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## The characterisation of planar silicon pin diodes for use in proton therapy

Joel Poder  
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**The Characterisation of Planar Silicon PIN Diodes for Use in Proton  
Therapy**

**Joel Poder**

**This thesis is presented as part of the requirements for the  
award of the Degree of:**

**Master of Science - Research  
of the Centre Of Medical Radiation Physics,  
University of Wollongong**

**2010**

## **CERTIFICATION**

I, Joel Poder, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Master of Science – Research, in the Centre for Medical Radiation Physics, University of Wollongong is wholly my own work unless otherwise referenced or acknowledged. This document has not been submitted for qualifications at any other academic institution.

Joel Poder

28<sup>th</sup> June 2010

## ABSTRACT

Many new techniques in the delivery of radiation therapy are being developed for the treatment of cancer. One of these new techniques, proton therapy is becoming increasingly popular due to the presence of the characteristic proton Bragg peak, which allows for better conformation of the dose to the tumour volume. The production of high LET secondary particles in the beam line and within the patient however could result in a significant contribution to the integral dose and diminish this potential advantage. Measured secondary particle doses from clinical proton facilities vary greatly; this is partly due to the differences in beam delivery methods at different centres and due also to the different methods used to measure this secondary particle dose.

The potential of quantification of this mixed particle dose can be achieved through practical and simple measurements of non-ionizing energy losses (NIEL) and ionizing energy losses (IEL). The suitable sensor for NIEL measurements is a silicon PIN diode, through the development of the silicon PIN diodes the possibility of the quantification and therefore significance of the dose delivered by the primary and secondary particles can be realised.

This thesis investigates the characterisation of the response of silicon PIN diodes for use in proton therapy, of particular interest is the in field forward bias response of the PIN diodes as well as their dependence on temperature and light.

Monte Carlo calculations are performed using the Geant4 platform to characterise the response of the silicon PIN diodes when placed in field during proton therapy. The forward bias response of the detector when placed in field was found to be dependent on protons only, with the neutron component of the response being negligible. This allows for the possibility of characterisation of the PIN diodes on the central axis of the beam.

The relative sensitivity of the PIN diodes to protons was found by dividing the forward bias response by the theoretical depth dose and it was found that the relative

sensitivity of the diode is independent of the phantom material and depends only on the initial energy of the primary proton beam.

Experiments are performed in order to characterise the response of the PIN diodes under various conditions. The effect on the forward bias response of the PIN diodes when exposed to visible light was examined by taking forward voltage measurements on each of the diodes both exposed and not exposed to visible light. It was found that the difference in forward bias voltage measurements with light incident on the diode and when light is blocked is no greater than the uncertainty involved in the measurement, using the dedicated forward bias voltage read – out system.

In order to investigate any change in forward bias voltage across the temperature range of interest each of the PIN diodes forward bias voltage is measured over a range from 25 - 35°C. The average temperature coefficient was found to be 0.75mV/°C at 1mA and 1.8mV/°C at 20mA. Considering that the variation in room temperature was expected to be minimal (< 1°C) the temperature of the diodes should differ very little over the several hours between pre and post irradiation read out.

The linearity of the current source in the read-out system is tested at current values of 1, 10, 15 and 20 mA over a wide range of resistances to ensure that the current remained constant over these values. A change in the linear relationship between voltage and resistance was observed in the 10, 15 and 20 mA characteristics. This change was attributed to the fact that the current source is no longer putting out a constant value, highlighting the limit of power in the forward bias voltage read-out device.

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## TABLE OF CONTENTS

Certification.....	i
Abstract .....	ii
Acknowledgements .....	iv
Table of Contents .....	v
List of Figures .....	vii
List of Tables.....	xi
1. Introduction .....	1
1.1 Vision of the Project.....	1
1.2 Motivation .....	1
1.3 Thesis Outline .....	2
2 Literature review & background .....	3
2.1 Proton Therapy.....	3
2.1.1 Introduction to Proton Therapy.....	3
2.1.2 Secondary Particles in Proton Therapy .....	5
2.1.3 Risk of Secondary Cancer in Proton Therapy.....	13
2.2 Monte Carlo Methods .....	15
2.2.1 The Geant4 Monte Carlo Simulation Toolkit .....	15
2.3 Semiconductor Detectors .....	16
2.3.1 PIN Diodes .....	17
3 The Geant4 Monte Carlo Toolkit.....	21
3.1 User Action Classes .....	25
3.1.1 G4UserDetectorConstruction.....	25
3.1.2 G4VUserPhysicsList.....	25
3.1.3 G4VUserPrimaryGeneratorAction.....	26
3.1.4 G4VUserEventAction .....	26
3.1.5 G4UserRunAction.....	27
3.1.6 G4UserSteppingAction .....	27
3.2 Interface Commands .....	27
3.3 Visualisation.....	28
4 PIN Diode Experimental Characterisation.....	29
4.1 Introduction .....	29
4.2 Methods.....	31

