

Contents

1 This Thesis	1
1.1 Introduction	1
1.1.1 Microcrystalline Silicon Based Solar Cells	1
1.1.2 Deposition of Microcrystalline Silicon	5
1.1.3 Objective and Outline	7
1.2 Diagnostics	8
1.3 Key Results	11
1.4 Discussion	13
1.5 Conclusions	15
2 Plasma-Induced Substrate Heating	21
2.1 Introduction	21
2.2 Experimental	22
2.3 Results	24
2.4 Discussion	26
2.5 Conclusions	29
3 Deposition from Pure SiH₄	33
4 Transient Depletion	39
4.1 Introduction	39
4.2 Model	40
4.2.1 General formulation	40
4.2.2 Analytical solutions: Steady-state solution for $t \rightarrow \infty$	45
4.2.3 Analytical solutions: The initial phase and transient depletion	45
4.2.4 Analytical solutions: Tailored initial source gas density	47
4.2.5 Summary	48
4.3 Experiments in an SiH ₄ - H ₂ plasma	48
4.3.1 Experimental	48
4.3.2 Application of the model	50
4.3.3 Results	51
4.4 Discussion: Implications for materials processing	53
4.5 Summary	55

5 Transient Depletion Induced Incubation Layer	57
5.1 Introduction	57
5.2 Experiment	59
5.3 Results and discussion	61
5.3.1 The Transient Depletion Induced Incubation Layer	61
5.3.2 Effect of the Incubation Layer on Solar Cells	62
5.3.3 Effect of the H ₂ flow on Solar Cells	65
5.3.4 Performance of Solar Cells Deposited from a Pure SiH ₄ Flow	67
5.4 Conclusions	67
6 Process Stability & Process Control	71
6.1 Introduction	71
6.2 Experimental details	72
6.3 Process stability	73
6.3.1 Powder formation	74
6.3.2 Transient depletion	74
6.3.3 Plasma heating	75
6.3.4 Long-term drift	75
6.4 Crystallinity gradient & Process control	76
6.5 Conclusions	77
7 Enhanced Open-Circuit Voltage	81
8 Flexible Modules	87
8.1 Introduction	87
8.2 Experimental details	90
8.3 Results: Tandem development	91
8.3.1 Substrates	91
8.3.2 a-Si:H modules	91
8.3.3 μ c-Si:H modules	92
8.3.4 Tandem modules	95
8.4 Discussion: Status and perspectives	96
8.4.1 Light trapping	98
8.4.2 Module stability	99
8.4.3 Deposition process	99
8.5 Summary	99
Summary	103
List of Publications	105
Acknowledgement	109
Curriculum Vitae	111