

CONTENTS

Contributors ix

Preface xiii

1. Electrolytes for Li- and Na-Ion Batteries: Concepts, Candidates, and the Role of Nanotechnology 1

E. Bekaert, L. Buannic, U. Lassi, A. Llordés, J. Salminen

1. Introduction and electrolyte concept 1
2. Liquid electrolytes 5
3. Solid electrolytes 12
4. Conclusions 32
- Glossary 34
- References 35

2. Review of Nanotechnology for Anode Materials in Batteries 45

S. Goutam, N. Omar, P. Van Den Bossche, J. Van Mierlo

1. A high-performance anode 45
2. Benefits of a nanostructured anode 46
3. Geometrical aspects and design of nanostructured anodes 49
4. Carbon-based anodes 55
5. Silicon-based anodes 57
6. Metal alloy anodes 60
7. Metal oxide-based anodes 63
8. Metal phosphide and sulfide anodes 66
9. Summary and conclusions 69
- Glossary 70
- References 71

3. Review of Nanotechnology for Cathode Materials in Batteries 83

S.-J. Cho, M.-J. Uddin, P. Alaboina

1. Introduction 83
2. Nanostructural design and synthesis of cathode materials for lithium-ion batteries 84
3. Nanoscale surface modification on cathode materials for lithium-ion batteries 108
4. Conclusions 125
- Glossary 126
- References 127

4. Nanotechnology in Electrochemical Capacitors	131
E. Goikolea, R. Mysyk	
1. Introduction	131
2. Basic principles and classification of electrochemical capacitors	132
3. Parameters governing supercapacitor performance	145
4. Nanotechnology in electrical double layer capacitors	148
5. Pseudocapacitive materials	156
6. Conclusions and perspectives	162
Glossary	162
References	163
5. Characterization of Nanomaterials for Energy Storage	171
A.M. Bittner, V. Koroteev	
1. Macro- and microscale characterization	173
2. Ex Situ, "Postmortem" analysis versus in situ electrochemistry	174
3. Structural analysis	175
4. Chemical analysis (spectroscopic techniques)	177
5. Nanoscale characterization	178
6. Electron microscopy	183
7. Improved instrumentation and inspirations for new methods	188
8. Summary	190
Glossary	190
References	191
6. Electrochemical–Thermal Characterization and Thermal Modeling for Batteries	195
C. Ziebert, A. Melcher, B. Lei, W. Zhao, M. Rohde, H.J. Seifert	
1. Introduction	195
2. Heat generation in lithium-ion batteries	197
3. Electrochemical–calorimetric measurements on lithium-ion batteries	200
4. Thermal modeling of lithium-ion batteries	212
5. Simulations with COMSOL multiphysics	217
6. Conclusions	223
Glossary	224
References	226
7. Life Cycle Assessment of Nanotechnology in Batteries for Electric Vehicles	231
L. Oliveira, M. Messagie, S. Rangaraju, M. Hernandez, J. Sanfelix, J. Van Mierlo	
1. Introduction	231
2. Case Study: Use of nanomaterials in li-ion battery anodes	240

3. Life cycle impact assessment	242
4. Discussion and conclusions	247
Glossary	248
References	249
8. Safety of Rechargeable Energy Storage Systems with a focus on Li-ion Technology	253
A. Pfrang, A. Kriston, V. Ruiz, N. Lebedeva, F. di Persio	
1. Introduction	253
2. Hazards	254
3. Failure scenarios	261
4. Risk mitigation	268
5. Safety tests	275
6. Conclusions and outlook	281
Glossary	283
References	284
9. Application of the Energy Storage Systems	291
P.N. Borza	
1. Introduction: Energy storage systems and their application	291
2. Characterization of storage cells and devices, parameters, and features	292
3. Overview of storage cells, modules, and systems	298
4. Applications that use storage facilities	303
5. Conclusions	316
Glossary	317
References	317
Index	321