

Rechargeable Batteries

Materials, Technologies and New Trends

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Preface

Rechargeable batteries are devices that reversibly convert electrical energy into chemical energy and store resulting chemical energy in the unit. In the past two decades, lithium-ion (Li-ion) batteries have been most rapidly developed and widely used in numbers of mobile consumer electronics, such as cellular phones, cameras, laptops, tablets, and power tools, due to their high energy density, high power capacity, and robust performance. Further developments of the Li-ion batteries are aimed at applications in the electric transportations and stationary grids for the effective harvest of renewable solar and wind power, which raise grand challenges in the performance and cost of the batteries. The performances are typically qualified by the energy density, powder capability, cycle life and safety, and the cost by the price of battery materials and engineering. In order to meet the energy and power requirements of these applications, many single cells are electrically connected into modules that are subsequently integrated into a battery pack. Therefore, the challenges are remained not only for the materials and process of single cells but also for the designs and engineering of battery packs. The Li-ion batteries store electrochemical energy through the reversible intercalation and deintercalation of Li^+ ions with a lithiated transitional metal oxide as the cathode material and natural or synthetic graphite as the anode material. The capacities of these Li^+ -ion intercalation materials are limited by their crystallographic structure and the present technology has approached to the theoretical values. While acceptable for the applications in mobile consumer electronics, the relatively high cost and limited earth abundance of the transitional metals used in the Li^+ -ion cathode materials become grand challenges for the transportation and stationary applications. In order to overcome the challenges of the performance and cost, new materials and concepts are necessary for the development and commercialization of the next generation rechargeable batteries.

The performance enhancement is realized generally by improving the battery materials and design, including the cathode, anode, and electrolyte/separator, and the cost reduction by selecting the low-cost raw materials and process. In response to the increased demands for the transportation and stationary applications, this book is designed to update the latest advancements in the research and development

of rechargeable batteries with focus on the materials and technologies for the synthesis and characterization of battery materials, as well as the diagnosis and analysis of single cells and battery packs. According to the battery reactions, this book is composed of Chaps. 1–17 covering the new materials and technologies in lithium-ion battery and Chaps. 18–24 covering the new developments and new trend in the battery systems beyond lithium-ion including lithium-sulfur battery, metal-air battery, magnesium battery, sodium-ion battery and redox flow battery.

This book is contributed by a group of leading scientists, engineers, and professors, who are directly working on the subjected areas. We believe that this book is extremely useful for the researchers who work in the conversion and storage of electrochemical energy, and also serves an excellent textbook or reference for the college/university undergraduates and graduates who are interested in the areas of materials, energy, and electrochemistry in relation to the electrochemical energy storage.

We gratefully acknowledge all chapter authors for their enthusiastic and collaborative contributions. We also wish to thank Ms. Garrett Ziolek, the editorial assistant of Springer, for her guidance and support in preparing this book. Finally, we give our deepest appreciation to our families for their continuous support while we were working on this book.

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