Sensor Superiority:
It's why the Sigma SD14 captures
the best color detail of any DSLR!

The heart of any digital camera is the image sensor—an amazing device that converts photons, bundles of light energy, into electrons, which are then collected, analyzed, and transformed into a visible image. Unlike all other digital SLRs on the market, the new Sigma SD14 incorporates a 3-layer, 14-megapixel Foveon X3 sensor that is, quite literally, cutting edge. Because this unique sensor captures full color data in all three primary colors at each pixel location, it can resolve finer details in color images than conventional sensors that only capture one color per pixel location. The result: The Sigma SD14 delivers superior real-world performance whenever you shoot high resolution pictures in color—an enormous practical edge you can easily see for yourself in comparison pictures of color test targets as well as in your own colorful digital images.

What makes the SD14's sensor better?

To really understand why the Foveon X3 sensor in the Sigma SD14 is inherently superior to conventional image sensors that use a Bayer-pattern color filter array, let's take a close look at how each type works.

The conventional image sensor

A conventional CCD or CMOS image sensor detects color by means of a specific checkerboard pattern of blue, green, and red color filters added on top of the light-sensitive silicon layer of the sensor chip at the end of the manufacturing process. These color filters are added successively in layers using a photo resist masking process, resulting in a Bayer-pattern color filter array consisting of tiny filter squares, 25% of them blue, 50% green, and 25% red. As a result of this design, there is only one color filter for each pixel location, and any small response generated by a pixel of the wrong color cannot be used to retrieve color information. While the best conventional Bayer-pattern sensors can take very sharp pictures and provide high color accuracy, their ability to resolve small details in color diminishes rapidly at higher spatial frequencies—in other words as the color details in the subject become finer and finer, the ability of a conventional sensor to resolve them decreases dramatically.

The Foveon X3 image sensor

The Foveon X3 CMOS image sensor, like color film, incorporates three separate light-sensitive layers placed directly above one another. As a result, light in the blue wavelengths, which have the highest energy, tend to be absorbed by the silicon very quickly, generating image-forming electrons in the top layer. Light in the lower-energy red wavelengths tends to penetrate further, to the bottom layer, before generating electrons, and intermediate-energy green light tends to produce electrons in the middle layer. Foveon's design takes advantage of this self-selecting, energy-dependent property of light by placing a separate pixel sensor at each of the three depths corresponding to the place where blue, green, and red light generate their highest density of electrons—in effect a separate color layer for each primary color. As a result, the Foveon X3 image sensor, unlike the Bayer-pattern sensor, captures full color data in blue, green, and red at each pixel location. Ultimately, having more and better color information is why the Sigma SD14 can outperform other DSLR cameras in being able to accurately reproduce finer details in color images.

How does the Foveon X3 outperform conventional sensors?

Since a completed full-color image requires information in all three primary colors for each pixel location, image sensors using the conventional Bayer-pattern color filter array must process the output image data using color interpolation—essentially a method of adding the missing colors, that are not actually sensed, to the final image. Sophisticated mathematical algorithms are employed to add the missing data, relying on sampling the data from neighboring pixels to make an educated guess as to what the missing colors should be. This guesswork works reasonably well for large areas of color like the sky or an expanse of grass, but it is inherently imperfect, and becomes more evident as adjacent areas of different colors get smaller, like the fine stripes on a necktie or the pattern on a multicolored scarf. Because the Bayer-pattern sensor must interpolate 2 of the 3 color values for each pixel based on the measured values from neighboring pixels, there is a fundamental loss of color resolution—that is, the ability to reproduce fine color details.

Why does the lack of complete color information result in a loss of color resolution with Bayer-pattern sensors? Because, due to the inherent limitations of a one-color-per-pixel-location grid there is no perfect solution

to the knotty problem of providing the data needed to reproduce fine color details accurately at the edges where colors change. The tradeoff: Go for higher color resolution at the risk of making incorrect color guesses in the interpolation process—which would show up as artifacts in the final image—or soften the image by using optical blur filters and post processing, thereby minimizing color artifacts but losing the details. The latter is the main strategy adopted by most camera makers. Foveon X3 sensors bypass all these problems by fully measuring all three primary colors using a stack of three color pixels at each pixel location. No interpolation is needed. In short, with the Foveon sensor architecture, the resolution in all colors is theoretically limited only by the interaction of the camera optics and the number of pixel locations on the sensor itself.

Counting pixels

Because of their unique structure, there has been some controversy in how to specify the number of pixels in Foveon sensors. While international standards bodies such as the ISO have not yet issued specific guidelines on pixel counting in either multi-chip or multi-channel sensors like the Foveon X3, the language in the present standards is consistent with the pixel data presented by Foveon and Sigma, and with the CIPA (Camera & Imaging Products Association) guidelines. The CIPA guidelines allow for the counting of all pixels in a 3-chip camera, and by extension, a camera with a 1-chip sensor like the Foveon X3 that provides three pixels at each location because its three sensor layers are 'magically' joined together in perfect alignment as opposed to separately located on the faces of a prism. It is also noteworthy that the existing standards on digital camera resolution unequivocally state that pixel count and resolution are *not* the same, and it is therefore *not* acceptable to use these terms interchangeably. Indeed, pixel count is only one piece of the resolution puzzle, and this is clearly demonstrated by the fact that several 5- and 7-megapixel cameras now on the market produce sharper pictures than comparable 10-megapixel models and that when it comes to capturing fine color details, the 14-megapixel Foveon X3 sensor in the Sigma SD14 outperforms many leading DSLRs with a greater number of pixel locations.

