BrillianSe – Development and applications of the world's highest spatial resolution direct conversion X-ray detector

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When conventional x-ray radiography presents inadequate absorption-contrast especially in low density materials, higher sensitivity can be achieved using phase-contrast methods. The implementation of phase-contrast x-ray imaging using propagation-based techniques requires stringent spatial resolution requirements that necessitate lengthy propagation distances and inefficient scintillator-based detectors limiting experimentation only at synchrotrons.

This work describes the more than a decade long development of a now commercially available hybrid direct X-ray conversion amorphous selenium and complementary metal-oxide-semiconductor detector technology called BrillianSe that offers a unique combination of high spatial resolution (8 micron pixel pitch) and quantum efficiency for hard x-rays to enable benchtop phase contrast micro-CT systems.

In this talk, the semiconductor fabrication process developed for large area compatible vertical detector integration by back-end processing is described along with characterization of signal and noise performance using Fourier-based methods of modulation transfer function, noise power spectrum, and detective quantum efficiency using radiography and microfocus x-ray sources.

The measured spatial resolution at each stage of detector development was one of the highest, if not the highest reported for hard x-rays (> 20 keV). In fact, charge carrier spreading from x-ray interactions with amorphous selenium was shown physically larger than the pixel pitch for the first time.

Lastly, fast (5 fps) propagation-based phase-contrast x-ray and micro-CT imaging in compact geometries (< 20 cm Source Detector distances) is demonstrated using a conventional low power microfocus source at 4W for the first time. The phase-contrast technique is applied to a number of samples including 3D semiconductors, flex electronics, Mini-LEDS, 3D printed composite materials (e.g. Kevlar), low density building materials, and even biological mouse organs, seeds, and insects where radiation dose must be minimized.

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