Image Sensor Selection: Key factors to Consider Based on Your Application

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The key to choosing the best image sensor for your application lies in understanding your specific application and needs. Whether the system is entirely new or an upgrade, the next step is carefully evaluating various factors in image sensors, including trade-offs, that would influence the overall system performance, image quality, and cost.

Ultimately, the goal is to have the best image quality while ensuring the application's needs are met within the system's constraints. However, keep in mind that, although there is so much that can be done to improve the image with the selection of high-quality lenses, image signal processing, and powerful processing platforms, all of these vision components fundamentally depend on the characteristics and performance of the image sensor. Therefore, as the smallest yet most critical component in the imaging process, choosing the right image sensor is the first crucial step towards building a vision system.

While there are many parameters to consider when choosing a Complementary Metal Oxide Semiconductor (CMOS) image sensor, below are a few considerations.

Global shutter vs. Rolling shutter

Rolling shutter sensors are used in consumer and streaming or camcorder applications. Because the exposure happens in a line-by-line manner, the main disadvantage is that fast-moving objects or scenes can cause image distortion and motion artifacts. Hence, many customers concerned about such unwanted effects turn to selecting a Global shutter sensor instead, where the exposure is done simultaneously (all pixels are exposed at the same time). However, many are surprised to know how significantly the cost increases when choosing a global shutter sensor due to its complex electronic design and manufacturing.

How can Frame Rate be a decisive factor?

It is then important to understand whether a Rolling shutter mode is already a good fit for specific applications. There are several strategies to minimize or avoid motion artifacts. Increasing the frame rate or decreasing the exposure time will allow the camera sensor less time to capture any motion. With the ever-increasing demand for faster image sensors, Sony rolling shutter image sensors can even go beyond 60 frames per second (fps), which is a typical frame rate in **HD video**, **sports broadcasts**, and **video games**. In the Sony Starvis2 product line, medium to high resolution sensors such as IMX585 (8MP) can run up to 90 fps, while IMX664 (4MP) can run up to 120 fps. Sony has also introduced other notable features, such as Dual Speed Streaming available for some sensors such as IMX675 (5 MP), where a windowed region of the frame can run to a much higher frame rate, e.g.,>300 fps[1], suitable for **object/facial recognition** and **ITS applications** requiring **license plate recognition**.

Dual Speed Streaming Function (Output dual data from an image sensor)

Sony [YouTube channel]. YouTube. Retrieved March 17, 2025, from https://www.youtube.com/watch?v=0lwwTUoKZAc

Another strategy to avoid motion artifacts is by employing a stabilized camera system, which reduces the strain on the rolling shutter sensor. This is especially needed in applications where a camera is mounted on a moving platform, such as **drones**, where it is common to have jitter due to small, rapid, and erratic changes in the drone's orientation and position. In addition to fast-moving objects and the drone's speed,

[1] High frame rate of the Region of Interest in Dual Speed Streaming mode depends on the settings. Please consult Macnica Americas for details.

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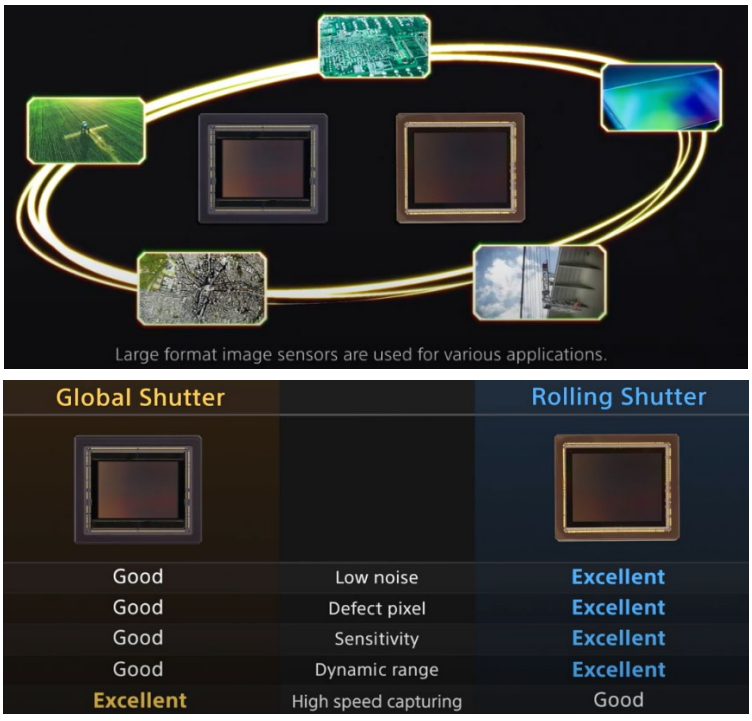
the jitter can lead to further blurry and jerky footage. In such cases where a stabilized camera system is employed, a rolling shutter sensor may already be suitable, especially when using a 'fast' lens. One would have to assess if the drone's trajectory, stability, object speed, and chosen lens would suffice for a high-speed rolling shutter.

