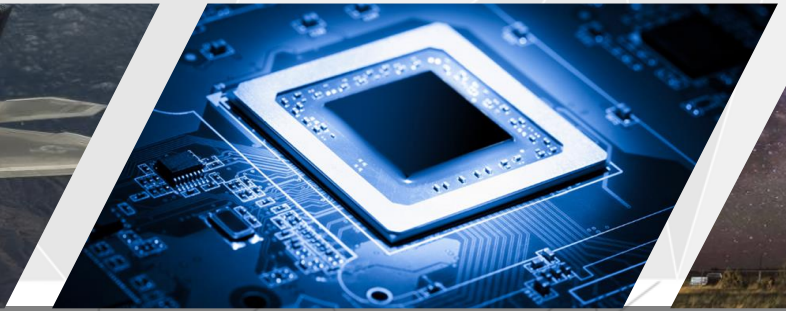
ALPHACORE

ROBUST HIGH-PERFORMANCE MICROELECTRONICS

“Ultra-Rad-Hard HD Image Sensor and Camera for Rare Isotope Beam Facilities”

Contract #: DE-SC0023654

DOE SBIR/STTR Phase II, Year 1 Summary



About Alphacore

Standard and customized IP

Global operation based in the U.S.

Our focus areas are:

Analog, Mixed Signal and RF Solutions

Imaging Solutions

Rugged, Radiation Hardened Electronics

Program

Technology Need:

For the SBIR solicitation topic C55 23, Rare Isotope Beam Production Technology, the subtopic e. states the following need: “Compact digital imaging systems are sought for beam and target system diagnostic applications. Sensor should be capable of **HD image resolution**, and demonstrate usable sensitivity from **440 nm to >1000 nm**. Sensors and electronics should be functional through integrated doses of **>1 MRad**, with functionality up to **100 MRad** preferred.”

Motivation for the Work

Commercially available cameras are vulnerable to radiation effects

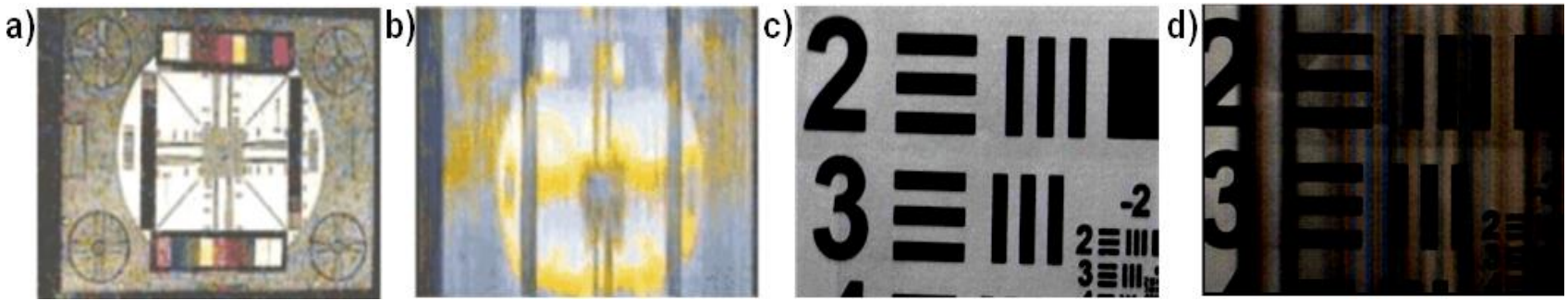


Figure 1: a) CCD image before irradiation and b) after 30krad(Si), c) image taken with a commercial high-speed camera at Alphacore after 0 krad(Si) and d) after 3.2krad(Si).

