

Elementary Semiconductor Device Physics

Understanding Energy Band Formation
Using Circuit Theory

Kaoyu Mao and
Shihon Amakawa



CRC Press
Taylor & Francis Group

Elementary Semiconductor Physics

Donald A. Neamen



Elementary Semiconductor Physics:

Elementary Semiconductor Physics Hubert Charles Wright, 1979 *Semiconductor Physics and Devices* Donald A. Neamen, 1992 Semiconductor Physics and Devices brings together the fundamental physics semiconductor material physics and semiconductor device physics required to understand semiconductor device characteristics operation and limitations It covers the three basic types of transistors bipolar JFET and MOSFET and includes discussions about processing techniques such as diffusion and ion implantation The book features important learning tools such as chapter preview sections chapter summary and review sections extensive examples chapter glossaries many problems chapter reading lists and an appendix with answers to selected problems **Basic Semiconductor Physics** Chihiro Hamaguchi, 2001 This book presents a detailed description of the basic physics of semiconductors All the important equations describing the properties of these materials are derived without the help of other textbooks The reader is assumed to have only a basic command of mathematics and some elementary semiconductor physics The text covers a wide range of important semiconductor phenomena from the simple to the advanced Examples include recent progress in semiconductor quantum structures such as two dimensional electron gas systems ballistic transport the quantum Hall effect the Landauer formula the Coulomb blockade and the single electron transistor Semiconductor Devices Jasprit Singh, 2000-08-03 This introductory text designed for the first course in semiconductor physics presents a well balanced coverage of semiconductor physics and device operation and shows how devices are optimized for applications The text begins with an exploration of the basic physical processes upon which all semiconductor devices diodes transistor light emitters and detectors are based Topics such as bandstructure effective masses holes doping carrier transport and lifetimes are discussed Next the author focuses on the operation of the important semiconductor devices along with issues relating to the optimization of device performance Issues such as how doping device dimensions and parasitic effects influence device operation are also included The book is appropriate for the following courses Device Physics Semiconductor Devices Device Electronics Physics of Semiconductor Devices Integrated Circuit Devices Device Electronics Solid State Devices Semiconductor Physics And Devices Donald A. Neamen, 2011-01-18 With its strong pedagogy superior readability and thorough examination of the physics of semiconductor material Semiconductor Physics and Devices 4 e provides a basis for understanding the characteristics operation and limitations of semiconductor devices Neamen s Semiconductor Physics and Devices deals with the electrical properties and characteristics of semiconductor materials and devices The goal of this book is to bring together quantum mechanics the quantum theory of solids semiconductor material physics and semiconductor device physics in a clear and understandable way **Elementary Semiconductor Device Physics** Kazuya Masu, Shuhei Amakawa, 2024-10-31 This book by two leading experts on integrated circuit design adopts an untraditional approach to introducing semiconductor devices to beginners The authors use circuit theory to provide a digestible explanation of energy band theory and understanding of energy band

diagrams After briefly summarizing the basics of semiconductors the authors describe semiconductor devices from a circuit theoretic point of view making the book especially suitable for circuit design students and engineers Further to the emphasis on the circuit perspective the book then uses circuit theory to introduce readers to the famously indigestible energy bands of crystalline solids Additionally the book explains how to read physics from energy band diagrams of semiconductor devices in great detail The key to appreciating the real power of energy band diagrams is shown to lie in the understanding of the concept of the quasi Fermi levels introduced in 1949 by William Shockley but remaining elusive to date and therefore often omitted from energy band diagrams To rectify this some of the energy band diagrams presented in this book complete with quasi Fermi levels were drawn using a device simulator a k a technology computer aided design TCAD offering quantitative information about device physics The book could therefore also serve as a hands on course text in TCAD drawn band diagram reading Because no prior exposure to quantum mechanics is required and the book does not attempt to teach it this book is ideal for students in various disciplines who may or may not be specializing in semiconductor devices The numerous practical examples of reading TCAD based energy band diagrams are also invaluable to practicing semiconductor device engineers