In **aerial mapping** and **remote sensing** applications, whereby a high-resolution image sensor with a wider field of view lens is used on a stabilized airborne platform, Sony large format rolling shutter sensors such as IMX411 (151 MP) and IMX811 (247 MP) stand out. When choosing these large-format rolling shutter sensors, one can take advantage of their excellent low noise and sensitivity, especially in low-light conditions. If motion artifacts still persist as an issue, consider Sony's large format Global shutter IMX661 (127 MP), where good image quality without motion artifacts can be obtained.



Advantages of Large Format Global Shutter and Rolling Shutter Image Sensor.

Sony [YouTube channel]. YouTube. Retrieved March 17, 2025, from https://www.youtube.com/watch?v=LevsuBIkn9s

In **machine vision applications**, where precision and accuracy of object identification are crucial, global shutter sensors come as the first choice. Depending on the application, an even much higher speed may be required, such as in applications involving **high-speed sorting**, **control of robotic arms**, and **inspection**

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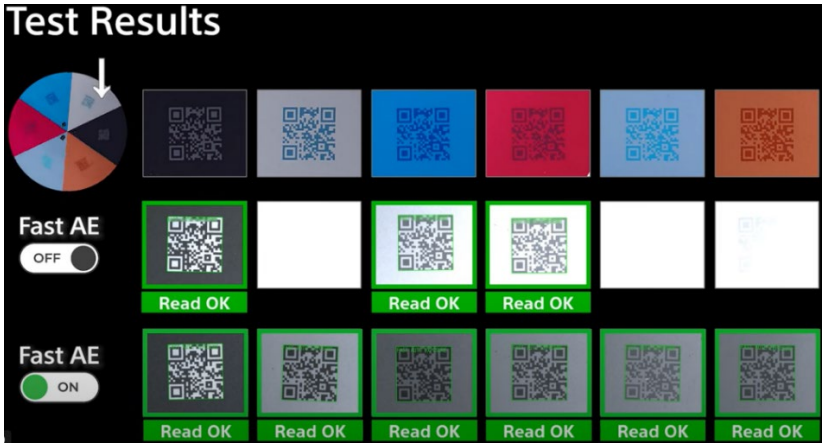
in an assembly line. IMX900, specifically, even with only MIPI CSI-2 or SLVS interface, includes a fast autoexposure mode that can be utilized for **quicker barcode reading**. When higher speed is definitely required, the Sony Global shutter product line with SLVS-EC interface in the Pregius/Pregius S category and Ultra-high speed (UHS) series sensors provides a wide range of selection.



Fast Auto Exposure Demo: Moving QR Codes Capture with the IMX900 | Sony Official.

Sony [YouTube channel]. YouTube. Retrieved March 17, 2025, from https://www.youtube.com/watch?v=XhPiIwGHou8

