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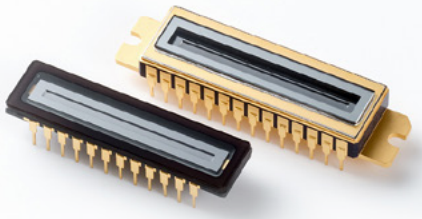

CMOS and its application in spectroscopy

Spectroscopy examines how matter interacts with electromagnetic radiation, revealing a substance's composition, structure, and physical properties. This essential technique is widely used in chemistry, physics, astronomy, and biology, with applications ranging from water analysis and identifying chemical compositions to studying astronomical objects. A vital component of spectroscopy instruments, and techniques, such as Raman spectroscopy, is the image sensor, with CMOS sensors gaining prominence for their ease of integration, high sensitivity, and capability for high-speed data acquisition. This has made the CMOS image sensor increasingly popular in spectroscopy.

Introduction to CMOS image sensors

An image sensor[1] is a device that captures light and converts it into digital signals, which can be processed, stored, and reproduced as an image. They consist of a pixel board that converts photons into electrical signals, a sensing node to amplify the charge and a convertor to translate analog to digital signals. The charge is transferred to the sensing node via the serial register. CMOS (Complementary Metal-Oxide-Semiconductor) technology is a type of image sensor that uses digital and analog circuits on the same chip. In other words, each pixel has its own transistor and amplifier, which allows it to convert light into an electrical signal independently. This design is more integrated and power efficient. The schematic of the CMOS structure is shown in Figure 1.

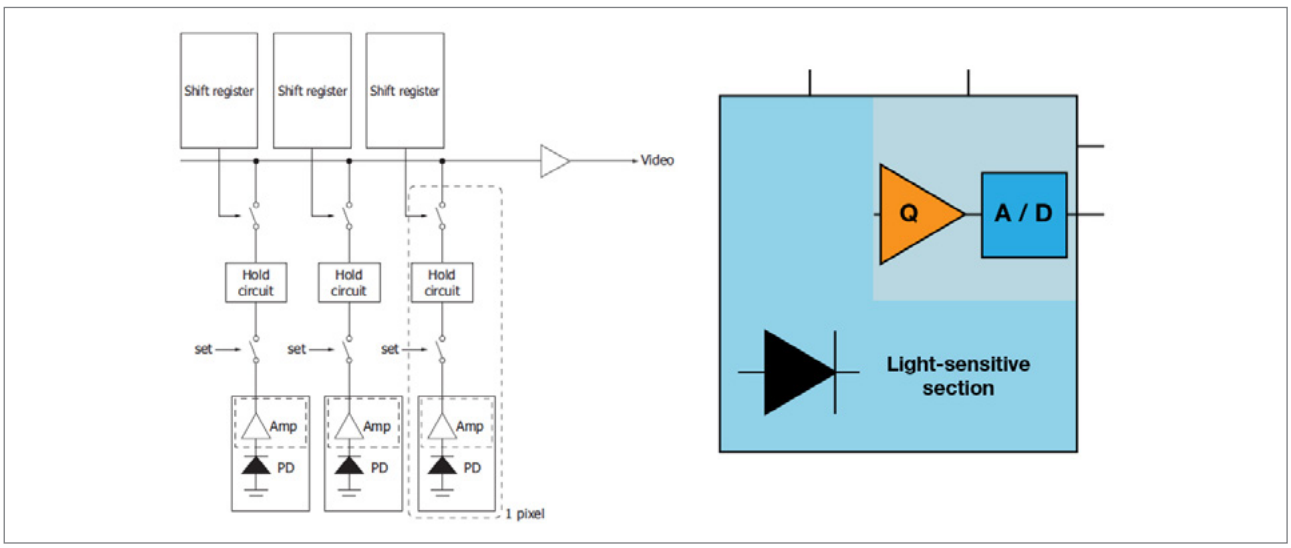

Figure 1: Typical CMOS structure: The light sensitive part (photodiode) and charge amplifier are integrated into each pixel

CMOS sensors in spectroscopy

The unique structure of CMOS technology provides distinct advantages that are valued in spectroscopy, including high sensitivity and high-speed data acquisition. Due to these qualities, CMOS sensors can detect the faint signals often encountered in spectroscopy and be used in real-time spectroscopy applications.

