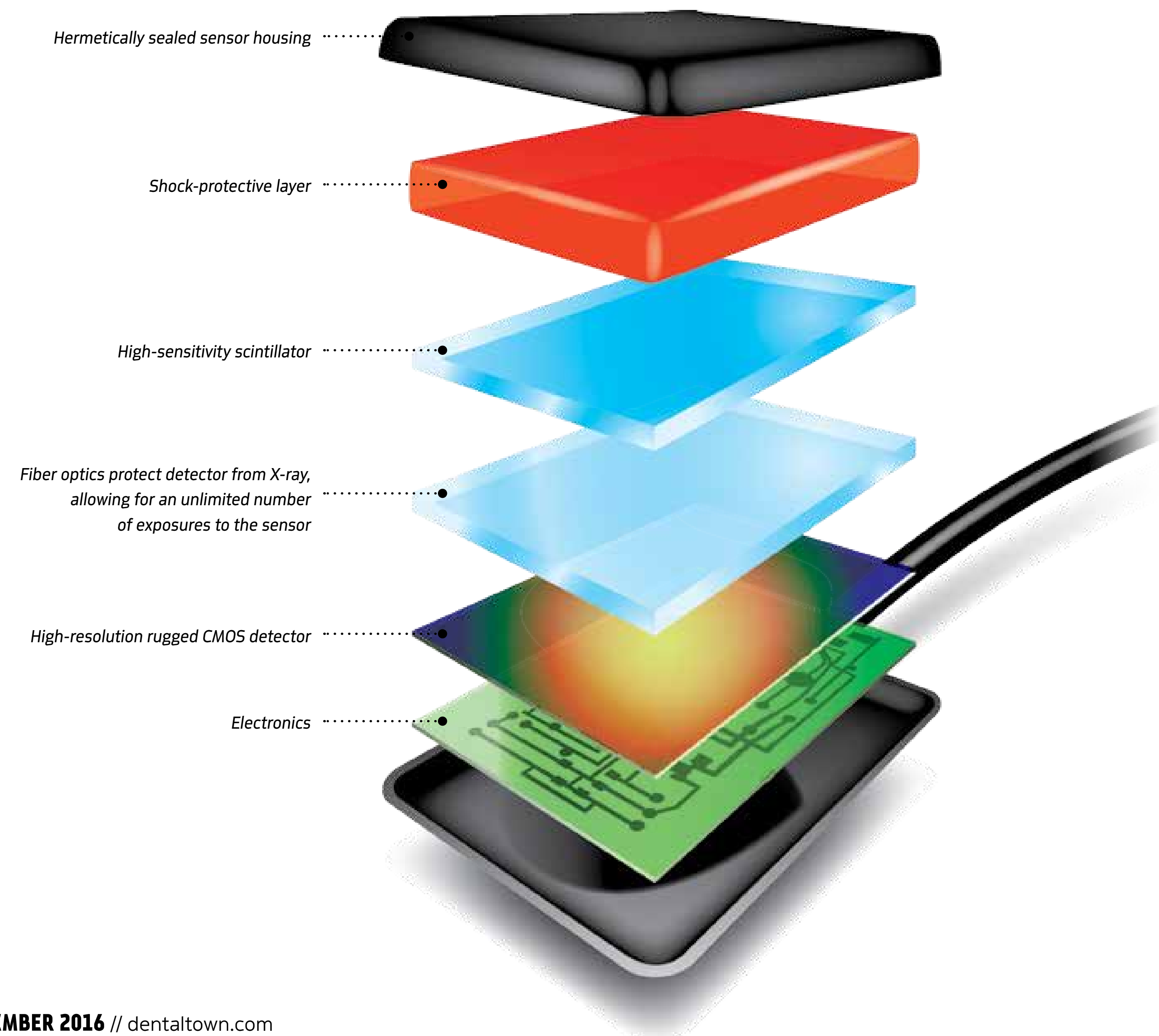
AN INSIDE JOB

Discover more about the technology in your digital sensors—and what to look for in your next one



How often do you think about the technology inside your digital intraoral sensor? After all, does it really matter if it includes a fiber optic plate, or uses a CCD detector instead of CMOS technology? These may seem like tech terms salespeople sprinkle into conversation to illustrate why their sensor is better than others, but these concepts are more important than that.