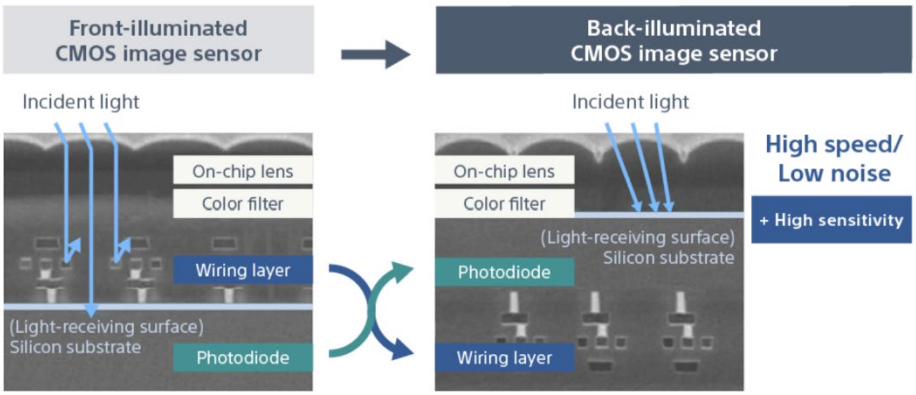
Pixel size and Resolution

A common notion is that a high-resolution sensor is preferred when capturing vivid images, such as in digital photography, and a bigger pixel size sensor is preferred when sensitivity is essential, such as in low-light situations. Understandably, a higher resolution sensor and higher pixel size would rank higher in price, and therefore, striking the balance between these two factors needs to be considered when choosing the right sensor.

Does the physical size only matter?

Advances in CMOS technology have pushed the traditional way of thinking regarding pixel size vs. sensitivity. With the demand for smaller form factor and higher resolution sensors, pixel sizes are becoming smaller. Sony's pioneering back-illuminated (BSI) structure has provided a pathway to boost the performance of a smaller pixel size while delivering large full well capacity. In the BSI structure, the metal

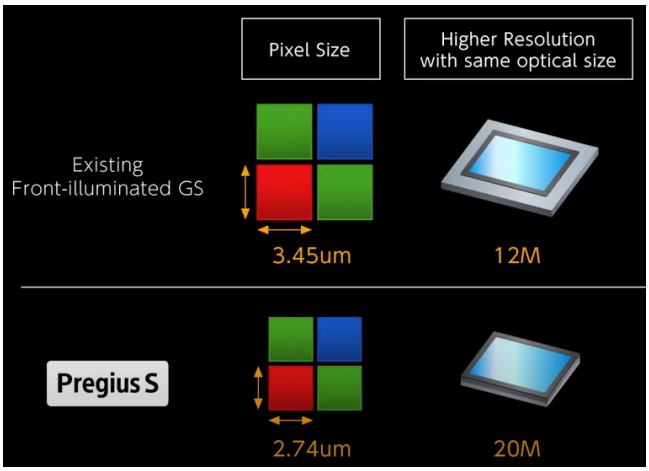
wirings are placed behind the photodiode, allowing more light collection. Compared to front-illuminated sensors such as IMX236 (2.8 µm pixel), sensors with BSI structure, such as IMX585 (2.9 µm pixel), have approximately a 4-fold increase[2] in sensitivity.



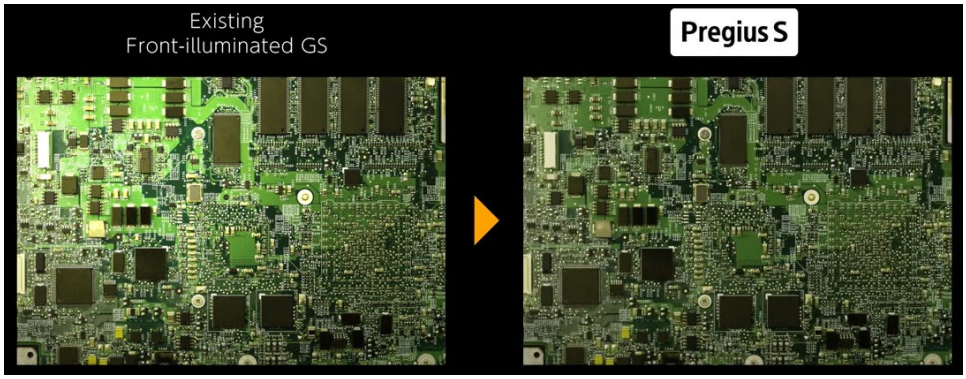
Front-illuminated vs. Back-illuminated CMOS image sensor [Online Image]. (2025)

https://www.sony-semicon.com/en/technology/is/back-illuminated.html

With the BSI technology and other proprietary manufacturing techniques, Sony's Starvis2 Rolling shutter line and Pregius S Global shutter line showcase high signal-to-noise ratio (SNR) and high dynamic range (HDR) features even with less than 3.0 µm pixel size. Therefore, the BSI technology paves the way for higher resolution with high picture quality capture while maintaining a small format sensor.



