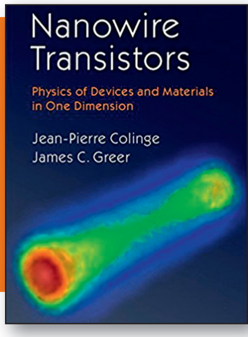


Nanowire Transistors: Physics of Devices and Materials in One Dimension

Jean-Pierre Colinge and James C. Greer

Cambridge University Press, 2016
265 pages, $84.99 (e-book $68.00)
ISBN 9781107052406

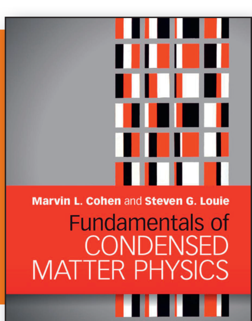
This is a very interesting and advanced book that gives a deep introduction to and explanation of the physics behind nanowire transistors, from the conceptual quantum models to the understanding of the charge-transport properties within one-dimensional (1D) nanostructured materials. It is well written, organized, and self-explanatory, and can be used as a reference by those who wish to enter into this field of nanowire and nanostructure-based electronics. The book has many up-to-date references and clear and precise text with plenty of figures and diagrams, and therefore is a fundamental resource.

It is divided into seven chapters. The first three chapters introduce the use of nanowires as the semiconductor channels in a transistor, while the last four chapters give deep insight into the physical formalism that rules the electronic structure and charge transport in low-dimensional materials, such as nanowires.

Chapter 1 gives a brief introduction to transistors and the consequences and limits of scaling down devices in order to achieve higher density electronics. Chapter 2 focuses on new approaches and architectures for transistors, namely multigate configurations and the use of nanowires as a channel active layer. The synthesis of nanowires and the fabrication of nanowire transistors are presented in chapter 3, focusing mainly on silicon-based nanowires. Top-down and bottom-up silicon nanowire growth methodologies are discussed and correlated to the mechanical properties of the channel achieved. Chapter 4 introduces quantum mechanics in a very simple and straightforward manner in order to explain and deduce fundamental relations related to electronic band structure and density of states in 1D structures. This chapter can be used as a reference for the subsequent chapters. The electronic structure from bulk materials to low-dimensional material properties is discussed in chapter 5, where both experimental and theoretical approaches are presented. Chapter 6 discusses the charge-transport models in 1D nanostructures. Chapter 7 discusses some applications and the performance of nanowires in circuits, memory-based devices, and sensors.

This is a well-organized book wherein the preceding chapters are used as the basis for understanding the following ones. Each chapter starts with a simple introduction and has a final summary where the main conclusions of the chapter are presented, and further reading is proposed for those who wish to go deeper in any covered topic. The book is suitable for graduate researchers in materials science and semiconductor devices as well as engineers who want deeper insight into the explanation of nanowire-based devices. It could be used as a supplementary book in higher grade studies but not as the main textbook of a course, as it contains no study/homework problems.

***Reviewer: Joana Vaz Pinto** of the Universidade Nova de Lisboa, Portugal.*



Fundamentals of Condensed Matter Physics

Marvin L. Cohen and Steven G. Louie

Cambridge University Press, 2016
460 pages, $84.99 (e-book $68.00)
ISBN 9780521513319

This graduate-level textbook on condensed-matter physics is written by two leading luminaries in this field. The volume draws its material from the graduate course in condensed matter physics that has been offered by the authors for several decades at the University of California, Berkeley. Cohen and Louie do an admirable job of guiding the reader gradually from elementary concepts to advanced topics. The book is divided into four main parts that have four chapters each.

In part I, chapter 1 presents models of solids in terms of interacting atoms, which is appropriate for the ground state, and excitations to describe collective effects. Chapter 2 deals with the properties of electrons in crystalline materials. The authors introduce the Born–Oppenheimer approximation and then proceed to the periodic potential approximation. Chapter 3 discusses energy bands in materials and covers concepts from the free-electron model to the tight-binding model and periodic boundary conditions. Chapter 4 starts with fixed atomic cores and introduces lattice vibrations, phonons, and the concept of density of states.

Part II presents electron dynamics and the response of materials to external probes. Chapter 5 covers the effective Hamiltonian approximation and the motion of the electron under a perturbation, such as an external field. The discussion moves to many-electron interactions and the exchange-correlation energy in chapter 6, the widely used density functional theory (DFT) in chapter 7, and the dielectric response function in chapter 8.

Part III begins with a discussion of the response of materials to photons in

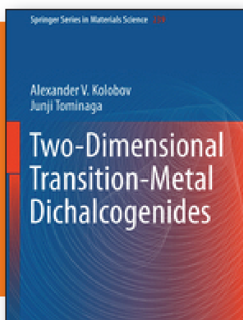
https://doi.org/10.1557/mrs.2017.134 Published online by Cambridge University Press

chapter 9. Chapter 10 details electron–phonon interactions in different materials and introduces the polaron. Chapter 11 presents electron dynamics in a magnetic field, and chapter 12 discusses electrical and thermal transport in materials.

