Photonics for
Advanced Automotive Solutions

HAMAMATSU

PHOTON IS OUR BUSINESS

automotive.hamamatsu.com

Every photonic solution
Every batch size
One quality

For more than 43 years, Hamamatsu Photonics has been supplying market leading, high-quality optical components which contribute to the diverse advanced technologies that assist in safe, reliable, green and comfortable automobiles.

From design to manufacturing, we deliver standard and customized solutions with high-volume manufacturing capabilities. Many vehicles use our ambient light sensors for automatic lighting and air conditioning, as well as our optical semiconductor devices for optical links used for in-vehicle information communication.

Technology for autonomous vehicles and advanced driving support systems is developing at a fast pace. Sensing technologies for detecting the distance between cars and surrounding obstacles has become increasingly important for LiDAR.

Look to Hamamatsu Photonics as a one-stop-shop for all your photonic needs now and in the future.

Corporate

- Established 1953
- $1,676 million sales turnover
- 5.4% R&D expense-to-sales ratio
- 5,491 employees
- 10 research and production facilities
- 100+ countries shipping destinations

Capacity

- In-house design and manufacturing – from chip to packaged components and modules
- New plants for higher capacity and module production

Core Devices & Key Enabling Technologies

From Design to Manufacturing

Hamamatsu has over 43 years of experience in delivering high-quality optical sensors contributing to diverse advanced technologies to assist in safe, reliable, green and comfortable car driving.

Advanced Automotive Solutions

Core Devices

- PIN PD & APD (single, arrays)
- MPPC (SiPM) & SPPC (SPAD)
- Sensor with front-end IC
- CMOS sensors (1D, 2D)
- NIR & SWIR LEDs
- Pulsed LDs (single, arrays)

Key Enabling Technologies

- Si, InGaAs, InAsSb, AlGaAs
- MOEMS technologies
- Special assemblies
- Filters (RGB, band-pass)
- ASIC (TIA, ADC, TDC)
- SMD molded package, ceramic to bare dies or special assemblies

Reliability

Tens of millions of Hamamatsu optical components are operating reliably in the field. Hamamatsu rigorously tests all products to ensure the highest level of quality and reliability.

Automotive standards

- AEC-Q100 & AEC-Q102
- IATF16949 (ISO)

Zero defects

- Semiconductor failure analysis contributes toward zero defects

Simulation technology

- Stress and thermal analysis

LiDAR and Safety



Optical Semiconductors Contributing to Improved Safety Features

Since the first vehicle appeared on the road, safety remains one of the key topics in the automotive world. Many companies have been working on safety improvements for drivers and other road users. While the obligation to wear a seat belt was one of the major improvements for cars in previous years, today car manufacturers, automotive suppliers and many governmental funded projects are researching into new and improved safety systems. The key objective of such research is to minimize the impact, and number of severe and lethal accidents.

We offer reliable optical semiconductors, which support active and passive safety systems. PIN Photodiode or APD Arrays are available with integrated TIAs as 'Hybrid Detector' and Infrared Laser diodes are used for laser distance measurement (LiDAR) systems, which use Time of Flight (TOF) or Phase Shift measurements. Fibre Optical Transceivers (FOTs) are used for safety systems, which work with special optical fibres, for example to protect pedestrians with a hood which automatically rises in the event of a collision.

LiDAR (Light Detection and Ranging) is a remote sensing method that measures distance by emitting laser light to a target and detecting its reflection with a photosensor. LiDAR is increasingly important in applications such as automotive ADAS (Advanced Driver Assistance Systems), AGV (Automated Guided Vehicle) and range finding.

Light sources such as laser and photosensors such as photodiodes are employed in LiDAR. We offer pulsed laser diodes for LiDAR and a variety of high-sensitivity photosensors that can be used for short-, mid-, and long-range detection by ADAS and autonomous vehicles. These photosensors include Si PIN photodiodes, Si APD, InGaAs APD, MPPCs (SiPMs), and distance image sensors.

