AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

ELECTRONICS & COMMUNICATIONS DEPARTMENT

Implementation and Characterization of X-Ray Medical Imaging System

A Thesis

Submitted to the Electronics and Communications Department,
Faculty of Engineering, Ain Shams University
For Master Degree in Electrical Engineering

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Cairo, Egypt, 2017

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Date of Examination: 29 / 7 / 2017

Abstract

X-ray imaging is a well-known imaging modality that has been used for over 100 years since Roentgen discovered X-rays based on his observations of fluorescence. His initial results were published in 1885. Since 1901, equipment manufacturers started selling X-ray equipment.

Today, X-ray and its three-dimensional (3D) extension, computed tomography (CT), are used commonly in medical diagnosis. Medical imaging system consists of source of x-ray and detectors. The detectors are developed to meet future medical application like decreasing charge sharing.

The 3D silicon detector structure and 3D cadmium telluride (CdTe) detector structure are investigated. The simulation of the 3D structure is carried out by using SILVACO TCAD. The obtained results are used as a proof of concept for investigating the 3D detectors in different scientific applications. Also, it is designed to have a good charge collection efficiency, position resolution and reduced charge sharing effects.

The collection time of 3D silicon detector evaluated 6 nsec at 1.5 V, 4 nsec at 3.3 V and stray capacitance of structure is .14 Pf at 10 V, the leakage current at 3.3 volts is about 9nA.

The collection time of the 3D CdTe structure is about 4×10^{-11}s at 15 V. The fast and hard detection of the structure makes it suitable for stopping power up to 3TeV, which meets the future applications of SLHC. The very low leakage current, which is about 16 pA at 16 volts, is very attractive for most future applications which allow us to apply higher bias voltage than was possible with previous traditional 2D CdTe detectors. The 3D CdTe technology could be recommended for future high-energy physics and medical applications.

Also, a system of a hybrid pixel detector has been developed. The purpose is to create a flexible and reliable model that simulates the entire system, starting from a 3D detector to a data acquisition system and processing analysis. The model flexibility is achieved by minimizing interdependencies among its entities, so they can be added or removed as needed. The implementation of the system is accomplished using SILVACO and Simulink/MATLAB.

Simulink is used to implement the readout circuit. The front-end readout circuit includes the Charge Sensitive Amplifier (CSA) and Active Shaper. The most suitable approach and parameters for a real system are selected according to the simulation results. Additionally, practical design constraints are also included in the model.

Keywords—SILVACO; Simulink/MATLAB; Silicon Detector; X-ray system; Three –dimensional structure; 3D CdTe Detector; Hybrid pixel detector

Statement

This thesis “Implementation and Characterization of X-Ray Medical Imaging System” is submitted to Faculty of Engineering, Ain Shams University for the degree of master in Electronics engineering.

The work included in this thesis was carried out by the author. No part of this thesis has been submitted for a degree or a qualification at any other University or Institution.

DATE: 29 /7 /2017

Author: Abdelhady Ali Hassan Ellakany.

Signature:…………..

Acknowledgements

This thesis could not be completed without the help and support from many people.

I would like to express my deepest gratitude to ***Prof. Dr. Ismail Mohamed Hafez,*** Electronics and Communication Department, Faculty of Engineering, Ain Shams University, and ***Prof. Dr. Christian Gontrand***, Lyon France, for their guidance, generous assistances, encouragement and supervision of this work.

Also, I would like to express my gratitude to my supervisor, ***Assoc. Prof. Mohamed Abouelatta***, for his continuous guidance. Without his valuable advice, none of this work would have been achieved. His efforts and encouragements will never be forgotten. But my only wish is that guiding me through this M. Sc has not been such a nightmare for him after all. Thanks to ***Assoc. Prof. Ahmed Shaker*** has also contributed in this mentoring process. Working with the SILVACO TCAD team has also been a great privilege. Also, I want to thank ***Prof. Abdelhalim Zekry*** and ***Dr. Gihan Sayah*** for their guidance.

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[1] A. Ellakany, A. Shaker, M. Abouelatta, I. M. Hafez and C. Gontrand, "Modeling and simulation of a hybrid 3D silicon detector system using SILVACO and Simulink/MATLAB framework," *28th International Conference on Microelectronics (ICM)*, Giza , pp. 377-380, *2016.*

[2] A. Ellakany, A. Shaker, M. Abouelatta, I. M. Hafez, and C. Gontrand, “Development and simulation of 3D CdTe Pillar detector”, IEEE Transactions on Radiation and Plasma Medical Science.(submitted)

[3] A. Ellakany, M. Abouelatta, A. Shaker, I. M. Hafez, and C. Gontrand, E. El-Rabaie, “Towards 3D Nuclear Detectors”.(It will be submitted to Menoufia Journal of Electronic Engineering Research, MJEER)