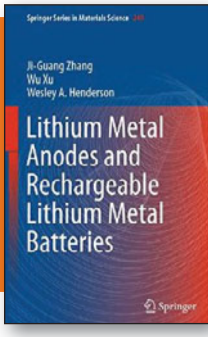


Lithium Metal Anodes and Rechargeable Lithium Metal Batteries

Ji-Guang Zhang, Wu Xu, and Wesley A. Henderson

Springer, 2017
194 pages, $99.99 (e-book $79.99)
ISBN 978-3-319-44053-8

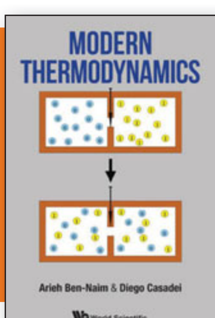
Lithium metal is light (with a density of 0.534 g/cm^3), has a specific capacity of 3860 mAh per gram, and has the highest electroactivity with redox potential of –3.04 against the standard hydrogen electrode. It should be the ideal anode material for rechargeable batteries. So what is stopping it? This book analyzes two barriers to the commercial development of rechargeable batteries with lithium-metal anodes: growth of lithium dendrites and low Coulombic efficiency of lithium cycling in the battery. At one time, the problems were considered insurmountable, and interest shifted to compromise candidates: disordered carbon and then to the present-day ordered graphite anode.

Is there a second coming for lithium-metal anodes? This book provides a structured response to this question. A brief introductory chapter on rechargeable batteries sets the stage for the use of lithium-metal anodes. The chapter introduces tree-like structures—with the generic name of dendrites—growing on the anode during charge/discharge cycles. These form internal short circuits, causing capacity loss. Chapter 2 describes seven techniques used to characterize the surface morphology and chemistry of dendrites. Micrographs and schematics contribute to the lucid description of test methods and failure mechanisms of the lithium anode. The chapter also discusses the important role of the solid-electrolyte interface. Theoretical models, including recent ones emphasizing interfacial elastic strength, are described. Chapter 3 discusses factors affecting Coulombic efficiency and dendrite growth, since most of them are common to both. The chapter also discusses various electrolytes and the influence of solvents, lithium salts, additives, and electrolyte concentration.

Chapter 4 considers the application of lithium-metal anodes mainly in lithium-sulfur and lithium-air batteries. The chapter also covers rechargeable batteries where a lithium-metal anode is formed *in situ*. Application of nanotechnology and progress in modeling and experimental work have led to new electrolytes and additives being used in batteries with lithium-metal anodes. Chapter 5 reviews these advances and offers perspectives on the future development of lithium-metal anodes.

References are extensive and cover the work completed up until 2015, with a few references from 2016. This is a valuable reference for people working in rechargeable batteries in general and lithium-metal anodes in particular. It is timely because the lithium anode has remained the holy grail for four decades, and recent developments discussed in the book may well take us nearer to the goal.

Reviewer: N. Balasubramanian *is an independent research scholar working in Bangalore, India.*



Modern Thermodynamics

Arieh Ben-Naim and Diego Casadei

World Scientific, 2016
372 pages, $95.00 (softcover $48.00)
ISBN 978-981-3200-75-3

This is not the first book entitled *Modern Thermodynamics*, but it is certainly a book from a very uncommon viewpoint for thermodynamics: the information theory proposed by Claude E. Shannon in 1948 (*Bell Syst. Tech. J.* **27** (3), 379). Ben-Naim and Casadei have written this book presenting their systematic research on the link between information theory and thermodynamic entropy.

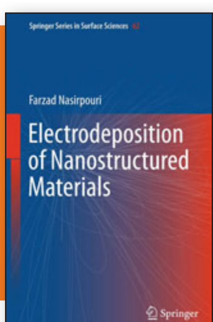
The book is divided into two sections: Fundamentals and Applications. Eight chapters cover the fundamentals, and four chapters cover specific applications. The first two chapters provide a brief historical development of thermodynamics and information theory. Perhaps the most interesting subsection is The Basic Idea of Information Theory, which is presented using a question game to find an unknown subject, person, or thing. The third chapter introduces the elements of probability theory, which are required to fully understand the concepts of Shannon's Measure of Information (SMI), called "entropy." The authors argue that SMI is definitely different from thermodynamic entropy because it is more general. They use the axiomatic approach to probability and introduce the three major probability distributions (uniform, exponential, and normal) that are required for deducing the ideal gas entropy. Chapters 4 and 5 present the principal theorems behind SMI, which are related to the defined probability distribution functions. They also provide an important discussion on the interpretation of SMI and its maximum value, which is associated with the most probable distribution, the equilibrium distribution density.

