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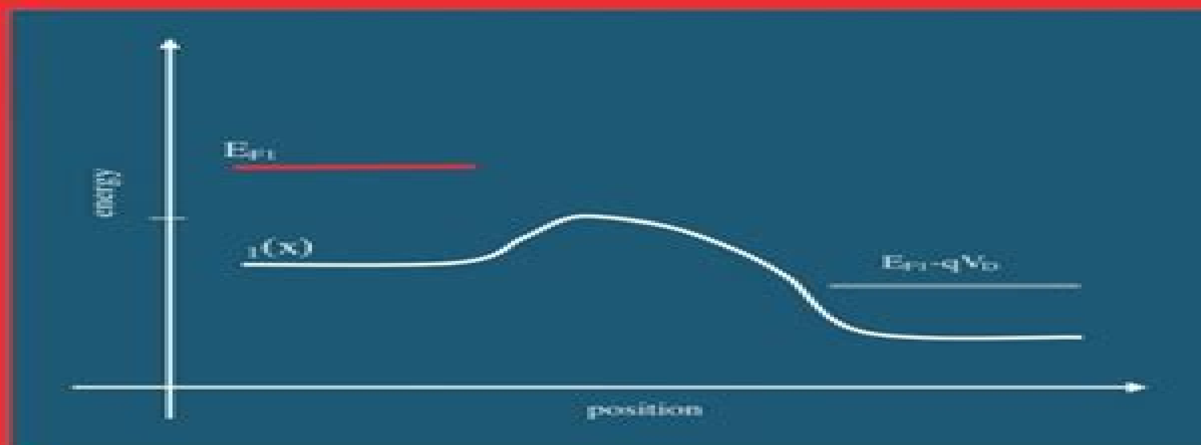
Jing Guo

Nanoscale Transistors

Device Physics, Modeling and Simulation



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Nanoscale Transistors Device Physics Modeling And Simulation

Kamakhya Prasad Ghatak

Nanoscale Transistors Device Physics Modeling And Simulation:

Nanoscale Transistors Mark Lundstrom,Jing Guo,2006-06-18 Silicon technology continues to progress but device scaling is rapidly taking the metal oxide semiconductor field effect transistor MOSFET to its limit When MOS technology was developed in the 1960 s channel lengths were about 10 micrometers but researchers are now building transistors with channel lengths of less than 10 nanometers New kinds of transistors and other devices are also being explored Nanoscale MOSFET engineering continues however to be dominated by concepts and approaches originally developed to treat microscale devices To push MOSFETs to their limits and to explore devices that may complement or even supplant them a clear understanding of device physics at the nano molecular scale will be essential Our objective is to provide engineers and scientists with that understandin not only of nano devices but also of the considerations that ultimately determine system performance It is likely that nanoelectronics will involve much more than making smaller and different transistors but nanoscale transistors provides a specific clear context in which to address some broad issues and is therefore our focus in this monograph *Nanoscale Transistors* Piero Ferri,Edward Greenberg,1989 To push MOSFETs to their scaling limits and to explore devices that may complement or even replace them at molecular scale a clear understanding of device physics at nanometer scale is necessary Nanoscale Transistors provides a description on the recent development of theory modeling and simulation of nanotransistors for electrical engineers physicists and chemists working on nanoscale devices Simple physical pictures and semi analytical models which were validated by detailed numerical simulations are provided for both evolutionary and revolutionary nanotransistors After basic concepts are reviewed the text summarizes the essentials of traditional semiconductor devices digital circuits and systems to supply a baseline against which new devices can be assessed A nontraditional view of the MOSFET using concepts that are valid at nanoscale is developed and then applied to nanotube FET as an example of how to extend the concepts to revolutionary nanotransistors This practical guide then explore the limits of devices by discussing conduction in single molecules Fundamentals of Nanotransistors Mark Lundstrom,2018 The transistor is the key enabler of modern electronics Progress in transistor scaling has pushed channel lengths to the nanometer regime where traditional approaches to device physics are less and less suitable These lectures describe a way of understanding MOSFETs and other transistors that is much more suitable than traditional approaches when the critical dimensions are measured in nanometers It uses a novel bottom up approach that agrees with traditional methods when devices are large but that also works for nano devices Surprisingly the final result looks much like the traditional textbook transistor models but the parameters in the equations have simple clear interpretations at the nanoscale The objective is to provide readers with an understanding of the essential physics of nanoscale transistors as well as some of the practical technological considerations and fundamental limits This book is written in a way that is broadly accessible to students with only a very basic knowledge of semiconductor physics and electronic circuits *Nanoscale MOS Transistors*

