SONY
SenSWIR
technology guide

MACNICA

SWIR Image Sensor Technology SenSWIR™

OVERVIEW

SenSWIR is a wide-band and high-sensitivity SWIR image sensor technology implemented by the combination of compound semiconductor InGaAs photodiodes and Silicon readout circuits through Cu-Cu bonding.

SWIR (Short Wavelength Infra-Red) light penetrates and is absorbed by different substances than visible light, so its attributes can be applied in a variety of different situations. As manufacturers in various industries continue to seek higher productivity, there is growing interest in sensing both in visible and invisible light range.

In IMX990 and IMX991, SenSWIR™ technology has enabled Sony to overwome challenges in pixel miniaturization to offer sensors that are compact, high-resolution, and capable of imaging from visible light to SWIR (Short Wavelength Infra-Red) light range. IMX990 and IMX991 are global shutter sensors with a digital output allowing for many features and functionality in industrial camera applications such as ROI and trigger mode.

The advances in performance and functionality introduced by the IMX990 and IMX991 pave the way for the development of SWIR industrial cameras and inspection equipment for a diverse range of applications such as inspection, identification, and measurement.

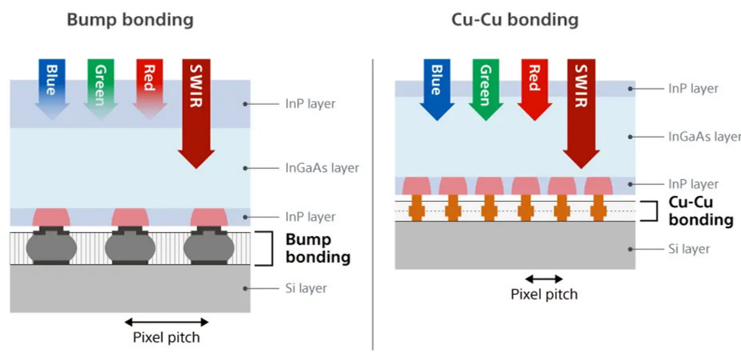
TECHNICAL FEATURES

Higher pixel count, smaller systems

Creating SWIR sensors with smaller pixels than in current industrial CMOS image sensors has been challenging with conventional bump bonding, because a certain bump pitch must be maintained to bond the indium-gallium-arsenide (InGaAs) photodiode layer to the silicon readout circuit layer. With SenSWIR technology, Cu-Cu bonding enables a finer pixel pitch and smaller pixels. As a result, smaller high-resolution cameras can be developed, which can support higher inspection precision.

The CU-Cu bonding is a technique that provides electrical conduction by bonding copper pads, as the pixel chip (top) and logic chip (bottom) are stacked. Advantages over the previous through-silicon via approach (which electrically connects top and bottom chips at the edge of the pixel area) include smaller systems and improved performance, which affords greater freedom in design and promises higher productivity.

Broad imaging (0.4-1.7µm) from a single sensor that extends to the visible spectrum



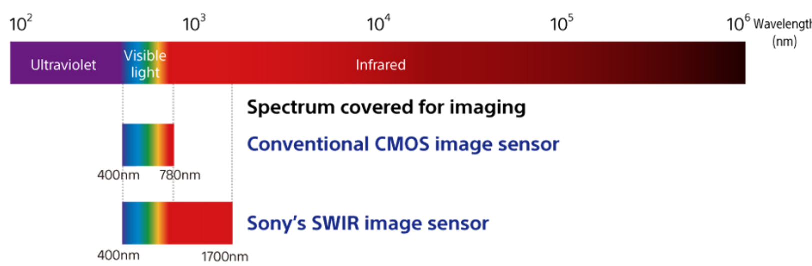
The top indium-phosphorus (InP: Substrate that forms the base of the InGaAs layer.) layer inevitably absorbs some visible light, but applying Sony's SWIR sensor technology makes this layer thinner, so that more light reaches the underlying InGaAs layer. The sensors have high quantum efficiency even in visible wavelengths. This enables broad imaging of wavelengths from 0.4 µm to 1.7 µm. A single camera equipped with the sensor can now cover both visible light and the SWIR spectrum, which previously required separate cameras. This results in lower system costs. Image processing is also less intensive, which accelerates inspection. These advances promise to expand the scope of inspection significantly.

