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This book provides an introduction to the physics of nanoelectronics, with a focus on the theoretical aspects of nanoscale devices. The book begins with an overview of the mathematics and quantum mechanics pertaining to nanoscale electronics, to facilitate the understanding of subsequent chapters. It goes on to encompass quantum electronics, spintronics, Hall effects, carbon and graphene electronics, and topological physics in nanoscale devices. Theoretical methodology is developed using quantum mechanical and non-equilibrium Green's function (NEGF) techniques to calculate electronic cur-

rents and elucidate their transport properties at the atomic scale. The spin Hall effect is explained and its application to the emerging field of spintronics - where an electron's spin as well as its charge is utilised - is discussed. Topological dynamics and gauge potential are introduced with the relevant mathematics, and their application in nanoelectronic systems is explained. Graphene, one of the most promising carbon-based nanostructures for nanoelectronics, is also explored. Begins with an overview of the mathematics and quantum mechanics pertaining to nanoscale electronics Encompasses quantum electronics, spintronics, Hall effects, carbon and graphene electronics, and topological physics in nanoscale devices Comprehensively introduces topological dynamics and gauge potential with the relevant mathematics, and extensively discusses their application in nanoelectronic systems

Brings the Band Structure of Carbon-Based Devices into the Limelight A shift to carbon is positioning biology as a process of synthesis in mainstream engineering. Silicon is quickly being replaced with carbon-based electronics, de-

vices are being reduced down to nanometer scale, and further potential applications are being considered. While traditionally, engineers are trained by way of physics, chemistry, and mathematics, Nanoelectronics: Quantum Engineering of Low-Dimensional Nanoensembles establishes biology as an essential basic science for engineers to explore. Unifies Science and Engineering: from Quantum Physics to Nanoengineering Drawing heavily on published papers by the author, this research-driven text offers a complete review of nanoelectronic transport starting from quantum waves, to ohmic and ballistic conduction, and saturation-limited extreme nonequilibrium conditions. In addition, it highlights a new paradigm using non-equilibrium Arora's Distribution Function (NEADF) and establishes this function as the starting point (from band theory to equilibrium to extreme nonequilibrium carrier statistics). The author focuses on nano-electronic device design and development, including carbon-based devices, and provides you with a vantage point for the global outlook on the future of nanoelectronics devices and ULSI. Encompassing

ten chapters, this illuminating text: Converts the electric-field response of drift velocity into current--voltage relationships that are driven by the presence of critical voltage and saturation current arising from the unidirectional drift of carriers Applies the effect of these scaled-down dimensions to nano-MOSFET (metal-oxide-semiconductor field-effect transistor) Considers specialized applications that can be tried through a number of suggested projects that are all feasible with MATLAB® codes Nanoelectronics: Quantum Engineering of Low-Dimensional Nanoensembles contains the latest research in nanoelectronics, identifies problems and other factors to consider when it comes to nanolayer design and application, and ponders future trends. Print Versions of this book also include access to the ebook version.

The advent of semiconductor structures whose characteristic dimensions are smaller than the mean free path of carriers has led to the development of novel devices, and advances in theoretical understanding of mesoscopic systems or nanostructures. This book has been thoroughly revised and

provides a much-needed update on the very latest experimental research into mesoscopic devices and develops a detailed theoretical framework for understanding their behaviour. Beginning with the key observable phenomena in nanostructures, the authors describe quantum confined systems, transmission in nanostructures, quantum dots, and single electron phenomena. Separate chapters are devoted to interference in diffusive transport, temperature decay of fluctuations, and non-equilibrium transport and nanodevices. Throughout the book, the authors interweave experimental results with the appropriate theoretical formalism. The book will be of great interest to graduate students taking courses in mesoscopic physics or nanoelectronics, and researchers working on semiconductor nanostructures.

