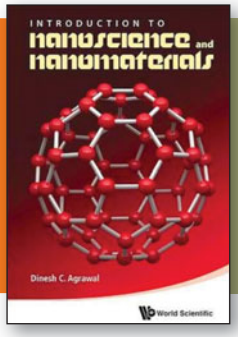


Introduction to Nanoscience and Nanomaterials

Dinesh C. Agrawal

World Scientific, 2013
556 pages, $89.00
ISBN 978-981-4397-97-1

The preface of this book states that it can be used as a textbook on nanoscience and nanotechnology for senior undergraduate or first-year graduate students from various disciplines, as well as a reference for researchers looking for basic information outside of their discipline. This is a tall order. This requires combining a proper pedagogical approach together with encyclopedic coverage of the multiple subdisciplines encompassed in the fields of nanoscience and nanomaterials. To a large extent, this book meets this challenge successfully. The 14 chapters cover an impressive variety of topics with sufficient information on each to allow the reader to understand the important physical and chemical concepts involved.

The pedagogical challenge is met by incorporating three important features: (1) adequate fundamental background material is provided to make this book self-sufficient for a reader with a basic scientific background; (2) numerous examples are included to clearly demonstrate a concept just presented (e.g., after discussing the quantum size effect, showing how to calculate the size of a Si particle that would exhibit quantum effects at room temperature); and (3) problems given at the end of each chapter.

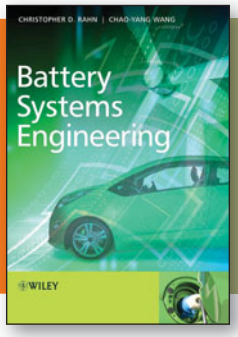
In order to satisfy the need to cater to individuals from varied backgrounds, the first two chapters of the book are devoted to some general concepts used in nanoscience such as surfaces, quantum effects, and electronic properties. These principles are then drawn on later in the book, and further background information is provided in later chapters as needed. The material is presented in both lucid and basic fashion so that only a general scientific background is required to use the book.

Much of the rest of the book is ordered according to dimensionality. Chapters 3–7 deal with electrical and quantum effects, growth of quantum structures, magnetism, and colloid physics. Chapters 8–9 are devoted to 1D structures, including carbon nanotubes and nanowires: preparation, properties, and applications. Chapter 10 covers 2D structures (thin films), chapter 11 covers bulk nanostructures, and the final three chapters cover polymers, their composites, and self-assembly.

Any attempt to cover a versatile and dynamic field such as this will have its shortcomings. The book has sacrificed some important and timely topics in favor of thoroughness of more fundamental background material. Thus, whereas basics of quantum mechanics such as solution of the Schrödinger equation for a particle in a box are included, there is no mention of density functional theory, which is becoming an increasingly important technique for the understanding of nanosystems. This is symptomatic of topics in the book being somewhat dated—the coverage of self-assembly describes Langmuir–Blodgett films extensively but barely touches upon self-assembled monolayers, which are much more relevant to modern nanoscience.

Despite these few shortcomings, this book still provides an excellent basis for learning about the wonders of nanoscience and nanomaterials.

Reviewer: Sidney Cohen *works at the Weizmann Institute of Science, Israel.*



Battery Systems Engineering

Christopher D. Rahn and Chao-Yang Wang

Wiley, 2013
250 pages, $125.00
ISBN 978-1-119-97950-0

Batteries are becoming such an organic part of modern life that my six-year-old daughter recommends changing the batteries when something breaks, and she alerts me immediately when the box pops up on the screen saying the battery is running out of energy. While materials researchers endeavor to find battery materials that can store more energy per unit weight and volume, the periodic table presents relatively few options for cost-effective solutions, so the control of batteries and the careful metering of their power and energy represent some of the more important research being done toward making them long-lived.

Christopher D. Rahn and Chao-Yang Wang explain methods and approaches to modeling batteries in *Battery Systems Engineering*. The philosophy of this book is that "fundamental model-based controllers have a built-in understanding of the underlying processes, allowing them to be more efficient, accurate and safe." Most of the book is dedicated to battery model development at the cell and system levels, focusing on rechargeable batteries for hybrid electric vehicles.

