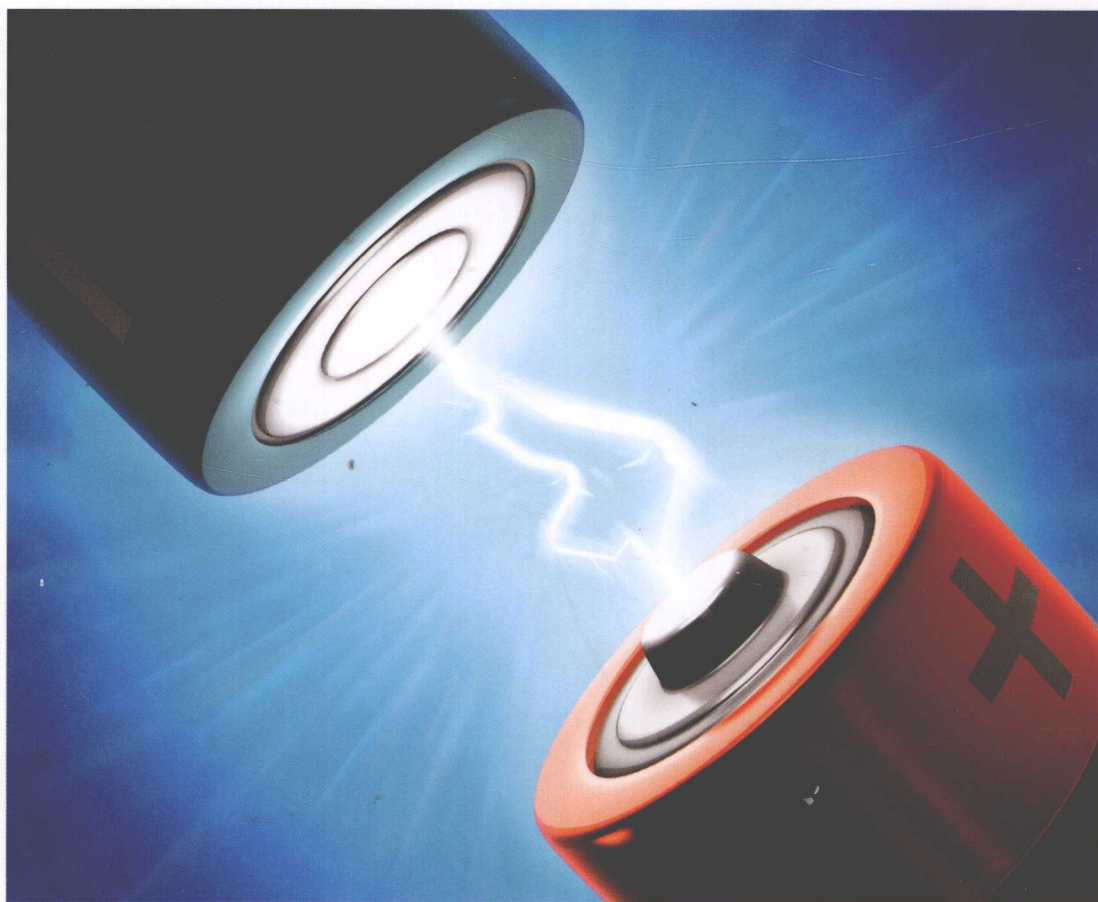


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Electrochemical Technologies for Energy Storage and Conversion

Volume 1



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and Jiujun Zhang*

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Preface

In today's world, clean energy technologies, which include energy storage and conversion, play the most important role in the sustainable development of human society, and are becoming the most critical elements in overcoming fossil fuel exhaustion and global pollution. Among clean energy technologies, electrochemical technologies are considered the most feasible, environmentally friendly and sustainable. Electrochemical energy technologies such as secondary (or rechargeable) batteries and fuel cells have been invented and used, or will be used in several important application areas such as transportation, stationary, and portable/micro power. With increasing demand in both energy and power densities of these electrochemical energy devices in various new application areas, further research and development are essential to overcome challenges such as cost and durability, which are considered major obstacles hindering their applications and commercialization. In order to facilitate this new exploration, we believe that a book covering all important areas of electrochemical energy technologies for clean energy storage and conversion, giving an overall picture about these technologies, should be highly desired.