[2]Reported here: https://www.sony-semicon.com/en/technology/security/index.html

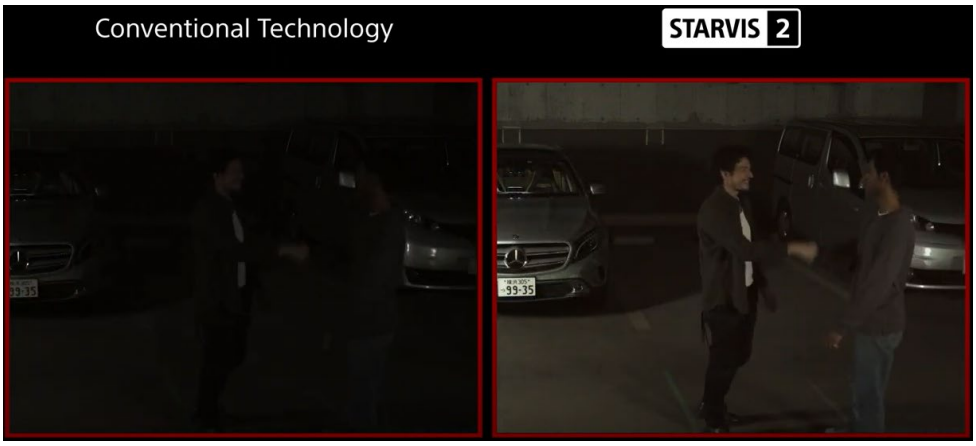


Pregius S (Global Shutter Technology). *Sony* [YouTube channel].

YouTube. Retrieved March 17, 2025, from https://www.youtube.com/watch?v=W89ZDOPTMIY

Additionally, the Starvis2 sensors equipped with deeper photodiodes enhance NIR absorption, making the quantum efficiency (QE) at NIR exceptional – an important feature in **security and surveillance** applications during low-light scenarios, as shown in the image below. Other applications include **scientific imaging**, where samples of investigation have small NIR emission. Therefore, besides pixel size, consider other factors that are important based on the applications, such as:

- Sensitivity – how efficiently the sensor converts light into charge determines the sensitivity, which can be represented in various measurements. Usually, this is measured in QE with respect to wavelength of light or measured in SNR to gauge how low the overall noise is. Lower SNR1 is indicative of low-illumination performance.
- Dynamic range- larger dynamic range is preferred when working with different lighting conditions or scenes where dark and bright images need to be resolved; hence, many **automotive** image sensors possess this feature.



STARVIS 2 Technology – For a Future with Safety and Security | Sony Official

Sony [YouTube channel]. YouTube. Retrieved March 17, 2025, from https://www.youtube.com/watch?v=CXGtjv8U6OM

Therefore, the pixel size may no longer be a single denominator when choosing the most suitable sensor for different applications. But when excellent performance is still required, combining large pixel size and advanced pixel structure wins, for example, the Global shutter Pregius 4.5 Series (with 4.5 µm pixel size), which boasts high SNR across a wide illuminance range.

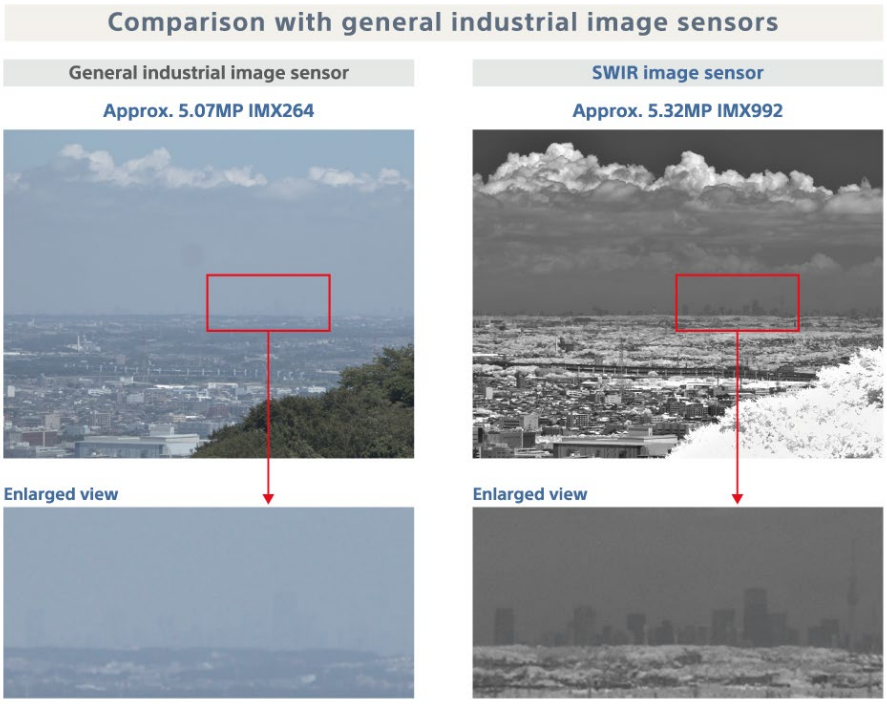
But how big of a resolution and how small/big a pixel size must one choose? Extreme choices on these key parameters may not always be beneficial.