Enhanced capabilities from digital output

Unlike the analog output that most SWIR sensors are limited to, the sensors achieved the same functionality as the current industrial CMOS image sensors by supporting digital output. Analog sensors require developers to implement an ADC or other functionality for industrial equipment on the camera. In contrast, the new sensors already include this functionality, which saves time and effort in camera development and makes it easier to develop versatile cameras.

What's SWIR?

Generally, light with a wavelength of 400 nm to 780 nm is referred to as visible light, and light with a wavelength of 780 nm to 106 nm as infrared light. The wavelength band of SWIR is from 900 nm to 2,500 nm, which is the region of infrared light closest to visible light. Image sensors equipped with SenSWIR technology are capable of broad imaging over the range of 400 nm - 1,700 nm, including visible light as well as SWIR light.



APPLICATIONS

Sorting fruits and vegetables

Water has the property of absorbing light at wavelengths around 1450 nm, so when utilizing that wavelength band with a SWIR sensor, areas containing water appear black. Since this sensor can detect water contained in materials, it is used in fruit and vegetable sorting and other applications.

Example of sorting fruits by detecting dents or scratches


Under visible light


Under SWIR (1,450 nm)

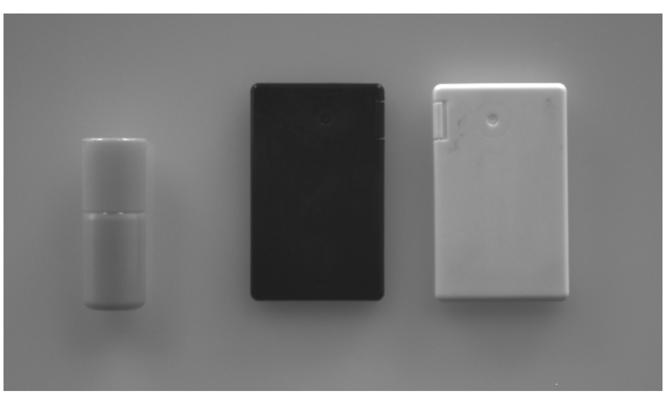
SWIR imaging makes the moisture concentrating in dents on the apples visible.

Container content inspections

In the food manufacturing process, final inspection of container content is difficult for opaque food packages. In addition, there are cases where the sealing section may bite into the contents when sealing, which is also difficult to discern.

In some cases, even packages that appear opaque in the visible range are transparent at SWIR wavelengths, making it possible to observe the contents. By utilizing this technology, the contents can be confirmed nondestructively, and it is also possible to detect chewing.

Example of inspecting the filling status of a plastic container by transmitting light through it


Under visible light


Under SWIR (1,550 nm)

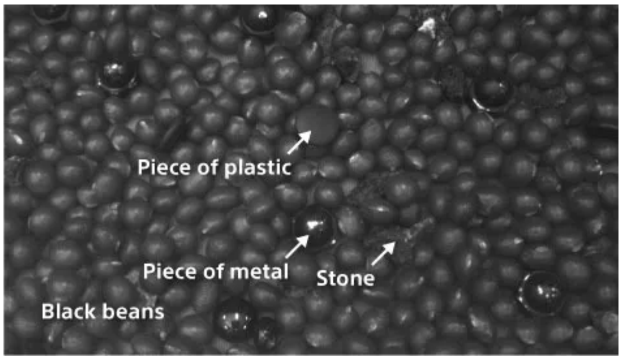
SWIR imaging makes it possible to check the content of opaque containers.

Foreign Material Inspection

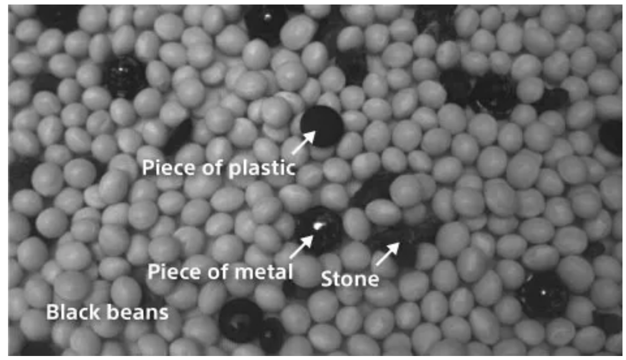
Inspection for foreign matter is important in food production. However, when foreign substances of similar colors are mixed in, it is sometimes difficult to detect them using visible light alone.

