

## Contents

### Preface *xi*

<b>1</b>	<b>On the Basis of Fibers and Textiles</b>	<b>1</b>
1.1	On the Basis of Fibers	2
1.1.1	Nature Fibers	2
1.1.2	Chemical Fibers	4
1.1.3	Classical Functional Fibers	7
1.2	On the Basis of Textiles	11
1.2.1	Traditional Textiles	12
1.2.2	Classical Functional Textiles	15
1.3	The Evolution from Classical Functional Fibers to Intelligent Fibers and Textiles	20
1.3.1	Shape Memory Fibers and Textiles	20
1.3.2	Intelligent Temperature-Regulating Fibers and Textiles	22
1.3.3	Intelligent Color-Changing Fibers and Textiles	24
1.3.4	Wearable Electronic Intelligent Fibers and Textiles	27
1.4	Conclusions	30
	References	31
<b>2</b>	<b>A Brief Introduction to Typical Film Deposition Technologies</b>	<b>33</b>
2.1	Dry-Process Film Deposition Technologies	34
2.1.1	Physical Vapor Deposition for Film Deposition	34
2.1.2	Chemical Vapor Deposition for Film Deposition	37
2.1.3	Morphology and Pattern Design	41
2.2	Typical Wet-Process Technologies for Roll-to-Roll Device Fabrication	44
2.2.1	Chemical Reaction Coating for Thin Film Preparation	45
2.2.2	Electrochemical Reaction Method for Thin Film Preparation	49
2.2.3	Spray Pyrolysis	50
2.2.4	Langmuir-Blodgett Technique	51
2.3	Typical Film Structure Characterization Technologies	54
2.3.1	Thin Film Analysis Method: Crystal Structure Properties	54

2.3.2	Thin Film Analysis Method: Morphology Properties	58
2.3.3	Thin Film Analysis Method: Chemical Composition and Structure Properties	60
2.4	Conclusions	64
	References	65
<b>3</b>	<b>The Fabrication Process of Intelligent Fibers and Textiles</b>	<b>69</b>
3.1	The Synthesis of Classical Functional Fibers	70
3.1.1	Wet Spinning	70
3.1.2	Electrospinning	71
3.1.3	Dry Spinning	74
3.1.4	Thermal Drawing Process	74
3.1.5	Surface Modification Method	76
3.2	The Nano/Micro-Assembly on Fiber Materials	79
3.2.1	Chemical Liquid Phase Deposition	79
3.2.2	Plasma Spraying Method	87
3.2.3	Chemical Vapor Deposition	88
3.2.4	Physical Vapor Deposition	90
3.3	Device Assembly from Fibers to Textiles	91
3.3.1	Direct Coating Based on Fabric	92
3.3.2	Layer Stacking of Fabric Electrodes	94
3.3.3	Interweaving of Fiber Electrodes	95
3.3.4	Weaving of Fiber Devices	97
3.3.5	Other Assembly Methods	97
	References	100
<b>4</b>	<b>Energy Harvesting Fibers</b>	<b>105</b>
4.1	Photovoltaic Fibers	105
4.1.1	Fiber-Shaped Inorganic Solar Cell	106
4.1.2	Fiber-Shaped Organic Polymer Solar Cell	108
4.1.3	Fiber-Shaped Dye-Sensitized Solar Cell	113
4.1.4	Fiber-Shaped Perovskite Solar Cell	119
4.2	Piezoelectric Fibers	124
4.2.1	Working Principle of Piezoelectricity	124
4.2.2	Piezoelectric Materials	125
4.2.3	Fiber-Shaped Piezoelectric Devices Based on Piezoceramics	126
4.2.4	Fiber-Shaped Piezoelectric Devices Based on Piezopolymers	127
4.2.5	Fiber-Shaped Piezoelectric Devices Based on Piezocomposites	130
4.3	Triboelectric Fibers	132
4.3.1	Working Principle of Triboelectric Nanogenerator	132
4.3.2	Triboelectrification Materials	134
4.3.3	Triboelectric Fiber Devices	135
4.4	Thermoelectric Fibers	140
4.4.1	Introduction of Thermoelectric Effect	140
4.4.2	TE Materials for Wearable Thermoelectric Devices	141