4.2.1	Linearity of Pulsed Current Source.....	31
4.2.2	Effect of Light Exposure on PIN Diode Response .....	32
4.2.3	PIN Diode Temperature Dependence .....	32
4.3	Results & Discussion .....	33
4.3.1	Linearity of Pulsed Current Source.....	33
4.3.2	Effect of Light Exposure on PIN Diode Response .....	37
4.3.3	PIN Diode Temperature Dependence .....	39
5	Simulation of pin diode in field proton therapy response .....	41
5.1	Introduction .....	41
5.2	Methods.....	42
5.3	Results & Discussion .....	48
5.3.1	PIN Diode Forward Bias Response to Protons .....	48
5.3.2	Depth Dose Comparison .....	51
5.3.3	PIN Diode Forward Bias Response to Neutrons.....	55
5.3.4	Calculation of Function $\beta$ .....	59
5.3.5	Experimental Comparison.....	62
6	Conclusions & Recommendations .....	65
6.1	Conclusions .....	65
6.2	Recommendations .....	66
	References .....	68

## LIST OF FIGURES

Figure 2.1 A typical proton Bragg peak. 62 MeV proton beam [2].....	4
Figure 2.2 Comparison of depth dose distributions for a mono-energetic 200 MeV proton beam incident on a number of different phantom materials [5]. .....	6
Figure 2.3 Depth dose distributions for a modulated 160 MeV proton beam incident on a water phantom in linear scale (upper figure) and in a logarithmic scale showing contributions of heavier secondary's (lower figure) [5].....	8
Figure 2.4 Energy-weighted neutron fluence spectra ( $\Phi(E_n).E_n$ ) as a function of neutron energy ( $E_n$ ) around a passive scattering nozzle, with a 250MeV beam entering the nozzle using a closed final proton collimating aperture [6].....	9
Figure 2.5 Energy-weighted neutron dose equivalent spectra ( $H(E_n).E_n$ ) as a function of neutron energy ( $E_n$ ) around a passive scattering nozzle, with a 250MeV beam entering the nozzle using a closed final proton collimating aperture [6].....	9
Figure 2.6 Results measured with the SOI microdosimeter for both a patient specific aperture/bolus portal and a 13cm circular QA aperture with no bolus present [4]. .....	11
Figure 2.7 Dose equivalent at 5 cm from the field edge compared with the depth dose distribution of the proton beam as measured along the central axis with a Markus chamber [4]. .....	11
Figure 2.8 Plot of the measured neutron ambient dose equivalent as a function of lateral distance from the beam. The squares correspond to measurements in a scatter beam line, the triangles correspond to measurements obtained at a sport scanning beam line [8]. .....	13
Figure 2.9 Total estimated lifetime second cancer risks due to externally produced neutrons, for a 72Gy proton therapy lung-tumour plan at a passively scattered facility [3].....	14
Figure 3.1 - The Top Level architecture of Geant4. The open circle represents a using relationship; the category at the end of the circle uses the adjoined category. ...	24
Figure 4.1 - The output of the in-built pulsed current source, with the 20 mA output shown in red and the 1mA output shown in black. ....	30
Figure 4.2– Experimental set-up for linearity measurements of pulsed current source for pin diode forward bias measurements. ....	31

