PHOTONICS

# How Photonics Can Transform Sensing for Imaging Systems

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IMAGE: TRIEYE

From medical diagnostics to autonomous vehicles and robotics, photonics is transforming how we perceive and interact with our world by enabling cameras that can capture images with an unprecedented level of detail. Using photonics principles like compressive sensing and computational imaging algorithms, these advanced cameras capture multiple low-resolution images from different angles and combine them into one high-resolution image. The resulting imagery showcases how photonics can enhance resolution capabilities beyond those offered by conventional cameras.

MIT researchers have demonstrated the role of photonics in improving medical imaging by employing a laser-induced ultrasound technique to create detailed images of biological tissue without invasive procedures or ionizing radiation exposure.[1] The technique uses laser pulses to generate ultrasonic waves that are detected by optical sensors, allowing for precise visualization within tissues beneath the surface. Photonics-enabled medical imaging techniques like this one hold immense potential for early disease detection, guiding surgical interventions with higher accuracy and monitoring the effectiveness of treatments.

Emerging solutions for automotive and robotics, meanwhile, include TriEye's CMOS-based short-wave infrared (SWIR) image sensors and Coherent's solid-state laser diodes. The companies recently teamed up to demonstrate a laser-illuminated SWIR imaging system for applications like front and rear cameras in cars as well as vision systems in industrial and autonomous robots.

## PHOTONICS-BASED SWIR IMAGE SENSOR

TriEye is bringing SWIR to mass production with Raven, a high-definition CMOS-based SWIR image sensor, and UltraBlaze, an eye-safe SWIR pulsed laser illumination source. "Developed through nearly a decade of nanophotonics research, Raven utilizes existing high-volume fabrication tools to create a scalable and cost-effective CMOS-based sensor with high resolution," TriEye co-founder and CEO Avi Bakal told EE Times Europe.

UltraBlaze, meanwhile, enables long-range night vision and depth measurement while remaining safe for human eyes, operating at much higher optical power per pulse than traditional visible or near-infrared (NIR) illumination sources, according to TriEye.

These components form the basis of TriEye's Sedar (spectrum-enhanced detection and ranging) platform, which the company claims delivers HD imaging and deterministic 3D information under all weather and lighting conditions. According to TriEye, Sedar differs from traditional

*TriEye's Avi Bakal*


*TriEye's Sedar sensing solution* (Source: TriEye)

LiDAR systems in that its "significantly higher" resolution enables objects to be detected and classified at greater distances. Operation in the SWIR spectrum gives Sedar the ability to see through fog, haze and rain while remaining resilient to ambient noise. Moreover, Sedar's depth-calculation-per-pixel approach enhances perception systems' ability to assess relative distances accurately, all without moving parts, the company says.

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"The Sedar platform enables mass markets to tap into the benefits of SWIR sensing, gaining advanced capabilities that were not previously available [to them] due to the prohibitive cost," Bakal said. "Sedar is highly customizable and can be tailored to solve sensing challenges in automotive, emerging industrial [applications], robotics and more."

A key consideration for applications in automobiles and robotics is power efficiency. TriEye said it has addressed this concern by ensuring that its Raven CMOS-based SWIR sensor operates at extremely low power levels, rivaling other commercial CMOS sensors. This ensures optimal performance without significantly impacting battery life in mobile systems, according to the company.

Talking about TriEye's collaboration with Coherent, Bakal said, "SWIR sensing can provide localization, mapping, collision avoidance and safety, allowing us to interact with our environment in ways that we have only imagined until recently."

## LASER-ILLUMINATED SWIR IMAGING

In the realm of optical communications, semiconductor laser diodes find their place in data centers and telecom networks, enabling efficient transceivers and optical amplifiers. Coherent, a provider of photonic and compound semiconductor solutions, has partnered with TriEye to provide semiconductor laser diodes tailored for the Sedar platform. The SWIR laser-illumination module addresses the limitations of current LED-based modules, extending the capabilities of SWIR imaging solutions.

Coherent builds its semiconductor diode lasers using gallium arsenide, indium phosphide and gallium antimonide materials to address a wavelength range covering the NIR, SWIR and mid-infrared (MIR) spectra from 750 nm to 3 µm. It offers a range of laser diode architectures, including edge-emitting lasers (EELs) and vertical-cavity surface-emitting lasers (VCSELs).

"We recognize the emerging ecosystem of SWIR sensing, which presents numerous benefits compared with sensing in the NIR wavelength range," said Gerald Dahlmann, senior director of marketing for consumer electronics at Coherent. For example, Sedar, operating in the SWIR wavelength range of 1,300 nm to 1,400 nm, offers advantages over traditional LiDAR-based systems, including improved signal-to-noise ratio in outdoor environments, higher eye safety (due to reduced light absorption by the human retina) and enhanced visibility through mist or dust.

"SWIR light interacts differently with matter compared with NIR light," Dahlmann said. "This unique characteristic allows for enhanced visibility through mist or dust, making objects visible that would otherwise remain invisible in the NIR range of the optical spectrum."

Traditional SWIR-range LEDs are inefficient and offer low optical output power. Coherent claims its laser-illumination module contributes to the expansion of the SWIR ecosystem by providing a compact, reliable and efficient light source that delivers 2 W of optical output.

Coherent and TriEye believe their collaboration will open up new applications for SWIR imaging. In robotics applications, SWIR imaging plays a key role in localization, mapping, collision avoidance and overall safety. Industries can benefit from SWIR imaging to optimize performance and efficiency in farming and construction machinery, while security systems can achieve improved accuracy and reliability.

*Coherent's Gerald Dahlmann*

Efficiency is a critical factor in applications with limited power supply, such as automobiles and robotics. SWIR lasers currently offer 20% to 30% efficiency. Coherent said its priority is to maximize the efficiency of its lasers, improving performance over time as technology advances and the gap with NIR lasers narrows. ■

## REFERENCE

[1]Chu, J. (Dec. 19, 2019). "Researchers produce first laser ultrasound images of humans." Massachusetts Institute of Technology. *tinyurl.com/2pbxtmtn*