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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.

Shanghai, China Huisheng Peng
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