

TABLE OF CONTENTS

	Page
1 Introduction	1
2 Theory	3
2.1 Epitaxy	3
2.1.1 Silicon epitaxy by Chemical Vapor Deposition	3
2.1.2 Growth process	5
2.1.3 Epitaxy Tool	7
2.1.4 Precursor gases	9
2.1.5 Doping Gases	10
2.2 P-I-N Diode	11
2.2.1 p-n Junction	11
2.2.1.1 pn regions before contact	12
2.2.1.2 Thermal equilibrium	12
2.2.1.3 Built-in potential	13
2.2.1.4 The full-depletion approximation	14
2.2.1.5 Depletion width of a p-n junction	14
2.2.1.6 Recombination	15
2.2.1.7 Forward and reverse biased p-n junction	15
2.2.2 Abrupt p-i-n Junction	16
2.3 Photodiode	16
2.3.1 p-i-n photodiode	17
2.3.2 I-V characteristics of the p-i-n photodiode	18
2.3.3 Spectral responsivity	19
2.3.4 Spectral responsivity and quantum efficiency of a p-i-n photodiode	20
2.3.5 p-i-n device configurations	21
2.4 Vertically stacked p-i-n diodes	22
3 Layer characterization	23
3.1 Crystal quality	23
3.2 Defect etching	23

TABLE OF CONTENTS

3.2.1	MEMC etch	26
3.2.2	Silver etch	29
3.2.3	Dash etch	31
3.2.4	Wright-Jenkins etch	32
3.3	Spiking	33
3.4	Electrical characterization of p-i-n diodes	38
3.5	Layer thickness	45
4	Photodiode Process	49
4.1	Basic concept	49
4.2	Process run	50
4.2.1	Process simulation	55
4.3	Processes developed	56
4.3.1	Buried δ -layer	56
4.3.2	Contacting the p- δ -layer	63
4.3.3	Passivation	67
4.3.4	Lithography	69
5	Experimental results	73
5.1	Characterization procedures	73
5.2	Initial measurements	76
5.3	Wafer level measurements	77
5.3.1	Diode measurements	79
5.4	Spectral measurements	83
5.4.1	Top diode	83
5.4.2	Bottom diode	87
5.4.3	Combined top/bottom diode measurements	90
5.5	Quantum efficiency	95
5.6	Comparison to literature	96
6	Conclusion and future work	99
A	Parameters	101
A.1	CVD gas parameter	101
B	Mask Design	103
B.1	Overview mask set	103
B.2	Wafermap PIXEL	103
C	Process sequence	109

D Defect density	113
Symbols and Constants	121
Terms, Definitions and Abbreviations	125
List of Tables	125
List of Figures	127
Bibliography	131
Acknowledgments	139