**Dissertation Title:** Development of Avalanche Amorphous Selenium for X-Ray Detectors

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**Abstract:**

Digital flat panel detectors (FPD) are replacing screen film, computed radiography, and the image intensifier in diagnostic and interventional radiology. Current FPDs are limited in low dose performance due to high electronic noise associated with the amorphous Silicon (a-Si) transistor in the pixelated readout. Reducing the electronic noise is neither cost effective nor compatible with large area fabrication techniques required for medical applications. We propose to overcome electronic noise through photoconductive avalanche gain ($g_{av}$) to amplify photo-generated holes. The primary goal is to replace the a-Si photodiodes used in modern FPDs with amorphous Selenium (a-Se) ones. Under a high external bias field ($E_{Se}$ > 70 V/μm), holes in a-Se undergo impact ionization to produce $g_{av}$, providing nearly noiseless signal amplification.

The development of solid-state avalanche a-Se has been limited by the ability to continuously apply an external bias without causing irreversible damage to the a-Se. Blocking layers must be incorporated to form a p-i-n junction [i.e., the electron blocking layer (*p*) followed by an intrinsic (i) a-Se layer and finally the hole blocking layer (n)] to reduce hole and electron injection at the Se-metal interface and reduce dark current. To add to the challenge, blocking layers must be deposited at room temperature to prevent crystallization of the a-Se during sensor fabrication. In this work, novel organic and inorganic room temperature hole blocking layers are developed. A charge transport model was created to predict effects on temporal performance prior to detector fabrication. Alternative fabrication techniques and high voltage protection mechanisms are considered to reduce the requirements of a hole blocking layer. Signal, dark current, ghosting and lag are evaluated first on single pixel sensors. The solid-state avalanche a-Se sensor with a successful hole blocking layer achieved a reliable $g_{av}$ > 75.

The first FPD to incorporate avalanche a-Se as the photoconductor is then fabricated and imaging performance is evaluated. The FPD is evaluated using linear system modeling of the noise power spectrum and detective quantum efficiency which are compared to experimental results with and without $g_{av}$. Image quality improves as $g_{av}$ is increased until

the signal overcomes electronic noise; thereby, demonstrating the potential improvements a-Se has to offer medical x-ray imaging.

**References to author publications that relate specifically to the dissertation:**


1. **J. Scheuermann**, Adrian Howansky, M. Hansroul, S. Leveille, K. Tanioka, W. Zhao, "Towards Scintillator High Gain Avalanche Rushing Photoconductor Active Matrix Flat Panel Imager (SHARP-AMFPI): initial fabrication and characterization," Medical Physics, (Accepted Nov 2017)

2. **J. Scheuermann**, Y. Miranda, H. Liu, W. Zhao, "Charge transport model in solid-state avalanche amorphous selenium and defect suppression design," Journal of Applied Physics, vol. 119, no. 2, pp. 024508 (2016). https://doi.org/10.1063/1.4939602

3. **J. Scheuermann**, A. Goldan, O Tousignant, S Leveille, W Zhao, "Development of solid-state avalanche amorphous selenium for medical imaging," Medical Physics, vol. 42, no. 3 pp.1223-1226, (2015) Link: http://onlinelibrary.wiley.com/doi/10.1118/1.4907971/abstract