The technology inside your digital sensor affects everything from its price to how quickly it can acquire an image to the quality of the radiograph it produces—even how comfortable it is for the patient. Let's take a look, layer by layer, at what makes a digital sensor work, and how each piece plays a role in clinical outcomes.

A radiograph is only as good as the weakest link

The sensor is just one link in the imaging chain, so for best results, the chain must be considered as a whole. This chain includes the source (generator), the technique used to position the sensor, the receptor (sensor head), data transmission (cord) and the display (computer).

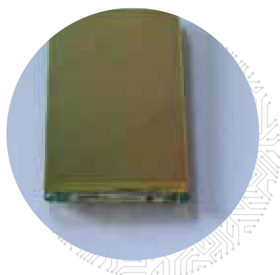
Assuming a doctor and her staff are experienced in positioning the sensor, we'll briefly touch on the generator and its role but spend most of our time examining the technology that makes a sensor tick. While a mistake at any point in the process affects the quality of the final radiograph, it can be argued that the sensor is the most important link in the chain.

The generator

First, the sensor must be activated by X-rays from a generator. The X-ray photons travel through space, through the patient's cheek, gums and teeth to the active surface sensor. A generator can operate by either direct current (DC) or alternating current (AC). Direct current generators emit a smooth, constant X-ray energy, which may provide a slight edge by giving more control over exposure time and provide a wider range of gray shades (all values between black and white). Though advanced sensor technology can handle either current, DC is typically preferred at 70kvP and 7mA. For the best image quality, generators should be less than 10 years old.

The scintillator

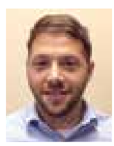
Beneath the hermetically sealed sensor housing and the shock-protective layer—a feature of any high-quality sensor, as a sensor is often the victim of bites, shocks and drops—is the high-sensitivity scintillator. The scintillator's molecules are able to turn X-rays into light by means of luminescence. When an X-ray photon crosses the scintillator, it hits the molecules and generates a light photon that can be easily detected by the next layer of the sensor.



A caesium iodide scintillator

The efficiency of the scintillator may be affected by the type of material that it's made from. Scintillators made of caesium iodide (CsI), an inorganic crystal, are currently the best technical compromise that provide higher resolution and increased sensitivity to X-rays. Other technologies do exist, but don't meet the same resolution/sensitivity balance one would look for in today's dental space. Also, the thickness of the scintillator can affect the quality of the final image. While thicker scintillators are more sensitive and better at converting X-rays, they also decrease the sharpness and spatial resolution of the radiograph.

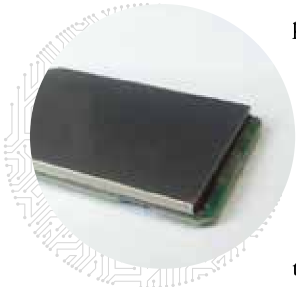
by Gil Orenstein



Gil Orenstein is the regional product manager for Carestream Dental's intraoral digital imaging solutions (including RVG sensors, imaging plate systems and intraoral cameras) and X-ray generators. Orenstein received his bachelor's degree in electrical engineering from the University of Toledo in Ohio, and is a certified Pragmatic Marketing III professional. He has more than 10 years of experience in medical device support and training gained at hospitals, cancer centers and offices around the globe, and now researches and delivers market input and improvements that help make a positive impact on doctors' user experiences.

The fiber optic plate

Since even the best scintillators can't prevent some X-rays from slipping past the barrier, high-end sensors feature a fiber optic plate to absorb stray X-ray photons. The plate is composed of millions of pipes that guide the light from the scintillator to the next layer of the sensor.



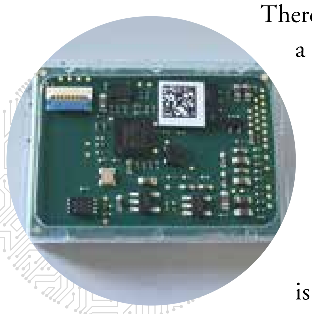
Fiber optic plate

The resulting output of the fiber optic plate is a signal made of pure light that can then be sensed by the next layer, the detector. Since the next layer can only produce an image as good as the light it receives, the fiber optic plate plays an important role in protecting the detector from unconverted X-ray photons that cause noise and false data on the final radiograph.

Some sensor manufacturers exclude fiber optic plates to keep the sensor head thin (and production cost low). However, without the added protection from direct X-rays, it's hard to guarantee the quality of the final radiograph captured with such a sensor.

