New SWIR Product Introduction from SUI

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ABSTRACT

Sensors Unlimited, Inc. (SUI), a Raytheon Company, introduces its latest infrared imaging products, focusing on two new camera systems: a 10 µm pixel-pitch, high-definition (HD) camera and a VGA, high-speed camera, both cameras offering superior low-noise capabilities. This work will cover the key technical features, including sensitivity, dynamic range, and frame rates, along with their potential applications. Additionally, it will highlight the potential expansion of the product line to meet future market needs, ensuring that SUI remains at the forefront of infrared imaging technology.

Keywords: SWIR, Time-of-Flight, ALPD, Shortwave, Infrared, IR, HD, Camera, ROIC

1. INTRODUCTION

Sensors Unlimited, Inc. (SUI) is a leading provider of shortwave infrared (SWIR) imaging products based on advanced InGaAs technology. Founded in 1991, the company pioneered the development of indium gallium arsenide (InGaAs) sensors, revolutionizing SWIR imaging for military, industrial, and scientific applications. Over the past three decades, SUI has consistently developed high-performance SWIR cameras, offering advanced capabilities such as high sensitivity, extended dynamic range, and low-noise operation.

Now part of Raytheon, SUI continues to push the limits of SWIR imaging technology. Through a combination of performance improvements and new feature integration, SUI's latest camera offerings are playing a crucial role in vision enhancement, target acquisition, hyperspectral imaging, and laser tracking. The following cameras represent the latest additions to the SUI portfolio:

- 1280JSX-10µm High-definition, ultra-low noise imaging, 10 micron pixel pitch.
- 640HSX2 High sensitivity, high frame rate imaging.

This paper details the performance, features and potential applications for these new cameras.

2. SUI 1280JSX-10µM

Overview

High-definition SWIR cameras emerged over a decade ago as the camera of choice for critical security and surveillance applications. Advancements in materials, pixel architecture, and readout circuitry drove the camera performance to a point where it could provide clear video from broad daylight down to starlight conditions, relying only on night glow to illuminate the scene[1]. At that time, a pixel pitch in the 25-50µm range was typical, with a drive to sub-15µm to support larger HD sensors. The SUI 1280JSX debuted around that time, offering a novel 12.5µm Buffered Gate Modulated (BGMOD) pixel, shown in Figure 1, capable of continuously variable gain while still delivering low noise HD video.[2]

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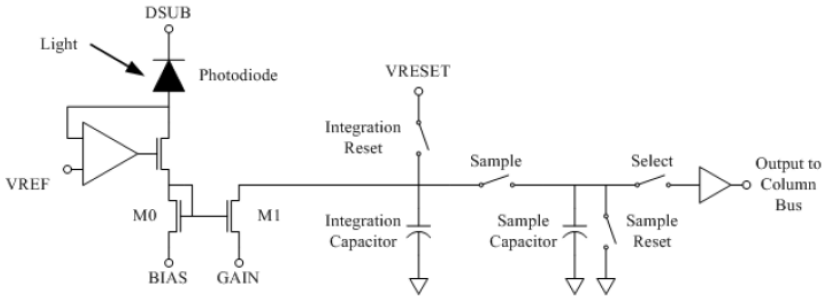

Figure 1: Simplified Schematic of the Buffered Gate Modulated Pixel Amplifier

Carrying on this trend, SUI has continued to reduce the size of the BGMOD pixel, while simultaneously improving overall focal plane performance. The SUI 1280JSX-10µm camera, shown in Figure 2, is a snapshot SWIR camera designed for high definition, ultra-low noise imaging at high frame rates. Like it's 12.5µm predecessor, this new 10µm pixel uses a similar BGMOD architecture to provide infinitely variable gain and integrate-while-read frame capture. However, the 1280JSX-10µm has several key improvements over the original JSX camera.

Figure 2: SUI 1280JSX-10µm Camera

As the name implies, the primary improvement in the 1280JSX-10µm is its reduced pixel size. The pixel layout was redesigned to fit into a 10µm square pixel, while still maintaining 100% fill factor. The benefit of the smaller pixel pitch is two-fold. First, the higher pixel density provides a significant improvement to the sensor's modulation transfer function (MTF). For example, an MTF of 50% is observed at a spatial frequency of 30 line-pairs per millimeter on the 1280JSX-10µm, compared with 23 line-pairs per millimeter on the 12.5µm. Second, the smaller pixel pitch results in a 36% reduction in the active area of the sensor, which facilitates the use of smaller, lighter, and less costly optics.

In addition to the pixel changes, several improvements were made to enhance the overall performance of the 1280JSX-10µm camera. While spectral response, fill factor and dynamic range have been maintained, total camera noise has been reduced by 42% to 20 electrons, with potential for further reduction in some specialized applications. This further enhances the camera's ability to image in photon-starved environments. Additionally, the readout circuitry has been improved to provide high speed imaging at increased frame rates. By default, the camera's full field of view is read out at 60 frame per second, but windowing options allow the frame rate to be increased up to a maximum of 9,092 frames per second.

Performance

The 1280JSX-10µm is designed to provide low noise, high resolution shortwave infrared imaging. The camera's key performance specifications are outlined in Table 1.