Transport Phenomena in Micro- and Nanoscale Functional Materials and Devices offers a pragmatic view on transport phenomena for micro- and nanoscale materials and devices, both as a research tool and as a means to implant new functions in materials. Chapters emphasize trans-

port properties (TP) as a research tool at the micro/nano level and give an experimental view on underlying techniques. The relevance of TP is highlighted through the interplay between a micro/nanocarrier's characteristics and media characteristics: long/short-range order and disorder excitations, couplings, and in energy conversions. Later sections contain case studies on the role of transport properties in functional nanomaterials. This includes transport in thin films and nanostructures, from nanogranular films, to graphene and 2D semiconductors and spintronics, and from read heads, MRAMs and sensors, to nano-oscillators and energy conversion, from figures of merit, micro-coolers and micro-heaters, to spin caloritronics. Presents a pragmatic description of electrical transport phenomena in micro- and nanoscale materials and devices from an experimental viewpoint Provides an in-depth overview of the experimental techniques available to measure transport phenomena in micro- and nanoscale materials Features case studies to illustrate how each technique works Highlights emerging areas of interest

in micro- and nanomaterial transport phenomena, including spintronics

Quantum transport is a diverse field, sometimes combining seemingly contradicting concepts - quantum and classical, conduction and insulating - within a single nanodevice. Quantum transport is an essential and challenging part of nanoscience, and understanding its concepts and methods is vital to the successful fabrication of devices at the nanoscale. This textbook is a comprehensive introduction to the rapidly developing field of quantum transport. The authors present the comprehensive theoretical background, and explore the groundbreaking experiments that laid the foundations of the field. Ideal for graduate students, each section contains control questions and exercises to check readers' understanding of the topics covered. Its broad scope and in-depth analysis of selected topics will appeal to researchers and professionals working in nanoscience.

A. Basic concepts. Why electrons flow ; The elastic resistor ; Ballistic and diffusive transport ; Conductance from fluctuation ; Energy band model ; The nanotransistor ; Diffusion equation for ballistic trans-

port ; Boltzmann equation ; Electrochemical potentials and quasi-Fermi levels ; Hall effect ; Smart contacts ; Thermoelectricity ; Phonon transport ; Second law ; Fuel value of information

This book provides an introduction to phenomena and models in nanoelectronics. It starts from the basics, but also introduces topics of recent interest, such as superconducting qubits, graphene, and quantum nanoelectromechanics.

This thesis develops novel numerical techniques for simulating quantum transport in the time domain and applies them to pertinent physical systems such as flying qubits in electronic interferometers and superconductor/semiconductor junctions hosting Majorana bound states (the key ingredient for topological quantum computing). In addition to exploring the rich new physics brought about by time dependence, the thesis also develops software that can be used to simulate nanoelectronic systems with arbitrary geometry and time dependence, offering a veritable toolbox for exploring this rapidly growing domain.

This book originated out of a desire to provide stu-

dents 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.

Modern electronics is being transformed as device size decreases to a size where the dimensions are significantly smaller than the constituent electron's mean free path. In such systems the electron motion is strongly confined resulting in dramatic changes of behaviour compared to the bulk. This book introduces the physics and applications of transport in such mesoscopic and nanoscale electronic systems and devices. The behaviour of these novel devices is influenced by numerous effects not seen in bulk semiconductors, such as the Aharonov-Bohm Effect, disorder and localization, energy quantization, electron wave interference, spin splitting, tunnelling and the quantum hall effect to name a few.

Including coverage of recent developments, and with a chapter on carbon-based nanoelectronics, this book will provide a good course text for advanced students or as a handy reference for researchers or those entering this interdisciplinary area.

A carefully developed textbook focusing on the fundamental principles of nanoscale science and nanotechnology.