Fundamentals Of Semiconductor Physics And Devices Rolf Enderlein, 1997-02-27 This book is an introduction to the principles of semiconductor physics linking its scientific aspects with practical applications It is addressed to both readers who wish to learn semiconductor physics and those seeking to understand semiconductor devices It is particularly well suited for those who want to do both Intended as a teaching vehicle the book is written in an expository manner aimed at conveying a deep and coherent understanding of the field It provides clear and complete derivations of the basic concepts of modern semiconductor physics The mathematical arguments and physical interpretations are well balanced they are presented in a measure designed to ensure the integrity of the delivery of the subject matter in a fully comprehensible form Experimental procedures and measured data are included as well The reader is generally not expected to have background in quantum mechanics and solid state physics beyond the most elementary level Nonetheless the presentation of this book is planned to bring the student to the point of research design capability as a scientist or engineer Moreover it is sufficiently well endowed with detailed knowledge of the field including recent developments bearing on submicron semiconductor structures that the book also constitutes a valuable reference resource In Chapter 1 basic features of the atomic structures chemical nature and the macroscopic properties of semiconductors are discussed The band structure of ideal semiconductor crystals is treated in Chapter 2 together with the underlying one electron picture and other fundamental concepts Chapter 2 also provides the requisite background of the tight binding method and the k p method which are later used extensively The electron states of shallow and deep centers clean semiconductor surfaces quantum wells and superlattices as well as the effects of external electric and magnetic fields are treated in Chapter 3 The one or multi band effective mass theory is used wherever this method is applicable A summary of group theory for application in semiconductor physics is given in an Appendix Chapter 4

deals with the statistical distribution of charge carriers over the band and localized states in thermodynamic equilibrium Non equilibrium processes in semiconductors are treated in Chapter 5 The physics of semiconductor junctions pn hetero metal and insulator is developed in Chapter 6 under conditions of thermodynamic equilibrium and in Chapter 7 under non equilibrium conditions On this basis the most important electronic and opto electronic semiconductor devices are treated among them uni and bi polar transistors photodetectors solar cells and injection lasers A summary of group theory for applications in semiconductors is given in an Appendix

Fundamentals of Semiconductor Physics Mijoe

Joseph,2015-05-11 Semiconductors have made an enormous impact on 20th century science and technology This is because components made from semiconductors have very favorable properties such as low energy consumption compactness and high reliability and so they now dominate electronics and radio engineering Semiconductors are indispensable for space exploration and where the requirements of small size low weight and low energy consumption are especially stringent The book uses quantum mechanical concepts and band theory to present the theory of semiconductors in a comprehensible for It also describes how basic semiconductor devices e g diodes transistors and lasers operate The book was written for senior high school students interested in physics

Theory of Electron Transport in Semiconductors Carlo

Jacoboni,2010-09-05 This book originated out of a desire to provide students with an instrument which might lead them from knowledge of elementary classical and quantum physics to modern theoretical techniques for the analysis of electron transport in semiconductors The book is basically a textbook for students of physics material science and electronics Rather than a monograph on detailed advanced research in a specific area it intends to introduce the reader to the fascinating field of electron dynamics in semiconductors a field that through its applications to electronics greatly contributed to the transformation of all our lives in the second half of the twentieth century and continues to provide surprises and new challenges The field is so extensive that it has been necessary to leave aside many subjects while others could be dealt with only in terms of their basic principles The book is divided into five major parts Part I moves from a survey of the fundamentals of classical and quantum physics to a brief review of basic semiconductor physics Its purpose is to establish a common platform of language and symbols and to make the entire treatment as far as possible self contained Parts II and III respectively develop transport theory in bulk semiconductors in semiclassical and quantum frames Part IV is devoted to semiconductor structures including devices and mesoscopic coherent systems Finally Part V develops the basic theoretical tools of transport theory within the modern nonequilibrium Green function formulation starting from an introduction to second quantization formalism

Basic Semiconductor Physics Hamaguchi,2004-01-01

Introduction to Semiconductor Physics and Devices Mykhaylo Evstigneev,2022-09-29 This classroom tested textbook provides a self

contained one semester course in semiconductor physics and devices that is ideal preparation for students to enter burgeoning quantum industries Unlike other textbooks on semiconductor device physics it provides a brief but

