



APN-001

CMOS sensor selection

Overview

CMOS sensors cover the spectral range of 200 to 1000 nm:

- UV: 200 to 400 nm
- Visible: 400 to 780 nm
- NIR: 780 to 1000 nm

When selecting a CMOS sensor the following should be considered:

- Sensitivity
 - Dark current
 - Spectral range
 - Number of pixels and line rate
 - Pixel size
-

Sensitivity

The following Hamamatsu CMOS sensors are available:

- High-sensitivity sensors
- Standard sensors

High-sensitivity sensors

These are active pixel sensors (APS) with a very high sensitivity. They are suited for:

- Fluorescence measurements
- Reflection absorption spectroscopy
- Other spectroscopic applications with low photon count

The drawback of APS sensors is a low well-depth. The well-depth is typically a few 100 ke⁻. As a result, the shot noise is significant and limits the signal-to-noise ratio (SNR) to around 500. However,

for low-light measurements the APS sensors are an excellent choice. Noise can further be reduced by averaging.

Standard sensors

Standard sensors (large well-depth) have low sensitivity and are suited for high-intensity measurements. They are suited for:

- Transient absorption spectroscopy (TAS)
- Other spectroscopic applications with high photon count

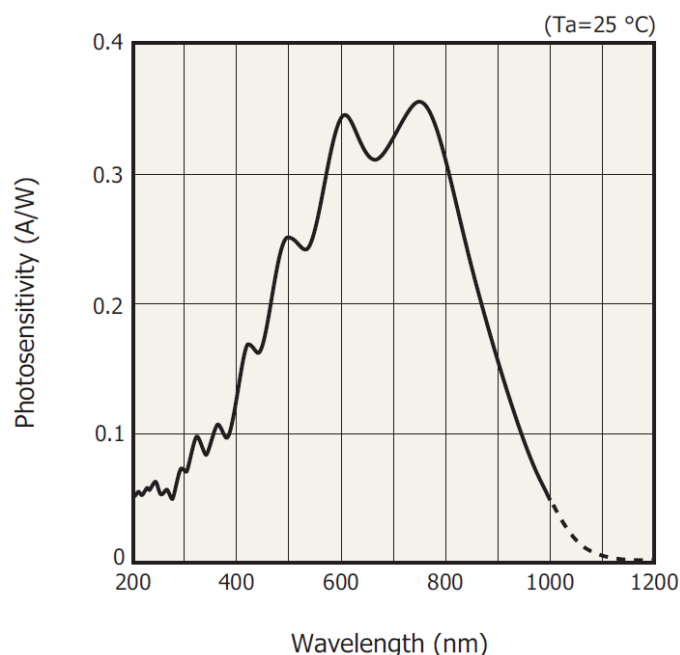
The well-depth is typically several 10^6 . Given high enough light intensity, the shot noise is lower compared to APS sensors and the shot noise limited signal-to-noise ratio (SNR) is above 2500. Standard (large well-depth) sensors are recommended for applications with sufficient light intensity and will outperform APS sensors.

Dark current

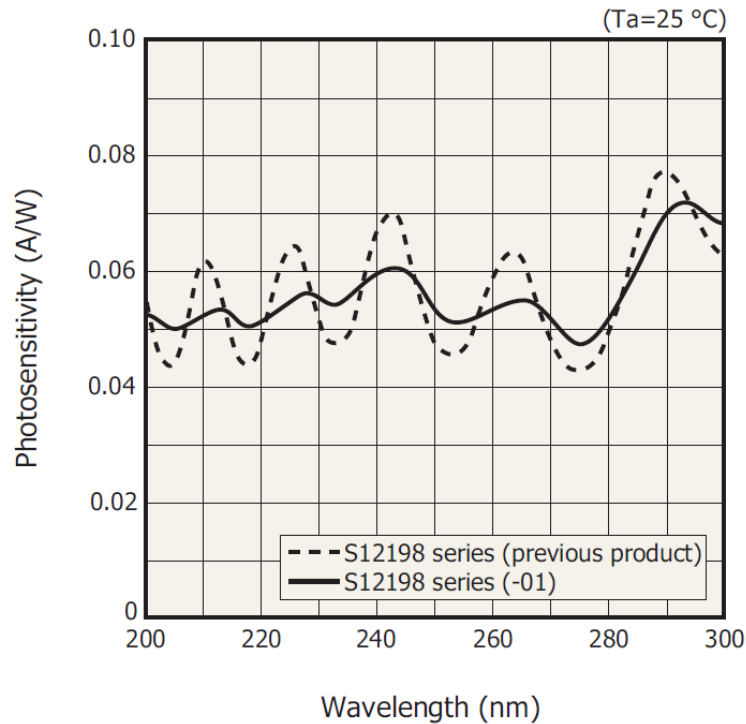
Compared to InGaAs sensors, CMOS sensors have lower dark currents and don't require cooling. CMOS sensors can handle integration times of several seconds without the dark current degrading the measurement.