We also offer custom specific products such as APD arrays integrated with Transimpedance Amplifier, to support diverse systems.

Hamamatsu Devices for LiDAR From Design to Manufacturing

Applying the Distance Measurement (Obstacle Detection) Principle to Collision Avoidance and Self-Driving

Collision Avoidance System

A collision avoidance system in a car automatically activates the brake when the car gets too close to an object such as a pedestrian or obstacle.

Auto-Cruise or Self-Driving System

An auto-cruise or self-driving system maintains the constant speed set by the driver without the need to keep pressing the accelerator pedal. These systems utilize LiDAR to measure distances such as the distance to the car ahead and distance for safely controlling the car. LiDAR uses a pulsed laser diode and a sensor such as a silicon APD.

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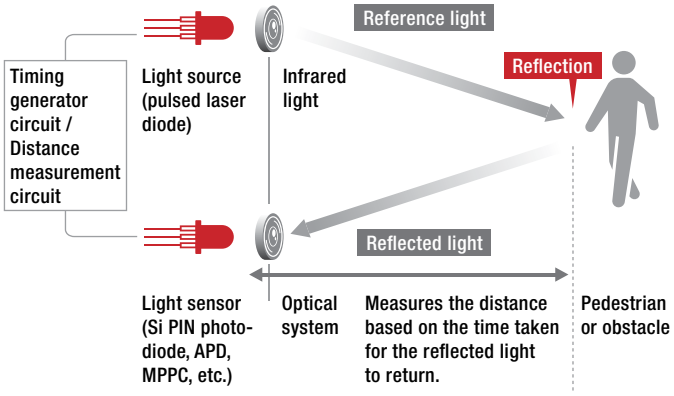
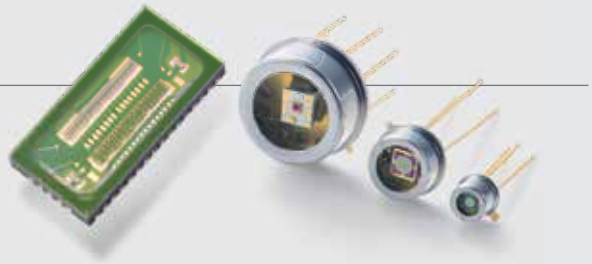


Photodetector

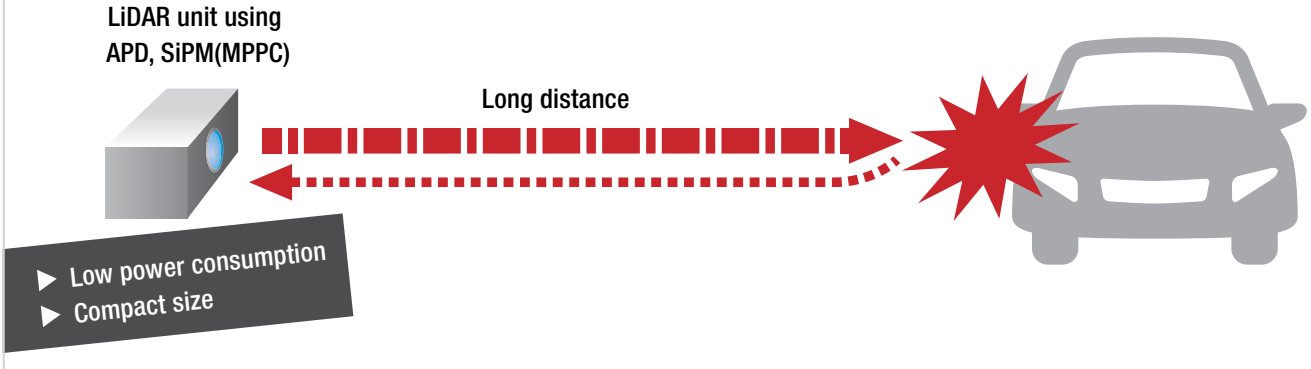


Hamamatsu can provide unbiased selection choices because we offer all types of photodetectors to meet your TOF (Time-Of-Flight) and FMCW (Frequency-Modulated-Continuous-Wave) LiDAR requirements.

