

Miniature Dual-Wavelength Camera Using InGaAs Focal Plane Arrays

Camera simultaneously images visible and shortwave infrared light.

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The recent development of indium gallium arsenide (InGaAs) focal plane arrays (FPAs) capable of imaging visible and shortwave infrared (SWIR) wavelengths has yielded a miniature dual-wavelength camera with no moving parts that weighs only 11 ounces, consumes less than 1.6 W of power, and operates at room temperature.

Capable of simultaneously imaging the visible and SWIR spectrum, the all solid-state camera can replace complex systems that previously required two cameras. Having a dual wavelength FPA in one camera decreases payload weight and size and simplifies image-fusion systems. The on-board non-uniformity corrections (NUCs) help make this compact imager simple to use and suitable for many applications in industrial machine vision, laser-beam profiling, and military imaging. Additionally, this camera outputs 12-bit digital RS-422 signals and EIA-170 analog video; the latter can be displayed on commercial TV monitors.

The camera's key element is a 320x240-pixel, backside-illuminated, substrate-removed, InGaAs photodiode array. In the traditional epitaxial structure for InGaAs PIN photodiodes, the absorption region is topped off with an InP cap. Unlike a frontside-illuminated format where light passes through the InP cap to reach the InGaAs absorption region, light in a backside-illuminated format must pass through the InP substrate to reach the pixel's active region — the InGaAs layer. Thinning or removing the InP substrate achieves increased quantum efficiency in the visible band because more visible light reaches the InGaAs absorption layer. Normally, visible light would be absorbed by the InP substrate because of its 920-nm cutoff. It is the absorption of wavelengths below 920 nm in the InP, not the capabilities of InGaAs itself, that has limited InGaAs FPAs' wavelength range to only the SWIR. The backside-illuminated, dual-wavelength FPA used here has just enough InP from the epitaxial growth process remaining to passivate the InGaAs surface and provide a contact layer for the frontside common-cathode contact to the ROIC. The result of the substrate removal process is an FPA consisting of just the epitaxial layers bump-bonded to a CMOS ROIC.

Using both wet etching and mechanical thinning produces a thinner InP contact layer than that which can be achieved using mechanical thinning alone. A thicker layer of InP can lead to imaging artifacts, such as image retention and high-pixel crosstalk from InP fluorescence. Combining the two methods also improves production capacity and uniformity between chips, which is critical for applications in both industry and defense where cameras must be reliable, delivered on time, and have consistent performance. Mechanical thinning on its own can lead to variations in a single device as well as dif-



Figure 1. InGaAs-Based MiniCamera can perform tasks that previously required two cameras and complex system integration.

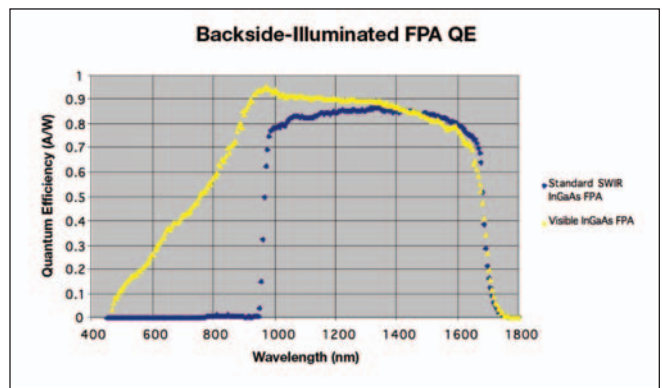


Figure 2. Backside-Illuminated FPA QE Graph

ferences between devices. Utilizing the epitaxial layers also contributes to a consistent and reproducible manufacturing process where the visible response can be successfully repeated from device to device.

The quantum efficiency of the FPAs used in the Visible-InGaAs MiniCamera exceeds 70% in the 1000 nm to 1600 nm portion of the spectrum. Efficiency tops 50% at 800 nm and 10% at 500 nm (see Figure 2). The FPA's high-responsivity in both the visible and SWIR wavelength bands allows the camera to assist in hyperspectral imaging, semiconductor wafer inspection, astronomy, and imaging of most laser pointers, designators, and range finders.

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