David Esseni,Pierpaolo Palestri,Luca Selmi,2011-01-20 Written from an engineering standpoint this book provides the theoretical background and physical insight needed to understand new and future developments in the modeling and design of n and p MOS nanoscale transistors A wealth of applications illustrations and examples connect the methods described to all the latest issues in nanoscale MOSFET design Key areas covered include Transport in arbitrary crystal orientations and strain conditions and new channel and gate stack materials All the relevant transport regimes ranging from low field mobility to quasi ballistic transport described using a single modeling framework Predictive capabilities of device models discussed with systematic comparisons to experimental results *The Physics of Semiconductor Devices* R. K. Sharma,D.S. Rawal,2019-01-31 This book disseminates the current knowledge of semiconductor physics and its applications across the scientific community It is based on a biennial workshop that provides the participating research groups with a stimulating platform for interaction and collaboration with colleagues from the same scientific community The book discusses the latest developments in the field of III nitrides materials devices compound semiconductors VLSI technology optoelectronics sensors photovoltaics crystal growth epitaxy and characterization graphene and other 2D materials and organic semiconductors

Carbon Nanotube and Graphene Device Physics H.-S. Philip Wong,Deji Akinwande,2011 The first introductory textbook to explain the properties and performance of practical nanotube devices and related applications **Nanoscale Devices** Brajesh Kumar Kaushik,2018-11-16 The primary aim of this book is to discuss various aspects of nanoscale device design and their applications including transport mechanism modeling and circuit applications Provides a platform for modeling and analysis of state of the art devices in nanoscale regime reviews issues related to optimizing the sub nanometer device performance and addresses simulation aspect and or fabrication process of devices Also includes design problems at the end of each chapter Nanoscale Electronic Devices and Their Applications Khurshed Ahmad Shah,Farooq Ahmad Khanday,2020-08-03 Nanoscale Electronic Devices and Their Applications helps readers acquire a thorough understanding of the fundamentals of solids at the nanoscale level in addition to their applications including operation and properties of recent nanoscale devices This book includes seven chapters that give an overview of electrons in solids carbon nanotube devices and their applications doping techniques construction and operational details of channel engineered MOSFETs and spintronic devices and their applications Structural and operational features of phase change memory PCM memristor and resistive random access memory ReRAM are also discussed In addition some applications of these phase change devices to logic designs have been presented Aimed at senior undergraduate students in electrical engineering micro electronics engineering physics and device physics this book Covers a wide area of nanoscale devices while explaining the fundamental physics in these devices Reviews information on CNT two and three probe devices spintronic devices CNT interconnects CNT memories and NDR in CNT FETs Discusses spin controlled devices and their applications multi material devices and gates in addition to phase change devices Includes rigorous mathematical derivations of the semiconductor physics Illustrates major concepts thorough discussions and various diagrams **Handbook of Research on Nanoelectronic Sensor Modeling and Applications** Ahmadi, Mohammad Taghi,Ismail, Razali,Anwar, Sohail,2016-09-20 Nanoelectronics are a diverse set of materials and devices that are so small that quantum mechanics need to be applied to their function The possibilities these devices present outweigh the difficulties associated with their development as biosensors and similar devices have the potential to vastly improve our technological reach The Handbook of Research on Nanoelectronic Sensor Modeling and Applications begins with an introduction of the fundamental concepts of nanoelectronic sensors then proceeds to outline in great detail the concepts of nanoscale device modeling and nanoquantum fundamentals Recent advances in the field such as graphene technology are discussed at length in this comprehensive handbook ideal for electrical engineers advanced engineering students researchers and academics Fundamentals of III-V Semiconductor MOSFETs Serge Oktyabrsky,Peide Ye,2010-03-16 Fundamentals of III V Semiconductor MOSFETs presents the fundamentals and current status of research of compound semiconductor metal oxide semiconductor field effect transistors MOSFETs that are envisioned as a future replacement of silicon in digital circuits The material covered begins with a review of specific properties of III V semiconductors and available technologies making them attractive to MOSFET technology such as band engineered heterostructures effect of strain nanoscale control during epitaxial growth Due to the lack of thermodynamically stable native oxides on III V s such as SiO2 on Si high k oxides are the natural choice of dielectrics for III V MOSFETs The key challenge of the III V MOSFET technology is a high quality thermodynamically stable gate dielectric that passivates the interface states similar to SiO2 on Si Several chapters give a detailed description of materials science and electronic behavior of various dielectrics and related interfaces as well as physics of fabricated devices and MOSFET fabrication