Hamamatsu standard products*

Parameter	Si PIN PD	InGaAs PIN PD	Si APD	Si APD+TIA	SiPM/MPPC	InGaAs APD
LiDAR Range	Short	Medium	Medium	Medium	Long	Long
Gain	1	1	100	100	10^6	30
QE @ 905/1550 nm	>92%	>98%	>92%	>92%	>20%	>80%
Operating Voltage	<10V	0.2 to 1 V	100 to 200 V	100 to 200 V	To several tens of V	50 to 60 V
Readout Circuit	Complex	Complex	Medium	Medium	Simple	Medium
Array	Suitable					
Products series						

Customization of photodetectors is possible, please contact Hamamatsu for more information.

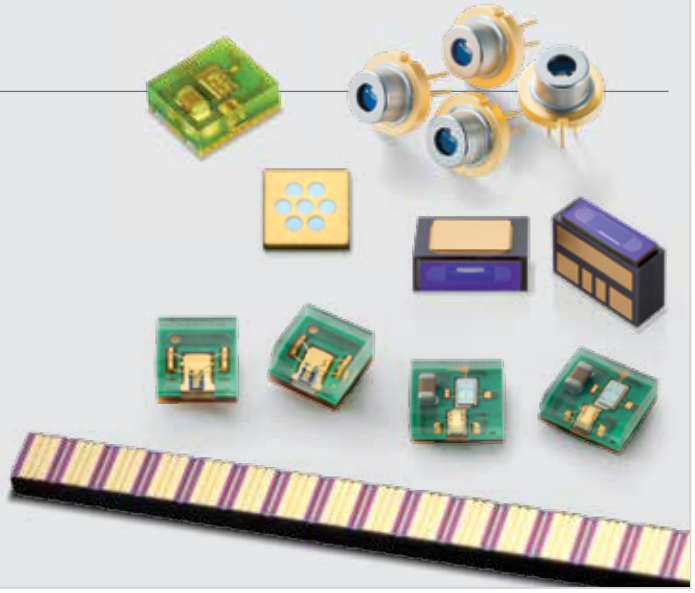


Light Source

High-power laser diodes with sharp near field pattern (NFP) and far field pattern (FFP) that are close to Gaussian shape.

- Peak emission wavelength: 870 nm to 905 nm
- Output power: >21 W to >100 W
- Emitting size: 70 x 10 µm to 360 x 10 µm
- Sharp NFP
- Long lifetime
- Low temperature dependence
- TO-Can, Ceramic package, Bare chip
- With FET or no FET

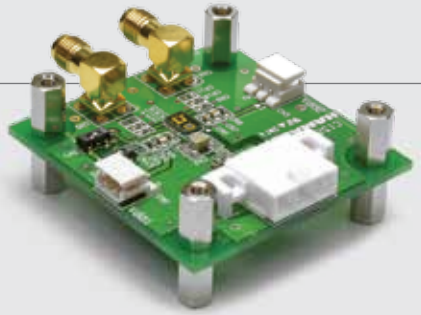
Customization of laser diodes is possible, please contact Hamamatsu for more information.



Evaluation Kit & Module

For quick evaluation, Hamamatsu provides evaluation kits and modules to help you save on costs and make your job easier.

