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The EOS 5D's CMOS advantage

The EOS 5D features a new full frame CMOS sensor designed and built in-house by Canon. One of Canon's core technology platforms, CMOS image sensors are now found inside every Canon D-SLR camera. This gives the EOS 5D and the EOS range a number of advantages.

History

Canon's history with image sensor development stretches back to 1987, when it created the BASIS sensor for its auto focus systems in the EOS 650. Continued R&D in the field led to the 2000 release of the 3.11 Megapixel EOS D30: the first commercialisation of CMOS for digital SLR image capture.

Encouraged by the camera's success, Canon continued to refine and develop the renegade technology. In March 2002, Canon released the second EOS camera to feature a CMOS sensor: the 6.3 Megapixel EOS D60.

The quest for a larger sensor

Both the EOS D30 and D60 cameras had APS-C sized sensors, measuring 22.7 x 15.1mm. By comparison, a full frame of 35mm film measures 36mm x 24mm.

One of the reasons Canon wanted to pursue full frame size sensor development is because of the potential for better image quality. Full frame sensor image quality is superior because it allows for improved resolution and larger pixels.

Moreover, the entire 35mm format – and therefore the complete EOS system – is based around full frame photography. Full frame restores the photographic experience; wide lenses stay wide, the viewfinder is larger and brighter and more subtle control over depth of field is available.

Improved resolution

It is a commonly held misconception that resolution is a sole function of the camera's image sensor. This is not the case. Resolution is the ability of an optical system to distinguish between two features that are close together. This ability to 'see' or resolve detail is first limited by the lens. This is a key reason why professional photographers are prepared to invest in professional series optics such as Canon's L-series EF lenses.

EF lenses were designed for film and optimised for covering the full 35mm frame. Yet the area of an APS-C sensor is only 40% that of full frame. It has been clear to

Canon's engineers since the advent of digital photography that in order to allow photographers to get the best from their EF lenses, full frame sensors would be necessary.

Larger pixels

A larger sensor means that pixel size can be increased while maintaining total pixel count. Larger pixels are more sensitive and have a wider dynamic range for better detail, particularly noticeable in deep shadow and highlight areas. They also have a better S/N ratio for noise free performance, especially at high ISO speeds.

Difficulties with manufacture

Image sensors – like other silicon chips – are produced by a process of photolithography. Most photolithography machines in the semi-conductor manufacturing industry are designed to make a maximum single exposure that is approximately the size of an APS-C size sensor. The manufacture of larger sensors requires accurate alignment and interconnection of multiple adjoining exposures.

When manufacturing a CCD sensor, this process of aligning multiple exposures can create incomplete or malformed connections between the charge transfer channels, the pathways along which the signals from each pixel site are fed.

This presents a potentially insurmountable problem because the un-amplified signal passing along the charge transfer channel is extremely susceptible to degradation caused by crossing the exposure boundary.

One of the ways to overcome this on a multiple exposure CCD sensor is to locate signal amplifiers at the outer corners of the sensor so the charge does not cross any exposure boundaries. Because signal processing always varies slightly from one amplifier to the next, however, each sensor segment's output can be visibly different from its neighbour.

In contrast to CCD sensors, CMOS sensors have an amplifier at each pixel site. Because the resulting signals are robust, they can cross boundaries between exposures with no detectable signal degradation. By optimising its silicon wafers, Canon achieves extremely consistent amplifier performance. Any remaining signal amplification variation is imperceptible because it is randomly distributed across the frame.

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The first full frame sensors

In November 2002, Canon released the 11.1 Megapixel EOS-1Ds, its first full frame sensor camera. The camera was an instant success. Its image quality, 100-1250 ISO range (expandable to L:50) and 3 frame per second performance provided the benchmark against which all other digital SLR cameras would be measured.

The EOS-1Ds would remain unchallenged until the November 2004 release of the Canon's second full frame sensor camera: the 16.7 Megapixel EOS-1Ds Mark II. With new micro lenses over each pixel site and redesigned noise reduction circuitry, the second generation CMOS sensor is virtually noise free. Its wide dynamic range enables the reproduction of subtle tonal gradations in shadow, midtone and highlight areas. According to many critics, the image quality not only surpasses that of 35mm film, it challenges that of medium format.

Low on noise, easy on power

An advantage of Canon's CMOS over CCD sensor technology is its lower noise and lower power consumption characteristics.

CCD sensors use a bucket relay system to transfer each pixel's accumulated electrical charge to a corresponding transfer channel. One by one, each pixel's charge is transferred to an amplifier at the edge of the sensor. Only after each individual pixel is read can the signal be amplified and passed to the camera's image processor.

The operation is time consuming and draws considerable power. It is difficult to manufacture a CCD camera that is responsive or efficient. High power consumption limits battery life and generates unwanted heat, further increasing noise and lowering image quality.

By contrast, signal conversion in Canon's CMOS sensors is handled by the individual amplifiers at each pixel site. Unnecessary charge transfer operations are avoided, vastly speeding up the process of getting signal to the image processor. Noise generation is reduced and power consumption limited.

The low noise characteristics of the EOS 5D's CMOS sensor are particularly beneficial at high ISO speeds and long exposure times.

Ongoing development

Canon has released five new second-generation CMOS sensors since the beginning of 2004:

- EOS-1Ds Mark II – 16.7 Megapixel full frame sensor
- EOS-1D Mark II and EOS-1D Mark II N – 8.2 Megapixel APS-H size sensor
- EOS 5D – 12.8 Megapixel full frame sensor
- EOS 20D and EOS 20Da – 8.2 Megapixel APS-C size sensor
- EOS 350D – 8.0 Megapixel APS-C size sensor