SAND2018-3997C

Sandia National Laboratories

High-Speed Solid-State X-ray Framing Camera Improvements and Performance Testing

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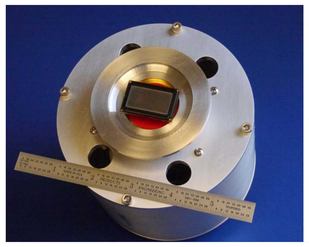
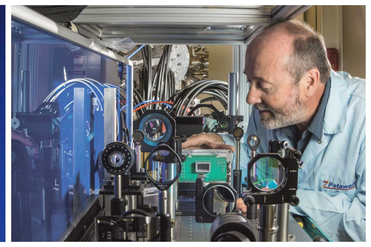
The Icarus sensor is the newest version of the hybrid-CMOS high-speed x-ray framing camera that has been under development at Sandia for over a decade. Icarus can store 4 images per pixel, has improved soft x-ray detection sensitivity, and an option to independently trigger each half of the sensor to effectively operate as two closely-spaced framing cameras with 1024x256 pixels each. Icarus maintains the 25µm pixel pitch, nearly 100% detector fill factor, and sub-2ns minimum integration time of our previous sensors: Griffin, Furi, and Hippogriff. We use a combination of pulsed visible and x-ray sources to measure the sensor performance. Results will be presented of gate time profiles for a variety of timing configurations, frame-to-frame cross talk, trigger jitter and insertion delay, spatial resolution, pixel response uniformity, dynamic range, and absolute x-ray sensitivity. We will also describe recent measurements of sensor performance when illuminated with multiple closely-spaced light pulses and with continuous illumination spanning multiple frames to determine effective on/off rejection ratios.


Icarus hCMOS sensor mounted on vacuum PCB


hCMOS system test station using visible laser light at 532nm


Pulsed laser used for hCMOS x-ray characterization studies

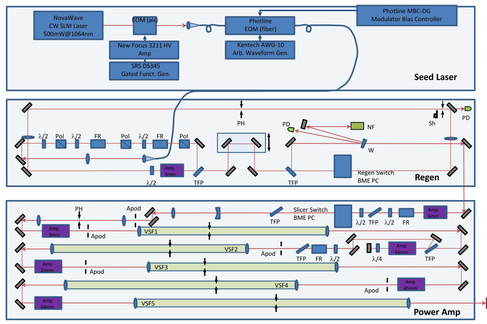
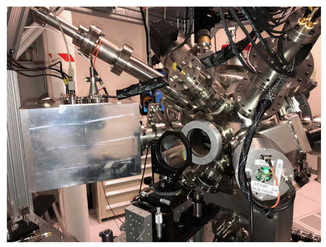
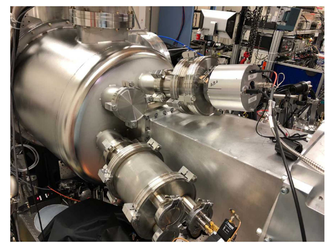
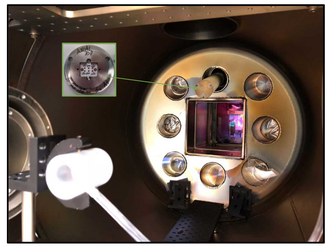


Diagram of the laser system used for hCMOS characterization measurements

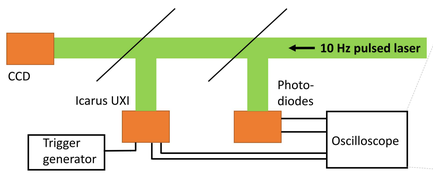

Vacuum chamber used in hCMOS x-ray characterization

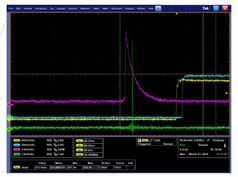

Icarus camera system used in x-ray pinhole camera (PHC)


PHC location in chamber, with pinhole array (inset)

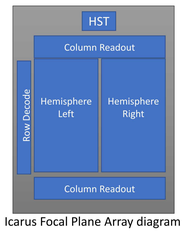
A pulsed laser with multi-pulse capability is used to uniformly illuminate the sensor with visible laser light.

Wavelength: 532 nm (frequency doubled)
Laser energy: 5 mJ (max. at 2ω)
Pulse duration: 200ps
Repetition rate: 10Hz

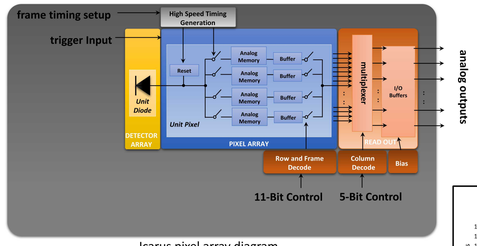




Icarus Architecture



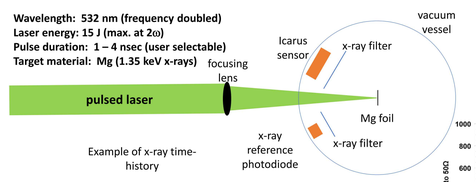
Icarus Focal Plane Array diagram



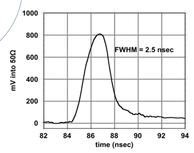
Icarus pixel array diagram

A pulsed laser-produced-plasma x-ray source is used to uniformly illuminate the sensor.