Chapters 6 and 7 represent the heart of the book: the deduction of the entropy of an ideal gas from SMI and the interpretation of the entropy change for some spontaneous processes in terms of SMI. These chapters argue that SMI provides the same function for the entropy of an ideal gas apart from a multiplicative constant, hence the entropy of an ideal gas is a measure of the information distributed among the gas particles: their number, energy, and volume. The last chapter of the first part deals with the basic formalism of thermodynamics and generalizes the previous theory with some constraints.

The second part of the book, chapters 9 to 12, presents thermodynamic applications on phase rule, phase diagram, mixtures and solutions, chemical equilibrium, pure water, and water solutions. The chapter on phase rule and phase diagrams covers the derivation of the Gibb's phase rule and its application for non-reacting and reacting systems, the coexistence of two phases in one-component systems, and a brief description of the two-component system. The chapter on mixtures and solutions provides an unusual approach to the thermodynamics of solutions using the pair correlation function (i.e., radial distribution function) and the Kirkwood–Buff theory to explain some properties and the interaction between different solute molecules with their environment. The chapter on chemical equilibrium derives the general equilibrium condition for a reaction and its dependence on pressure and temperature. The final chapter is devoted to water and aqueous solutions. It presents the different water phases and water properties as an equilibrium mixture of two species with low and high local density.

Edwin T. Jaynes provided the first connection of SMI to statistical thermodynamics in 1957 (*Phys. Rev.* **106** (4), 630). It was a mathematical approach without simple examples. Ben-Naim and Casadei have provided a more didactic approach. This book may not be considered a textbook for a normal graduate course on thermodynamics, though there are exercises throughout the book with solutions in the appendix. The figures are simple, but they provide important support for the text. The references are adequate. This book is a must for physicists, chemists, engineers, and people with some knowledge of mathematics who want to deepen their understanding of thermodynamic entropy and applications.

Reviewer: Roberto Ribeiro de Avillez *of the Pontifícia Universidade Católica do Rio de Janeiro, Brazil.*



Electrodeposition of Nanostructured Materials

Farzad Nasirpouri

Springer, 2017
325 pages, $179.00 (e-book $139.00)
ISBN 978-3-319-44919-7

Nanostructured materials include zero-dimensional, one-dimensional, two-dimensional (2D), and three-dimensional (3D) nanoscale materials. They have attracted considerable attention for a few decades due to the very different physical and chemical properties from the bulk properties. There are many methods for synthesis of nanostructured materials. Among them, electrochemical deposition (i.e., electrodeposition), which has been widely used in the plating industry for anticorrosion and decorative applications in metals and alloys, has been successfully used in the growth of a wide range of nanoscale materials in recent years. Electrodeposition is an effective and low-cost method for mass production of nanomaterials.

This book gives an excellent introduction to electrodeposition of nanostructured materials, from basic concepts to practical applications. The author has more than 15 years of research experience on the electrodeposition of coatings and nanostructures. This book combines the information and knowledge in the literature as well as the research experience and results of the author.

The book comprises eight chapters. Chapter 1 gives an introduction to nanostructured materials with their concepts and classifications. Chapter 2 provides an overview of electrochemistry with a focus on basic knowledge. Chapter 3 introduces the fundamentals and principles of electrodeposition and details the process. By using the electrodeposition method, many kinds of nanostructured materials can be deposited. Chapters 4–8 discuss the growth of various nanomaterials by electrodeposition, including 2D and 3D meso- and nanostructures, nanowire arrays, nanocrystalline films and coatings, nanocomposite films, and miscellaneous nanostructures, respectively. These five chapters also cover nanoscale materials, deposition processes, measurements and evaluation, and applications. References are provided at the end of each chapter. An index is given at the end of the book.

This book provides a clear and comprehensive introduction to electrodeposition of nanostructured materials, from fundamental principles to recent advances. The figures and tables are adequate, and the book provides problem sets. As the author states, "this book is prepared to disseminate the major factors and principles of electrodeposition towards the fabrication of nanostructured materials as a unique reference." The author succeeded in doing this. I recommend this book to all interested in electrodeposition and nanostructured materials, particularly to those entering the field. The book is suitable as a text for a graduate course. In addition, it is a good monograph for researchers with a chemistry, physics, or materials background.

Reviewer: Jianguo Lu *is an associate professor at Zhejiang University, China.*

https://doi.org/10.1557/mrs.2017.264 Published online by Cambridge University Press