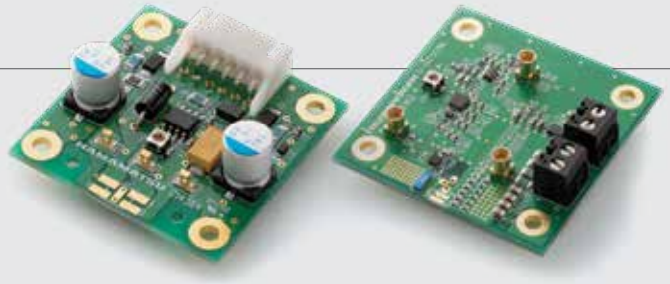
- Evaluation board for photodetectors (APD+TIA, MPPC and others)
- Photodetector modules



Laser Diode Driver Board

Off-the-shelf driver boards allow you to quickly operate and evaluate the laser diode of your choice for your LiDAR design.

- Driver board for laser diode with FET and capacitor
- Driver board for laser diode only



Comfort



Photonics for Enhanced Comfort

In today's cars, many comfort functions support drivers all over the world on their journeys. Working in the background without being noticed, they provide more comfort every day, in all driving and weather conditions.

We offer reliable optical semiconductors such as Silicon Photodiodes, Photo ICs, Colour Sensors and Infrared LEDs, which support automotive comfort systems by providing information about brightness, light colour or refraction of light.

Ambient Light Sensors for Smart Headlights and Auto Anti-Glare Rear and Side View Mirrors

Illuminance sensor

Si photodiode

Smart auto headlights respond to the ambient light level to automatically turn the headlights of a car on or off. An illuminance sensor mounted near the dashboard monitors the brightness outside the car and turns on the parking lights or headlights when the brightness drops below a certain light level. Auto anti-glare rearview mirrors also have an illuminance sensor that automatically adjusts the mirror reflectance when it detects intense light (high beam headlights) from a rear-approaching car at night, so that the driver is not dazzled by the headlight glare.

Hamamatsu offers for this application:

Ambient Light Sensors and Photo ICs for automatic lighting functions and laser diode control. Ambient Light Sensors for rear and side view mirrors to minimize glare.

- Special filters are used to achieve sensitivity close to the human eye.
- Available with different analog or digital output, such as current or voltage output, light-to-frequency converter or I2C interface.
- Our Ambient Light Sensors are built for excellent linearity and a large dynamic range with 5 orders of magnitude, in order to detect low light levels in the dark, as well as bright daylight.

Headlights are OFF during daytime, since the sensor detects bright light.

Headlights are turned ON in the evening, during nighttime or in a tunnel, as the sensor detects no bright light as seen at daytime light levels.

Rain Sensors for Windshield Wiper Control

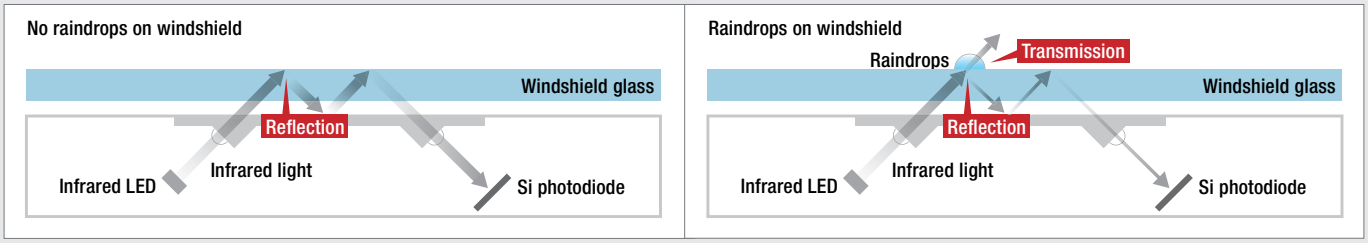
Infrared LED

Si photodiode

When there are no raindrops on a car windshield, infrared light emitted from an infrared LED reflects from the front surface of the windshield and is detected by a silicon photodiode. When there are raindrops on the car windshield, infrared light passes through the raindrops and less light is reflected and detected by the silicon photodiode. Using this principle, the windshield wipers will automatically start, stop and adjust their speed according to the amount of light detected by the silicon photodiode.