Everyone is familiar with the amazing performance of a modern smartphone, powered by a billion-plus nanotransistors, each having an active region that is barely a few hundred atoms long. The same amazing technology has also led to a deeper understanding of the nature of current flow and heat dissipation on an atomic scale which is of broad relevance to the general problems of non-equilibrium statistical mechanics that pervade many different fields. This book is based on a set of two online courses originally offered in 2012 on nanoHUB-U and more recently in 2015 on edX. In preparing the second edition the author decided to split it into parts A and B titled Basic Concepts and Quantum Transport respectively.

ly, along the lines of the two courses. A list of available video lectures corresponding to different sections of this volume is provided upfront. To make these lectures accessible to anyone in any branch of science or engineering, the author assumes very little background beyond linear algebra and differential equations. However, the author will be discussing advanced concepts that should be of interest even to specialists, who are encouraged to look at his earlier books for additional technical details.

Advances in nanotechnology have allowed physicists and engineers to miniaturize electronic structures to the limit where finite-size related phenomena start to impact their properties. This book discusses such phenomena and models made for their description. The book starts from the semiclassical description of nonequilibrium effects, details the scattering theory used for quantum transport calculations, and explains the main interference effects. It also describes how to treat fluctuations and correlations, how interactions affect transport through small islands, and how superconductivity modifies these effects. The last two chapters de-

scribe new emerging fields related with graphene and nanoelectromechanics. The focus of the book is on the phenomena rather than formalism, but the book still explains in detail the main models constructed for these phenomena. It also introduces a number of electronic devices, including the single-electron transistor, the superconducting tunnel junction refrigerator, and the superconducting quantum bit. This book is the result of dynamic developments that have occurred in condensed matter physics after the recent discovery of a new class of electronic materials: topological insulators. A topological insulator is a material that behaves as a band insulator in its interior, while acting as a metallic conductor at its surface. The surface current carriers in these systems have Dirac-like nature and are protected by an intrinsic topological order, which is of great interest for both fundamental research and emerging technologies, especially in the fields of electronics, spintronics, and quantum information. The realization of the application potential of topological insulators requires a comprehensive and deep understanding of transport pro-

cesses in these novel materials. This book explores the origin of the protected Dirac-like states in topological insulators and gives an insight into some of their representative transport properties. These include the quantum spin-Hall effect, nonlocal edge transport, backscattering of helical edge and surface states, weak antilocalization, unconventional triplet p-wave superconductivity, topological bound states, and emergent Majorana fermions in Josephson junctions as well as superconducting Klein tunneling.

Nanoelectronics: Devices, Circuits and Systems explores current and emerging trends in the field of nanoelectronics, from both a devices-to-circuits and circuits-to-systems perspective. It covers a wide spectrum and detailed discussion on the field of nanoelectronic devices, circuits and systems. This book presents an in-depth analysis and description of electron transport phenomenon at nanoscale dimensions. Both qualitative and analytical approaches are taken to explore the devices, circuit functionalities and their system applications at deep submicron and nanoscale levels. Recent devices, including FinFET,

Tunnel FET, and emerging materials, including graphene, and its applications are discussed. In addition, a chapter on advanced VLSI interconnects gives clear insight to the importance of these nanotransmission lines in determining the overall IC performance. The importance of integration of optics with electronics is elucidated in the optoelectronics and photonic integrated circuit sections of this book. This book provides valuable resource materials for scientists and electrical engineers who want to learn more about nanoscale electronic materials and how they are used. Shows how electronic transport works at the nanoscale level Demonstrates how nanotechnology can help engineers create more effective circuits and systems Assesses the most commonly used nanoelectronic devices, explaining which is best for different situations

The first introductory textbook to explain the properties and performance of practical nanotube devices and related applications.

