SONY

SWIR image sensor

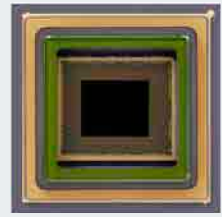|			
IMX990	Type 1/2 (8.2 mm diagonal) approx. 1.34 effective megapixels	**IMX992**	Type 1/1.4 (11.4 mm diagonal) approx. 5.32 effective megapixels
IMX991	Type 1/4 (4.1 mm diagonal) approx. 0.34 effective megapixels	**IMX993**	Type 1/1.8 (8.9 mm diagonal) approx. 3.21 effective megapixels

In industrial applications, we can now find cameras that capture visible light and non-visible light. This allows for new applications and previously difficult computer vision tasks to be challenged. Let us introduce our new SWIR (Short-Wavelength InfraRed) image sensor that can support these opportunities.

What is SWIR?

Generally, light with a wavelength of 400 nm to 780 nm is called visible light, and light with a wavelength of 780 nm to 10^6 nm is called infra-red 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.

[Photo 1] is a comparison of images taken with visible light and infra-red light of the same subject. In contrast to the visible light image (A) that we are accustomed to, the infra-red image (C), which has a long wavelength, cannot capture the characteristics of a person. On the other hand, although the SWIR image (B) looks like visible light because their wavelengths are close, unique information which is different from the visible light image can be captured under SWIR light.

[Photo 1]

(A) Visible light
(B) Short-wavelength infrared (SWIR)
(C) Long-wavelength infrared

Conventional CMOS image sensor
Sony's SWIR image sensor

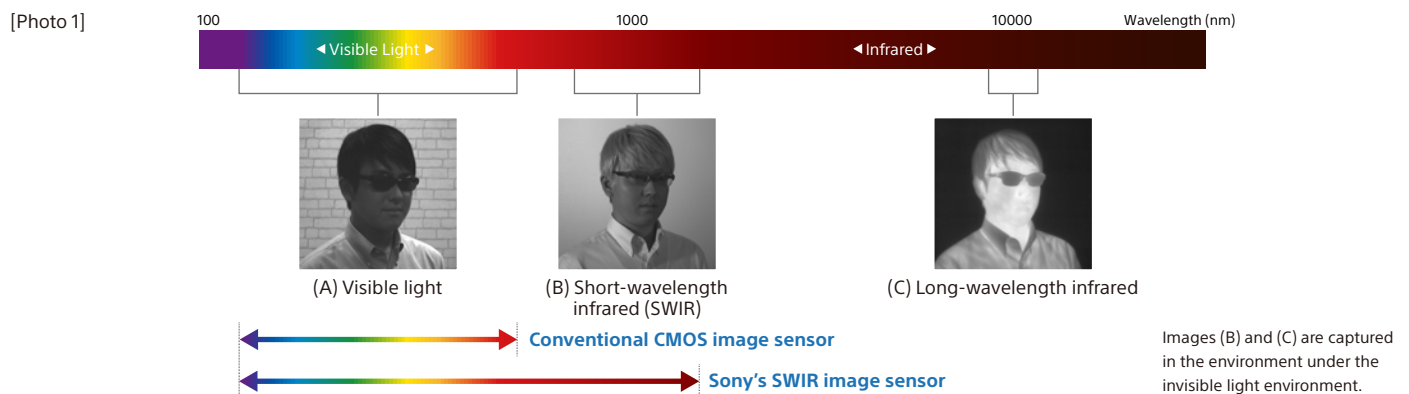Images (B) and (C) are captured in the environment under the invisible light environment.

Image sensors with SenSWIR™ technology are compatible both with the SWIR spectrum and a wide band of 400 nm to 1,700 nm wavelengths, which includes the visible light spectrum. This allows one camera to perform two functions for visible light and SWIR, not only widening the scope of items and purposes of inspection, but also helping to reduce system cost and accelerate image processing to improve throughput. Also, one camera means the captured images in two modes are identical to the pixel level, avoiding image shift.

SenSWIR

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

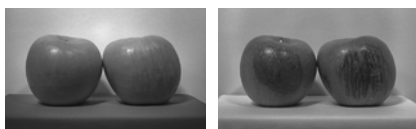*SenSWIR and its logo are registered trademarks or trademarks of Sony Group Corporation or its affiliates.

Summary of application of SWIR technology

Visualizing water
Detecting moisture in the dents on the apple skin

Smartphone camera image
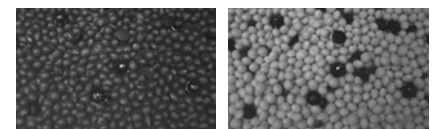Under visible light
Under SWIR (1,450 nm)

Water becomes black in an image taken with a camera set at the wavelength of 1,450 nm because water absorbs the light at this wavelength. This attribute can be leveraged for detecting moisture in objects.