Hamamatsu offers for this application:
Silicon photodiodes or Photo ICs with Infrared LED

- Our photodiodes and Photo ICs are available with analog or digital output.
- We also offer the components in different packages, such as TO packages for high reliability, hermetic sealing and good aligning precision, or SMD packages for small package sizes and standard reflow soldering.



Detection of Solar Radiation to Adjust the Automatic Climate Control

Sunlight sensor

Automatic air conditioners use various sensors to detect conditions such as temperatures inside and outside the car and the amount of sunlight. Based on such information, the air conditioner controls the blow temperature and air flow rate. It also switches air vents on or off to keep the temperature inside the car at the set level. Sunlight sensors incorporating a silicon photodiode are used to detect the amount of sunlight.

Hamamatsu offers for this application:
Silicon photodiodes or Photo ICs

- Our sensors output an analog or digital signal as data for the ASIC or the control unit, which regulates the climate control.
- Due to a specially designed black cap for wide angle directivity and to filter only the infrared light, our sun sensor module detects the sunlight regardless of the sun's position, thus maintaining a regular temperature inside the vehicle.
- Customized sun sensor modules, as well as suitable Silicon photodiodes and Photo ICs, are available for integration into a customers' module.

Interior

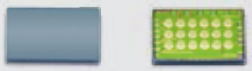


Intelligent Solutions to Realize Your Idea

Automotive interiors are more than just seats and a steering wheel. They include many electronic components, building the interface from the occupants to the vehicle and its environment.

We offer reliable optical semiconductors such as Photodiodes and Photo-ICs, Ambient Light Sensors and Infrared LEDs, which support the automotive interior systems by providing information about brightness or light colour. This information is used as feedback for interior lighting with LEDs or light guides, or for control of displays. When combined with an encoder or light barrier, they can also be used for jog dials, rotary knobs, or proximity switches in the interior, or as simple gesture detectors. We also offer CMOS TOF Sensors, which provide 3D information for more complex motion detection.

Smart Sensors for Optical Switches, Jog Dials and Gesture Recognition



Back side TOF sensor

Encoder Photo IC

A human-machine interface or HMI is a general term for the system, equipment and software that help a human to operate a machine or the device to inform the operator of the current status and results. In the case of automobiles, the HMI is utilized to operate the steering wheel and instrument panel.

Hamamatsu offers for this application:
Smart Sensor, Encoders and CMOS TOF Sensor with LEDs or Laser Diodes for optical switches, jog dials and gesture recognition.

- For proximity switches, our smart sensor is ideally suited, as it integrates 3 coloured LEDs, a colour sensor and a small IC chip with I2C interface, inside one tiny package.
- More complex gesture recognition for the HMI is possible using our TOF CMOS sensor, which works with an indirect time of flight (TOF) measurement as a 3D sensor.
- Jog dials work with an optical encoder module, which consist of an LED and Photodiode Array, or a CMOS line sensor. A rotating encoder wheel is placed in the light

Auto Brightness and Colour Functions for Displays, Dashboard and Interior Lighting

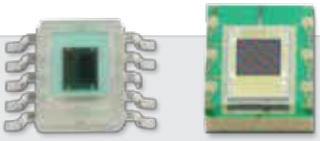


Photo IC for RGB

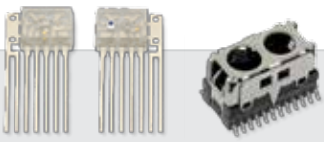
Interior illumination according to certain situations or moods is one of the big topics for car manufacturers today. Scientific studies show that light influences mood and the condition of the driver. Adjustment of brightness or colour can support the driver to remain attentive whilst driving.

Hamamatsu offers for this application:
Ambient Light or RGB Sensors for auto brightness and colour functions for displays, dashboard and interior lighting.