By utilizing the absorption and reflection characteristics of light in the SWIR band, it is possible to detect differences in substances that are difficult to detect with visible light alone. Taking advantage of this property, SWIR image sensors are also used in the inspection of foreign matter.

Example of detecting foreign maters in food
SWIR imaging makes it easier to distinguish between a food product (black beans) and black-colored contaminants.



Under visible light



Under SWIR (1,300 nm)

Examle of detecting walnut shells by processing images taken at multiple SWIR wavelengths
Walnut shells and nuts are difficult to distinguish with the naked eye, but SWIR imaging makes them easier to identify. The image on the right was taken with three SWIR wavelengths and pseudo-colored. This kind of image processing makes it easier to distinguish walnut shells from nuts.

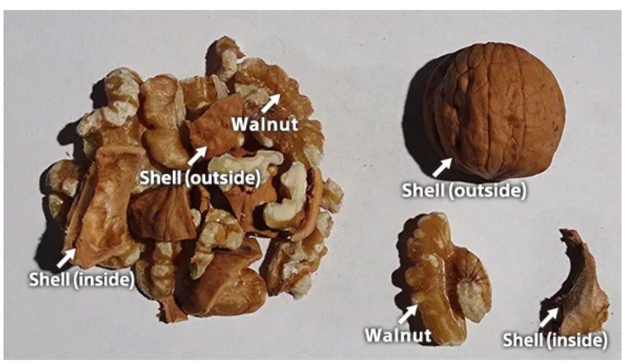


Image taken with a standard color camera

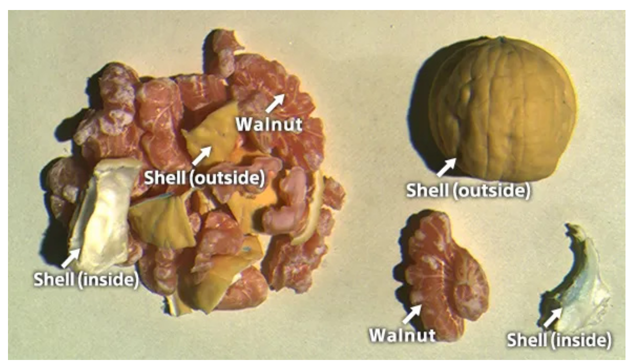


Image taken and processed with SWIR (1,050/1,200/1,450 nm)

Sorting materials

Since there are many different types of plastics, each of which requires its own recycling, the first step in the recycling process is to sort them.

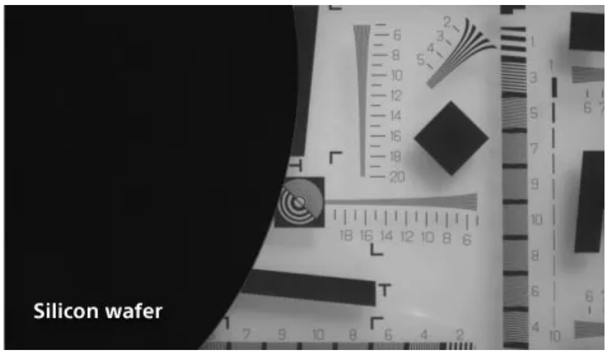
Plastics are transparent in the visible range, making it difficult to determine the characteristics of each material, but when viewed at SWIR wavelengths (especially multiple wavelengths), characteristics can be found and sorting can be performed.

Positioning in Semiconductor Manufacturing

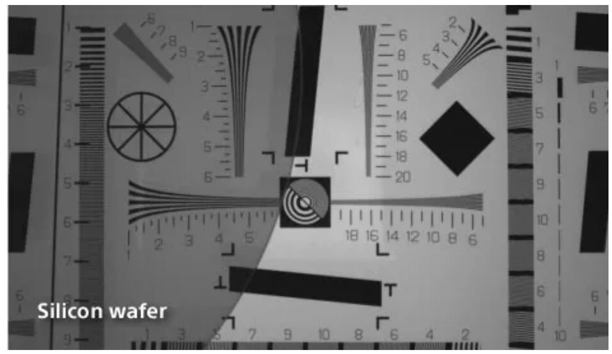
n recent years, the miniaturization of semiconductor devices has led to a demand for high precision in the silicon wafer lamination process. In order to improve accuracy, it is important to precisely match the alignment marks on the wafers.

