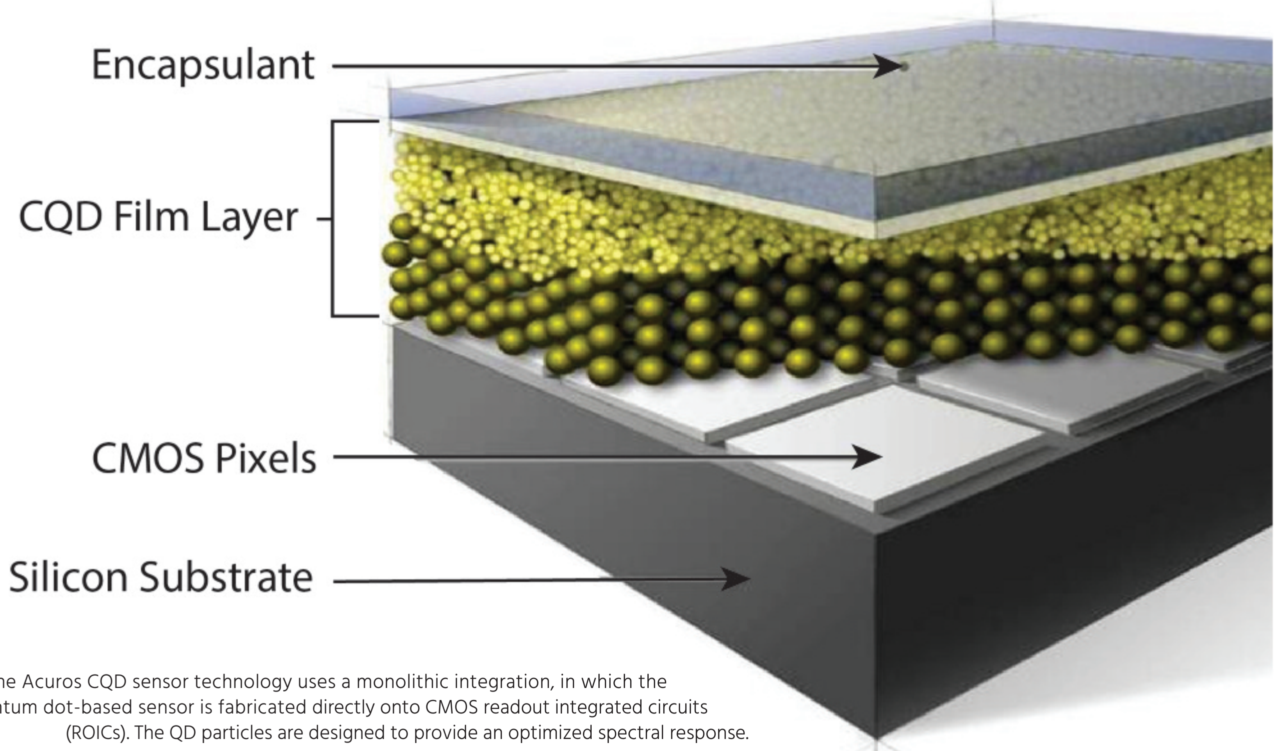
QD Full HD SWIR Imaging

Quantum Dot Sensor Technology for Full HD SWIR Imaging



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Quantum Dot (QD) technology is already commercialized for making large format, flat panel television displays. Setting off in a novel direction, SWIR Vision Systems determined to develop QDs for high performance infrared camera sensors.