Camera System Architecture

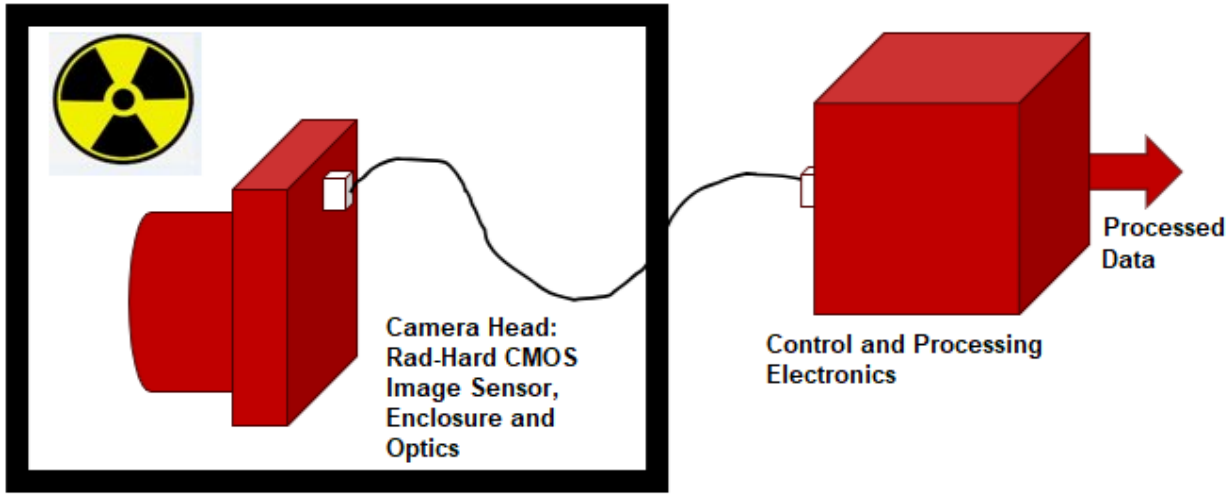


Figure 2: In this configuration the camera enclosure contains the custom-hardened Vulture-HD image sensor and the data is transferred to the FPGA board that is in a less harsh radiation environment. This type of configuration is used in Nuclear reactor inspections, as an example.

Camera System Architecture

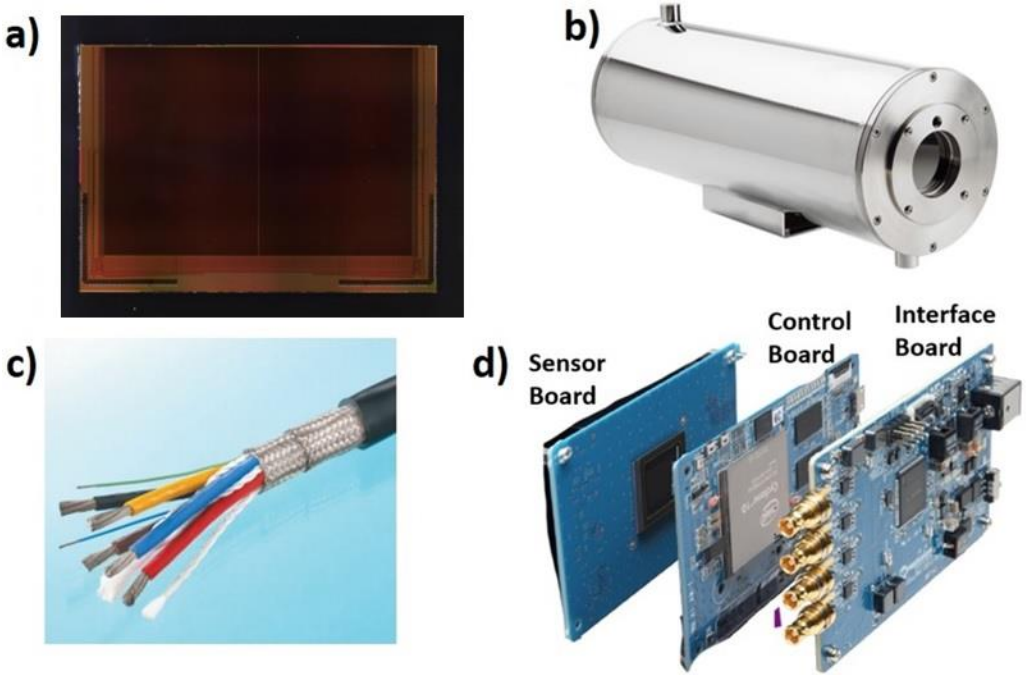


Figure 3: Alphacore's camera system contains: a) custom-designed and hardened CIS, b) customized steel enclosure, c) radiation-hard cable (125ft), and d) FPGA / COTS IC based camera control / data capture / data transfer module designed on PCBs (i.e. "the Camera System")

