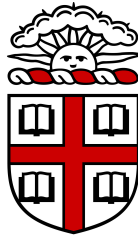


Silicon Sensor Irradiation Studies for the LHC HL Upgrade



BROWN

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Submitted in partial satisfaction of the requirements for the
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in Physics

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*This thesis by Andrew Thomas Kent is accepted in its present form by the
Department of Physics as satisfying the thesis requirement for the degree of Master
of Science.*

.....
Date Ulrich Heintz, Advisor

Recommended by the Graduate Council

.....
Date Andrew G. Campbell, Dean of the Graduate School

This work is dedicated to my parents, Zaida Soriano and Ron Kent.

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Table of Contents

1	Introduction	1
1.1	The Silicon Tracker for CMS at CERN	1
1.2	The Silicon Diodes	1
1.2.1	Types of Diodes Used at CMS	1
2	Radiation Damage	2
2.1	Bulk Silicon Damage	2
2.2	Annealing	2
2.2.1	Hamburg Annealing Model	2
3	Probe Station Experimental Setup	3
3.1	Test Diodes	3
3.1.1	DZero Diodes	3
3.1.2	PIN Diodes	3
3.1.3	2S and PSS Halfmoon Diodes	3
3.1.4	HGCAL Diodes	3
3.2	Electrical Characterization	3
3.2.1	Current-Voltage Measurement (IV)	3
3.2.2	Capacitance-Voltage Measurement (CV)	3
3.3	Environmental Control	3
3.3.1	Temperature Control	3
3.3.2	Dew-Point Control	3
3.3.3	Humidity Control	3
4	Alibava Station Experimental Setup	4
4.1	Test Diodes	4
4.1.1	2S and PSS Halfmoon Diodes	4
4.2	Radioactive Source	4
4.3	Environmental Control	4
4.3.1	Temperature Control	4
4.3.2	Dew-Point Control	4
4.3.3	Humidity Control	4
4.4	Measuring Halfmoon Diodes	4
4.4.1	Printed Circuit Board	4

5	Irradiating at RINSC	5
5.1	Rabbit	5
5.1.1	Configuration	5
5.1.2	Directionality Studies	5
5.1.3	Linear Fluence Intensity Studies	5
5.2	Beam-Port	5
6	Analysis	6
6.1	Calculating Fluence	6
6.1.1	Depletion Voltage Calculation	6
6.1.2	Current Temperature Conversion	6
6.2	Hamburg Model Analysis	6
6.2.1	Ljubljana Diodes	6
6.2.2	HGCAL Diodes	6
6.3	PIN Analysis	6
6.3.1	Temperature Study	6
6.3.2	Annealing Study	6
7	Conclusions	7
7.1	Use of Diodes in a High Fluence Environment	7
7.1.1	PINs	7
7.1.2	DZero	7
7.1.3	HGCAL	7
7.2	Affects of Concurrent Annealing and Irradiation	7
7.3	RINSC Ljubljana Cross Calibration	7
7.3.1	Silicon Damage Constant	7
	Bibliography	7
	Appendix A	8

Chapter 1

Introduction

1.1 The Silicon Tracker for CMS at CERN

1.2 The Silicon Diodes

1.2.1 Types of Diodes Used at CMS

Chapter 2

Radiation Damage

2.1 Bulk Silicon Damage

2.2 Annealing

2.2.1 Hamburg Annealing Model

Chapter 3

Probe Station Experimental Setup

3.1 Test Diodes

3.1.1 DZero Diodes

3.1.2 PIN Diodes

3.1.3 2S and PSS Halfmoon Diodes

3.1.4 HGICAL Diodes

3.2 Electrical Characterization

3.2.1 Current-Voltage Measurement (IV)

3.2.2 Capacitance-Voltage Measurement (CV)

3.3 Environmental Control

3.3.1 Temperature Control

3.3.2 Dew-Point Control

3.3.3 Humidity Control

Chapter 4

Alibava Station Experimental Setup

4.1 Test Diodes

4.1.1 2S and PSS Halfmoon Diodes

4.2 Radioactive Source

4.3 Environmental Control

4.3.1 Temperature Control

4.3.2 Dew-Point Control

4.3.3 Humidity Control

4.4 Measuring Halfmoon Diodes

4.4.1 Printed Circuit Board

Chapter 5

Irradiating at RINSC

5.1 Rabbit

5.1.1 Configuration

5.1.2 Directionality Studies

5.1.3 Linear Fluence Intensity Studies

5.2 Beam-Port

Chapter 6

Analysis

6.1 Calculating Fluence

6.1.1 Depletion Voltage Calculation

6.1.2 Current Temperature Conversion

6.2 Hamburg Model Analysis

6.2.1 Ljubljana Diodes

6.2.2 HGCal Diodes

6.3 PIN Analysis

6.3.1 Temperature Study

6.3.2 Annealing Study

Chapter 7

Conclusions

7.1 Use of Diodes in a High Fluence Environment

7.1.1 PINs

7.1.2 DZero

7.1.3 HGCAL

7.2 Affects of Concurrent Annealing and Irradiation

7.3 RINSC Ljubjana Cross Calibration

7.3.1 Silicon Damage Constant

Appendix A

3D Parts

Location for 3D CAD models. Either link will work, all files end in .stl.

1. DropBox:

```
https://www.dropbox.com/sh/qibj3qp2merqm7s/AAC390ZVfnTCeMwkV6fiN8t0a?  
dl=0
```

2. Thingiverse:

```
https://www.thingiverse.com/thing:4263553
```

Code

Copy this code directly into the Arduino text editor:

```
//Creating the environment  
void setup() {  
    // initialize digital pin 13 as an output.  
    pinMode(13, OUTPUT);  
}  
  
// the loop function for continuous laser beam  
void loop() {  
    digitalWrite(13, HIGH);  
}
```