comprehensive introduction to quantum physics and statistical physics with derivations and explanations of the key facts that are suitable for second year undergraduates rather than simply postulating the main results The book is structured into three parts each of which can be covered in around ten lectures The first part covers fundamental background material such as quantum and statistical physics and elements of crystallography and band theory of solids Since this provides a vital foundation for the rest of the text concepts are explained and derived in more detail than in comparable texts For example the concepts of measurement and collapse of the wave function which are typically omitted are presented in this text in language accessible to second year students The second part covers semiconductors in and out of equilibrium and gives details which are not commonly presented such as a derivation of the density of states using dimensional analysis and calculation of the concentration of ionized impurities from the grand canonical distribution Special attention is paid to the solution of Poisson's equation a topic that is feared by many undergraduates but is brought back down to earth by techniques and analogies from first year physics Finally in the third part the material in parts 2 and 3 is applied to describe simple semiconductor devices including the MOSFET the Schottky and PN junction diodes and optoelectronic devices With a wide range of exercises this textbook is readily adoptable for an undergraduate course on semiconductor physics devices and with its emphasis on consolidating and applying knowledge of fundamental physics it will leave students in engineering and the physical sciences well prepared for a future where quantum industries proliferate

Semiconductor Physics and Applications M. Balkanski, Richard Fisher Wallis, 2000-08-31 The textbook combines a thorough theoretical treatment of the basic physics of semiconductors with applications to practical devices by putting special emphasis on the physical principles upon which these devices operate Graduate students and lecturers in semiconductor physics condensed matter physics electromagnetic theory and quantum mechanics will find this a useful textbook and reference work Jacket **Basic Semiconductor Physics** James Fordemwalt, DM Data Inc, 1993 **Physics of Semiconductor Devices** Simon M. Sze, Kwok K. Ng, 2006-12-13 The Third Edition of the standard textbook and reference in the field of semiconductor devices This classic book has set the standard for advanced study and reference in the semiconductor device field Now completely updated and reorganized to reflect the tremendous advances in device concepts and performance this Third Edition remains the most detailed and exhaustive single source of information on the most important semiconductor devices It gives readers immediate access to detailed descriptions of the underlying physics and performance characteristics of all major bipolar field effect microwave photonic and sensor devices Designed for graduate textbook adoptions and reference needs this new edition includes A complete update of the latest developments New devices such as three dimensional MOSFETs MODFETs resonant tunneling diodes semiconductor sensors quantum cascade lasers single electron transistors real space transfer devices and more Materials completely reorganized Problem sets at the end of each chapter All figures reproduced at the highest quality Physics of Semiconductor Devices Third Edition offers engineers research scientists faculty and students a

practical basis for understanding the most important devices in use today and for evaluating future device performance and limitations A Solutions Manual is available from the editorial department

Physics of Semiconductor Devices J.-P. Colinge, C.A. Colinge, 2002-05-31 Physics of Semiconductor Devices covers both basic classic topics such as energy band theory and the gradual channel model of the MOSFET as well as advanced concepts and devices such as MOSFET short channel effects low dimensional devices and single electron transistors Concepts are introduced to the reader in a simple way often using comparisons to everyday life experiences such as simple fluid mechanics They are then explained in depth and mathematical developments are fully described Physics of Semiconductor Devices contains a list of problems that can be used as homework assignments or can be solved in class to exemplify the theory Many of these problems make use of Matlab and are aimed at illustrating theoretical concepts in a graphical manner

Semiconductor Physics Karlheinz Seeger, 2013-11-09 This book has been designed primarily as a text book for a three semester three hour per week senior or graduate course in semiconductor physics for students In electrical engineering and physics It may be supplemented by a solid state physics course Prerequisites are courses in electrodynamics and for some of the chapters basic quantum mechanics Emphasis has been laid on physical rather than technological aspects Semiconductor physics is in fact an excellent and demanding training ground for a future physicist or electrical engineer giving him an opportunity to practice a large variety of physical laws he was introduced to in the more fundamental courses A detailed treatment of the transport and optical properties of semiconductors is given It was decided to omit the usual description of the material properties of certain semiconductors and instead to include the in between equations In mathematical derivations which I hope will make life simpler for a non theoretician In view of the many thousands of papers which appear every year in the field of semiconductor physics and which are distributed among more than 30 journals it would have been impossible for a single person to write comprehensive book unless there had not been some excellent review articles on special topics published in the series Solid State Physics Festkörper Probleme Advances in Solid State Physics Semiconductors and Semimetals and Progress in Semiconductors and I have leaned heavily on such review articles