Increased NIR Sensitivity

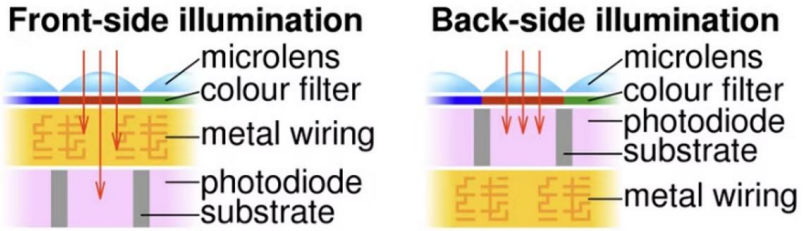


Figure 4: As compared to BSI pixels, the conventional FSI pixels have much lower fill factor, arising from the chip metal wiring layers being on the path of the light.

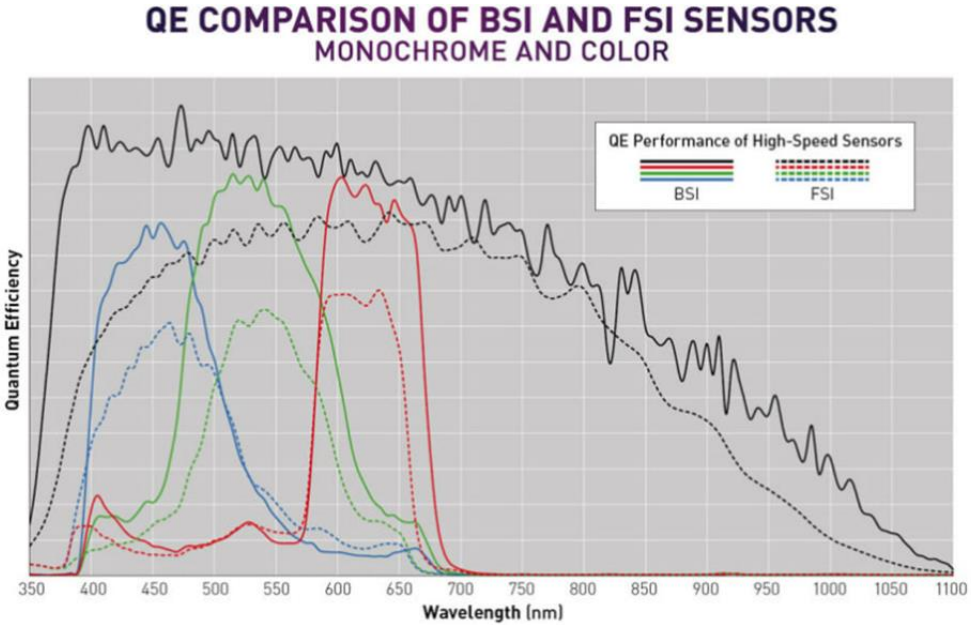


Figure 5: Compared with FSI sensors, BSI sensors achieve a higher quantum efficiency (QE) throughout the visible light and NIR spectrums[1].

[1] https://www.techbriefs.com/component/content/article/39826-backside-illumination-gets-fast