- Figure 4.3– Experimental set-up for PIN diode temperature dependence measurements, the area of temperature control is indicated by the dashed line. 33
- Figure 4.4– Forward Bias Voltage measured on the voltage read out system (red curve) and an externally attached multimeter (blue curve) at 1mA as a function of resistance..... 34
- Figure 4.5 – Forward Bias Voltage measured on the voltage read out system (red curve) and an externally attached multimeter (blue curve) at 10mA as a function of resistance..... 34
- Figure 4.6 - Forward Bias Voltage measured on the voltage read out system (red curve) and an externally attached multimeter (blue curve) at 15mA as a function of resistance..... 35
- Figure 4.7– Forward Bias Voltage measured on the voltage read out system (red curve) and an externally attached multimeter (blue curve) at 20mA as a function of resistance..... 35
- Figure 4.8– Output of the pulsed current source at 1, 10, 15 and 20 mA as a function of resistance..... 36
- Figure 4.9– Forward bias voltage temperature characteristic of PIN diode dosimeter. .... 39
- Figure 5.1- Experimental set-up adopted of the Geant4 application. The sensitive silicon block was placed at different depths within the phantom, in the configurations indicated by the red boxes. The phantom is made of water and Lucite alternatively. The primary field direction is indicated by the blue arrow. .... 43
- Figure 5.2– Detector geometry showing the residual range cuts by region. Charged particles produced within the red region have range cuts of  $1\mu\text{m}$ , the yellow region has cuts of  $10\mu\text{m}$  and the white region has cuts of  $1\text{mm}$ . The primary field direction is indicated by the blue arrow..... 46
- Figure 5.3 - The dose distribution along the Bragg peak was calculated in sensitive volumes (shown in red) –  $1 \times 1 \text{ cm}^2$ - placed face to face along the central axis of the beam covering the entire length of the phantom. The sensitive detectors are made of water or Lucite, depending on the phantom configuration under study. The primary field direction is shown by the blue arrow. .... 47
- Figure 5.4 – Proton Energy Fluence/ $\text{cm}^2$ , per incident proton, shown at various depths in a Lucite phantom, as indicated in the legend. The results are affected

with an uncertainty of 1%. The initial primary beam energy of the protons was 225 MeV, corresponding to a range of 32.61 cm.....	49
Figure 5.5 - Proton Displacement KERMA values as a function of energy [1]. .....	50
Figure 5.6 – Comparison of forward bias response of silicon PIN diode normalised to the depth 2cm to an uncertainty of 1% for each of the situations outlined in the legend. ....	50
Figure 5.7 - Comparison of depth dose profiles to an uncertainty of 1% for each of the situations outlined in the legend. The energy deposition distribution was normalised at 2.5 cm depth, in the phantom. ....	51
Figure 5.8– Relative forward bias PIN diode response comparison with theoretical depth dose distribution to an uncertainty of 1% in a Lucite phantom with 150 MeV primary beam. ....	52
Figure 5.9 – Relative forward bias PIN diode response comparison with theoretical depth dose distribution with an uncertainty of 1% in a water phantom with 150 MeV primary beam. ....	53
Figure 5.10 – Relative forward bias PIN diode response comparison with theoretical depth dose distribution with an uncertainty of 1% in a Lucite phantom with 225 MeV primary beam. ....	53
Figure 5.11 – Relative forward bias PIN diode response comparison with theoretical depth dose distribution, with an uncertainty of 1% in a water phantom with 225 MeV primary beam. ....	54
Figure 5.12 – Comparison of the change in electronic stopping power in silicon as a function of energy with the displacement KERMA in silicon as a function of energy.....	55
Figure 5.13– Neutron Energy Fluence/Incident Proton/cm <sup>2</sup> shown at various depths in a Lucite phantom, with an uncertainty of 1%. The initial primary beam energy of the protons was 225 MeV. ....	56
Figure 5.14 - Neutron Displacement KERMA values as a function of energy [1]....	57
Figure 5.15 – Comparison of the PIN diode forward bias response due to neutrons and protons, with an uncertainty of 1% in a water phantom with a 150 MeV primary proton beam. ....	57
Figure 5.16 – Comparison of the PIN diode forward bias response due to neutrons and protons, with an uncertainty of 1% in a Lucite phantom with a 225 MeV primary proton beam. ....	58

Figure 5.17 – $\beta$ plotted as a function of depth with Lucite depths converted to water equivalent depths, with an uncertainty of 2%. .....	59
Figure 5.18 – $\beta$ plotted as a function of average proton energy, with an uncertainty of 3%. .....	60
Figure 5.19 – Experimental comparison of the pin diode forward bias response for a 150 MeV primary proton beam in a water phantom, with an uncertainty of 1%. .....	63

**LIST OF TABLES**

Table 4.1– Forward bias voltage and uncertainties at 1mA and 20 mA with light exposed on the PIN diodes.....	38
Table 4.2– Forward bias voltage and uncertainties at 1 mA and 20 mA with light blocked from the PIN diodes.....	38
Table 4.3– Difference in forward bias voltage at 1 mA and 20 mA, compared to the uncertainty in these measurements. ....	38
Table 5.1– Positions of silicon volumes along the Bragg peak in each simulation...	44
Table 5.2 – Comparison of range of primary protons from simulation study and NIST data. ....	52