QD-enhanced displays are beginning to displace LCD and OLED flat panels due to the valuable properties of QD semiconductor nano-particles. Measuring only a few nanometers in diameter, a quantum dot is quite literally a nano-sized semiconductor. Cadmium selenide, zinc selenide and other semiconducting materials with very narrow and tunable emission spectrums, are engineered to create a bright and brilliant colour response. Setting off in a novel direction, SWIR Vision Systems is determined to develop QDs for high performance infrared camera sensors. The goal of this work is to commercialize the world's lowest cost and highest resolution SWIR-band machine vision cameras. To accomplish this, the group synthesizes lead-sulfide (PbS) based QD nanoparticles, and processes these into very thin-layered photodiodes. The photodiodes and their underlying silicon CMOS circuitry form a novel photosensor, sensitive to light in the shortwave IR band. Unlike QDs for TV displays, which rely on a wavelength up-conversion process, PbS based photodiodes directly convert photons of incident light into electrons, which are subsequently read out by the circuitry within individual pixels. The QD particles are designed to provide an optimized spectral response tuned for the 400 to 1,700nm visible-SWIR wavelength band.

CQD Sensor Technology

These new sensors have the potential to leverage the scale and cost structure of the silicon integrated circuit industry, moving SWIR imaging from a specialized niche into broad commercial markets. Indium gallium arsenide (InGaAs) sensors, built on indium phosphide (InP) substrates, currently dominate the SWIR imaging market. However, this fabrication method imposes limitations on pixel size, pixel spacing, and sensor resolution; commercially practical InGaAs SWIR cameras are generally limited to VGA resolutions, and even these are considered too costly for most machine vision applications. With a new approach, the Acuros CQD sensor technology uses a monolithic integration, in which the quantum dot-based sensor is fabricated directly onto CMOS readout integrated circuits (ROICs) using well-established, low-cost semiconductor deposition techniques. The process requires no hybridization, no epitaxial growth or exotic substrate materials, no pixel-level sensor patterning, and can ultimately be scaled to wafer-level fabrication. SWIR Vision has already demonstrated photodiode arrays with pixel pitch as low as 3µm. The relative crystalline disorder of colloidal quantum dots currently results in lower quantum efficiency when compared to InGaAs cameras, which may make these cameras less suitable for photon-starved applications. However, in the majority of machine vision applications, a CQD sensor-based camera can be paired with relatively inexpensive active illumination, resulting in near InGaAs equivalent performance with a significant reduction in overall system cost.

Acuros Camera Family

The Acuros camera family features InGaAs equivalent noise, pixel operability greater than 99%, 15µm pixel pitch, and three different pixel array sensor formats (640x512, 1,280x1,024, and 1,920x1,080). The cameras are capable of imaging at speeds up to 380fps via GigE Vision and USB3 Vision. The HD camera's 2.1MP are 6.3 times higher clarity than today's InGaAs VGA cameras, providing users with richer imaging detail. The 1,920x1,080 high density arrays have pixels with 6 times smaller area than 640x512 VGA cameras directly improving spatial resolution and defect detection. The CQD SWIR camera sensors fabricated with low cost materials and CMOS-compatible fabrication techniques represent an advance towards broadly accessible high definition SWIR imaging. It is expected that the camera's lower cost points and its non-ITAR, EAR99 export classification to drive higher adoption rates globally, broadening the market for SWIR camera technology.

Applications

Silicon wafer inspection is an important application that can clearly leverage this new capability to see smaller features. The CQD cameras can be used to illuminate silicon wafers for: identifying front-to-back alignment marks, detecting voids in bonded wafers, imaging of for backside dicing, visualizing and detecting sub-surface cracks, and inspecting wafers for buried features, to name a few. Vision systems designed to inspect solar cells, glass bottles, and hosts of other industrial parts will now also see more. This higher resolving power can also be used to broaden the field-of-view, where machine vision cameras may now be configured to image both small and large format objects at the same imaging distance, with superior spatial resolution. Additional applications for the CQD cameras include: accurately identifying fill levels of transparent and opaque containers, inspection of embedded electronics, detection of moisture levels in packaged products, thickness and void detection on clear coat films, glass bottle imaging, bruise detection in fruits and vegetables, inspection of lumber products, detection of water/oil on metal parts, chemical analysis, imaging through smoke and mist environments, surveillance and security monitoring, crop monitoring, glucose monitoring and many more. ■

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