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Fiber-Shaped Energy Harvesting and Storage Devices

 Springer

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Preface

The effective energy harvest and storage is critical to the modern society. For the energy harvest, solar energy that is inexhaustible, free, environmentally friendly and uniformly distributed to all countries represents one of the most explored strategies, and a solar cell that converts solar energy to electrical energy has been widely investigated. The silicon-based solar cells are already available for practical applications, but the high cost and pollution prevent their large spread. As a result, a lot of efforts have been made to develop next-generation solar cells including dye-sensitized, polymer and perovskite solar cells in recent decades. They are expected to dominate the future life due to the environmental friendliness and low cost. For the energy storage, electrochemical storage devices such as lithium ion batteries and supercapacitors are widely used to power various electronic facilities. Currently, main attentions are paid to discover new materials and design new structures to further improve the energy storage capability.

Generally, the solar cells, lithium ion batteries and supercapacitors appear in a rigid plate or flexible film that cannot effectively meet the combined requirement on the light weight, miniaturization and weaveability in the modern electronics such as wearable facilities, the proposed next-generation resolution in the near future. The large and heavy lithium ion battery at the leg end of Google glasses makes them inconvenient and uncomfortable. It even becomes a bottleneck for wearable electronic products such as smart clothes. To this end, a new family of fiber-shaped energy devices has been recently discovered as an effective solution. Compared with the conventional two- or three-dimensional structures, the one-dimensional energy devices show some unique and promising advantages including smaller size, lighter weight, three-dimensional flexibility and weaveability.

This book has summarized the advancement of fiber-shaped energy devices mainly based on the research work at our lab. To realize these one-dimensional energy devices with high performances, it is critically important to develop desirable fiber electrodes. Therefore, the available fiber electrodes are first compared and a new family of aligned carbon nanotube-based fibers are recommended for both energy conversion and storage devices. Based on the aligned carbon nanotube fiber

as one or two electrodes, fiber-shaped dye-sensitized solar cells, polymer solar cells and perovskite solar cells are sequentially investigated. Two main structures, i.e., twisted and coaxial, have been described for the three kinds of solar cells with an emphasis on their advantages and disadvantages. Fiber-shaped energy storage devices including lithium ion batteries and supercapacitors are then followed on the basis of similar fiber electrodes and structures. To realize self-powering functionality that is highly desired in the wearable facilities as well as other portable electronic products, fiber-shaped solar cells are further integrated with fiber-shaped energy storage devices. In other words, both photoelectric conversion and electrochemical storage are achieved at a single fiber device. Finally, the above fiber-shaped energy devices have been woven into flexible energy textiles, and the future directions on these wearable energy devices are also highlighted.

This book is intended for scientists, engineers, graduate students and undergraduate students, majoring in chemistry, physics, biomedical science and engineering who are interested in the energy materials and devices. It may be also useful to many non-specialists in industry who are devoted to promoting the wearable and related technologies. As fiber-shaped energy devices have been studied just for a few years, there may be many imperfections and omissions in this book also due to the limit of my ability. I will greatly appreciate critical and suggestive comments from the readers.

I strongly hope to acknowledge many postdoctoral fellows and graduate students who joined in the writing of this book at my lab with Chapter 1 drafted by Hao Sun, Chapter 2 by Longbin Qiu, Chapter 3 by Shaowu Pan and Xin Fang, Chapter 4 by Zhitao Zhang, Chapter 5 by Jue Deng and Longbin Qiu, Chapter 6 by Houpu Li, Huijuan Lin and Guozhen Guan, Chapter 7 by Wei Weng and Ye Zhang, Chapter 8 by Hao Sun and Jue Deng, Chapter 9 by Shaowu Pan and Chapter 10 by Hao Sun. In particular, I would like to thank Hao Sun for the organization work during writing and Xin Fang for revising the whole book at the final stage. Yifan Xu, a graduate student in my lab, also contributed to the book by drafting several illustrations. I sincerely thank Editor June Tang for the kind invitation on writing this book and warm support in publishing the book.

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Huisheng Peng

Contents

1	Introduction	1
1.1	Development in Energy Harvesting and Storage	1
1.1.1	Energy Harvesting	1
1.1.2	Energy Storage	2
1.2	Challenges for Conventional Planar Devices	2
1.3	Emergence of Fiber-Shaped Devices	3
1.3.1	Fiber-Shaped Energy Harvesting Devices	3
1.3.2	Fiber-Shaped Energy Storage Devices	4
1.3.3	Fiber-Shaped Integrated Devices	4
1.4	Advancement of Fiber-Shaped Device	5
	References	6
2	Electrically Conducting Fiber	7
2.1	Introduction	7
2.2	Metal Wire	8
2.2.1	Titanium Wire	9
2.2.2	Stainless Steel Wire	10
2.2.3	Other Metal Wires	11
2.3	Carbon Nanotube Fiber	12
2.3.1	Preparation Methods	12
2.3.2	Dry Spinning from Carbon Nanotube Array	16
2.4	Graphene Fiber	25
2.4.1	Synthesis	25
2.4.2	Preparation	27
2.4.3	Properties	28
2.4.4	Composite Fiber	29
2.5	Carbon Fiber and Polymer Fiber	30
2.5.1	Carbon Fiber	30
2.5.2	Polymer Fiber	30
2.6	Summary	31
	References	32