- Ambient Light Sensors are available with different analog or digital outputs, such as current or voltage output, light-to-frequency converter or I2C interface.
- Special filters are used to achieve sensitivity close to the human eye. RGB Sensors improve the categorization of the measured light, in order to distinguish the different times of the day, weather conditions, or between natural and artificial light sources.
- Beneath the ambient light, Photo ICs or RGB sensors are also used to measure the brightness and light colour of the LEDs or OLEDs of the interior lighting in operation.

Infotainment

Light emitter and receiver modules for VICS



Light emitter and receiver photo ICs for optical links

Multimedia information including the video and audio data we enjoy in a car is sent via a wire harness or optical fiber cable between various devices such as a display, in-car camera, audio player, and speakers. Light emitter and receiver photo ICs are used for such information exchange through optical links using optical fibers. Light emitter and receiver modules are also used for VICS (Vehicle Information and Communication System) that utilizes FM multiplex broadcasting and beacons to enable a car navigation system to receive real-time road traffic information such as traffic jams and regulations. Due to the increasing number of in-car displays, cameras for 360° view parking, data fusion of video with Radar and LiDAR, more and more bandwidth is needed.

Hamamatsu offers for this application:
Fiber Optical Transceivers for optical communication via MOST bus and for future Gigabit Ethernet over POF, IR LED and Si PIN Photodiode Array for optical communication with Car2X systems.

The second generation FOT can transmit 150 Mbps (DCA coding), operates at 3.3 V supply voltage and is available as a sidelooker (through-hole-mount) and SMD version. The SMD package is a connector built-in type, which can be placed anywhere on the PC board of the infotainment device.

Sustainability/Green



Optical Devices for Analytical Measurement

Gas and liquid analysis are traditional optical applications and where Hamamatsu Photonics has extensive experience. Testing for exhaust gas analysis in engines is also an example of such traditional applications and is performed using SWIR, MWIR infrared spectroscopy. It is a mandatory test to meet the requirements of the rigid environmental exhaust gas standards.

Due to strict environmental regulations, analytical systems have become on-board devices, which continuously analyze gases or liquids in cars or trucks. Additionally, the use of optical sensors for safety reasons is becoming more important, for example to detect moisture or ice, or to detect dangerous gases in the interior of the car. The requirements for such on-board sensors are extremely high and completely different from conventional analytical measurement systems.

We offer InGaAs Photodiodes, InAsSb photovoltaic detectors, MEMS-FPI (Fabry-Perot Interferometer) and infrared LEDs to detect moisture or ice, or, in combination with suitable filters, to analyze the contents of exhaust gas or fuels in order to provide data to the catalytic converter or engine control.

Humidity Sensing


Surface Mount LED

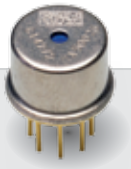

IR Detector

There are two main techniques to measure humidity. Absorption spectroscopy, which measures the infrared light absorbed by water vapour. Optical fibre measurement, looks at the change in reflected or transmitted light, using an optical grating or a hydroscopic coating.

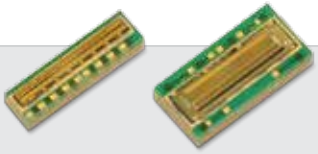
Hamamatsu offers for this application:
NIR (near infrared) LEDs and InGaAs or Silicon photodiodes

- We offer a range of NIR LEDs which are specifically designed for moisture detection measurements at 1450 nm, a strong absorption line in water molecules.
- Depending on the chosen operating wavelength then InGaAs photodiodes or silicon photodiodes can be used as the detector in the humidity sensing system.
- It should be noted that the same technique, absorption spectroscopy, can be used to detect not only humidity but also many other substances in gases or liquids, such as dangerous gases in the cabin, or fuel quality measurements.

