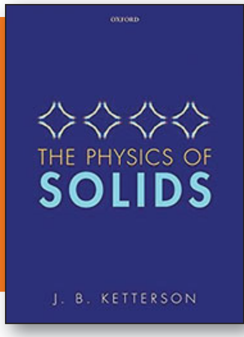

The Physics of Solids
J.B. Ketterson
Oxford University Press, 2016
1072 pages, $89.95 (e-book $88.99)
ISBN 9780198742906

For the past few decades, solid-state physics has expanded tremendously, and it typically takes a complete year as a student to understand its fundamentals. The author has covered all the traditional solid-state physics course contents in this book, including the fundamentals of solid-state physics; group theory basics; and electrical, magnetic, optical, structural, mechanical, cohesive, and dielectric properties of solids, discussed using both classical and quantum approaches. There are 13 parts, consisting of 49 chapters, two main appendices at the end, and numerous appendices at the ends of the chapters. The chapters also contain homework problems. Many figures, diagrams, and tables are provided. Suggestions for additional reading are included at the end of many chapters. Footnotes provide additional information, such as reference citations. The book is aimed toward undergraduate, postgraduate, and research-level students in various disciplines, such as physics, materials science, and solid-state chemistry.

Part I (seven chapters) covers elastic behaviors and electrical, magnetic, and thermal properties of solids, as well as crystal bondings. All the necessary theories, such as the Langevin equation, quantum theory of magnetism, and Debye models, are discussed using both classical and quantum approaches. Appropriate diagrams depict the concepts.

Part II (two chapters) discusses the basics of x-ray crystallography and crystal structures. This part will be useful for beginners, and it could have been included in Part I. All the crystallographic illustrations are excellent and will help students to understand the different Bravais lattices and symmetries.

Part III (four chapters) describes the electronic structure of solids, various models explaining the potentials in solids, and band structures of solids and their applications. Various models, such as the free-electron model, tight-binding approximation, plane-wave method, and Green's functions, are well covered. Theories treated in this part are useful for master's-level students and research scholars performing coursework.

Part IV (two chapters) explains the self-consistent dielectric function as well as the Hartree–Fock and density functional theories. These chapters discuss various interactions in solids (such as electron–electron interactions) and methods to solve the single-body and many-body problems. The appendices and problems given in this part are useful for students to understand the concepts and theories. References are up to date.

Part V (two chapters) covers lattice dynamics, such as lattice vibrations and its related properties, with both classical and quantum approaches. Phonon contributions to the thermal expansion, thermal conductivity in dielectrics, and heat transport in solids are covered with appropriate models.

Part VI (four chapters) discusses electron transport and conduction electron dynamics, Fermi surfaces, and metallic electron–phonon interactions. Effects of magnetic and electric fields on Bloch functions, transport under electric field and temperature gradient, and thermoelectric properties of solids, such as the Seebeck effect, Peltier effect, and Hall effect are elaborated with appropriate theories.

Part VII (two chapters) explains semiconductor physics and discusses band structures, band properties, carrier concentration-related topics, and intrinsic and extrinsic semiconductors. Functionalities of semiconducting devices such as *p–n* junctions, various types of diodes, and the effect of an external electric field on *p–n* junctions are discussed with models and illustrations.

Part VIII (two chapters) covers electrical and magnetic properties of insulators. Different types of polarization in dielectrics, including piezoelectricity, pyroelectricity, and ferroelectricity, are treated with various theories. Piezoelectric transducers and example problems are provided at the end. Various phase transitions and discontinuities at transition points and the effect of the external electric field on ferroelectric properties are discussed with appropriate diagrams.

Part IX (three chapters) discusses the fundamentals of ferromagnetism, antiferromagnetism, dynamic properties of magnetic materials, and the basics and applications of magnetic resonance. Various models explain the origins of magnetism. Measurements of magnetization and related problems are provided with experimental setup and the functionality of the instruments. The appendix discusses various mechanisms involved in magnetic resonance, such as spin echoes, relaxation effect, energy dissipation, and chemical and kinetic shifts.

Part X (three chapters) explains optical properties of solids, including excitons, polaritons, plasmons, and material response under various light illuminations. Frequency-dependent susceptibility, the Kramers–Kronig relation, and various excitons are discussed with quantum mechanical approaches. Nonlinear and higher order susceptibility as well as electron–hole liquids with band diagrams are also discussed.

Part XI (seven chapters) is dedicated to fundamentals and phenomenological theories of superconductivity and superfluidity. All the basics, theories, and experiments are included in detail with appropriate plots and illustrations. This part is useful for students studying low-temperature physics.