Table 1: SUI 1280JSX-10µm Performance Specifications

Focal Plane Array Format	1280 x 1024 pixels
Pixel Pitch	10 µm
Active Area	12.8 mm x 10.3 mm
Maximum Frame Rate (Full FOV)	60 fps
Maximum Frame Rate (2x1024 FOV)	9092 fps
Fill Factor	100%
Spectral Response	0.5µm to 1.7µm
Quantum Efficiency (0.7µm to 1.6µm)	≥ 65%
Mean Detectivity	2.8 x 10^{13} cm√Hz/W
Noise Equivalent Irradiance	1.5 x 10^{9} photons/cm2×s
Noise (typ.)	20 electrons
Dynamic Range	1850:1
Power Consumption	3W @ +20°C 10W max

Applications

The SUI 1280JSX-10µm camera is designed for a wide range of applications that benefit from high-speed, high resolution SWIR imaging. Some of these applications include:

- Defense & Security
  - Target Acquisition and Tracking: The JSX provides real-time SWIR imaging for battlefield surveillance, drone detection, missile and vehicle tracking.
  - Enhanced Vision: Operation in low-light conditions, penetration through atmospheric obscurants.
- Remote Sensing
  - Satellite/UAV Imaging: High resolution images can be used for terrain analysis and resource mapping.
  - Atmospheric Monitoring: SWIR images provide information on water vapor and aerosol concentration in the atmosphere, improving weather forecasting and climate research.
- Inspection
  - Silicon Wafer Inspection: JSX high resolution imaging can be used to inspect wafers for cracks and defects, and check alignment of layers.

3. SUI 640HSX2

Overview

The SUI 640HSX2 camera, shown in Figure 3, is a high-performance SWIR camera developed for applications requiring high sensitivity and high frame rate. Based on the original 640HSX camera, this new version carries on the legacy of the HSX family's highly sensitive 25µm pixels, while making significant improvements in frame rate.

Figure 3: SUI 640HSX2 Camera

The 640HSX2 has been updated with a state-of-the-art multi-channel high speed digitizer, allowing for the full field-of-view frame rate of 120 frames per second, a 4x improvement over its predecessor. In addition, the frame rate can be further increased by reducing the field of view, with a maximum frame rate of 30,000 frames per second for a 16x8 pixel window. This makes the 640HSX2 ideal for acquisition and tracking applications, where a wide field of view is initially needed for target acquisition, and high frame rate is needed for high-speed tracking.

In addition to high frame rate operation, one of the key advantages of the 640HSX2 is its high sensitivity. With its ability to capture clear images in low-light conditions, it is well suited for applications like surveillance, hyperspectral imaging, and laser tracking.

Performance

The SUI 640HSX2 is designed to provide high speed shortwave infrared imaging in low light conditions. The camera's preliminary performance specifications are outlined in Table 2.

Table 2: SUI 640HSX2 Preliminary Performance Specifications

Focal Plane Array Format	640 x 512 pixels
Pixel Pitch	25 µm
Active Area	16.0 mm x 12.8 mm
Maximum Frame Rate (Full FOV)	120 fps
Maximum Frame Rate (16x8 FOV)	30,000 fps
Fill Factor	100%
Spectral Response	0.5µm to 1.7µm
Quantum Efficiency (0.7µm to 1.6µm)	≥ 65%
Mean Detectivity	4.2×10^{13} cm√Hz/W
Noise Equivalent Irradiance	2.1×10^{8} photons/cm^2×s
Noise (typ.)	35 electrons
Full Well (in lowest sensitivity mode)	12×10^{6} electrons
Dynamic Range	4000:1
Power Consumption	3.8W @ +20°C 7.5W max

Applications

The SUI 640HSX2 camera is designed for a wide range of applications that benefit from high sensitivity, high dynamic range, and high frame rate SWIR imaging. Some of these applications include:

- Defense & Security
    - Target Acquisition and Tracking: Capturing fast moving objects especially in environments where lighting conditions can vary significantly.
    - Remote sensing: Ideal for high-speed events and rapidly changing scenes with variable light conditions.
    - Night Vision and low light imaging: High dynamic range and sensitivity make the HSX2 ideal for operations in these conditions.
- Commercial
    - Cockpit displays and heads-up displays: Clear imagery in varying lighting conditions on fast moving aircraft or vehicles.
    - Industrial inspection: Detecting defects in reflective or transparent materials in high contrast scenes.
    - Machine Vision: High speed manufacturing operations and reflective materials.
- Automotive
    - Advanced driver assistance systems and autonomous vehicles: Improving reliability and safety in challenging environments, and visibility through obscurants.
    - Traffic surveillance: Operation in low-light conditions, tracking high speed vehicles, and clarity in varying light conditions.

4. EXPANDING THE TECHNOLOGY

While the 1280JSX-10µm and 640HSX2 cameras provide exceptional SWIR imaging performance, SUI is always looking for opportunities to enhance these products and provide more value to the end user. Several ongoing development efforts have potential to be incorporated into these cameras in the future.

Among these efforts is the incorporation of pulse detection circuitry into each pixel circuit. This functionality can be adapted to capture synchronous events like Time of Flight (ToF) measurements, or asynchronous events like Free Space Optical (FSO) communication and Asynchronous Laser Pulse Detection (ALPD)[3,4].

Detector material improvements will pave the way for imaging beyond the SWIR band and into the Extended SWIR, or eSWIR range. Current development efforts are focused on InGaAs variants with cutoff frequencies at 2.2µm and 2.6µm.

5. CONCLUSION

This work introduced SUI's latest infrared imaging products including the 1280JSX-10µm and the 640HSX2. 1280JSX-10µm is a HD SWIR imager with a 10µm square pixel while the 640HSX2 is a high-performance SWIR camera for high sensitivity and high frame rate applications. The performance specification and applications of each new offering are described herein. SUI continues to explore opportunities to expand these product lines to meet future market requirements and remain a leader in SWIR imaging products.

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