Sorting materials
Detecting plastic and metal pieces in a pile of black beans

Smartphone camera image
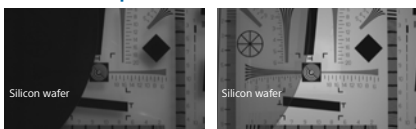Under visible light
Under SWIR (1,300 nm)

Infrared reflectance and absorptance vary at different wavelengths from one material to another. Utilizing this attribute, a specific material can be singled out among other materials, such as plastics, that may look very similar to one another under visible light.

Transmission observation
Inspection of silicon wafer

Silicon wafer

Smartphone camera image
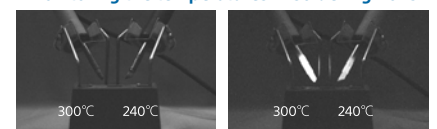Under visible light
Under SWIR (1,550 nm)

SWIR includes a spectrum that penetrates certain materials, and this has been leveraged in manufacturing, such as a transmission inspection for semiconductors.

Temperature observation
Monitoring the temperatures in soldering irons

300℃ 240℃

Smartphone camera image
Under visible light
Under SWIR (1,550 nm)

Some image sensors can convert heat into luminosity information. SWIR image sensors are suitable for the observation of heat over 250°C.

Features of image sensors with SenSWIR technology

Compact size and high resolution realized

The IMX990/IMX991 uses 5µm miniature pixels to achieve both miniaturization and a large number of pixels, achieving high image quality equivalent to SXGA. This feature can increase flexibility for camera positioning and enhance accuracy for inspections, expanding the applications of SWIR sensing.

The IMX992 has a high resolution of approximately 5.32 megapixels, and the IMX993 has a high resolution of approximately 3.21 megapixels with a miniature pixel size of 3.45 µm. This specification is a widely used specification among general global shutter image sensors compatible for C-mount size, and this is the first SWIR image sensor for industrial use to achieve similar specifications. High-resolution imaging allows even tiny objects to be captured clearly, greatly improving the accuracy of various inspections and measurements using SWIR.

Comparison of SWIR images with different resolutions

Approx. 0.32MP VGA Approx. 1.34MP IMX990 Approx. 5.32MP IMX992
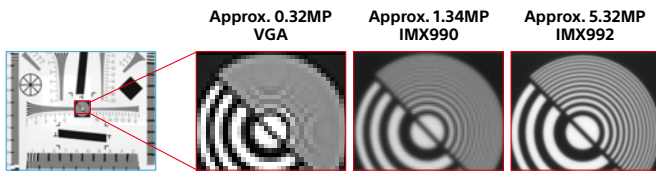
Achieves low-noise performance regardless of the brightness or darkness of the environment

The high-end model IMX992/IMX993 is equipped with shooting modes that can be selected according to the purpose. By selecting the optimal mode, high-quality images with little noise can be obtained, regardless of the brightness or darkness of the environment. This sensor demonstrates its power in scientific measurement, outdoor observation, and other applications where image quality in low-light environments is important.

High conversion gain (HCG) and low conversion gain (LCG) modes

HCG mode amplifies the signal immediately after light is converted into an electrical signal, at a stage when there is still little noise, thereby reducing noise that occurs afterwards. This allows low-noise images to be obtained even in dark shooting environments, leading to improved recognition accuracy. In bright conditions where dynamic range is important, it is possible to switch to LCG mode.

Dual-read rolling shutter (DRRS) function

Furthermore, these Sony sensors are equipped with a DRRS function that allows shooting with reduced noise. This can obtain images with noise reduced to approximately 1/4.

Digital output-ready for efficient camera design

In general, most SWIR image sensors output analog signals only. This means camera manufacturers need to add a digital conversion circuit on the camera side before developing camera functionality. Sony's SWIR image sensors incorporate a digital conversion circuit, eliminating the needs for such extra work. This allows camera manufacturers to make a quick start to develop versatile camera functions as they wish more easily and efficiently. Furthermore, the IMX992/IMX993 supports MIPI in addition to SLVS interface, which is common for industrial cameras, increasing flexibility in camera design and component selection.
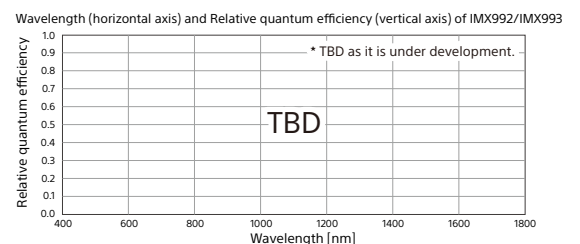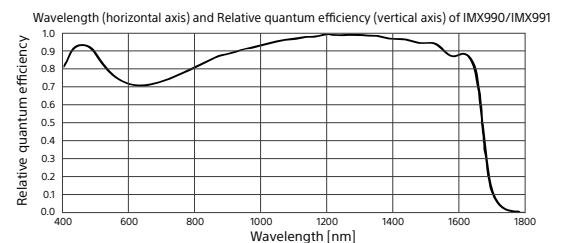
Specifications