The detector

The next layer, the detector, converts the light generated by the scintillator into a digital signal that can be sent to the computer. There was once a debate whether a charge-coupled device (CCD) or a complementary metal-oxide semiconductor (CMOS) were a better detector. These are terms you may still hear today. We now recognize that CMOS is the technology of choice for quality, speed and miniaturization. However, even with a CMOS detector, there are still key elements that contribute for making a high-quality or poor-quality sensor.



Electronic board that directly supports the CMOS. These electronic components receive the image from the CMOS and send the image via USB protocol.

The pixel size, for one, can affect the final radiograph. Pixels are the basis of any digital image. If they're too small, the sensitivity of the detector is reduced and more X-rays are required to obtain a good image. Some manufactures play up unnecessarily small pixel size to give the illusion of enhanced theoretical resolution (which we'll define later) without any true benefit to the image quality. If the pixels are too large, the spatial resolution (the ability to accurately discriminate two objects that are close together) of the image is reduced. Pixel size should be determined based on the type of the scintillator used; for CsI scintillators, 19µm is optimal for maximizing both spatial resolution and sensitivity.

Another element of the detector is its dynamic range, which determines how low and how high dose can be while still capturing a good image. So the wider the dynamic range of a sensor, the more flexibility users have with X-ray timer settings, X-ray source-to-detector distance, patient morphology, etc.

The cable

Once the image has been successfully converted into pixels, the information is transferred up the cable to the computer. Nowadays, sensors integrate a USB communication protocol with the detector, which means fewer connection points along the cable, eliminating the control box along the cord makes for a distortion-free signal to the computer.

The value of a strong cable is not to be underestimated and fewer contact points inside the cable dramatically contribute to its strength. Cables should be tough and tested to stand up to tugs, pulls, being stepped on, etc., and also to ensure that the fine wires within the cable housing are protected. Some wireless transmission systems came in and out in the dental industry, but the hassle-to-benefit ratio remains unfavorable.

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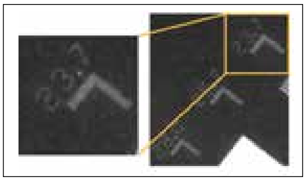
The image

Last, but not least is the screen where images are displayed. It was once believed that the human eye couldn't detect more than 20 gray shades or 12 line pairs per millimeter. Now, digital processing and software filters can reveal even the tiniest detail on the final radiograph. However, it's important to note that all the software manipulation in the world can't fix a bad radiograph captured by a low-quality sensor: "garbage in, garbage out," as they say. Start with a sensor that features the advanced technology mentioned above for best results, then fine-tune to your clinical needs and visual preferences using filters.



Example of line pairs per millimeter. When measuring true resolutions, these line pairs are measured with a spatial resolution gauge or pattern made of a high-contrast material.

Theoretical/actual resolution

In this digital age, we've probably covered some terms that you're already familiar with, such as pixels, contrast and resolution. A sharp, high-resolution image is preferable to something that's blurry and "low-res." Having already touched on pixels, let's take a closer look at the importance of spatial resolution, mentioned previously.

Spatial resolution is measured in line pairs per millimeter (lp/mm). Despite claims of very high lp/mm by some manufacturers, almost all competitive, high-quality sensors offer similar resolution. Instead of high lp/mm, doctors should take note as to whether a manufacturer makes claims of theoretical or true resolution.

Theoretical resolution is the maximum spatial resolution of an imaging system under ideal conditions, based solely on the number of pixels and pixel size of the sensor's detector. Therefore, theoretical spatial resolution is simply a calculated resolution.

However, in the real-world clinical environment, it's impossible to not have some noise, scatter and other factors that affect resolution in a radiographic imaging system. In contrast, actual or true spatial resolution factors in the components of the finished sensor, including sealants, shock layers, the scintillator and protective housing, as well as detector noise, to determine the measured resolution in lp/mm from an image acquired by the sensor. When purchasing a sensor, always ask if the lp/mm listed is the true or theoretical resolution for a better idea of what your radiographs will look like in a real-world situation.

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Conclusion

You may be able to hold an intraoral sensor in the palm of your hand, but the advanced technology that makes it work is truly remarkable. If you're new to digital, or even if you already use a digital sensor but are unhappy with the quality of the radiographs, ask questions about what makes a sensor tick: Does it include a fiber optic plate? What's the true resolution?

In the end, be assured you're getting the highest-quality radiographs for the best diagnosis possible. ■