

Table of contents

Remerciements

Summary/Sommaire

Table of contents

Chapter I: Introduction and aims of the work

1. PART OF THE PHOTOVOLTAIC TECHNOLOGIES IN THE PRESENT ENERGY CONTEXT	3
2. DYE-SENSITIZED SOLAR CELLS (DSSCs)	5
2.1. PRINCIPLE OVERVIEW	5
2.2. PHOTOELECTRODES AND SEMICONDUCTOR LAYERS	7
2.3. DYES	8
2.4. ELECTROLYTES	10
2.5. COUNTER-ELECTRODES	12
2.6. PHOTOVOLTAIC PARAMETERS	12
2.7. STABILITY	14
2.8. BENEFITS COMPARED TO SILICON CELLS	14
2.9. COMMERCIAL PERSPECTIVES	14
3. TiO₂ POROUS LAYER	15
3.1. EISA AND EIMP SYNTHESIS PROCESSES	16
3.2. FILM CRYSTALLIZATION AND PORES MERGING	18
4. SCOPE AND OBJECTIVES	18
5. OUTLINE OF THE THESIS	20
6. REFERENCES	21

Chapter II: Tuning of the experimental settings

1. INTRODUCTION	29
2. EXPERIMENTAL SECTION	29
2.1. MESOPOROUS THIN FILMS SYNTHESIS	29
2.2. CHARACTERIZATION TECHNIQUES	30
3. RESULTS AND DISCUSSION	31
3.1. DIFFUSION OF THE SUBSTRATE	31
3.2. INFLUENCE OF THE STRUCTURING AGENT	32
3.3. INFLUENCE OF THE RELATIVE HUMIDITY CONDITIONS	33
3.4. WITHDRAWAL RATE EFFECTS	34
3.5. TUNING OF THE THERMAL TREATMENT	35
3.5.1. WIDE-OPEN MESOSTRUCTURE PRESERVATION	36
3.5.2. MESOSTRUCTURE OPTIMIZATION FOR DSSC APPLICATIONS	36
4. CONCLUSIONS	38
5. REFERENCES	40

Chapter III: Effects of stabilization and repeated thermal treatments

1. INTRODUCTION	45
2. EXPERIMENTAL SECTION	46
2.1. MESOPOROUS THIN FILMS SYNTHESIS	46
2.2. CHARACTERIZATION TECHNIQUES	47
3. RESULTS AND DISCUSSION	47
3.1. EFFECT OF THE REPEATED THERMAL TREATMENTS ON THE FILM MESOSTRUCTURE	47
3.2. EFFECT OF THE REPEATED THERMAL TREATMENTS ON THE FILM SURFACE AREA	49
3.3. EFFECT OF THE REPEATED THERMAL TREATMENTS ON THE FILM CRYSTALLINITY	51
4. CONCLUSIONS	52
5. REFERENCES	54

Chapter IV: Multilayer thick films and their use in DSSCs

1. INTRODUCTION	57
2. EXPERIMENTAL SECTION	58
2.1. MESOPOROUS THIN FILMS SYNTHESIS ($\leq 1 \mu\text{m}$)	58
2.2. MESOPOROUS THICK FILMS SYNTHESIS ($> 1 \mu\text{m}$)	59
2.3. SOLAR CELLS ASSEMBLY	59
2.4. CHARACTERIZATION TECHNIQUES	60
3. RESULTS AND DISCUSSION	60
3.1. MESOSTRUCTURE ORGANIZATION	61
3.2. THIN FILM POROSITY ($\leq 1 \mu\text{m}$)	62
3.3. DYE LOADING	65
3.4. PHOTOVOLTAIC PERFORMANCES OF THICK FILMS ($> 1 \mu\text{m}$)	65
4. CONCLUSIONS	70
5. ACKNOWLEDGMENTS	70
6. REFERENCES	71

Chapter V: Long-term stability

1. INTRODUCTION	75
2. EXPERIMENTAL SECTION	77
2.1. MESOPOROUS THIN FILMS SYNTHESIS	77
2.2. SOLAR CELLS ASSEMBLY	77
2.3. ACCELERATED AGEING TESTS	78
2.4. CHARACTERIZATION TECHNIQUES	78
3. RESULTS AND DISCUSSION	78
3.1. UV SENSITIVITY OF THE CELLS	78
3.2. LIGHT SOAKING UNDER OPEN CIRCUIT CONDITIONS	82
3.3. LIGHT SOAKING UNDER RESISTIVE LOAD	83
3.4. THERMAL STRESS	85
3.5. ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY (EIS)	86
3.5.1. GENERAL TRENDS IN EIS DATA	86
3.5.2. LIGHT SOAKING	89
3.5.3. THERMAL STRESS	90
4. CONCLUSIONS	92
5. ACKNOWLEDGMENTS	93
6. REFERENCES	94

Chapter VI: Solid-state dye-sensitized solar cells

1. INTRODUCTION	101
2. EXPERIMENTAL SECTION	102
2.1. TEMPLATED THIN FILMS SYNTHESIS	102
2.2. NANOPARTICLES THIN FILMS SYNTHESIS	103
2.3. LIQUID ELECTROLYTE DSSCs ASSEMBLY	103
2.4. SOLID-STATE DSSCs ASSEMBLY	104
2.5. CHARACTERIZATION TECHNIQUES	104
3. RESULTS AND DISCUSSION	106
3.1. MESOSTRUCTURE CHARACTERIZATION	106
3.2. DYE LOADING	109
3.3. LIQUID-STATE PHOTOVOLTAIC PERFORMANCES	110
3.4. SPIRO-OMETAD FILLING	112
3.5. SOLID-STATE PHOTOVOLTAIC PERFORMANCES	119
4. CONCLUSIONS	121
5. REFERENCES	122

Chapter VII: Conclusions and perspectives

1. CONCLUSIONS	127
1.1. TUNING OF THE EXPERIMENTAL SETTINGS	127
1.2. INCREASE OF THE FILM THICKNESS: TUNING OF A MULTILAYER DEPOSITION PROCESS	127
1.3. MULTILAYER FILMS AS EFFICIENT PHOTOELECTRODES IN DSSCs	129
1.4. CELLS STABILITY	129
1.5. INCREASE OF THE PORE SIZE: SOLID-STATE DSSCs	130
1.6. GENERAL CONCLUSIONS	131
2. PERSPECTIVES	131
2.1. FUNDAMENTAL RESEARCH FIELD	131
2.1.1. FURTHER INVESTIGATIONS OF SOLID-STATE DSSCs ASSEMBLY AND CHARACTERIZATION	131
2.1.2. HIERARCHICAL POROSITY	132
2.2. APPLIED RESEARCH FIELD	132
2.2.1. SCALE-UP	132
2.2.2. INDUSTRIALIZATION PERSPECTIVES	133
3. REFERENCES	134

List of acronyms and abbreviations

List of publications
