Technology Advances Lead to CMOS Sensor with Record Resolution

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In the past decade, CMOS sensors have emerged as the imaging technology of choice for many applications. Today, they are not only used in almost all cell phones and mobile devices, but are also commonly found in industrial and medical cameras.

Canon has invested heavily in CMOS, developing sensors that incorporate technology to counteract inherent noise and adding microlenses to the sensors to capture more light. These advances have led to CMOS sensors that typically outperform CCDs, allowing system integrators to take advantage of their lower power requirements, cost, and faster readout speeds.

As image sensor designers continue to push the limits of CMOS technology, new methods are needed to overcome the inherent challenges of increasingly larger chip size and the decreasing size of pixels.

Canon's new solid-state CMOS sensor takes the technology to new frontiers by delivering 120-megapixel (MP) resolution, the highest currently available for this type and size sensor. This imaging sensor features approximately 6 times the number of pixels as today's highest end professional camera (EOS 1Dx Mark II) and 2.4 times the resolution of the highest resolution commercially available cameras (EOS 5Ds). By incorporating close to the same number of pixels as receptors in the human eye, it can achieve a resolution similar to what we see.

The sensor features a pixel size of 2.2 microns and an imaging area of 29.2 millimeters X 20.2 millimeters (APS-H). Despite its small pixels and large chip size, this CMOS sensor delivers a maximum output speed of 9.4 frames per second (fps) thanks to a unique combination of innovations. This imaging speed makes it useful for continuous shooting of extremely high-resolution images. The sensor is available for OEM integration and is ideal for a number of demanding applications such as biomedical and surveillance imaging.

Upping data transmission speed

One of the key challenges for a large chip with so many pixels is transferring the data from those pixels at high speeds. Each pixel outputs data in 10 bit at 9.4 fps, producing 18 gigabits of data each second.

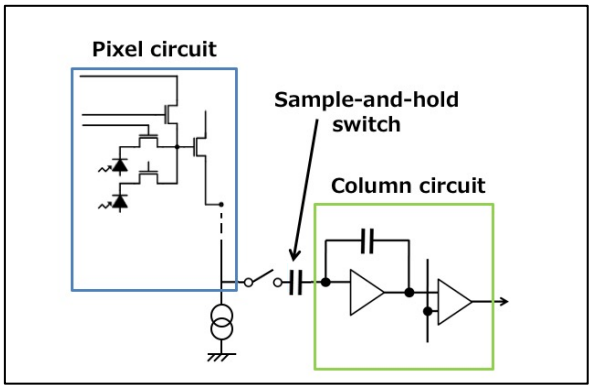


Figure 1. The sample-and-hold circuits are 35 percent faster, significantly improving the data processing time.

To deal with this extremely large amount of data, the sensor uses seven parallel readout blocks, each with four channels. This means a total of 28 channels, or 28 pairs of low-voltage differential signals, read out the

signal. This is a great deal more than the four readout channels found in most HD sensors.

CMOS imaging sensors typically contain sample-and-hold circuits that act as analog-to-digital converters. These circuits hold the analog input signal from each pixel for a specified minimum amount of time before processing.

Eliminating crosstalk

The new sensor's small pixels bring the potential for light to leak from pixel to pixel, which is known as crosstalk. When this happens, it can create color shading and inaccurate color representation that degrades image quality. Canon used its expertise and experience in designing optics and sensor technology to incorporate unique solutions to these problems in the 120 MP chip.

In order to precisely place these components allowing optimized light collection in each region of the sensor, a new fabrication process was developed allowing for consistent application of this new method. Finally, a wire layer incorporated into the sensor structure between each pixel creates an arrangement that surrounds the pixel and keeps light from leaking between them.

Simplified design

On a CCD sensor, photo diodes occupy a majority of the surface. However, for a CMOS imaging sensor, space is needed for amplifier circuitry, leaving less space for the actual photodiodes. Part of this circuitry is a floating diffusion that converts the pixel's charge to voltage. Most CMOS sensors have one floating-diffusion per pixel, however, the new 120 MP sensor shares one floating-diffusion circuit for four pixels.

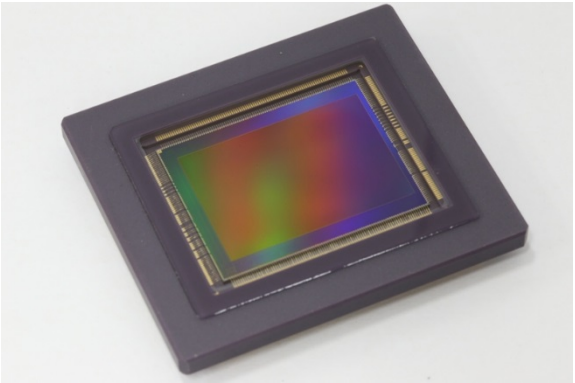
Sharing the floating diffusion circuitry among pixels reduces the number of parts and complexity of wires in the chip. This simplified design, in turn, allows the photodiode to be larger, which helps improve the sensor's sensitivity and dynamic range. The four-to-one ratio was carefully chosen to strike the right balance between increasing readout speed without sacrificing the signal-to-noise ratio.

The 120 MP chip's high number of small pixels and advanced semiconductor processing help make sure detected light is processed extremely efficiently. The result is a random noise level of only 2.1 electrons root mean square, much lower than other similar CMOS sensors.

Taking advantage of the high resolution

With an extremely high resolution and large field of view, users can acquire either the whole frame or just a region of interest. The high number of pixels gives a selected region of interest a large imaging area and resolution that is adequate for most applications. The sensor can provide full HD imaging with just $1/60^{th}$ of its surface area.

For remote imaging or surveillance applications, 120 MP allows closer observations using digital zoom than is possible with conventional cameras. This means when imaging from a plane, for example, there's no need to change from a wide-angle lens to a telephoto lens to get a more detailed look at something on the ground.



Other industries such as biomedical, machine vision, and automated inspection, can benefit from the increase in resolution as well as take advantage of the relatively high frame rate. The sensor gives a significant performance increase over similar sized sensors used by industry today allowing for improved capabilities to their end products and applications.

In conclusion, the new 120 MP CMOS sensor uniquely combines a number of innovations to achieve fast imaging without sacrificing resolution or image quality. As OEMs begin incorporating this powerful sensor into their imaging systems, it will likely enable new applications beyond what can be imagined today.

About Canon USA Inc.
Canon's proprietary CMOS sensors are among the most advanced in the world, capturing high-resolution images and featuring accurate color reproduction. The company continues to work to improve the sensitivity and resolution of CMOS imaging sensors, allowing them to enable new scientific and industrial applications.

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