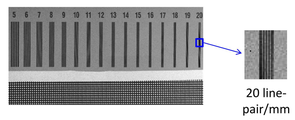
Wavelength: 532 nm (frequency doubled)
Laser energy: 15 J (max. at 2ω)
Pulse duration: 1 – 4 nsec (user selectable)
Target material: Mg (1.35 keV x-rays)

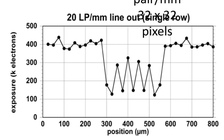


Example of x-ray time-history

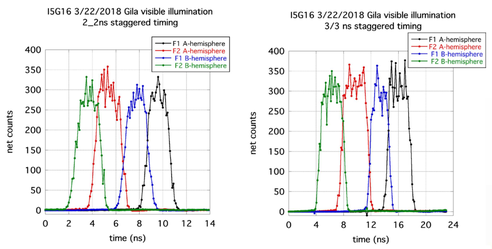


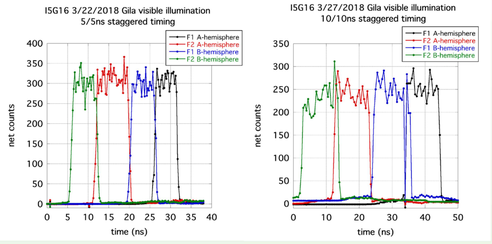
An x-ray line-pair test pattern is used to measure the spatial resolution.

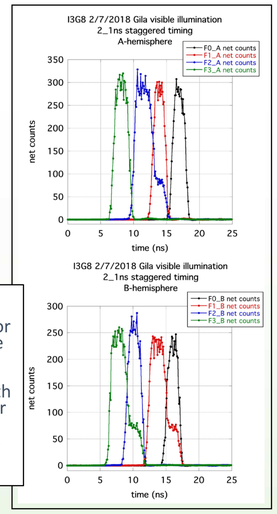




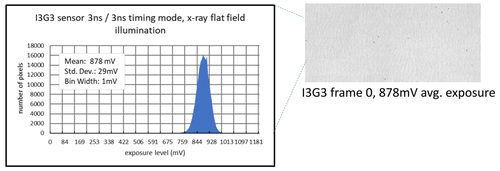
Gate time profiles for various integration/interframe times. These were obtained by advancing the Icarus (Iv1) 2-frame shutter trigger timing through the pulsed laser beam at 100ps time steps, with both staggered and non-staggered A/B hemisphere timing.





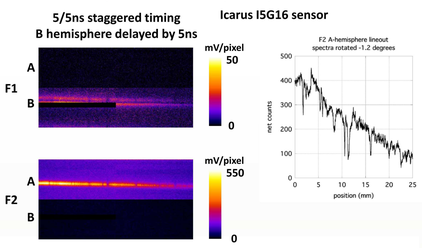


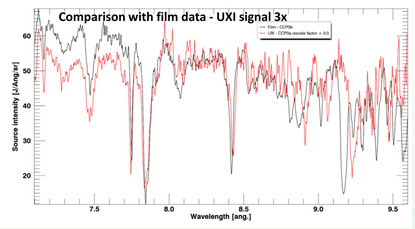
Gate time profiles for Icarus (Iv2) 4-frame sensor for 2ns integration/1ns interframe time, with staggered timing for A/B hemisphere timing, with 100ps time steps



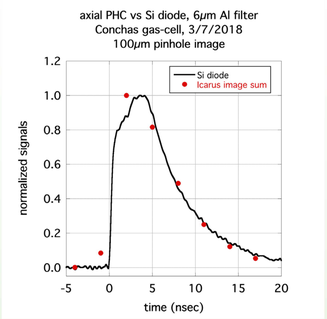
I3G3 frame 0, 878mV avg. exposure

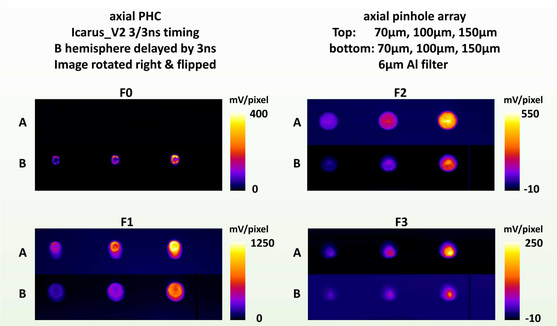
X-ray spectrum captured on 2-frame Icarus sensor fielded on the Opacity spectrometer on the Z-machine. Icarus lineout is compared to calibrated film plane for detector responsivity calibration.





Pin Hole Camera (PHC) images from gas cell target x-ray emission excited by ZBL Beamlet Laser System is used for performance verification studies of the 4-frame Icarus sensor when imaging constant illumination.





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NNSA National Nuclear Security Administration

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SAND No. SAND2018-

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