Device structure

Thermoelectric cooling element included model	IMX990-AABA	IMX991-AABA	IMX992-AABA	IMX993-AABA
Thermoelectric cooling element not included model	IMX990-AABJ	IMX991-AABJ	IMX992-AABJ	IMX993-AABJ
Image size	8.2 mm diagonal (Type 1/2)	4.1 mm diagonal (Type 1/4)	11.4 mm diagonal (Type 1/1.4)	8.9 mm diagonal (Type 1/1.8)
Effective pixels	1296 (H) × 1032 (V) approx. 1.34 megapixels	656 (H) × 520 (V) approx. 0.34 megapixels	2592 (H) × 2056 (V) approx. 5.32 megapixels	2080 (H) × 1544 (V) approx. 3.21 megapixels
Unit cell size	5 µm (H) × 5 µm (V)		3.45 µm (H) × 3.45 µm (V)	
Optical black — Horizontal direction	Front 0 pixels, rear 96 pixels		Front 96 pixels, rear 0 pixels	
Optical black — Vertical direction	front 20 pixels, rear 0 pixels		front 24 pixels, rear 0 pixels	
Input drive frequency	37.125 MHz/74.25 MHz/54 MHz		37.125 MHz/74.25 MHz/54 MHz	
Power supply	1.2 V, 1.8 V, 2.2 V, 3.3 V, 1.2 V (Pixel), 2.2 V (Pixel)		1.2 V, 1.8 V, 2.2 V, 3.3 V, 2.2 V (Pixel)	
Shutter mode	Global shutter		Global shutter (rolling shutter when DRRS on)	
Output interface	SLVS (2 ch/4 ch)		SLVS (2 ch/4 ch/8 ch) / MIPI (2 lane/4 lane)	
Package	Thermoelectric cooling element included:30.0 mm (H) × 30.0 mm (V) Thermoelectric cooling element not included:20.0 mm (H) × 16.8 mm (V)		Thermoelectric cooling element included:30.0 mm (H) × 30.0 mm (V) Thermoelectric cooling element not included:21.0 mm (H) × 20.0 mm (V)	

Imaging characteristics

Model name	IMX990	IMX991	IMX992	IMX993	Notes
Sensitivity	121 mV		TBD		F8, 1/30 sec. accumulation
Saturation signal	360 mV		TBD		
Quantum efficiency	>75 %		TBD		λ=1200 nm
Operability[1]	>99.5 %		TBD		

*Measurement conditions: Tj = 15 C, all-pixel readout mode.
[1]: Operability: percentage of pixels free of defects

Wavelength (horizontal axis) and Relative quantum efficiency (vertical axis) of IMX990/IMX991

Basic drive mode

Model name	IMX990	IMX991	IMX992	IMX993
Drive mode	All-pixel readout		All-pixel readout	
Recommended recording pixels	1280 (H) × 1024 (V) Approx. 1.31 megapixels	640 (H) × 512 (V) Approx. 0.33 megapixels	2560 (H) × 2048 (V) Approx. 5.24 megapixels	2048 (H) × 1536 (V) Approx. 3.14 megapixels
Frame rate (max.) — ADC 8 bit	134 frame/s	258 frame/s	130* frame/s	170* frame/s
Frame rate (max.) — ADC 10 bit	125 frame/s	240 frame/s	120* frame/s	150* frame/s
Frame rate (max.) — ADC 12 bit	71 frame/s	137 frame/s	70* frame/s	90* frame/s

* Tentative values under development.

Wavelength (horizontal axis) and Relative quantum efficiency (vertical axis) of IMX992/IMX993
* TBD as it is under development.
TBD
Data may vary depending on conditions and the environment.

URL for product information webpage about SWIR image sensors:
https://info.sony-semicon.com/en/swir-prod

Please inquire from the URL below or the QR code, to the right, for detailed information of Sony's SWIR image sensors or evaluation data samples:
https://info.sony-semicon.com/en/inquiry-form0001pr