Microwave Semiconductor Devices Sigfrid Yngvesson, 2012-12-06 We have reached the double conclusion that invention is choice that this choice is imperatively governed by the sense of scientific beauty Hadamard 1945 Princeton University Press by permission The great majority of all sources and amplifiers of microwave energy and all devices for receiving or detecting microwaves use a semiconductor active element The development of microwave semiconductor devices described in this book has proceeded from the simpler two terminal devices such as GUNN or IMPATT devices which originated in the 1960s to the sophisticated monolithic circuit MESFET three terminal active elements of the 1980s and 1990s The microwave field has experienced a renaissance in electrical engineering departments in the last few years and much of this growth has been associated with microwave semiconductor devices The University of Massachusetts has recently developed a well recognized program in microwave

engineering Much of the momentum for this program has been provided by interaction with industrial companies and the influx of a large number of industry supported students This program had a need for a course in microwave semiconductor devices which covered the physical aspects as well as the aspects of interest to the engineer who incorporates such devices in his designs It was also felt that it would be important to introduce the most recently developed devices HFETs HBTs and other advanced devices as early as possible *The Physics of Semiconductors* Marius Grundmann, 2010-11-11

Semiconductor electronics is common place in every household Semiconductor devices have also enabled economically reasonable fiber based optical communication optical storage and high frequency amplification and have recently revolutionized photography display technology and lighting Along with these tremendous technological developments semiconductors have changed the way we work communicate entertain and think The technological progress of semiconductor materials and devices is evolving continuously with a large worldwide effort in human and monetary capital For students semiconductors offer a rich diverse and exciting field with a great tradition and a bright future This book introduces students to semiconductor physics and semiconductor devices It brings them to the point where they can specialize and enter supervised laboratory research

It is based on the two semester semiconductor physics course taught at Universität Leipzig in its Master of Science physics curriculum Since the book can be followed with little or no pre-existing knowledge in solid state physics and quantum mechanics it is also suitable for undergraduate students For the interested reader some additional topics are included in the book that can be covered in subsequent more specialized courses The material is selected to provide a balance between aspects of solid state and semiconductor physics the concepts of various semiconductor devices and modern applications in electronics and photonics **Essentials of Semiconductor Physics** W. Tom Wenckebach, 1999-11-12 Provides a modern introduction to semiconductor physics presenting the basic information necessary to understand semiconductors along with some of the latest theories and developments Based on the author's undergraduate course this book bridges the gap between basic subjects such as quantum mechanics and Maxwell's equations and the fundamental processes determining the behaviour of semiconductors Following a quantum mechanics approach this text is predominantly aimed at scientists rather than engineers and forms the basis for the understanding of modern mesoscopic physics in semiconductors and quantum devices like resonant tunneling diodes Rather than attempting to comprehensively cover all aspects of semiconductor physics this text aims to cover the most important and interesting aspects of this subject to scientists Starting with the development of semiconductor physics from basic quantum mechanics the text moves on to cover band structure and effective mass theory before covering electron phonon coupling and charge transport It concludes with a chapter on optical transitions Students will need some knowledge of quantum mechanics and solid state although this is covered to some extent in the book

FEATURES Concise introduction to the basics of semiconductor physics Bridges the gap between fundamental subjects such as quantum mechanics and Maxwell's equations and the processes determining the behaviour of semiconductors Describes

semiconductor theory from a full quantum mechanical approach An accessible introduction avoiding reliance on group theory

CONTENTS Preface Notation Conventions Introduction Electrons nuclei and Hamiltonians Band Structure The k p Approximation Effective Mass Theory The Crystal Lattice Electron phonon Coupling Charge Transport Optical Transitions Band Electrons in an Optical Field Appendix A The Hydrogen Atom Appendix B The Harmonic Oscillator Appendix C Perturbation Theory Appendix D Tensors in Cubic Crystals Appendix E The Classical Limit Appendix F Some Fourier Transforms Appendix G Exercises Bibliography

Quantum Theory of the Optical and Electronic Properties of Semiconductors Hartmut Haug, Stephan W. Koch, 1994 This textbook presents the basic elements needed to understand and engage in research in semiconductor physics It deals with elementary excitations in bulk and low dimensional semiconductors including quantum wells quantum wires and quantum dots The basic principles underlying optical nonlinearities are developed including excitonic and many body plasma effects The fundamentals of optical bistability semiconductor lasers femtosecond excitation optical Stark effect semiconductor photon echo magneto optic effects as well as bulk and quantum confined Franz Keldysh effects are covered The material is presented in sufficient detail for graduate students and researchers who have a general background in quantum mechanics

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