Throughout their college career, most engineering students have done problems and studies that are basically situated in

the classical world. Some may have taken quantum mechanics as their chosen field of study. This book moves beyond the basics to highlight the full quantum mechanical nature of the transport of carriers through nanoelectronic structures. The book is unique in that addresses quantum transport only in the materials that are of interest to microelectronics—semiconductors, with their variable densities and effective masses. The author develops Green's functions starting from equilibrium Green's functions and going through modern time-dependent approaches to non-equilibrium Green's functions, introduces relativistic bands for graphene and topological insulators and discusses the quantum transport changes that these bands induce, and discusses applications such as weak localization and phase breaking processes, resonant tunneling diodes, single-electron tunneling, and entanglement. Furthermore, he also explains modern ensemble Monte Carlo approaches to simulation of various approaches to quantum transport and the hydrodynamic approaches to quantum transport. All in all, the book describes all approaches to quantum tran-

sport in semiconductors, thus becoming an essential textbook for advanced graduate students in electrical engineering or physics.

This introductory text develops the reader's fundamental understanding of core principles and experimental aspects underlying the operation of nanoelectronic devices. The author makes a thorough and systematic presentation of electron transport in quantum-confined systems such as quantum dots, quantum wires, and quantum wells together with Landauer-Büttiker formalism and non-equilibrium Green's function approach. The coverage encompasses nanofabrication techniques and characterization tools followed by a comprehensive exposition of nanoelectronic devices including resonant tunneling diodes, nanoscale MOSFETs, carbon nanotube FETs, high-electron-mobility transistors, single-electron transistors, and heterostructure optoelectronic devices. The writing throughout is simple and straightforward, with clearly drawn illustrations and extensive self-study exercises for each chapter. Introduces the basic concepts underlying the operation of nanoelectronic devices. Offers a

broad overview of the field, including state-of-the-art developments. Covers the relevant quantum and solid-state physics and nanoelectronic device principles. Written in lucid language with accessible mathematical treatment. Includes extensive end-of-chapter exercises and many insightful diagrams.

Nanobiotechnology is a new interdisciplinary science with revolutionary perspectives arising from the fact that at nanosize the behaviour and characteristics of matter change with respect to ordinary macroscopic dimensions. Nanotechnology is a new way for producing and getting materials, structures and devices with greatly improved or completely new properties and functionalities. This book provides an introductory overview of the nanobiotechnology world along with a general technical framework about mathematical modelling through which we today study the phenomena of charge transport at the nanometer level. Although it is not a purely mathematics or physics book, it introduces the basic mathematical and physical notions that are important and necessary for theory and applications in nanobiotech-

nology. Therefore, it can be considered an extended formulary of basic and advanced concepts. It can be the starting point for discussions and insights and can be used for further developments in mathematical-physical modelling linked to the nanobiotechnology world. The book is dedicated to all those who follow their ideas in life and pursue their choices with determination and firmness, in a free and independent way.

Textbook presenting the fundamentals of nanoscience and nanotechnology with a view to nanoelectronics. Covers the underlying physics; nanostructures, including nanoobjects; methods for growth, fabrication and characterization of nanomaterials; and nanodevices. Provides a unifying framework for the basic ideas needed to understand the recent developments in the field. Includes numerous illustrations, homework problems and a number of interactive Java applets. For advanced undergraduate and graduate students in electrical and electronic engineering, nanoscience, materials, bioengineering and chemical engineering. Instructor solutions and Ja-

va applets available from www.cambridge.org/9780521881722.

Charge migration through DNA has been the focus of considerable interest in recent years. This book presents contributions from an international team of researchers active in this field. It contains a wide range of topics that includes the mathematical background of the quantum processes involved, the role of charge transfer in DNA radiation damage, a new approach to DNA sequencing, DNA photonics, and many others.

Graphene is one of the most intensively studied materials, and has unusual electrical, mechanical and thermal properties, which provide almost unlimited potential applications. This book provides an introduction to the electrical and transport properties of graphene and other two dimensional nanomaterials, covering ab-initio to multiscale methods. Updated from the first edition, the authors have added chapters on other two dimensional materials, spin related phenomena, and an improved overview of Berry phase effects. Other topics include powerful order N electronic structure, transport calculations, ac transport and multiscale

transport methodologies. Chapters are complemented with concrete examples and case studies, questions and exercises, detailed appendices and computational codes. It is a valuable resource for graduate students and researchers working in physics, materials science or engineering who are interested in the field of graphene-based nanomaterials.