Camera tests: Are new standards needed?

The digital camera tests published in magazines and on websites usually provide resolution data (sharpness in rendering details) and color

performance data separately, using variants of the MacBeth Color Checker and standard finely patterned black & white test targets like the Siemens Star and the IT10 resolution chart. All these charts are decades old, dating back to the days of film and even black & white TV. Because color film has a layered structure much like a Foveon X3 sensor, the differences in resolution measurements between black & white and color were negligible when film was the dominant image-capture medium.

However, this is definitely not the case today. The majority of digital cameras use conventional Bayer-pattern color filter array sensors, and they yield dramatically lower resolution in color than they do in black & white. While conventional sensors can sample adjacent pixels to access information on brightness and therefore achieve very good results with black & white test targets, they have only a single blue-, green-, or red-filtered pixel at each pixel location, Therefore, in scientific terms, the spatial sampling grid for any one color is sparse compared to the spatial sampling grid of the sensor as a whole. It is this sparseness of color sampling that has the direct result of reducing color resolution.

Imaging scientists and test standards committees are well aware of this discrepancy and have been studying how to implement test standards and procedures that are more appropriate for the digital age. Indeed, the technical community is hard at work developing new upgraded test methodologies that more accurately reflect what people actually perceive when they capture and view color images. In the coming years we expect that new measurement techniques that assess color resolution as opposed to black & white resolution will become part of the standard test procedures.

We know from published tests conducted using standard black & white test targets photographed under colored light, and others using color versions of the Siemens Star and linear-pattern targets in color, that the Foveon X3 sensor outperforms conventional sensors in capturing full color information at every pixel location and in delivering higher resolution (MTF test) across the visible spectrum, especially at high spatial frequencies (that is, with highly detailed subjects in color). This will be evident to everybody, digital camera testers and consumers included, when the new test procedures are in place and the results are widely available.

Putting it all in perspective

Neither Sigma nor Foveon, the U.S.-based manufacturer of the 14-megapixel X3 sensor used in the new Sigma SD14 DSLR, claims that the Bayer-pattern sensors used in all the leading DSLRs made by other reputable manufacturers are not capable of delivering excellent picture quality. As a result of constant development, careful design and manufacture, and ingenious software, their performance has been brought up to a very high standard indeed. Nevertheless, we must point out that the overwhelming majority of pictures taken with DSLRs and other digital cameras are shot in color. Optimizing the capture of fine color detail is therefore a crucial design parameter, and here the Foveon X3 14-megapixel sensor provides photographers with a distinct edge in delivering images of surpassing quality. It is perhaps most significant that those who have had the highest praise for Sigma cameras and their Foveon sensors are the testers, professionals, and serious enthusiasts who have actually used them.

Sidebar

The Sigma SD14: It's got a lot more than just a great image sensor!

While the cutting-edge 14MP Foveon X3 image sensor is the centerpiece of the new top-of-the-line Sigma SD14 that sets it apart from every other serious pro-caliber DSLR on the market, there's a lot more to the SD14 that makes it a natural choice for professionals and serious enthusiasts who want to take their DSLR photography to another level. Here's a rundown of its exciting new features:

1. Choice of RAW or JPEG files. With a total effective 14.06MP pixel count, the SD14 lets you capture 12- bit RAW files of approximately 13.3MB and Super High/Fine JPEGs of 7.5MB. Sigma's exclusive Photo Pro 3.0 software will even let you delicately tweak the colors and textural tones of RAW image data using a single intuitive color wheel control.
2. Dust Protector. A standard feature of all Sigma SD cameras, it prevents external dust and debris from adhering to the image sensor. In the SD 14 it can be installed and removed for easy cleaning with a single action, Removing the dust protector also noticeably enhances the SD 14's performance when shooting infrared images,
3. 5-Point Distance Measurement AF. It's a superior autofocus system based on measuring the subject distance at 5 points, left, right, top,

and bottom, for maximum ease of use, and provides central crosshairs for improved accuracy and manual or automatic point selection.

4. Big LCD, powerful built-in flash, mirror lockup. With a 2.5-inch, 150,000-pixel TFT LCD with new simplified control pad, powerful (ISO100 GN in feet 44) built-in flash, Quick Set Button for easy control access, and easy-to-use mirror lockup function, the SD14 is the most convenient and capable SD camera yet—a real pro.
5. Great lenses and accessories. With a full line of world class Sigma zoom and prime lenses ranging from an 8mm fisheye to an 800mm super-telephoto, and a full range of dedicated Sigma accessories including the Power Grip PG-21, Remote Controller RS-31, and high powered flash units including the top-of-the-line Sigma EF-500 DG Super with auto-zoom, and S-TTL automatic flash metering with high-speed sync, the sleek, rugged Sigma SD14 is ready to meet any challenge and deliver topnotch imaging performance that sets a new standard for the industry.