Study on: Evaluation of Large Area Polycrystalline CdTe Detector for Diagnostic X-ray Imaging

Xiance Jin, Ph.D

(jinxc1979@hotmail.com; xiance.jin@rockets.utoledo.edu)

Department of Physics and Astronomy, University of Toledo, Toledo-43606, OH

Thesis advisor: Dr. E. Ishmael Parsai (E.Parsai@utoledo.edu)

Thesis was defended on 22nd June 2011.

Abstract

Introduction of digital radiography systems and successive use of flat panel detectors revolutionized the field of diagnostic imaging. One of the decisive factors contributing to further advancements remains the continuous development of different X-ray detecting materials, from traditional phosphor screens in combination with secondary photodetectors for indirect detection to thin-film photoconductors in direct detection systems. Detectors based on a-Se offer superior spatial resolution due to the simple conversion process. However, low atomic number and density leading to low X-ray absorption, and high effective ionization energy (~50 eV) result in inadequate sensitivity, especially important for low exposure levels of fluoroscopic mode. Materials of high atomic number and density have been investigated to replace a-Se. The purpose of this work was to evaluate polycrystalline Cadmium Telluride (CdTe) semiconductor material for application in large area diagnostic X-ray digital imaging in the direct detection configuration. The intrinsic image quality characteristics of the polycrystalline CdTe detectors under diagnostic X-ray imaging, such as modulation transfer function (MTF), noise power spectrum (NPS), and

detective quantum efficiency (DQE), have been investigated by Monte Carlo simulation using MCNP5 software package. Thin film CdTe detector device operation was modeled with 1-D SCAPS (solar cell capacitance simulator) software package based on the energy deposition profiles obtained for diagnostic X-ray beams with Monte Carlo simulation. The sensitivity, linearity, and time response of prototype thin film CdTe detectors were measured. Electronic characteristics of a subset of thin detectors were verified against SCAPS simulation results allowing for model adjustments. Based on our simulation and measurement results, we believe thin film polycrystalline CdTe is a promising material for direct detection large area digital medical imaging.

Keywords:

Polycrystalline CdTe, Diagnostic X-ray Imaging, Monte Carlo Simulation, Detective Quantum Efficiency, Active Matrix Flat panel Imagers.

List of Publications related to this thesis

1. X Jin, D Shvydka, E Parsai, and J Kang, 2009. Monte Carlo Simulation of Thin-Film CdTe Detector Performance for Diagnostic Imaging Applications. Medical Physics, 36 (6) 2462.
2. X Jin, D Shvydka, and E Parsai, 2010. Thin Film CdTe Photovoltaic Detector Performance under Diagnostic X-Ray Beams. Medical Physics, 37 (6) 3331.