Part IV takes the reader further into many-body effects, superconductivity, and nanoscale materials. The authors introduce Feynman diagrams and many-body perturbation theory in chapter 13, theories of superconductivity in chapter 14, magnetism in chapter 15, and low-dimensional systems in chapter 16.

The first two parts are required reading for the beginner planning to perform DFT calculations. The advanced student interested in conducting research in condensed-matter physics will benefit from continuing on to the last two parts. The narrative is aided by appropriate equations and detailed figures. References at the end of the book direct the reader to relevant books and review articles for each chapter. The authors pre-sent the underlying mathematics elegantly, which makes the textbook quite readable for those with a good mathematical background. Students lacking a firm footing in math will find the terrain rough after chapter 1. This book covers new ground by explaining Feynman diagrams and by making a foray into the low-dimensional world of carbon nanotubes and graphene nanostructures. It fills the need for a rigorous graduate-level textbook, and is a required addition to the bookshelf of every condensed-matter physicist.

Reviewer: Ram Devanathan *is Technical Group Manager of the Reactor Materials and Mechanical Design Group, Pacific Northwest National Laboratory, USA.*



Two-Dimensional Transition-Metal Dichalcogenides

Alexander V. Kolobov and Junji Tominaga

Springer, 2016
538 pages, $229.00 (e-book $179.00)
ISBN 978-3-319-31449-5

Two-dimensional (2D) materials are among the advanced materials that have currently gained a lot of research interest. Transition-metal dichalcogenides (TMDCs) are 2D semiconducting materials that find applications in electronics and optoelectronic devices. Two-dimensional-TMDCs are often referred to as "next-generation graphene," with interesting properties due to their unique band structures in the monolayer. This book provides a thorough description of 2D-TMDCs in a reader-friendly manner.

Chapter 1 provides an introduction to the composition of TMDCs. Chapter 2 discusses the chemistry of transition-metal elements and chalcogenides in TMDCs. Chapter 3 describes the properties of bulk (3D) TMDCs, including their crystal structures and the associated group theory, electronic structures, magnetic properties, and optical properties as revealed by absorption, Raman, and infrared spectroscopy. The pressure-induced transformation of TMDCs is also summarized.

In chapter 4 and onward, the focus is on 2D-TMDCs. Chapter 4 introduces the top-down and bottom-up approaches to form 2D-TMDCs, as well as the materials transfer and analysis techniques. Chapter 5 focuses on the structural analysis of TMDC phases (1T [tetragonal] and 2H [hexagonal]) and their phase transitions, defects, grain boundaries, and doping. The chapter describes other TMDC nanostructures, including TMDC nanotubes, nanoribbons, and quantum dots.

Chapters 6 to 12 provide detailed descriptions of various properties of 2D-TMDCs. Chapter 6 reviews theoretical aspects of the electronic band structure, the indirect-to-direct gap transition, and bandgap tuning. This is followed by experimental evidence such as photoluminescence (PL), photocurrent, scanning tunneling spectroscopy, and angle-resolved photoemission spectroscopy. Chapter 7 discusses the symmetry structures in odd and even layers of TMDCs and their characterization by Raman spectroscopy. Chapter 8 focuses on luminescence in 2D-TMDCs, especially PL spectroscopy. Chapter 9 continues discussion of exciton behaviors and dynamics in 2D-TMDCs and their heterostructures. Chapter 10 discusses magnetic properties due to edges, defects, dislocations, grain boundaries, and doping. Chapter 11 discusses "valleytronics" in 2D-TMDCs in view of the strong coupling of the spin and valley indices. Chapter 12 summarizes miscellaneous topics in 2D-TMDCs that warrant further investigation, including second-harmonic generation, piezoelectric effects, quantum spin Hall effect, Burstein–Moss effect, polaritons, and superconductivity.

Chapter 13 describes heterostructures of 2D-TMDCs, in particular, the vertically stacked heterostructures. The lateral heterostructures and TMDC/2D heterostructures are also mentioned. Chapter 14 highlights applications of 2D-TMDCs, including transistors, integrated circuits, optoelectronic devices, nanoelectromechanical systems, catalysis, energy, and biomedical devices. Chapter 15 provides a list of up-to-date publications on the book's covered topics. Finally, Chapter 16 speculates on the future of 2D-TMDCs.

The book provides a comprehensive introduction to and review of almost every aspect of TMDCs. There are a few books about TMDCs and 2D-TMDCs, but this book is more comprehensive and covers almost every aspect of the materials, therefore, this can be treated as the encyclopedia of TMDCs and suitable as a textbook for graduate students. It is also a good reference for scientists and engineers who are interested in TMDCs.

Reviewers: Mingxiao Ye *and* ***Yoke Khin Yap*** *of Michigan Technological University, USA.*

https://doi.org/10.1557/mrs.2017.134 Published online by Cambridge University Press