This book provides a comprehensive overview of the rapidly developing field of molecular electronics. It focuses on our present understanding of the electrical conduction in single-molecule circuits and provides a thorough introduction to the experimental techniques and theoretical concepts. It will also constitute as the first textbook-like introduction to both the experiment and theory of electronic transport through single atoms and molecules. In this sense, this publication will prove invaluable to both researchers and students interested in the field of nanoelectronics and nanoscience in general. Molecular Electronics is self-contained and unified in its presentation. It may be used as a textbook on nanoelectronics by graduate students and advanced un-

dergraduates studying physics and chemistry. In addition, included are previously unpublished material that will help researchers gain a deeper understanding into the basic concepts involved in the field of molecular electronics.

This textbook is aimed at second-year graduate students in Physics, Electrical Engineering, or Materials Science. It presents a rigorous introduction to electronic transport in solids, especially at the nanometer scale. Understanding electronic transport in solids requires some basic knowledge of Hamiltonian Classical Mechanics, Quantum Mechanics, Condensed Matter Theory, and Statistical Mechanics. Hence, this book discusses those sub-topics which are required to deal with electronic transport in a single, self-contained course. This will be useful for students who intend to work in academia or the nano/ micro-electronics industry. Further topics covered include: the theory of energy bands in crystals, of second quantization and elementary excitations in solids, of the dielectric properties of semiconductors with an emphasis on dielectric screening and coupled interfacial modes, of electron scatter-

ing with phonons, plasmons, electrons and photons, of the derivation of transport equations in semiconductors and semiconductor nanostructures somewhat at the quantum level, but mainly at the semi-classical level. The text presents examples relevant to current research, thus not only about Si, but also about II-V compound semiconductors, nanowires, graphene and graphene nanoribbons. In particular, the text gives major emphasis to plane-wave methods applied to the electronic structure of solids, both DFT and empirical pseudopotentials, always paying attention to their effects on electronic transport and its numerical treatment. The core of the text is electronic transport, with ample discussions of the transport equations derived both in the quantum picture (the Liouville-von Neumann equation) and semi-classically (the Boltzmann transport equation, BTE). An advanced chapter, Chapter 18, is strictly related to the 'tricky' transition from the time-reversible Liouville-von Neumann equation to the time-irreversible Green's functions, to the density-matrix formalism and, classically, to the Boltzmann transport equa-

tion. Finally, several methods for solving the BTE are also reviewed, including the method of moments, iterative methods, direct matrix inversion, Cellular Automata and Monte Carlo. Four appendices complete the text.

This book presents the conceptual framework underlying the atomistic theory of matter, emphasizing those aspects that relate to current flow. This includes some of the most advanced concepts of non-equilibrium quantum statistical mechanics. No prior acquaintance with quantum mechanics is assumed. Chapter 1 provides a description of quantum transport in elementary terms accessible to a beginner. The book then works its way from hydrogen to nanostructures, with extensive coverage of current flow. The final chapter summarizes the equations for quantum transport with illustrative examples showing how conductors evolve from the atomic to the ohmic regime as they get larger. Many numerical examples are used to provide concrete illustrations and the corresponding Matlab codes can be downloaded from the web. Videostreamed lectures, keyed to specific sections of the book, are also avail-

able through the web. This book is primarily aimed at senior and graduate students.

This volume collects several in-depth articles giving lucid discussions on new developments in statistical and condensed matter physics. Many, though not all, contributors had been in touch with the late S-K Ma. Written by some of the world's experts and originators of new ideas in the field, this book is a must for all researchers in theoretical physics. Most of the articles should be accessible to diligent graduate students and experienced readers will gain from the wealth of materials contained herein.