Spectral range

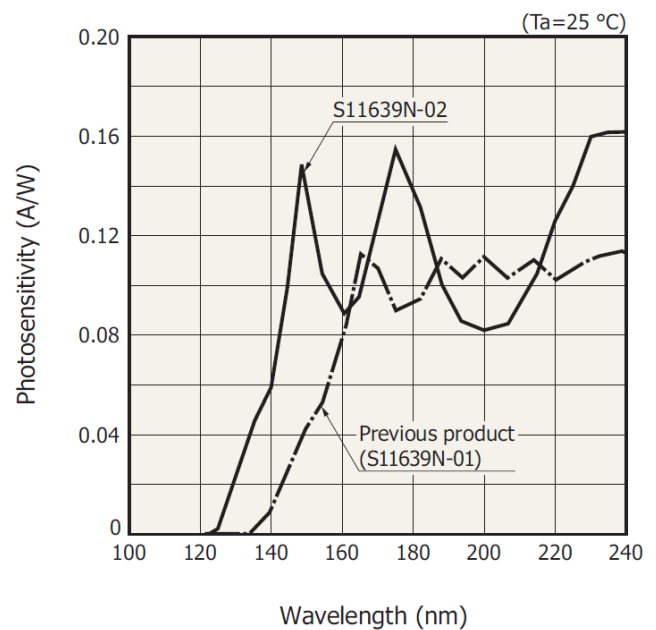
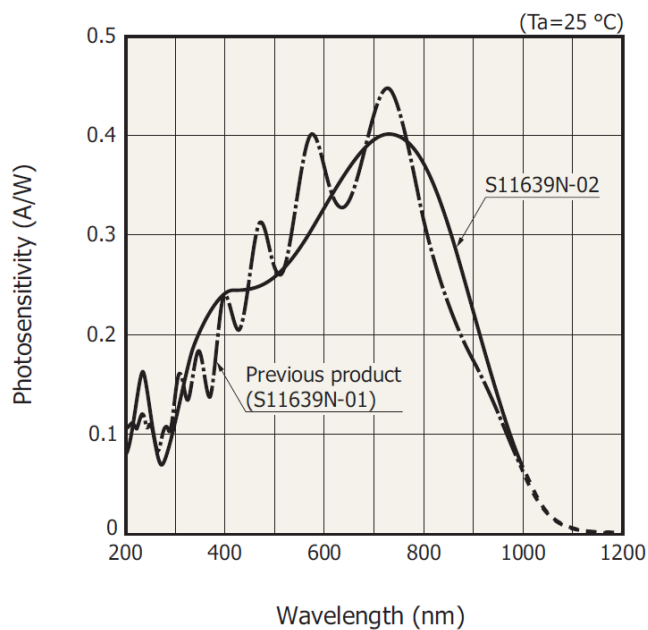
The spectral range of CMOS sensors are limited to 200 to 1000 nm (UV, visible and NIR). CMOS sensors are usually supplied with quartz windows which limits UV transmission to 200 nm. Below is the typical spectral response of a CMOS sensors:



Hamamatsu provides newer versions of their sensors on a regular basis with improved spectral response. Below is an example of the S12198 (old version) and S12198-01 (new version) with improved spectral response in the UV:



CMOS are sensitive to VUV radiation and without quartz windows the spectral range can be increased to 140 to 1000 nm (VUV, visible and NIR). Please enquire about windowless CMOS sensor options. Below is an example of the S11639N (windowless version of the S11639):



Number of pixels and line rate

The maximum readout clock speed for CMOS sensors is 10 MHz. The clock speed and number of pixels determine the maximum line rate:

Number of pixels	Max line rate [lines/s]
512	18000

Number of pixels	Max line rate [lines/s]
1024	9000
2048	4500
4096	2200

Pixel size

Compared to other CMOS sensor manufacturers, Hamamatsu provides CMOS sensors with large pixel heights ranging from 0.2 to 0.5 mm. The pixel pitch depends on the pixel count and ranges from 14 to 25 μm .

Summary

Below is a summary of available sensors:

Sensor	Type	Well depth	Spectral range	Pixels	Pixel size	Line rate
S12198-512Q-01	Standard	5.9 Me ⁻	200-1000 nm	512	25x500 μm	18000 lines/s
S12198-1024Q-01	Standard	5.9 Me ⁻	200-1000 nm	1024	25x500 μm	9000 lines/s
S11637-2048Q	Standard	2.8 Me ⁻	200-1000 nm	2048	12.5x500 μm	4500 lines/s
S11639-01	APS	0.1 Me ⁻	200-1000 nm	2048	14x200 μm	4500 lines/s
S16514-2048-11	APS	0.1 Me ⁻	400-1050 nm	2048	14x200 μm	4500 lines/s