

Contents

Foreword *xi*

Preface *xiii*

1	Introduction	<i>1</i>
1.1	Introduction of Amorphous Materials	<i>1</i>
1.2	Structural Differences between Amorphous Materials and Crystals	<i>3</i>
1.2.1	Crystals and Quasicrystals	<i>3</i>
1.2.2	Amorphous Materials	<i>5</i>
1.3	History of Amorphous Materials	<i>7</i>
1.3.1	Establishment of Crystallography	<i>8</i>
1.3.2	Enlightenment of Amorphous Materials	<i>9</i>
1.3.3	Modern Amorphous Materials 1-Disordered Elementary Substance	<i>10</i>
1.3.4	Modern Amorphous Materials 2-Metallic Glass	<i>11</i>
1.3.5	Modern Amorphous Materials 3-Nontraditional Amorphous Nanomaterials	<i>14</i>
1.4	Growth Mechanisms of Amorphous Nanomaterials	<i>15</i>
1.4.1	Classical Nucleation Theory	<i>15</i>
1.4.2	Multistep Transformation Mechanism with Amorphous Participation	<i>17</i>
1.4.3	Complex Growth Process in Solution	<i>19</i>
1.5	Summary and Outlook	<i>19</i>
	References	<i>20</i>
2	Local Structure and Electronic State of Amorphous Nanomaterials	<i>23</i>
2.1	Spherical Aberration-Corrected Transmission Electron Microscopy	<i>23</i>
2.1.1	Introduction	<i>23</i>
2.1.2	Spherical Aberration-Corrected Transmission Electron Microscopy	<i>24</i>
2.1.3	Electron Energy Loss Spectroscopy in TEM	<i>28</i>
2.1.4	Applications in Amorphous Nanomaterial Characterization	<i>34</i>
2.1.5	Summary and Outlook	<i>41</i>

2.2	X-ray Absorption Fine Structure Spectrum	41
2.2.1	Introduction	41
2.2.2	Extended X-ray Absorption Fine Structure	42
2.2.3	X-ray Absorption Near-Edge Structure	45
2.2.4	Application in Amorphous Nanomaterial Characterization	47
2.2.5	Summary and Outlook	51
	References	52
3	Defect Characterization of Amorphous Nanomaterials	61
3.1	Introduction	61
3.2	Positron Annihilation Spectrum	64
3.3	Electron Paramagnetic Resonance	71
3.4	Photoluminescence Spectroscopy	79
3.5	Summary and Outlook	82
	References	84
4	Synthesis of 0D Amorphous Nanomaterials	89
4.1	Introduction	89
4.2	Bottom-Up Method	90
4.2.1	Solution-Based Chemical Method	90
4.2.2	Thermal Treatment Method	98
4.2.3	Other Methods	101
4.3	Top-Down Method	104
4.4	Summary and Outlook	106
	References	106
5	Synthesis of 1D Amorphous Nanomaterials	111
5.1	Introduction	111
5.2	Hydrothermal/Solvothermal Method	113
5.3	Chemical Precipitation Method	116
5.4	Electrochemical Deposition Method	120
5.5	Templating Method	122
5.6	Other Synthetic Methods	124
5.7	Summary and Outlook	131
	References	132
6	Synthesis of 2D Amorphous Nanomaterials	137
6.1	Introduction	137
6.2	Thermal Decomposition Method	138
6.3	Exfoliation Method	139
6.4	Deposition Method	143
6.4.1	Physical Vapor Deposition Method	143
6.4.2	Electrodeposition Method	143
6.5	Chemical Precipitation Method	147
6.6	Templating Method	148

6.7	Phase Transformation Method	151
6.8	Sol–Gel Method	151
6.9	Element Doping Method	152
6.10	Summary and Outlook	155
	References	155
7	Synthesis of 3D Amorphous Nanomaterials	163
7.1	Introduction	163
7.2	Template-Engaged Strategies	163
7.2.1	Coordinating Etching Method	164
7.2.2	Acid/Alkali Etching Method	166
7.2.3	Redox Etching Method	169
7.2.4	Self-Templated Method	171
7.3	Electrochemical Method	173
7.4	Hydrothermal/Solvothermal Method	174
7.5	Common Solution Method	176
7.6	Laser/Ultrasonic-Assisted Solution Method	177
7.7	Other Synthetic Methods	179
7.8	Summary and Outlook	182
	References	183
8	Synthesis of Amorphous-Coated and Amorphous-Doped Nanomaterials	189
8.1	Introduction	189
8.2	Amorphous Coated Nanomaterials by ALD	190
8.2.1	Amorphous Metal Oxide Coating	190
8.2.2	Amorphous Metal Fluoride Coating	192
8.3	Amorphous-Coated Nanomaterials With Different Dimensions	193
8.3.1	1D Amorphous-Coated Nanomaterials	193
8.3.1.1	Homojunction Structure	193
8.3.1.2	Hetrojunction Structure	197
8.3.2	2D Amorphous-Coated Nanomaterials	198
8.3.2.1	Carbon-Based Nanomaterials	198
8.3.2.2	Ni-Based Nanomaterials	200
8.3.2.3	Other Metal-based Nanomaterials	201
8.3.3	3D Amorphous-Coated Nanomaterials	202
8.3.3.1	Silica Coating	202
8.3.3.2	Carbon Coating	204
8.3.3.3	Metal Oxide Coating	205
8.3.3.4	Metal Sulfide Coating	207
8.4	Amorphous-Doped or Hybrid Nanomaterials	208
8.4.1	2D Amorphous-Doped Nanomaterials	208
8.4.2	3D Amorphous-Doped Nanomaterial	211
8.5	Summary and Outlook	215
	References	215