Sustainability in spectroscopy and advancements in on-chip technologies are important factors contributing to the rapid expansion of CMOS sensors. CMOS sensors are more energy-efficient than other sensors and offer easy integration, allowing them to adapt to evolving applications. Furthermore, the cost-effective manufacturing processes used to produce CMOS technology make CMOS-based spectroscopic devices more affordable.

Applications using Hamamatsu CMOS image sensors

Hamamatsu Photonics is a leading supplier of high-quality, high-performance, and cost-effective CMOS technology tailored for industrial, analytical, and spectroscopy markets. With extensive experience in photonics technology, including optics, electronics, mechanics, and software, we offer a wide product portfolio.

Spectroscopy instruments utilizing CMOS image sensors have become indispensable across various fields. One of the most well-known applications employing CMOS technology is Raman spectroscopy[2], used in medical diagnostics to identify biomarkers. Other spectroscopy instruments, commonly referred to as spectrometers, are employed to monitor water quality, analyze food composition, and oversee manufacturing processes.

CMOS sensors designed for spectroscopy and high-speed, in-line scanning are available. In addition, we can customize products to suit specific requirements.

Monitoring water quality

UV-Vis spectroscopy is an efficient method for online water analysis and monitoring water quality. Physical methods consist of spectral remote sensing technology in the UV and visible wavelengths. The principle of UV-Vis spectrophotometry relies on the correlation between the absorption of specific light wavelengths by a substance and its concentration[3]. Thanks to software particle compensation, spectrophotometry generally does not require sample filtrations. It is reagent-free and allows fast measurements of water quality in real-time. This method has been increasingly utilized in rapid water quality assessment in recent years. Hamamatsu's CMOS image sensor S10123-1024Q-0 is specifically designed for precision in water analysis and offers effective monitoring of water quality.

Explore our water quality solutions[4] >

Industrial processes – position detection

Hamamatsu has developed a variety of photosensors and light emitters, used for distance measurement, including in AGVs. AGVs (Automatic Guided Vehicle) keep from colliding with obstacles or workers by using lasers, optical sensors, MEMS mirrors, and other devices to measure the surrounding distance while driving automatically. These devices include CMOS linear image sensors. Inexpensive, compact and thin, CMOS linear image sensors are utilized in the triangulation method to allow position detection and object measurement. Hamamatsu's S10121-256Q-01 sensor is a good example of this.

Learn more about industrial applications[5] >

Food inspection

For UV-VIS imaging used in food inspection, we offer a selection of CMOS image sensors in linear and area arrays. Innovations in CMOS technology have made these image sensors easy to use because all essential signal processing circuits are formed on the sensor chip, and only simple input pulses and a single power supply are needed to operate them. Special features include:

- High sensitivity from UV to the near-infrared region up to 1100 nm. They are available in a variety of pixel configurations (from 128 pixels to 4,096 pixels), sensitivity, and line speeds.

- Availability in various array configurations, ranging from 30 x 30 pixels to 1,280 x 1,024 pixels. Designed to be integrated into cameras, CMOS area arrays offer imaging capability across a wide spectral range from UV to NIR.

CMOS sensors designed for spectroscopy and high-speed, in-line scanning are available. We can also customize products to suit specific requirements. Examples include our S9226-03 CMOS linear image sensor and S16101 CMOS image sensor.

Learn more about food safety and inspection[6] >

Further information on CMOS technology

The adoption of CMOS technology in spectroscopy has significantly enhanced the performance, affordability, and versatility of spectroscopic instruments. CMOS sensors have become integral in advancing various scientific and industrial applications, primarily due to their on-chip integration. Its applications are expected to grow, driving further innovations and discoveries. Engineers at Hamamatsu Photonics are ready to discuss the most suitable CMOS image sensors for your project or application.

Contact us at info@hamamatsu.eu or visit www.hamamatsu.com to start the conversation.

References

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