3	Fiber-Shaped Dye-Sensitized Solar Cell	39
3.1	Overview of Dye-Sensitized Solar Cell	39
3.1.1	Principle in an Energetic View	40
3.1.2	Principle in a Kinetic View	44
3.1.3	Materials	47
3.1.4	Characterization	50
3.1.5	Summary	51
3.2	Overview of Fiber-Shaped Dye-Sensitized Solar Cell	51
3.2.1	Metal-Based Electrode	52
3.2.2	Metal-Free Electrode	53
3.3	Fiber-Shaped Dye-Sensitized Solar Cell in a Twisting Structure	54
3.3.1	Working Electrode	54
3.3.2	Counter Electrode	60
3.3.3	Electrolyte	65
3.4	Fiber-Shaped Dye-Sensitized Solar Cell in a Coaxial Structure	66
3.5	Multifunctional Fiber-Shaped Solar Cell	69
3.6	Perspective	72
	References	73
4	Fiber-Shaped Polymer Solar Cell	77
4.1	Overview of Polymer Solar Cell	77
4.1.1	Working Mechanism	78
4.1.2	Structure	79
4.1.3	Materials	80
4.1.4	Characterization	83
4.1.5	Summary	85
4.2	Overview of Fiber-Shaped Polymer Solar Cell	85
4.2.1	Fiber-Shaped Polymer Solar Cells in Twisting Structure	86
4.2.2	Fiber-Shaped Polymer Solar Cells in a Coaxial Structure	87
4.3	Fiber-Shaped Polymer Solar Cells Based on Carbon Nanotubes	88
4.4	Perspective	92
	References	94
5	Fiber-Shaped Perovskite Solar Cell	97
5.1	Overview of Perovskite Solar Cell	97
5.1.1	Working Mechanism	99
5.1.2	Structure	100
5.1.3	Material	103
5.1.4	Summary	104
5.2	Flexible Perovskite Solar Cell	104

5.3	Fiber-Shaped Perovskite Solar Cell	106
5.4	Stretchable Fiber-Shaped Perovskite Solar Cell	108
5.5	Perspective	112
	References	113
6	Fiber-Shaped Supercapacitor	117
6.1	Overview of Supercapacitor	117
6.1.1	Energy Storage Mechanism	118
6.1.2	Electrode Material	121
6.2	Twisting Fiber-Shaped Supercapacitor	125
6.2.1	Overview	125
6.2.2	Carbon Nanotube Fiber/Ti Wire Hybrid Supercapacitor	127
6.2.3	Carbon Nanotube Fiber/Conducting Polymer Composite Fiber	128
6.2.4	Carbon Nanotube Hybrid Fiber	129
6.2.5	Graphene Fiber	130
6.3	Coaxial Fiber-Shaped Supercapacitor	131
6.3.1	Architecture	131
6.3.2	Fabrication	132
6.3.3	Performances of Coaxial Fiber-Shaped Supercapacitor	135
6.4	Multifunctional Fiber-Shaped Supercapacitors	138
6.4.1	Stretchable Supercapacitor	138
6.4.2	Chromatic Supercapacitor	140
6.4.3	Supercapacitor Textile	141
	References	143
7	Fiber-Shaped Lithium Ion Battery	147
7.1	Overview of Lithium Ion Battery	147
7.1.1	General Principle	148
7.1.2	Cathodes	151
7.1.3	Anodes	152
7.1.4	Electrolytes	154
7.2	Flexible Lithium Ion Batteries	155
7.2.1	Flexible Lithium Ion Batteries in Planar Shape	155
7.2.2	Stretchable Lithium Ion Batteries	157
7.2.3	Cable-Type Lithium Ion Battery	158
7.3	Fiber-Shaped Lithium Ion Batteries	159
7.3.1	Fiber-Shaped CNT/MnO ₂ Cathode	160
7.3.2	Fiber-Shaped CNT/Si Anode	162
7.3.3	Fiber-Shaped LiMn ₂ O ₄ -Si Battery	166
7.3.4	Fiber-Shaped LiMn ₂ O ₄ -Li ₄ Ti ₅ O ₁₂ Battery	170
7.4	Perspective	176
	References	177

8	Fiber-Shaped Integrated Device	179
8.1	Overview of Integrated Device	179
8.1.1	All-in-One Device	180
8.1.2	Assembled Devices	182
8.1.3	Materials and Characterization	184
8.1.4	Summary	184
8.2	Overview of Fiber-Shaped Integrated Device	185
8.3	Integrated Devices Based on Dye-Sensitized Solar Cell and Electrochemical Capacitor	185
8.3.1	Integrated Device in Coaxial Structure	186
8.3.2	Integrated Device in a Twisting Structure	189
8.4	Integrated Polymer Solar Cell and Electrochemical Capacitor	191
8.5	Stretchable Fiber-Shaped Integrated Device	193
8.6	Perspective	195
	References	196
9	Energy Textiles	199
9.1	Overview of Energy Textiles	199
9.2	Energy Textiles from Fabric Electrode	200
9.2.1	Photovoltaic Textiles	201
9.2.2	Supercapacitor Textiles	205
9.3	Perspective	210
	References	211
10	Summary and Outlook	213
10.1	Advantages	213
10.1.1	Flexibility	214
10.1.2	Miniaturization	214
10.1.3	Weavability	214
10.1.4	Wearability	214
10.1.5	Others	215
10.2	Applications	215
10.2.1	Portable Devices	215
10.2.2	Miniature Devices	215
10.2.3	Military Applications	216
10.2.4	Wearable Applications	216
10.3	Challenges and Directions	216
10.3.1	Fiber Electrode	216
10.3.2	Capacity of Energy Harvesting and Storage	217
10.3.3	Stability	217
10.3.4	Safety	218
10.3.5	Scale-Up Fabrication	218