9	Applications of Amorphous Nanomaterials in Electrocatalysis	223
9.1	Introduction	223
9.2	Fundamentals of Electrocatalysis	225
9.3	Amorphous Nanomaterials as Electrocatalysts for Water Splitting	226
9.3.1	Amorphous Nanomaterials for HER	226
9.3.1.1	Amorphous Single Metallic Nanomaterials for HER	226
9.3.1.2	Amorphous Binary Metallic Nanomaterials for HER	232
9.3.1.3	Amorphous Composite Nanomaterials for HER	234
9.3.2	Amorphous Nanomaterials for OER	237
9.3.2.1	Amorphous Single Metallic Nanomaterials for OER	238
9.3.2.2	Amorphous Binary Metallic Nanomaterials for OER	241
9.3.2.3	Amorphous Polynary Metal Nanomaterials for OER	244
9.3.2.4	Amorphous Composites for OER	246
9.3.3	Amorphous Nanomaterials for ORR	248
9.3.3.1	Amorphous Noble Metal-based Nanomaterials for ORR	249
9.3.3.2	Amorphous 3d Metal-based Nanomaterials for ORR	249
9.3.4	Amorphous Nanomaterials for CRR	251
9.3.5	Amorphous Nanomaterials for NRR	252
9.3.6	Amorphous Nanomaterials as Bifunctional Electrocatalysts	253
9.3.6.1	Amorphous Nanomaterials as Bifunctional Electrocatalysts of HER and OER	254
9.3.6.2	Amorphous Nanomaterials as Bifunctional Electrocatalysts of ORR and OER	256
9.4	Summary and Outlook	256
	References	258
10	Applications of Amorphous Nanomaterials in Batteries	269
10.1	Introduction	269
10.2	Negative Electrodes in Batteries	269
10.2.1	Amorphous Phosphorus Compounds	269
10.2.2	Amorphous Silicon Compounds	273
10.2.3	Amorphous Transition Metal Oxides	280
10.2.3.1	Amorphous Iron Oxides	280
10.2.3.2	Amorphous Titanium Oxides	281
10.2.3.3	Amorphous Vanadium-Based Oxides	282
10.2.3.4	Amorphous Tin-Based Oxides	288
10.2.4	Amorphous Carbon	289
10.3	Positive Electrodes in Batteries	295
10.3.1	Amorphous Ferric Phosphate	295
10.3.2	Amorphous Vanadium-Based Oxides	300
10.3.3	Amorphous Metal Polysulfides	302
10.4	Summary and Outlook	304
	References	306

11	Applications of Amorphous Nanomaterials in Supercapacitors	317
11.1	Introduction	317
11.2	Applications in Electric Double-Layer Capacitors	318
11.3	Applications in Pseudocapacitors	324
11.3.1	Amorphous Metal Oxides	325
11.3.2	Amorphous Metal Sulfides	334
11.3.3	Other Amorphous Nanomaterials	337
11.4	Summary and Outlook	341
	References	342
12	Applications of Amorphous Nanomaterials in Photocatalysis	347
12.1	Introduction	347
12.2	Photocatalytic Degradation	349
12.3	Photocatalytic Decomposition of Water	355
12.4	Photo-Electrocatalysis	359
12.5	Amorphous Nanomaterial as Cocatalyst in Photocatalysis	363
12.6	Other Applications in Photocatalysis	366
12.7	Summary and Outlook	370
	References	370
13	Engineering Applications of Amorphous Nanomaterials	375
13.1	Introduction	375
13.2	Mechanical Properties of Amorphous Nanomaterials	376
13.2.1	Amorphous Alloys/Metals	376
13.2.2	Amorphous Nonmetallic Materials	382
13.3	Strategy for Enhancing the Mechanical Performance	386
13.3.1	Introduction of Micro/Nanosecond Phase	387
13.3.2	Introduction of Micro/Nano-Inhomogeneity	393
13.3.3	Surface Modification	395
13.3.4	Amorphous Based Composite Materials	396
13.4	Summary and Outlook	401
	References	402
	Index	407