Both Rahn and Wang are supremely qualified experts on the fundamental processes in batteries and relevant controls mathematics. Rahn is a professor of mechanical engineering at The Pennsylvania State University (Penn

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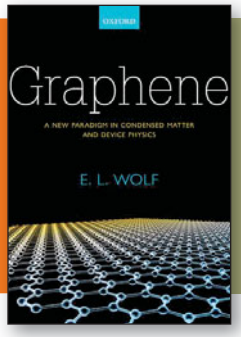
State), where he specializes in modeling electronic control systems for mechanical systems and leads the Mechatronics Research Laboratory. Wang is a Distinguished Professor of Mechanical Engineering and professor of materials science and engineering also at Penn State, and his research interests focus on the transport, materials, manufacturing, and modeling aspects of batteries and fuel cells. Rahn and Wang co-direct Penn State's Battery and Energy Storage Technology (BEST) Center.

This book briefly tours the electrochemistry of batteries and then follows with mathematical methods for modeling such electrochemical systems. The models are built up from the fundamental processes in the batteries. The governing equations are presented for rechargeable batteries, based mainly on thermodynamics, reaction kinetics, and transport in porous electrodes and electrolyte, plus the impact of cell voltage, temperature, and aging. From there, the authors present 40 pages of discretization methods. Much of the same mathematical approaches are used in the chapter on system response. The chapter on battery systems models attempts to give fair balance to the several approaches, making clear that there are numerous ways to model the batteries and that estimation methods are still necessary. The last chapter is dedicated to battery management systems, with a top-level description of how one would build electronics around a battery for a car. Each chapter ends with questions and answers for readers to check their understanding of the book material.

By the end of the book, I had a hearty respect for the mathematical and modeling abilities of Rahn and Wang, but I did not have a solid feeling about how to use their methods in a simple hybrid system. For a practical prototype, much simpler models can be developed based on experimental polarization curves incorporated into relatively straightforward mathematical models. I also did not have a sense of how to use the modeling in the event that something went wrong with the battery—that is, it is unclear how to use the models to improve the longevity of the batteries or to make them safer. There is also no indication of how expensive the computational effort would be for running such detailed models.

A more accurate title for the book might be *Battery Modeling for Hybrid Electric Vehicles* as there is little practical systems engineering in the book. The detailed battery models would be very useful to people studying controls, and the methodology would be relevant to other electrochemical systems. The questions at the end of each chapter make it ideal for a graduate-level engineering controls class. The book would also be useful to battery materials scientists who are curious about how controls engineers work with their batteries.

Reviewer: Karen Swider Lyons *researches fuel cell and battery materials and their integration into naval systems in Alexandria, Va., USA.*



Graphene: A New Paradigm in Condensed Matter and Device Physics
E.L. Wolf

Oxford University Press, 2014
320 pages, $110.00
ISBN 978-0-19-964586-2

Graphene has attracted significant attention in the scientific community in recent years because of its exceptional physical properties. The 2010 Nobel Prize in Physics was awarded to Sir Andre Geim and Sir Konstantin Novoselov "for groundbreaking experiments regarding the two-dimensional material graphene." There has been an explosion in research and corresponding rapid increase in scientific publications in this area in the last decade. Given the diversity and multitude of publication sources and content, there is a need for books that will distill this information and present it in a cogent form useful for researchers. This book by Wolf serves this purpose admirably and is recommended for students and researchers who have a basic understanding of quantum mechanics and solid-state physics.

The book discusses how the structure of graphene results in the exceptional physical properties from a fundamental physics perspective. The technical content of the book begins with the description of 2D electron behavior in systems such as liquid helium and semiconductor heterojunctions (chapter 2). In the third chapter, different forms of carbon and its molecular compounds are discussed from the perspective of quantum mechanics; namely, starting from the Schrödinger equation for the carbon atom. Chapter 3 serves as a useful foundation for chapter 4, which deals with the electronic band structure of graphene. Chapter 5 describes different methods used to synthesize graphene. Chapter 6 provides a brief overview of some of the optical, electrical, and thermal characterization techniques of this material. The mechanical and electrical properties of graphene are discussed in chapter 7, and chapter 8 examines graphene's physical properties that are not well understood. Potential applications of graphene in devices, interconnects, Li-ion batteries, and hydrogen storage are presented in chapter 9.

In summary, the book is a well-written and concise introduction to the structure, synthesis, properties, and applications of graphene.

Reviewer: Nirmal Govindaraju *is a research assistant professor at Oklahoma State University, USA.*

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