Key Circuit Blocks: SLVS Interface

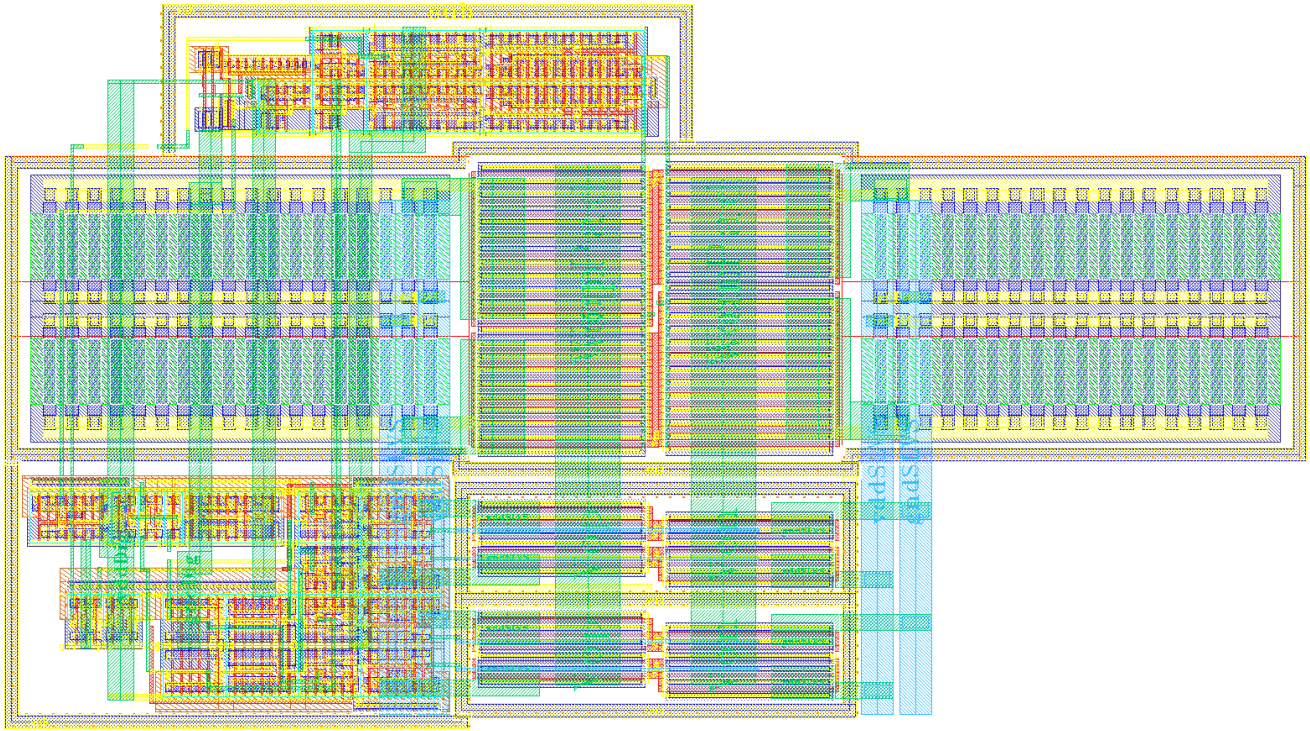


Figure 6: Layout of the Whole SLVS circuit (LVS and DRC clean)

Key Circuit Blocks: 14-bit Ramp Generator

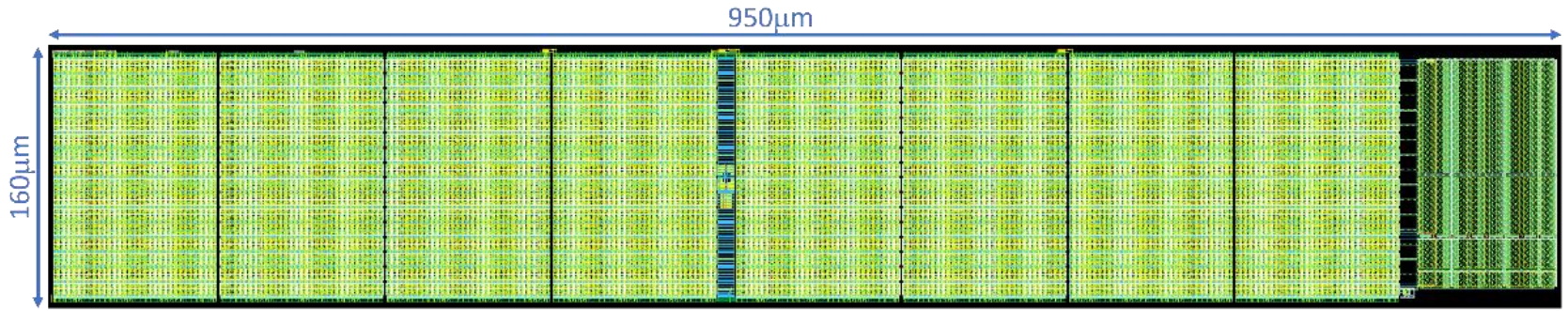


Figure 7: 14-Bit Ramp Generator Top Level Layout (LVS and DRC clean)