As electric devices become smaller and smaller, transport simulations based on the quantum mechanics become more and more important. There are currently numerous textbooks on the basic concepts of quantum transport, but few present calculation methods in detail. This book provides various quantum transport simulation methods and shows applications for transport properties of nanometer-scale systems. It starts with a short review of quantum transport, followed by various calculation methods based on scattering ap-

proaches, non-equilibrium Green's function (NEGF), master equation, and time-dependent wave-packet diffusion (TD-WPD). With these tools, transport properties of various nanosystems are then explored.

The second edition offers an update on the single most comprehensive survey of the two intertwined fields of spintronics and magnetism, covering the diverse array of materials and structures, including silicon, organic semiconductors, carbon nanotubes, graphene, and engineered nanostructures. It focuses on seminal pioneering work, together with the latest in cutting-edge advances, notably extended discussion of two-dimensional materials beyond graphene, topological insulators, skyrmions, and molecular spintronics. The main sections cover physical phenomena, spin-dependent tunneling, control of spin and magnetism in semiconductors, and spin-based applications.

This book is aimed at senior undergraduates, graduate students and researchers interested in quantitative understanding and modeling of nanomaterial and device physics. With the rapid

slow-down of semiconductor scaling that drove information technology for decades, there is a pressing need to understand and model electron flow at its fundamental molecular limits. The purpose of this book is to enable such a deconstruction needed to design the next generation memory, logic, sensor and communication elements. Through numerous case studies and topical examples relating to emerging technology, this book connects 'top down' classical device physics taught in electrical engineering classes with 'bottom up' quantum and many-body transport physics taught in physics and chemistry. The book assumes no more than a nodding acquaintance with quantum mechanics, in addition to knowledge of freshman level mathematics. Segments of this book are useful as a textbook for a course in nanoelectronics.

Written by one of the founders of this field, this book provides a historical overview of the invention of superlattice, one of the most important devices of the second half of the twentieth century. In addition to describing the fundamental concepts, this completely revised and updated edition provides

new insights in the field of man-made solids. Written by one of the founders of this field Delivers over 20% new material, including new research and new technological applications Provides a basic understanding of the physics involved from first principles, while adding new depth, using basic mathematics and an explanation of the background essentials

Graphene is a perfectly two-dimensional single-atom thin membrane with zero bandgap. It has attracted huge attention due to its linear dispersion around the Dirac point, excellent transport properties, novel magnetic characteristics, and low spin-orbit coupling. Graphene and its nanostructures may have potential applications in spintronics, photonics, plasmonics and electronics. This book brings together a team of experts to provide an overview of the most advanced topics in theory, experiments, spectroscopy and applications of graphene and its nanostructures. It covers the state-of-the-art in tutorial-like and review-like manner to make the book useful not only to experts, but also newcomers and graduate students.

Heat in most semiconductor materials, including the traditional group IV elements (Si, Ge, diamond), III-V compounds (GaAs, wide-bandgap GaN), and carbon allotropes (graphene, CNTs), as well as emerging new materials like transition metal dichalcogenides (TMDCs), is stored and transported by lattice vibrations (phonons). Phonon generation through interactions with electrons (in nanoelectronics, power, and nonequilibrium devices) and light (optoelectronics) is the central mechanism of heat dissipation in nanoelectronics. This book focuses on the area of thermal effects in nanostructures, including the generation, transport, and conversion of heat at the nanoscale level. Phonon transport, including thermal conductivity in nanostructured materials, as well as numerical simulation methods, such as phonon Monte Carlo, Green's functions, and first principles methods, feature prominently in the book, which comprises four main themes: (i) phonon generation/heat dissipation, (ii) nanoscale phonon transport, (iii) applications/devices (including thermoelectrics), and (iv) emerging materials (graphene/2D). The book

also covers recent advances in nanophononics—the study of phonons at the nanoscale. Applications of nanophononics focus on thermoelectric (TE) and tandem TE/photovoltaic energy conversion. The applications are augmented by a chapter on heat dissipation and self-heating in nanoelectronic devices. The book concludes with a chapter on thermal transport in nanoscale graphene ribbons, covering recent advances in phonon transport in 2D materials. The book will be an excellent reference for researchers and graduate students of nanoelectronics, device engineering, nanoscale heat transfer, and thermoelectric energy conversion. The book could also be a basis for a graduate special topics course in the field of nanoscale heat and energy.

