

Contents

1	Introduction	1
2	Fundamentals	7
2.1	Structural Properties of Microcrystalline Silicon	7
2.2	Electronic Density of States	9
2.2.1	Band-Tail States	10
2.2.2	Deep Defects	11
2.3	Charge Carrier Transport	14
2.3.1	Barrier Limited Transport	15
2.3.2	Dispersive Transport in Disordered Semiconductors	15
3	Sample Preparation and Characterization	19
3.1	Characterization Methods	19
3.1.1	Raman Spectroscopy	19
3.1.2	Electron Spin Resonance (ESR)	21
3.1.3	Electrical Conductivity	24
3.1.4	Transient Photocurrent Measurements (TOF)	24
3.1.5	Thickness Measurements	30
3.2	Deposition Technique	32
3.2.1	Plasma-Enhanced Chemical Vapor Deposition (PECVD) .	32
3.2.2	Hot-Wire Chemical Vapor Deposition (HWCVD)	33
3.3	Sample Preparation	34
3.3.1	Sample Preparation for ESR and conductivity measurements	35
3.3.2	PIN-Diodes for Transient Photocurrent Measurements . .	36
4	Intrinsic Microcrystalline Silicon	39
4.1	Raman Spectroscopy	39
4.2	Electrical Conductivity	41
4.3	ESR Signals and Paramagnetic States in Intrinsic μ c-Si:H	42
4.4	Discussion - Relation between ESR- and Structural Properties . .	47
4.5	Summary	50

CONTENTS

5 N-Type Doped μc-Si:H	51
5.1 Structure Characterization	51
5.2 Electrical Conductivity	52
5.3 ESR Spectra	54
5.4 Dangling Bond Density	55
5.5 Conduction Band-Tail States	57
5.6 Discussion	59
5.7 Summary	61
6 Reversible and Irreversible Effects in μc-Si:H	63
6.1 Metastable Effects in μ c-Si:H	63
6.1.1 Influences of Sample Preparation	63
6.1.2 Reversible Effects in the ESR Signal	70
6.1.3 Reversible Effects in the Electrical Conductivity	73
6.2 Irreversible Oxidation Effects	75
6.2.1 Reversibility by Chemical Reduction	77
6.2.2 Charge Transfer caused by Oxidation of N-Type μ c-Si:H	78
6.3 On the Origin of Instability Effects in μ c-Si:H	80
6.3.1 Adsorption of Atmospheric Gases	80
6.3.2 Irreversible Effects caused by Oxidation	84
6.4 Summary	84
7 Transient Photocurrent Measurements	85
7.1 Electric Field Distribution	85
7.2 Transient Photocurrent Measurements	87
7.2.1 Non-Uniform Electric Field Distribution	87
7.2.2 Uniform Electric Field Distribution	90
7.3 Temperature Dependent Drift Mobility	93
7.4 Multiple Trapping in Exponential Band-Tails	94
7.5 Discussion	96
7.5.1 Photocurrent and Photocharge Transients	97
7.5.2 Hole Drift Mobilities	98
7.5.3 The Meaning of Multiple Trapping	99
8 Schematic Density of States	101
9 Summary	105
A Algebraic Description of the Multiple Trapping Model	107
B List of Samples	111

CONTENTS

C Abbreviations, Physical Constants and Symbols	115
Bibliography	119
Publications	135
Acknowledgments	137