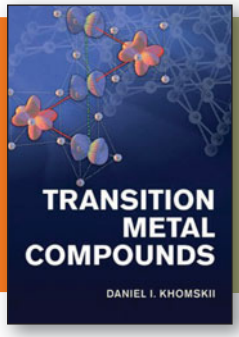


Transition Metal Compounds

Daniel I. Khomskii

Cambridge University Press, 2014
496 pages, $125.00
ISBN 978-1-107-0217-7

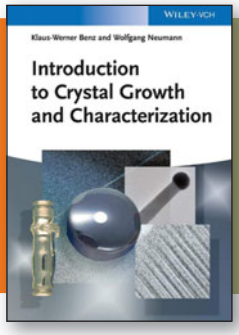
This book gives an overview of transition-metal compounds and the physics of highly correlated systems. The application areas discussed include magnetoelectricity, multiferroicity, high-T_c superconductivity, and spintronics. These systems are classified around a few concepts, including the interelectron Coulomb repulsion between metal sites (U), the site-to-site electron hopping matrix element between metal sites (t), and the number of electrons per site (n).

Chapter 1 describes the simplest system, Mott insulators, where all the sites are occupied ($n = 1$), and there is strong electron correlation ($U/t >> 1$). Chapters 2–8 present modifications of the simple model that give more realistic descriptions of these materials. Chapter 2 summarizes the behavior of isolated transition-metal ions, including atomic physics and the behavior of d orbitals and Hund's rules and spin–orbit interaction. Chapter 3 focuses on the behavior of transition-metal ions in crystals, discussing crystal field splitting, the Jahn–Teller effect, the behavior of high-spin versus low-spin states, spin–orbit coupling effects, and the principles of crystal structure formation. Chapter 4 highlights the role of the oxygen ligand in electron hopping between metal atoms, where oxygen has a small effect on the hopping rate in Mott–Hubbard insulators and a large effect in charge-transfer insulators. Chapter 5 discusses a wide variety of magnetic structures and their effect on the character, sign, and strength of the exchange interaction. These concepts are applied to magnetic anisotropy, magnetostriction, and weak ferromagnetism. Spinels, face-centered-cubic lattices, and frustrated magnets are given as magnetic ordering examples. Chapter 6 describes the cooperative Jahn–Teller effect, where structural phase transitions lead to splitting of the degenerate crystal orbitals. Chapter 7 describes ordering phenomena associated with charge degrees of freedom. There is an extensive discussion of charge ordering occurring with systems having non-integer numbers of electrons per site. Chapter 8 builds on the concepts developed in chapter 7 and discusses magnetoelectrical coupling in multiferroic materials.

Chapter 9 extends the previous chapters to systems having non-integer electron occupancy per site ($n < 1$), but with strong electron correlation ($U/t >> 1$). In this chapter, the author delves into high-T_c superconductors. In chapter 10, the author discusses the general case of variable U/t, focusing on metal–insulator transitions in Mott insulators. Chapter 11 applies these ideas to rare-earth and actinide systems containing partially filled f orbitals.

Each chapter is self-contained and has a helpful summary at the end. There are three appendices giving the history of the key concepts, an explanation of the method of second quantization, and a discussion of Landau theory. The references list critical books and review articles. The equations and illustrations enable an understanding of how these materials work and provide clarity. Khomskii successfully leads the reader through the field of transition-metal compounds by focusing on physical insight without detailed mathematical derivations. He has a deep understanding of the field and communicates his knowledge very well. This book can be used as a textbook for students with a background in solid-state physics or inorganic chemistry, although exercises are not included. It can also serve as a reference book for entry into the transition-metal compound field.

***Reviewer: Thomas M. Cooper** of the Air Force Research Laboratory, USA.*



Introduction to Crystal Growth and Characterization

Klaus-Werner Benz and Wolfgang Neumann

Wiley-VCH, 2014
438 pages, $120.00
ISBN 978-3-527-31840-7

Single crystals are important to many industrial and commercial applications, including electronics, solar cells, light-emitting devices, lasers, optics, and jewelry, just to cite a few examples. The ability to produce high-quality crystals is also essential for exploring material properties and for developing new applications.

