEMS chip



View of entire MEMS chip



Enlarged view of MEMS chip edge

Chip is cut vertically up to its edge faces.

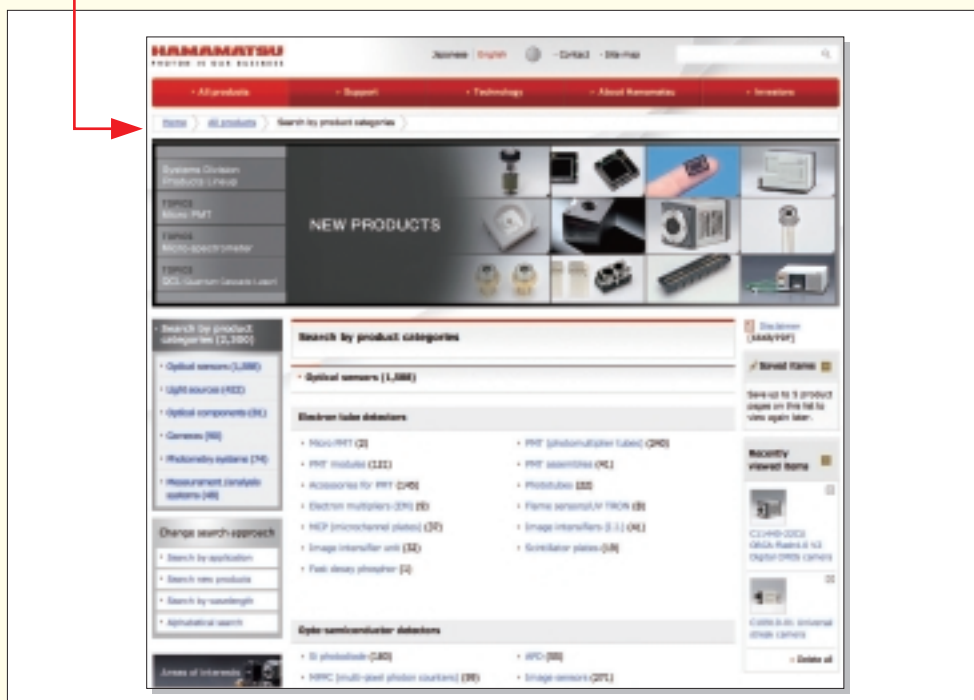
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