Part XII (six chapters) elaborates on disorders and defects in solids, phase diagrams, phase equilibrium, and appropriate theories. Various defects such as point defects, color centers, dislocations, and grain boundaries are explained. The quantum theory of electrical transport in dilute alloys, localization/interaction effects, temperature-dependent electrical conductivity, hopping mechanisms, effects of

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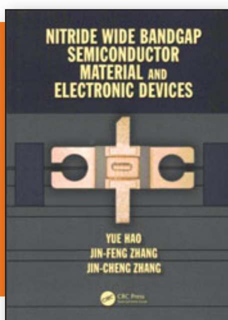
magnetic fields on transport properties of solids, effects of magnetic impurities, and their interaction are explained. The Anderson model, Kondo effect, and RKKY interactions in solids are discussed using quantum approaches.

Part XIII (five chapters) is provided as a special advanced topic dedicated to strongly correlated systems, high-temperature superconductivity, artificial structures and patterned materials, and the quantum Hall effect. This part is useful for researchers working in strongly correlated systems. Graphene, carbon nanotubes, and fullerenes are discussed with beautiful schematics. The electronic properties and band structure of graphene, as well as the effects of magnetic field on their structure and the quantum Hall effect, are treated with quantum approaches.

This is an outstanding book covering fundamental concepts and advanced theories explaining classical and quantum phenomena in solids. Solving the homework problems given at the end of each chapter will provide students with an in-depth understanding of the concepts. This is an advanced-level book on traditional solid-state physics. I strongly recommend it to all undergraduate, master's level, and research students interested in learning solid-state physics.

Reviewer: K. Kamala Bharathi *of the National Institute of Standards and Technology, USA, and the Department of Physics, SRM Institute of Science and Technology, Kattankulathur, India.*



Nitride Wide Bandgap Semiconductor Material and Electronic Devices

Yue Hao, Jin-Feng Zhang, and Jin-Cheng Zhang

CRC Press, 2016
368 pages, $219.95 (e-book $153.97)
ISBN 9781315368856

This book illustrates how incredibly far the technology of gallium nitride-based electronic devices has progressed in the past 25 years. Gallium nitride transistors are commercially available and are preferred over their silicon counterparts for high-frequency and high-power electronics.

This volume emphasizes transistors. Optoelectronic devices, such as light-emitting diodes and laser diodes, are not covered. Chapter 1 gives an overview of the applications of gallium nitride-based devices. Chapters 2–7 discuss specific electrical properties of the nitrides, the standard procedures (atomic force microscopy, x-ray diffraction) for characterizing their structural properties, and the growth methods that have been optimized to produce high-quality thin films. Chapter 4 explains the underlying physics responsible for forming a two-dimensional electron gas at a heterojunction. The growth of specific heterostructures is covered in chapters 5 (AlGaN/GaN) and 7 (InAlN/GaN). Chapter 8 describes crystalline defects and residual impurities, which are important in GaN-based devices because they are unavoidable with the current technology. This includes methods for their identification and how they vary with different process conditions, as, for example, the tendency for nitrogen polarity materials to more readily incorporate oxygen than gallium polar GaN. Chapter 9 covers the principles and performance of the most widely employed GaN-based transistor: the high-electron-mobility transistor (HEMT). Chapter 10 covers the steps for fabricating HEMTs, including etching, metal contact formation, and surface passivation. High temperatures and high electrical fields can deteriorate the performance of GaN HEMTs; chapter 11 reports on the fundamental causes and their remedies. GaN HEMTs are most frequently on devices, but enhancement mode devices have been developed, and their structures and operations are delineated in chapter 12. To reduce leakage currents, insulating layers have been added under the gate to create GaN metal oxide semiconductor (MOS) HEMTs, covered in chapter 13.

Chapter 14 discusses areas likely to see further research and advances, including the use of nitrogen polar materials (advantageous for lower contact resistances and higher operating frequencies), Al-rich materials for ultrawide-bandgap devices with higher breakdown voltages, GaN on diamond for better heat dissipation, power electronics, terahertz frequency devices, and the use of silicon as a substrate. The authors conclude with the prediction that nitride semiconductors will be the successor to silicon. Even with all of its technological progress, only the surface has been scratched on what is possible, given their current advantages and tremendous potential for further improvements and cost reduction.

For some chapters, the authors provide passing coverage of the topic based primarily on their own work, giving minimal exposure to research results by others. Generally speaking, this is fine, as their studies are thorough, as is their depth of understanding. The majority of references cited in the book are from 2011 and earlier. Thus, even the authors' most recent studies on enhancement mode transistors and interface traps in Al_2O_3/AlGaN/GaN MOS field-effect transistors are not included. Several of the most recent trends in gallium nitride electronics are covered either sparsely or not at all, including vertical power devices and GaN transistors on bulk substrates. The inclusion of homework problems would have made it more practical as a course textbook. Still, this is an appealing book for introducing state-of-the-art practices and current research on GaN transistors.

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