



## Book review

**Encyclopedia of Electrochemical Power Sources, J. Garche, C. Dyer, P. Moseley, Z. Ogumi, D. Rand, B. Scrosati (Eds.). Elsevier (2009)**

In view of the limited resources of natural oil and gas and the growing environmental standards, electrochemical power conversion and storage have gained enormous importance. This is reflected in the great efforts of many countries to develop fundamental and applied research in the field.

In this environment a comprehensive encyclopedia is highly valued as it takes into account the multidisciplinary nature of the subject and the fact that scientists of different disciplines are entering this field. In 351 papers written by about 540 authors the encyclopedia of electrochemical power sources covers nearly all topics in this developing field. 5 volumes and more than 4500 pages cover applications, batteries, capacitors, electrochemical theory, fuel cells and photoelectrochemical cells. Other important topics include materials, measurement methods, recycling and safety.

Volume 1 starts with a description of applications of portable and stationary batteries and fuel cells, e.g. in notebooks, power tools, electrical vehicles and hybrid systems. Prominent topics such as automotive applications as well as side issues like military and aircraft batteries are presented. Established systems in addition to new developments are also discussed, supplemented by market aspects and overviews. For example, the chapter on portable power tools *presents actual data of the worldwide battery market and market share of different battery types and cell manufacturers for power tools*.

The second part of volume 1 provides an introduction to fundamental aspects of batteries, e.g. definitions, nomenclature, self-discharge, charging methods and the characterization of batteries by electrochemical impedance spectroscopy. The final part of volume 1 offers an introduction to different aspects of electrochemical capacitors, e.g. polymer capacitors, metal oxide capacitors and application of capacitors. Volume 1 also includes chemistry, electrochemistry and applications of selected metals, e.g. aluminum, lithium, zinc, carbon and other chemical elements.

The first part of volume 2 presents a comprehensive overview of electrochemistry. The electrochemical theory chapter introduces the reader to the basics. Explanations for electrochemical thermodynamics, double layer models and electrochemical kinetics, including special subjects like hydrogen and oxygen evolution, basic principles of corrosion and nanoelectrodes, *are informative and concise*.

Volumes 2 and 3 are primarily concerned with fuel cells, describing different types of fuel cells in detail. Specific topics such as modeling, membranes, electrodes, cells, stack design, microbial fuel cells, hydrogen storage, safety considerations and the description of several exploratory fuel cells are included.

The final part of volume 3 contains short reviews relevant to fuel cell and battery characterization such as the history of electrochem-

istry, fuel cells, batteries and capacitors and articles on material aspects, e.g. nanofibers, sol-gel, and several measurement methods, cyclic voltammetry, electrochemical impedance spectroscopy and transmission electron microscopy.

The first part of volume 4 gives a short introduction to photoelectrochemical cells. The main part volume 4 and the entire volume 5 discuss several aspects of batteries. *Aqueous and nonaqueous primary batteries are also included*. Several articles are focused on *recycling of batteries* and metals, e.g. lithium, nickel and noble metals. *Safety considerations* of batteries are also part of volume 4.

A comprehensive overview of many topics in secondary batteries is given in volumes 4 and 5. Subjects include high temperature systems, e.g. sodium-sulfur, metal-air systems, iron-air, lithium-air, zinc-air, nickel based batteries, nickel-cadmium, nickel-metal hydride, nickel-zinc, several aspects of lead battery, electrodes design, electrolyte, performance and lifetime determining processes. Volume 5 describes many aspects of rechargeable lithium and lithium ion batteries, e.g. positive and negative electrodes, electrolytes, lithium-sulfur, lithium-iron sulfide, polymer batteries and lifetime predictions. Redox flow-systems, e.g. vanadium redox flow battery in volume 5 and lead redox flow battery in volume 4, are also covered. The final part of volume 5 discusses several secondary zinc batteries, e.g. zinc-bromine, zinc-manganese, zinc-silver.

The basic introductions to electrochemistry, measurement methods and material aspects are written by *famous experts* and offer a vital support to students and newcomers in the field of electrochemical energy storage and conversion. *The content overlap is especially very informative and complimentary*. For example, the Butler-Volmer equation is introduced in the kinetics chapter (volume 2) based on electron energy diagrams and in the electrokinetics chapter (volume 2) based on the activation energy model. Unfortunately, the Marcus theory based on a molecular approach is only mentioned briefly in both chapters. Despite such shortcomings these chapters offer a convenient introduction to the principles of fundamental and material science on which fuel cells and batteries are based.

A descriptive example of this comprehensive encyclopedia is the reaction mechanism of oxygen reduction at the solid oxide fuel cell (SOFC) cathode: the corresponding overview paper (volume 3) describes material and structural aspects of air cathodes and also some experimental approaches to elucidate the reaction mechanism, e.g. by secondary ion mass spectrometry. The original papers are not cited unfortunately. However, if the reader is interested in air cathodes and the reactions taking place with these electrodes, another paper in volume 3 describes SOFC air cathodes in more detail, e.g. materials, stability, thermal properties. Several aspects of gas distribution in electrodes and on stack and module level are also described in volume 3. Readers interested in basic principles of oxygen reduction reaction and not focused on SOFC will find these aspects described in volume 1.

*The main focus of the encyclopedia is on fuel cells and batteries. Compared to this very comprehensive information, the description of other electrochemical power sources is brief. Only two papers (volume 4) describe photoelectrochemical cells and only nine papers (volume 1) are focused on capacitors with six of them written by the same author. For comparison: about 100 papers are focused on secondary batteries.*

*The encyclopedia of electrochemical power sources is well written and clearly structured. The figures are of high quality and there is an overall index and a glossary. Each article is completed by a list of further publications, mainly of the last two decades, and a list of symbols, abbreviations and acronyms, which is especially useful because the symbols are not standardized. This excellent and comprehensive encyclopedia is highly recommended to scien-*

*tists and engineers, especially to those who are active in fuel cells and battery development. Many articles can be provided as informative introductions for students and people who start to work in this field.*

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