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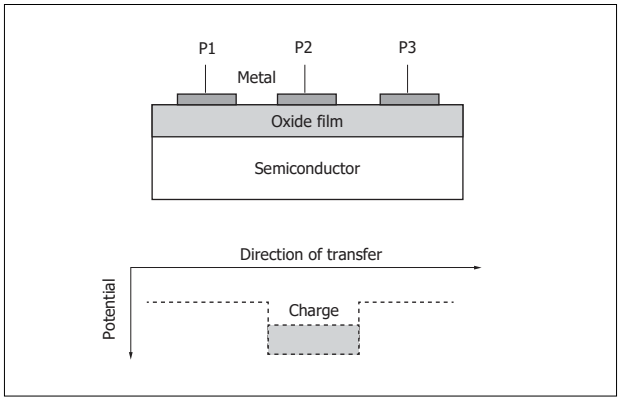
Advancing Imaging Technology with CCD Sensors

Advancements in semiconductor manufacturing, particularly the ability to create increasingly smaller and more efficient systems, have made image sensors integral to most people's daily lives. But what exactly is an image sensor?

Understanding CCD image sensors

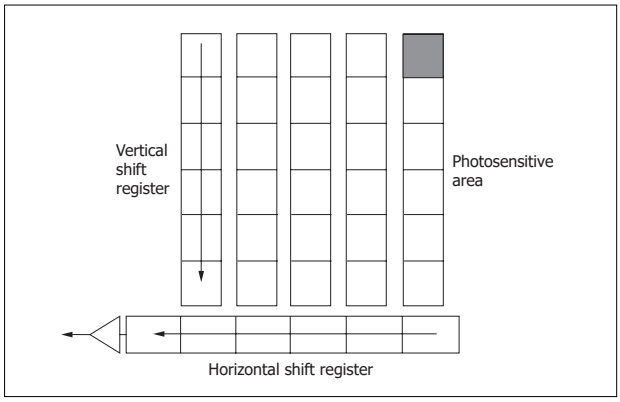
An image sensor is a device that converts light into an electrical signal, which can be processed, stored, and reproduced in the form of an image. These sensors are important across various fields of applications depending on their unique parameters. For instance, when highly resolved images are required, Charge-Coupled Devices (CCDs) are often the preferred choice. Their specificity lies in their ability to transfer accumulative charges collected in potential wells through one amplifier, as illustrated in Figures 1 and 2.

Figure 1: Schematic of a CCD sensor



One of the most prominent structures in CCD technology is the Full Frame transfer (FFT), which achieves a high pixel count without increasing the overall chip size. In this structure, the signal charge is collected in a potential well in the photosensitive area during the integration time and then transferred to the output section via the horizontal shift register. However, this configuration results in slow frame rates.

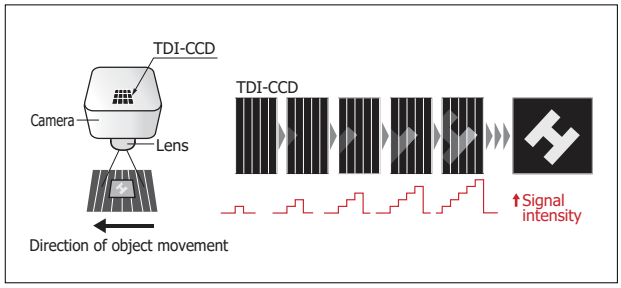
Figure 2: Charge collection through one amplifier



Addressing frame rate limitations: TDI-CCD solution

To address the frame rate limitations, Hamamatsu Photonics developed the Time Delay Integration CCD (TDI-CCD). In this system, the vertical transfer timing is synchronized with the movement of the object being imaged, allowing the signal charges to be integrated multiple times –equal to the number of vertical stages of the CCD pixels. In addition, this design requires only low-level light exposure. The operating principle is shown in Figure 3.

Figure 3: Operating principle of TDI-CCD

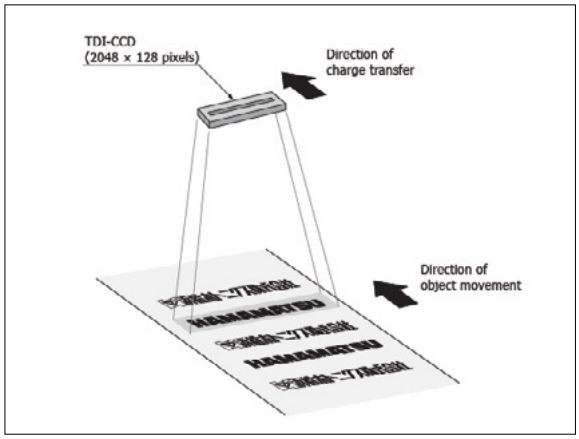


These sensors can capture fast-moving objects with high sensibility and low noise, even under low-light conditions. They operate across a broad spectrum, from visible light to ultraviolet (UV), and near-infrared (NIR), opening up new applications across a range of fields, from industrial processes to astronomy and medicine.

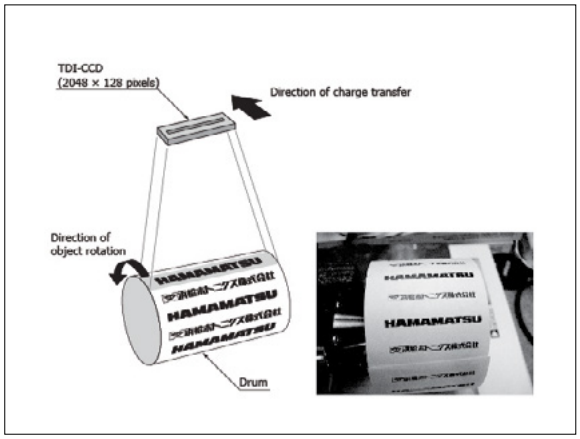
Hamamatsu's sensors are already in use across various industries. For example, they have been successfully used to image the rotation of drums in industrial processes, as shown in the images below.

Figure 4: Example of Hamamatsu's TDI-CCD in industrial applications

Imaging of fast moving object



Imaging of fast rotating object



Imaging in TDI operation (continuous image during drum rotation) in two-dimensional operation

a. When drum is in idle

b. When drum is rotating

c. When drum is rotating (with shutter time shortened)

The future of real-time imaging with FFT CCDs

The FFT CCD is a significant step forward in the real-time capture of fast-moving objects. If you are experiencing slow frame rates or transparency issues with your imaging systems, we encourage you to contact us.

This article highlights the advantages of CCD technology, particularly in high-speed applications, but if your needs differ, Hamamatsu offers a wide range of sensors suited for various use cases. Contact our sales team to learn more about the best image sensor for your specific application: info@hamamatsu.eu