Fuel Quality Control



MEMS-FPI Spectrum Sensor



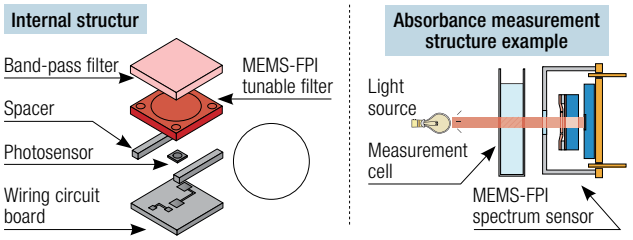
CMOS Image Sensor

A Fuel Quality Sensor (FQS) is required not only to ensure good engine operation, but it also contributes to lower fuel consumption and less emissions. Such fuel quality sensors are necessary to give feedback data to the catalytic converter or engine control, to ensure that the mandatory control limits are continuously maintained. One optical measuring method is to analyze the fuel quality using near infrared or infrared spectroscopy. Knowing the spectral signature means knowing the absorption profile of the fuel, allowing the exact identification of each contained substance and thus allowing the engine to be adjusted via ECU accordingly. The near infrared (NIR) range of 800 nm - 1100 nm can be met by our infrared enhanced silicon components such as silicon photodiodes or CMOS Image Sensors. For the shortwave infrared (SWIR) spectral range, InGaAs Photodiodes and MEMS-FPI (up to 2.15 µm) are available.

Hamamatsu offers for this application:
InGaAs Photodiode, CMOS linear image sensor or MEMS-FPI for on-board liquid analysis.

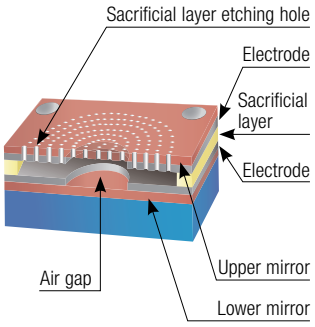
What is a MEMS-FPI spectrum sensor?

A spectrum sensor combining an MEMS-FPI tunable filter and a single element InGaAs photodiode. Unlike regular spectrometers, it does not require optical components such as grating or mirrors nor multi-channel photosensors such as image sensors, enabling an extremely compact form and mass production.

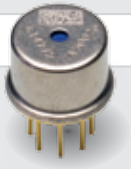


MEMS-FPI tunable filter

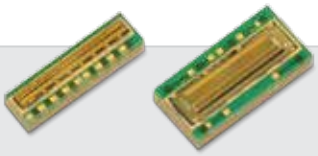
A filter which can be set to any transmissiveness wavelength, created through combining Fabry Perot interferometers and MEMS technology. It is comprised of an upper and a lower mirror facing each other, mounted on a circuit board with an air gap in between. The upper mirror has a membrane structure; when voltage is applied, static electricity is created between the mirrors and the upper mirror moves, enabling adjustment of the air gap distance. When the air gap is an integral multiple of λ/2, it functions as a filter transmitting wavelength λ.



AdBlue® Sensor



MEMS-FPI Spectrum Sensor



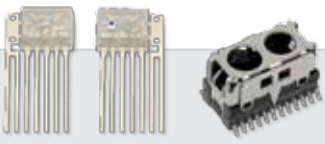
CMOS Image Sensor

In modern diesel engines, the Selective Catalytic Reduction method 'SCR' is widely used to reduce the NOx content in exhaust gases. SCR is an advanced active emissions control technology system that injects an aqueous urea solution through a special catalyst into the exhaust stream of a diesel engine. It is important that the urea tank level and quality is continually monitored to ensure it is working efficiently.

For accurate on-board monitoring and diagnosis, robust optical solutions are utilised and methods such as optical refraction and SWIR absorption are adopted.

Hamamatsu offers for this application:
NIR LEDs, Linear CMOS sensor, InGaAs Photodiode, MEMS-FPI

Battery Management System (BMS)



Light emitter and receiver photo ICs for optical links

An intelligent BMS monitors and controls the current, voltage, temperature and functionality of each individual battery cell in order to assure the best reliability and performance of the battery pack. Utilising the benefit of data communication over POF, the BMS is also communicating through our FOT solutions.