Striking the Balance between Pixel vs. Resolution

Is a smaller pixel size always better?

While smaller pixel sizes can provide higher resolution in a smaller sensor format, there are trade-offs one must carefully consider. For example, in long-range imaging and machine vision, achieving high spatial resolution and contrast (measured as Modulation Transfer Function (MTF)) at various working distances is essential. The size and sensitivity of the sensor's pixel should match the MTF of the lens to optimize the overall imaging system performance. Sensors with smaller pixels may require precise optics with tight manufacturing tolerances, potentially increasing the imaging system's cost.

Additionally, when dealing with imaging at longer wavelengths, such as in NIR and Short-wave Infrared (SWIR), it is important to ensure that the small pixel size will not create optical diffraction that will produce blurry images. The SWIR sensor IMX992 has the smallest pixel size of 3.4 µm and the highest resolution at 5.3 MP among the InGaAs-based CMOS SWIR sensors to date. But even with the smaller pixel, it provides vivid imagery in near and far field imaging with applications ranging from **silicon semiconductor inspection**, **material identification and sorting**, **laser beam profiling**, **smoke/wildfire, and atmospheric observation**.



High-resolution, High-performance SWIR Image Sensor [Online Image]. (2025)

https://www.sony-semicon.com/en/products/is/industry/swir/imx992-993.html

Is higher resolution always better?

As for a high-resolution image sensor, one must also consider the data rate that comes with it, and consequently, one must check the available image sensor interface that supports it. As such, Sony's high-resolution sensor comes with an SLVS-EC interface, which can support up to 12.5 Gbps/lane (version v3.1). For customers looking to explore the interface and choosing which platform to pair with such high-

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resolution sensors, Macnica Americas can support customer development by providing an SLVS-EC v3.0 Rx IP core, which can be evaluated with their Luminous platform, either with Global shutter IMX537 or IMX901 sensor modules. Additionally, an FPGA is best-suited for handling such high data throughput. Thus, the SLVS-EC IP core is made to work with different powerful Altera FPGAs.

Utilizing Special Features that Come with High-Quality CMOS Sensors

Apart from the key parameters mentioned above, it is also worthwhile to consider many other special features that the latest CMOS technology can deliver. Notable examples include IMX900's Quad shutter/HDR. Pregius S global shutter sensors with an SLVS-EC interface, like IMX530 (24.5 MP), have a dual ADC (parallel shots of low and high gain images) to enable HDR function with a reasonably fast frame rate applicable to machine vision applications. Other global shutter sensors like IMX536 (8MP) have a motion detection feature that can reduce processing time and power consumption. Beyond achieving high quality image, there are other on-chip modes and features, some of which are not advertised online, that customer can utilize to get the best out of their investment.

Therefore, working with a reliable and established distributor is key in helping customers like you make informed choices. Macnica Americas is a trusted partner in image sensor distribution. With a strong partnership with Sony, customers can access up-to-date product information, such as new sensor models, product roadmaps, and upgrades. By partnering with Macnica Americas, you can benefit from technical expertise, reliable supply chains, compliance support, and cost efficiency, all of which are key to ensuring that the chosen image sensor meets the specific requirements of your applications.

For more information, please contact your local Macnica Americas sales representatives, or visit macnica.com/americas

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