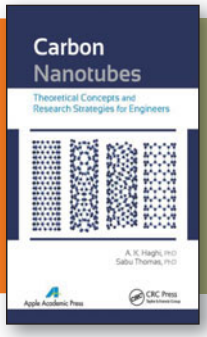
This book is a new classic in the canon of important books on crystal growth and characterization. Its unique purview is to cover the basics of both crystallography and crystal growth, tandem topics that are interrelated. It is both quantitative, with many equations, and descriptive: it is profusely illustrated with insightful figures that make important ideas and theories clear. A few examples are scattered throughout the book demonstrating how the equations are used. It does not contain problems, as would be helpful for a textbook. Its treatment is very modern: it draws on the many discoveries and detailed understanding made possible

from x-ray diffraction techniques and electron microscopy. This book is thoroughly referenced, with 398 citations that range in date from 1783 to 2013; more than 20% are studies published since 2000.

The book is divided into four chapters. Chapter 1 covers crystal lattices, concepts of symmetry, Bravais lattices, the reciprocal lattice, crystal structures, polymorphism and polytypism, and selected examples of molecular crystals. Chapter 2 explains the fundamental processes that take place during crystal growth, including homogeneous and heterogeneous nucleation, the equilibrium shape of crystals, interfaces and the roughening of surfaces, the vapor–liquid–solid growth mechanism, phase diagrams, constitutional supercooling, and mass transfer by convection. Chapter 3 briefly describes the major bulk crystal growth and epitaxy methods divided into two groups: those driven by phase changes and those driven by chemical reactions. The former includes growth from melts (such as the Czochralski and Bridgman methods) and solutions, sublimation and condensation, and liquid-phase epitaxy. The latter includes chemical vapor deposition and vapor-phase epitaxy. Examples from specific material systems (primarily semiconductors) are also presented. Chapter 4 recounts the wide variety of defects that occur in crystals and how they are detected and quantified. Defects discussed include zero-, one-, two- and three-dimensional defects, dislocations, stacking faults, antiphase boundaries, twins, inclusions, precipitates, and voids. X-ray topography, scanning and transmission electron microscopy, and defect-sensitive etching are introduced as methods for detecting and quantifying these defects.

This book is an excellent introduction to the field of crystal growth and characterization. It clearly defines important terms, and fundamental concepts (e.g., crystallography, thermodynamics, and transport phenomena) are well-explained, making it valuable for learning the subject. With the addition of appropriate problems, it is suitable for graduate studies and provides a firm background for understanding contemporary issues and challenges in crystal growth.

***Reviewer: James H. Edgar** of the Department of Chemical Engineering, Kansas State University, USA.*



Carbon Nanotubes: Theoretical Concepts and Research Strategies for Engineers
A.K. Haghi and Sabu Thomas

Apple Academic Press, 2015
364 pages
ISBN 978-1-77188-052-7

Carbon nanotubes are a hot topic because of their potential technological utility and economic importance. Performing experiments can be expensive and sometimes difficult; therefore, modeling and simulation are of increasing value. Combining these two topics in one book should be very useful.

This book first gives an overview on the properties of carbon nanotubes and of composites incorporating carbon nanotubes. These topics are clearly written and can be understood by any engineer with a background in materials. The authors avoid discussing the theories of all these properties and applications in detail. This makes the book accessible to readers who are not physicists. On the other hand, a physicist expecting a helping hand to learn details of theory in the field will be disappointed. Thus, this book is written for engineers and not for physicists.

In the Properties section, the book describes electrical properties, structural and thermal properties, and methods for synthesis. The differences between three-dimensional and one-dimensional electrical conductors are explained, as well as the differences between single- and multiple-wall nanotubes. In addition, structure and thermal properties are discussed in context of the thermodynamic properties. However, the very special mechanical properties of carbon nanotubes are not discussed.

The main part of the book is devoted to modeling and simulation. All the established methods are described, ranging from quantum mechanical *ab initio* methods to rather experience-based methods. The authors explain in detail the differences between deterministic and probabilistic (Monte Carlo) methods. As it is a common problem often not realized by scientists doing Monte Carlo calculations, the authors give a program code to calculate random numbers and to test existing codes. This is of great importance, as random number generators often do not have a sufficient period length (pseudo random numbers).

This is a book on simulation and modeling applied to problems connected to carbon nanotubes. The selected mathematical notation is very clear to engineers and physicists. Additionally, the authors give a list of mathematical symbols, and the 37 illustrations in the book are quite instructive. At the end of the book, there is a list of 192 references connected to nearly all aspects of the topic. As modeling depends too specifically on the problem in question, the book does not give instructions on how to perform these calculations. This book is recommended to everyone who wants an introduction to modeling and simulation.

***Reviewer: Dieter Vollath** is CEO of NanoConsulting, Stutensee, Germany.*