Since light in the SWIR wavelength range penetrates the silicon layer of the wafer, the use of SWIR image sensors makes it possible to clearly see the marks. Sony's high-definition SWIR image sensor can be expected to improve edge detection accuracy.

Example of imaging by penetrating silicon wafers



Under visible light



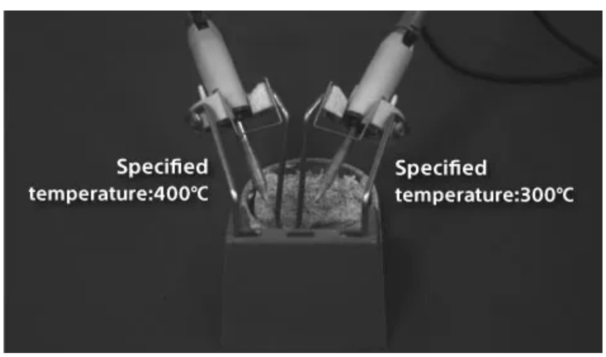
Under SWIR (1,550 nm)

The photograph on the right was taken in an SWIR environment, so the resolution chart behind the silicon wafer is visible. This was taken using an IMX990 sensor at a high resolution of approximately 1.34 megapixels, so even small marks can be detected with high precision. In addition, using an IMX992 sensor, which has a resolution of approximately 5.32 megapixels, enables even higher-resolution inspection and measurement applications.

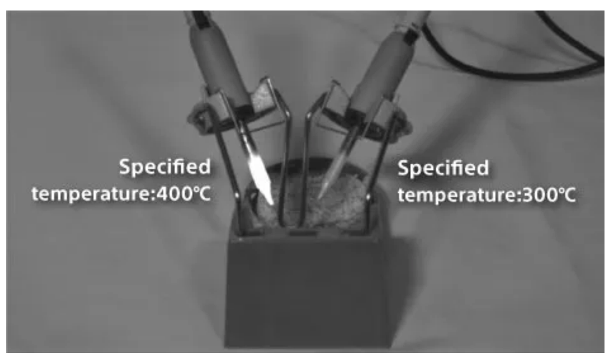
Temperature monitoring

Image sensors can capture differences in material temperature as differences in luminance. Among other things, objects above about 250°C emit light in the SWIR band, so SWIR image sensors can be used for temperature monitoring at high temperatures above 250°C. Applications in the steel industry and other industries are expected.

Example of monitoring the temperature at the tips of soldering irons



Under visible light



Under SWIR (1,550 nm)

In the SWIR image, it is possible to confirm not only that the tips of the soldering irons have become hot, but also to identify their differences in temperature.

Firefighting

Smoke can obstruct firefighters' vision during firefighting activities. SWIR image sensors, which are less susceptible to light scattering, are expected to be useful in checking the situation at the scene of a fire and in firefighting activities because they can capture images with less influence from smoke.
In addition, fire emits strong SWIR light, and by capturing this light with a SWIR image sensor, flames can be clearly projected. This can be useful in identifying the origin of a fire, such as a forest fire.

Distant Observation

When observing objects at a distance, the camera may not be able to capture distant objects well because they are obscured by particulate matter in the air. In contrast, light in the SWIR band, which has a longer wavelength than visible light, is less affected by particulate matter in the air, making it easier to clearly capture distant objects.

Observation of agricultural lands

Currently, efforts are underway in the agricultural industry to observe farmland with cameras from the sky. The ability to grasp the growth status of crops has made it possible to make limited fertilization and yield forecasts based on data.

However, it is not easy to judge the growth status based on color information alone; the SWIR image sensor allows visualization of the presence or absence of moisture, making it possible to visualize the growth status and distribution according to moisture content, thereby improving the accuracy of judgment.

Sony's SenSWIR™ Sensors are available through **Macnica Americas, Inc.**

The seeds of tomorrow.

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