Nanoelectronics: Physics, Materials and Devices addresses the concepts involved in the exploration of research on nanoscale electronics and photonic devices and their application in next-generation integrated circuits (ICs). The book presents a detailed discussion on the field of nanoscale electronic and photonic devices, as well as the most recent techniques for the modeling

and simulation of these devices. It provides an in-depth analysis of theoretical frameworks, the fundamental physics underlying device operation, computational modeling, simulation methods, and circuit applications of nanoscale devices. The purpose of this book is to provide a desirable balance between basic background and concepts to improve device performance. In this book, both qualitative and quantitative approaches are considered to analyze and explore the contributions made by various researchers actively engaged in nanoscale device research. The book's main motivation is to help solve the challenges of analyzing and exploring the electrical behaviors of contemporary nanoscale device technologies. It purposefully builds the principles of nano electronic devices gradually, invigorating those of micro electronic devices. Addresses the conceptual, architectural, and design challenges faced by emerging nanoscale devices as a replacement of conventional MOSFET. Serves as a guide to researchers by suggesting research directions and potential applications. Explains the use of Technology Computer-Aided Design software (TCAD) to

produce numerical simulations of nanoscale devices. This book covers the state of the art in the theoretical framework, computational modeling, and the fabrication and characterization of nanoelectronics devices. It addresses material properties, device physics, circuit analysis, system design, and a range of applications. A discussion on the nanoscale fabrication, characterization and metrology is also included. The book offers a valuable resource for researchers, graduate students, and senior undergraduate students in engineering and natural sciences, who are interested in exploring nanoelectronics from materials, devices, systems, and applications perspectives.

Advances in semiconductor technology have made possible the fabrication of structures whose dimensions are much smaller than the mean free path of an electron. This book gives a thorough account of the theory of electronic transport in such mesoscopic systems. After an initial chapter covering fundamental concepts, the transmission function formalism is presented, and used to describe three key topics in mesoscopic physics: the quantum Hall effect; localisation; and

double-barrier tunnelling. Other sections include a discussion of optical analogies to mesoscopic phenomena, and the book concludes with a description of the non-equilibrium Green's function formalism and its relation to the transmission formalism. Complete with problems and solutions, the book will be of great interest to graduate students of mesoscopic physics and nanoelectronic device engineering, as well as to established researchers in these fields.

The information revolution would have been radically different, or impossible, without the use of the materials known generically as semiconductors. The properties of these materials, particularly the potential for doping with impurities to create transistors and diodes and controlling the local potential by gates, are essential for microelectronics. Semiconductor Transport is an introductory text on electron transport in semiconductor materials and is written for advanced undergraduates and graduate students. The book provides a thorough treatment of modern approaches to the transport properties of semiconductors and their calculation. It al-

so introduces those aspects of solid state physics, which are vitally important for understanding transport in them.

Major developments in the semiconductor industry are on the horizon through the use of two-dimensional (2D) materials, such as graphene and transition metal dichalcogenides, for integrated circuits (ICs). 2D Materials for Nanoelectronics is the

first comprehensive treatment of these materials and their applications in nanoelectronic devices. Comprised of chapters authored by internationally recognised researchers, this book: Discusses the use of graphene for high-frequency analog circuits Explores logic and photonic applications of molybdenum disulfide (MoS₂) Addresses novel 2D materials including silicene, ger-

manene, stanene, and phosphorene Considers the use of 2D materials for both field-effect transistors (FETs) and logic circuits Provides background on the simulation of structural, electronic, and transport properties from first principles 2D Materials for Nanoelectronics presents extensive, state-of-the-art coverage of the fundamental and applied aspects of this exciting field.