Key Circuit Blocks: Full Chip Floorplan

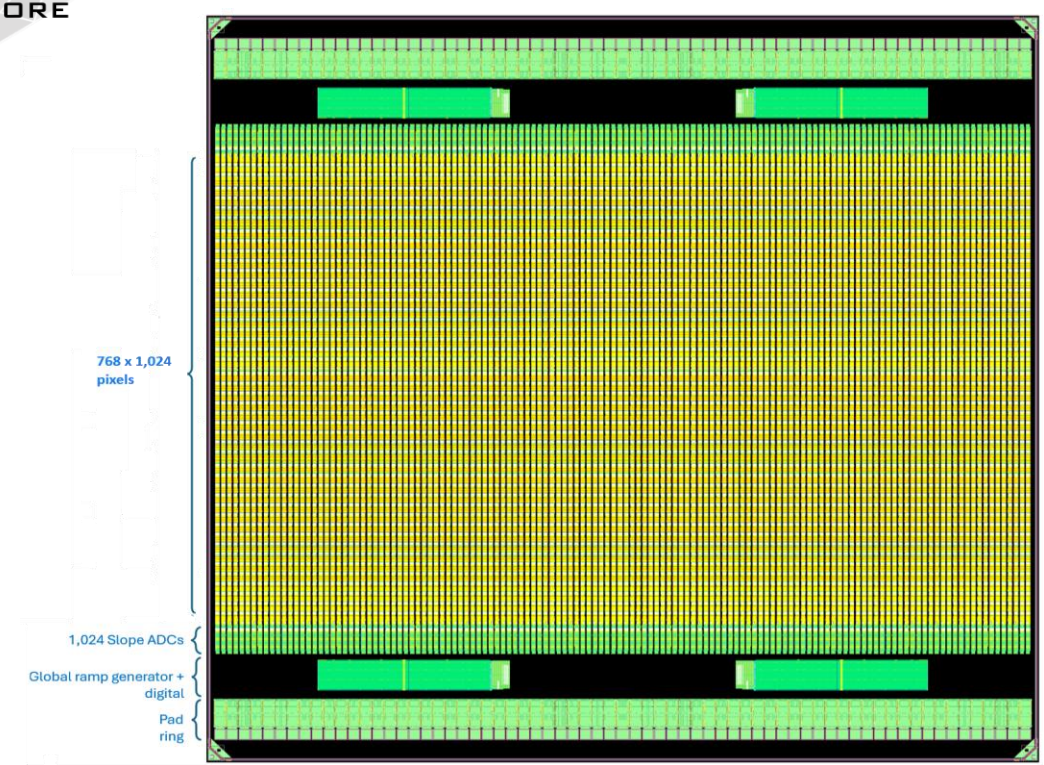


Figure 8: 1024 x 768 Image Sensor Floorplan

Alphacore will be ready for tapeout by the end of 2025

Phase II Objectives

Objective 1: Design a Radiation Hardened VIS-NIR Image Sensor (Year 1)

Objective 2. Fabricate, Package and Characterize VIS-NIR Image Sensors (Year 2)

Objective 3: Integrate and Test the Complete Vulture-HD Camera System, Including Radiation Hardness Evaluation (Year 2)

Summary

- Alphacore has been working on a rad-hard camera with 1,024 x 768 resolution, usable sensitivity from 440 nm to >1000 nm and functional through integrated doses of >1 Mrad.
- First, smaller version has been tested for 500krad and 1e-14 n/cm2 with good functionality.
- Final sensor is scheduled for tapeout by the end of 2025.
- Full camera delivery is expected for Q3 2026.
- We want to thank DOE Nuclear Physics for this opportunity, and especially Dr. Michelle Shinn, Dr. Manouchehr Farkhondeh and Dr. Steven Lidia.

Questions?

Contacts:
Presenter: Esko.Mikkola@alphacoreinc.com
Business: Rusafa.Shahreen@alphacoreinc.com

Thank You !