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 μc-Si:H .... 42
  4.4 Discussion - Relation between ESR- and Structural Properties 47
  4.5 Summary .................................................. 50
CONTENTS

5 N-Type Doped $\mu$c-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 $\mu$c-Si:H 63
  6.1 Metastable Effects in $\mu$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 $\mu$c-Si:H 78
  6.3 On the Origin of Instability Effects in $\mu$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

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>C Abbreviations, Physical Constants and Symbols</td>
<td>115</td>
</tr>
<tr>
<td>Bibliography</td>
<td>119</td>
</tr>
<tr>
<td>Publications</td>
<td>135</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>137</td>
</tr>
</tbody>
</table>