The proposed book will give a comprehensive description of electrochemical energy conversion and storage methods and the latest development, including batteries, fuel cells, supercapacitors, hydrogen generation and storage, as well as solar energy conversion. It addresses a variety of topics such as electrochemical processes, materials, components, assembly and manufacturing, degradation mechanisms, as well as challenges and strategies. Note that for battery technologies, we have tried our best to focus on rechargeable batteries by excluding primary batteries. With chapter contributions from scientists and engineers with excellent academic records as well as strong industrial expertise, who are at the top of their fields on the cutting edge of technology, the book includes in-depth discussions ranging from comprehensive understanding, to engineering of components and applied devices. We wish that a broader view of various electrochemical energy conversion and storage devices will make this book unique and an essential read for university students including undergraduates and graduates, scientists, and engineers working in related fields. In order to help readers to understand the science and technology of the subject, some important and representative figures, tables, photos, and comprehensive lists of reference papers, will also be presented

in this book. Through reading this book, the readers can easily locate the latest information on electrochemical technology, fundamentals, and applications.

In this book, each chapter is relatively independent of the others, a structure which we hope will help readers quickly find topics of interest without necessarily having to read through the whole book. Unavoidably, however, there is some overlap, reflecting the interconnectedness of the research and development in this dynamic field.

We would like to acknowledge with deep appreciation all of our family members for their understanding, strong support, and encouragement.

If any technical errors exist in this book, all editors and chapter authors would deeply appreciate the readers' constructive comments for correction and further improvement.

Ru-Shi Liu, Lei Zhang, Xueliang Sun, Hansan Liu, and Jiujun Zhang

About the Editors



Ru-Shi Liu received his bachelor's degree in chemistry from Shoochow University, Taiwan, in 1981, and his master's in nuclear science from the National Tsing Hua University, two years later. He gained one Ph.D. in chemistry from National Tsing Hua University in 1990, and one from the University of Cambridge in 1992. From 1983 to 1995 he worked as a researcher at the Industrial Technology Research Institute, before joining the Department of Chemistry at the National Taiwan University in 1995 where he became a professor in 1999. He is a recipient of the Excellent Young Person Prize, Excellent Inventor Award (Argentine Medal) and Excellent Young Chemist Award. Professor Liu has over 350 publications in scientific international journals as well as more than 80 patents to his name.



Lei Zhang is a Research Council Officer at the National Research Council of Canada Institute for Fuel Cell Innovation. She received her first M.Sc. in inorganic chemistry from Wuhan University in 1993, and her second in materials chemistry from Simon Fraser University, Canada in 2000. She is an adjunct professor at the Federal University of Maranhao, Brazil and at the Zhengzhou University, China, in addition to being an international advisory member of 7th IUPAC International Conference on Novel Materials and their Synthesis and an active member of the Electrochemical Society and the International Society of Electrochemistry. Ms. Zhang has co-authored over 90 publications and holds five US patent applications. Her main research interests include PEM fuel cell electrocatalysis, catalyst layer/electrode structure, metal-air batteries/fuel cells and supercapacitors.



Xueliang (Andy) Sun holds a Canada Research Chair in the development of nanomaterials for clean energy, and is Associate Professor at the University of Western Ontario, Canada. He received his Ph.D. in materials chemistry in 1999 from the University of Manchester, UK, after which he worked as a postdoctoral fellow at the University of British Columbia, and as a research associate at l'Institut national de la recherche scientifique, Canada. He is the recipient of a number of awards, including the Early Researcher award, Canada Research Chair award and University Faculty Scholar award, and has authored or co-authored over 100 papers, 3 book chapters and 8 patents. Over the past decade, Dr. Sun has established a remarkable track record in nanoscience and

nanotechnology for clean energy, mainly in the synthesis and structure control of one-dimensional nanomaterials, as well as their applications for fuel cells and Li ion batteries.



Hansan Liu is a researcher at the Oak Ridge National Laboratory, US Department of Energy. He obtained his Ph.D. in electrochemistry from Xiamen University where he studied cathode materials for lithium ion batteries. After graduation, he worked at the Hong Kong Polytechnic University and the National Research Council Canada on electrophotocatalysis and fuel cell electrocatalysis, respectively. He is currently working on next generation high-energy density batteries at ORNL. Dr. Liu has 14 years of research experience in the

field of electrochemical energy storage and conversion. His research interests mainly include battery and supercapacitor materials, fuel cell electrocatalysts, and synthesis and applications of high surface area materials. He has authored and co-authored over 70 publications, including 3 books, 4 book chapters and 3 patent applications relating to batteries and fuel cells. Dr. Liu is an active member of the Electrochemical Society and the International Society of Electrochemistry.



Currently a Senior Research Officer and PEM Catalysis Core Competency Leader at the National Research Council of Canada Institute for Fuel Cell Innovation, **JiuJun Zhang** received his B.Sc. and M.Sc. in electrochemistry from Beijing University, China, in 1982 and 1985, respectively, and his Ph.D. in electrochemistry from Wuhan University in 1988. After this, he took up a position as an associate professor at the Huazhong Normal University, and in 1990 carried out three terms of postdoctoral research at the California

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