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# 8 micron pixel pitch direct conversion X-ray detector for phase contrast X-ray imaging in biomedical applications

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When conventional x-ray radiography presents inadequate absorption-contrast, 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. Thus, imaging throughput is limited, and the absorbed dose by the sample can be unacceptable for radiation sensitive life science and biomedical applications.

This work develops a hybrid direct X-ray conversion amorphous selenium and complementary metal-oxide-semiconductor detector technology that offers a unique combination of high spatial resolution and quantum efficiency for hard x-rays. A semiconductor fabrication process was developed for large area compatible vertical detector integration by back-end processing. Characterization of signal and noise performance using Fourier-based methods was performed by modulation transfer function, noise power spectrum, and detective quantum efficiency experiments 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. In fact, charge carrier spreading from x-ray interactions with amorphous selenium was shown physically larger than the pixel pitch for the first time. A simultaneous factor of three improvement in quantum efficiency was achieved compared to scintillator-based detectors, despite the detector being a relatively unoptimized prototype.

Fast propagation-based phase-contrast x-ray imaging in compact geometries is demonstrated using a conventional low power microfocus source and the phase-contrast technique was applied to imaging mice. The results from this research suggest that hybrid semiconductor technology offers the potential to fill the large performance deficit in high spatial resolution scintillator-based detectors for phase-contrast X-ray imaging and to even enable high speed dynamic phase contrast X-ray imaging when used with more powerful sources of X-rays.

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