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CsI vs Gadox for X-ray Imaging Applications

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If you've ever been to visit the dentist, you've almost certainly had at least one X-ray of your teeth. This is often done with an external X-ray source pointed towards your mouth, and a film-holder or special sensor placed inside your mouth to image capture the image. The imaging part is usually either a piece of traditional X-ray film, which stores the information and needs to be developed to show the image, or a digital imaging sensor. Such X-Ray imaging sensors have become increasingly common over recent years, as digital camera technology has advanced. Improvements have taken place in both their resolution and sensitivity, and such sensors have ease-of-use advantages such as connecting more seamlessly into digital workflows.

These so-called *Intra-Oral* (IO) X-Ray imaging sensors typically use a conventional optical CMOS camera sensor to capture the image, but need an additional conversion layer on the front to convert the X-rays into visible light which the sensor can then detect. This conversion component, coupled to the optical sensor, is known as a scintillator.

Many different materials scintillate, but the materials most commonly used for dental applications are Cesium Iodide (CsI) and Gadolinium Oxysulfide (Gadox or GadOx). Knowing which material is right for particular applications can be complicated, so here we look at the differences between these two technologies, their properties, and common use-cases for both.

Gadox

Gadox has a long history of being used as a scintillator for X-ray detection and Scintacor has been making devices based on such technology for over 30 years. The biggest advantage that Gadox has over CsI is its lower cost. Gadox can be spread on very large sheets of material or 'screens' which can be flexible and cut into almost any shape. CsI scintillating layers on the other hand are slowly grown on substrates in a vacuum deposition chamber. Such processes are costly to run and maintain.

Although generally lower cost, this benefit of Gadox comes at the expense of performance. Gadox typically has a lower spatial resolution and signal-to-noise ratio (SNR) than CsI for the same X-ray dose. This means that Gadox is more suited for low-cost, lower quality dental imaging sensors.

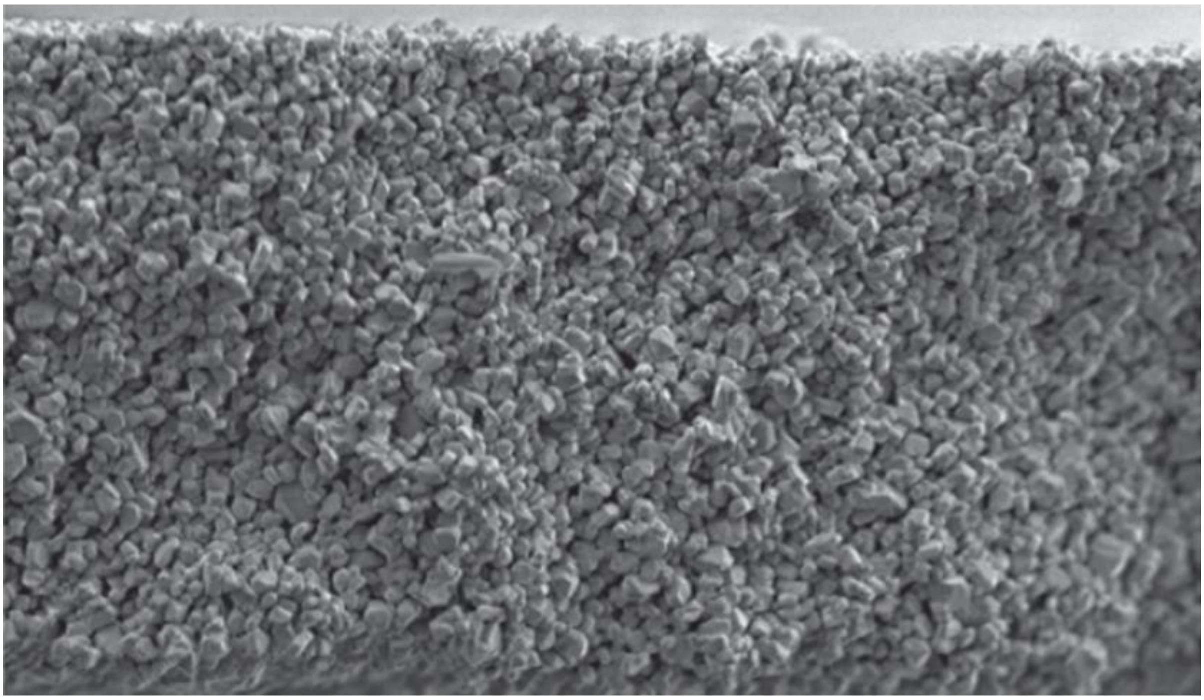

Figure 1 – SEM cross-section of a Gadox screen, showing the random arrangement of grains in the sample.