4.4.3	Fiber-Shaped Thermoelectric Devices	145
4.5	Conclusions and Outlook	147
	References	148
<b>5</b>	<b>Energy Storage Fibers</b>	<b>157</b>
5.1	Supercapacitor Fibers	157
5.1.1	Supercapacitor Fibers with Carbon-Based Capacitive Materials	159
5.1.2	Supercapacitor Fibers with Compositing Capacitive Materials	166
5.2	Battery Fibers	169
5.2.1	Primary Battery Fibers	170
5.2.2	Lithium-Ion Battery Fibers	173
5.2.3	Lithium-Sulfur Battery Fibers	174
5.2.4	Metal-Air Battery Fibers	177
5.2.5	Other Battery Fibers	180
5.3	Phase-Transit Fibers	182
5.3.1	Phase-Transit Fibers Based on Hydrocarbons and Fatty Acids	184
5.3.2	Phase-Transit Fibers Based on Fatty Alcohols	187
5.3.3	Phase-Transit Fibers Based on Other Kinds of Phase-Transit Materials	190
5.4	Conclusions	192
	References	193
<b>6</b>	<b>Smart Energy Textiles</b>	<b>197</b>
6.1	Energy Harvesting Textiles	198
6.1.1	Photovoltaic Energy Harvesting Textiles	198
6.1.2	Thermoelectric Energy Harvesting Textiles	203
6.1.3	Mechanical Energy Harvesting Textiles	205
6.2	Energy Storage Textiles	209
6.2.1	Supercapacitor Textiles	209
6.2.2	Primary Battery Textiles	212
6.2.3	Secondary Battery Textiles	213
6.3	Hybrid Energy Textiles	218
6.3.1	Multiple Energy Harvesting Hybrid Textiles	219
6.3.2	Harvesting-Storage Hybrid Energy Textiles	222
6.4	Commercialization Power Requirements of Smart Energy Textiles	224
	References	225
<b>7</b>	<b>Function Expansion of Smart Energy Fibers and Textiles</b>	<b>231</b>
7.1	Stretchability of Smart Energy Fibers and Textiles	231
7.1.1	Stretchable Electrode Based on Elastic Conductive Materials	232
7.1.2	Stretchable Electrode Based Electrode Structural Designs	236
7.1.3	Assembling of Fiber-Type and Textile-Type Stretchable Devices	238
7.2	Hydrophobicity of Smart Energy Fibers and Textiles	240
7.2.1	The History of Conventional Hydrophobic Fabrics	240
7.2.2	The Development of Hydrophobic Coatings	241

7.2.3	Fabricating Technologies for Hydrophobic Smart Energy Fibers and Textiles	245
7.3	Endurability of Smart Energy Fibers and Textiles	247
7.3.1	Mechanical Stability of Smart Energy Fibers and Textiles	247
7.3.2	Chemical Stability of Smart Energy Fibers and Textiles	249
7.3.3	Other Working Stability Under Complicate Environment	251
7.4	Air Permeability of Smart Energy Fibers and Textiles	253
7.4.1	The Influence of Textile Materials on Air Permeability	253
7.4.2	The Influence of Textile Structure Design on Air Permeability	255
7.5	Color-Change Ability of Smart Energy Fibers and Textiles	258
7.5.1	Color-Changeable Materials	259
7.5.2	Color-Changeable Textiles	261
7.6	Conclusions	263
	References	264
<b>8</b>	<b>Emerging Electronic Fibers and Textiles</b>	<b>273</b>
8.1	Stress Sensing Textiles	274
8.1.1	Piezoresistive Stress Sensing Textiles	274
8.1.2	Capacitive Stress Sensing Textiles	278
8.1.3	Other Stress Sensing Textiles	284
8.2	Strain Sensing Textiles	286
8.2.1	Piezoresistive Strain Sensing Textiles	286
8.2.2	Capacitive Strain Sensing Textiles	292
8.2.3	Triboelectricity Strain Sensing Textiles	296
8.3	Chemical Sensing Textiles	298
8.3.1	Ion Sensing Textiles	298
8.3.2	Humidity Sensing Textiles	301
8.3.3	Gas Sensing Textiles	301
8.4	Other Function Coupled Textiles	304
8.5	Conclusions and Outlook	306
	References	306
<b>9</b>	<b>Towards Self-Powered Electronic Textiles</b>	<b>313</b>
9.1	Self-Powered Electronic Devices	313
9.1.1	Independent Self-Powered Electronic Devices	314
9.1.2	Integrated Self-Powered Electronic Devices	317
9.1.3	Other Types of Self-Powered Electronic Devices	320
9.2	Flexible Self-Powered Electronic Devices	321
9.2.1	Flexible Independent Self-Powered Electronic Devices	322
9.2.2	Flexible Integrated Self-Powered Electronic Devices	324
9.2.3	Other Types of Flexible Self-Powered Electronic Devices	327
9.3	Self-Powered Electronic Fibers	327
9.3.1	Fiber-Type and Textile-Type Independent Self-Powered Electronic Devices	329

9.3.2	Textile-Type Integrated Self-Powered Electronic Devices	331
9.4	Summary	335
	References	336
<b>10</b>	<b>The Future of Electronic Textiles</b>	<b>341</b>
10.1	Commercialization Requirements Beyond Energy Efficiency	342
10.1.1	Energy Supply	343
10.1.2	Electronic Function Expansion	344
10.1.3	Mechanical Durability	344
10.1.4	Wearability	345
10.2	Challenges for Smart Electronic Textiles	345
10.2.1	Energy Efficiency	346
10.2.2	Diversity of Functions	347
10.2.3	Wearing Comfort	347
10.2.4	Fabrication Technology	349
10.3	A Prospective Discussion on Smart Electronic Textiles	351
	References	355
	<b>Index</b>	<b>357</b>