Hamamatsu offers for this application:
Fibre Optical Transceivers (FOTs)

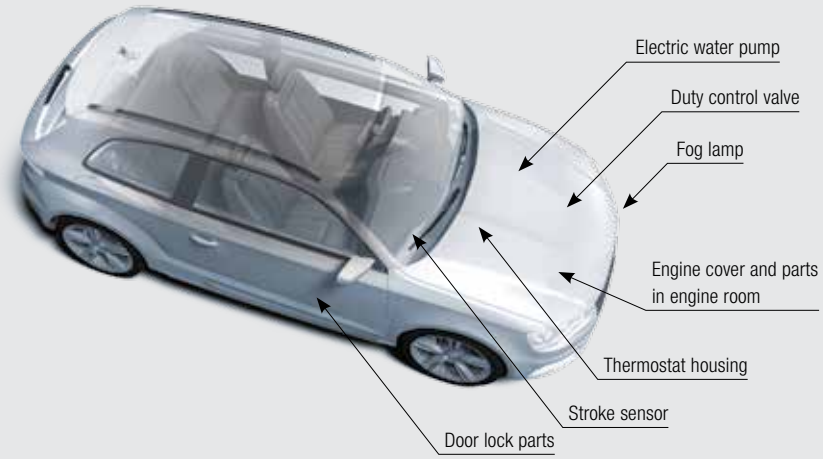
Devices for Assembly / Manufacturing / Testing

LED Light Source for UV Curing

- Shorten curing time with high intensity and custom wavelength
- UV LED source (365 nm, 385 nm and 405 nm)
- Simple design for ease of operation and shorter learning curve
- Custom head design for limited spacing
- Feedback control function permits stable irradiation

SPOLD: Laser Diode Irradiation Light Source for Plastic Welding

The SPOLD built-in process monitor constantly captures thermal information on the laser irradiation point to allow quality control during laser processing, making it ideal for use in mass-production processes such as for plastic welding and soldering.



Failure Analysis Phemos System

Micro-Focused X-Ray Source

Failure Analysis System and Non Destructive Testing (NDT)

A defect in just one component (semiconductor) can lead to major failures and potential recalls.

To minimize failures and ensure high quality components, the early detection and identification of defects is vital. Semiconductor failure analysis technologies and Non-Destructive Testing (NDT) are commonly employed to achieve this. Our solutions include imaging systems for the localization of low light photoemission defects, thermal signal emitting semiconductor failures and solutions for Non-Destructive Testing (NDT) from X-ray to IR.

X-ray NDT Battery Inspection for Electric Vehicles

Lithium-ion batteries (LiB) are used in various fields, including smartphones and electric vehicles. Our X-Ray solutions enable in-line inspection for defects such as electrode mispositioning and stacking errors inside. They also contribute to the improvement of takt time for in-line inspection by achieving both high sensitivity and high line speed.

Possible to inspect the mismatch of rolling and measure the length of electrode with no distortion.

Linear X-Ray Camera

Optical Pinhole Inspection Unit

Technical innovations aiming at reducing environmental impact are appearing at a rapid pace. Typical examples are next-generation vehicles such as EV, HV and FCA. It is therefore essential to deliver high-accuracy and high-speed quality control in the manufacture of batteries and power supplies as they are core parts in these next-generation vehicles.

Our “optical pinhole inspection unit” is a powerful tool for Reduces the Takt Time (Production) for Manufacturing In-vehicle Batteries finding pinhole defects by detecting light coming through the pinholes as electrical signals using a high sensitivity photodetector. Compared to other methods for detecting pinholes, such as the use of fluids or gases, this optical method applies no actual physical pressure to the workpiece during inspection.

Our detection units will improve inspection accuracy and speed for tasks such as inspecting pinhole defects in fuel cell separators for fuel cell vehicles, aluminum laminate films for pouch rechargeable batteries, and pressed thin plates.

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