In recent years Scintacor has developed new Gadox products which consist of thinner layers, notably UltraFine, UltraFine Plus and HyperFine. These have a similar resolution to CsI for a given X-ray dose but suffer from a lower Signal to Noise ratio (SNR). To achieve the same SNR the X-ray dose must be increased. This means this technology is less sought after for human applications, where the dose needs to be minimised. For veterinary applications, non-destructive testing (NDT), or low-cost products, Gadox can be an attractive option.

CsI

Like Gadox, CsI has been used as a scintillator for many years, with a long history of X-ray detection. Scintacor has been making CsI-based products for over 20 years.

CsI is typically used in modern IO dental detectors, as it allows for a lower X-ray dose to be used to achieve the same spatial resolution and SNR as Gadox. A low dose is highly sought after for human applications, as reducing X-ray exposure can reduce the risk of developing cancer and other health complications later in life.

CsI manages to achieve a higher resolution than Gadox because under certain growth conditions it will form layers with a micro-columnar structure. Each needle-like column acts like a mini light-guide, channelling the light towards the sensor while reducing any scattering in the material, improving image resolution. The columns in CsI are very narrow, in the order of 1μm to 10μm diameter, thinner than a human hair, and smaller than the pixels in most sensors. This allows many columns to be mapped onto each sensor pixel.

CsI is more transparent than Gadox too, so thicker layers can be produced which still allow the light to reach the sensor. These thicker films absorb more X-rays, therefore giving an improved SNR, while the micro-columnar structure allows them to maintain a high spatial resolution.

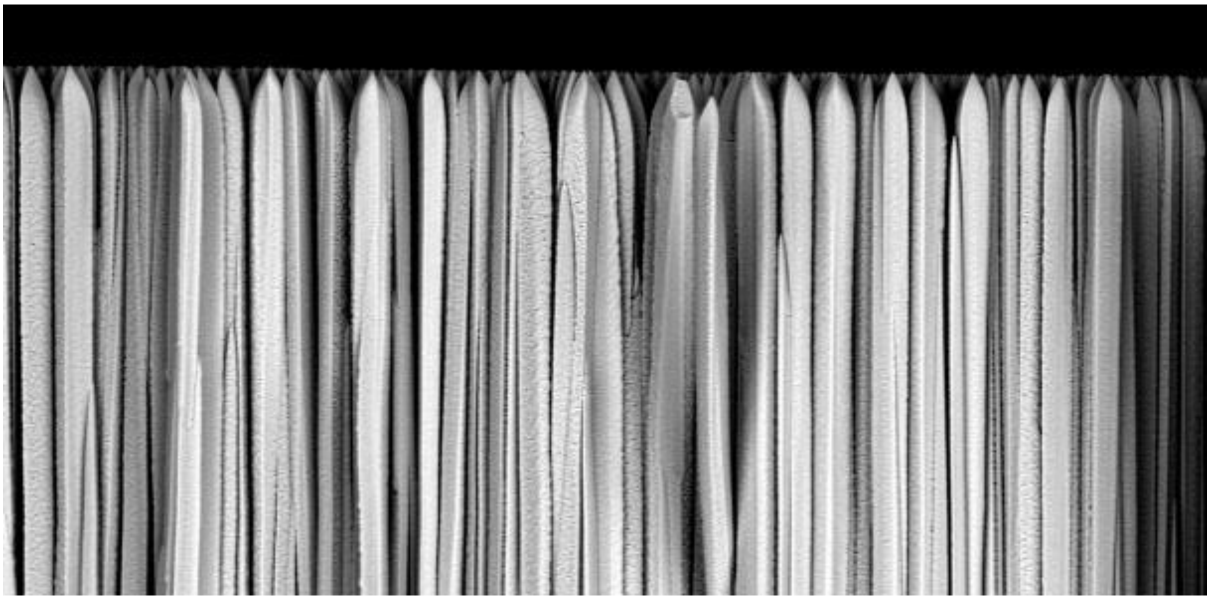

Figure 2: SEM cross-section of a columnar CsI film. Each needle-like crystal is less than 10μm wide.

CsI scintillators as large as 31cm x 31cm can now be produced by Scintacor, enabling higher resolution detectors for applications such as medical radiography and mammography. These applications have similar needs to the dental industry, where high resolution is critical for detecting early signs of cancer, and low dose is critical to minimise risk with repeat screenings, so they suit CsI detectors very well.