technologies Topics also include recent progress and understanding of various materials systems specific issues for electrical measurement of gate stacks and FETs with low and wide bandgap channels and high interface trap density possible paths of integration of different semiconductor materials on Si platform *Operation and Modeling of the MOS Transistor* Yannis Tsividis,Colin McAndrew,2011 The MOS Metal Oxide Semiconductor transistor is the most important building block of modern silicon integrated circuits This book fills an important gap in the literature by presenting a unified treatment of the operation and modeling of the MOS transistor that is complemented with extensive intuitive discussions The MOS transistor is the dominant VLSI Very Large Scale Integration device and understanding of this device is mandatory for those people planning a career in device physics and modeling as well as in circuit design Especially important for university courses there is a logical systematic and progressive description that starts with semiconductor fundamentals and builds up to a comprehensive understanding of the basics of MOS transistors For practicing professionals there are details of nuances observed in MOS transistor behavior and various approaches to modeling these are presented Detailed derivations are given for modeling dc currents charges for large signal operation small signal operation at low frequencies and high frequencies and noise *Nanomaterials* Engg Kamakhya Prasad Ghatak,Madhuchhanda Mitra,2018-11-05 The work studies under different physical conditions the carrier contribution to elastic constants in heavily doped optoelectronic materials In the presence of intense photon field the authors apply the Heisenberg Uncertainty Principle to formulate electron statistics Many open research problems are discussed and numerous potential applications as quantum sensors and quantum cascade lasers are presented **The Predictive Technology Model in the Late Silicon Era and Beyond** Yu Cao,Asha Balijepalli,Chi-Chao Wang,Wenping Wang,Wei Zhao,2010 The aggressive scaling of CMOS technology has inevitably led to vastly increased power dissipation process variability and reliability degradation posing tremendous challenges to robust circuit design To continue the success of integrated circuits advanced design research must start in parallel with or even ahead of technology development This new paradigm requires the Predictive Technology Model PTM for future technology generations including nanoscale CMOS and post silicon devices This paper presents a comprehensive set of predictive modeling developments Starting from the PTM of traditional CMOS devices it extends to CMOS alternatives at the end of the silicon roadmap such as strained Si high k metal gate and FinFET devices The impact of process variation and the aging effect is further captured by modeling the device parameters under the influence Beyond the silicon roadmap the PTM outreaches to revolutionary devices especially carbon based transistor and interconnect in order to support explorative design research Overall these predictive device models enable early stage design exploration with increasing technology diversity helping shed light on the opportunities and challenges in the nanoelectronics era **Fowler-Nordheim Field Emission** Sitangshu Bhattacharya,Kamakhya Prasad Ghatak,2012-01-13 This monograph solely presents the Fowler Nordheim field emission FNFE from semiconductors and their nanostructures The materials considered are quantum confined non linear optical III V II VI Ge Te carbon nanotubes PtSb2 stressed materials Bismuth GaP Gallium Antimonide II V Bi2Te3 III V II VI IV VI and HgTe CdTe superlattices with graded interfaces and effective mass superlattices under magnetic quantization and quantum wires of the aforementioned superlattices The FNFE in opto electronic materials and their quantum confined counterparts is studied in the presence of light waves and intense electric fields on the basis of newly formulated electron dispersion laws that control the studies of such quantum effect devices The importance of band gap measurements in opto electronic materials in the presence of external fields is discussed from this perspective This monograph contains 200 open research problems which form the very core and are useful for Ph D students and researchers The book can also serve as a basis for a graduate course on field emission from solids **Heavily-Doped 2D-Quantized Structures and the Einstein Relation** Kamakhya P. Ghatak,Sitangshu Bhattacharya,2014-07-30 This book presents the Einstein Relation ER in two dimensional 2 D Heavily Doped HD Quantized Structures The materials considered are quantized structures of HD non linear optical III V II VI Ge Te Platinum Antimonide stressed materials GaP Gallium Antimonide II V Bismuth Telluride together with various types of HD superlattices and their Quantized counterparts respectively The ER in

HD opto electronic materials and their nanostructures is studied in the presence of strong light waves and intense electric fields on the basis of newly formulated electron dispersion laws that control the studies of such quantum effect devices The suggestion for the experimental determination of HD 2D and 3D ERs and the importance of measurement of band gap in HD optoelectronic materials under intense built in electric field in nanodevices and strong external photo excitation for measuring photon induced physical properties are also discussed in this context The influence of crossed electric and quantizing magnetic fields on the ER of the different 2D HD quantized structures quantum wells inversion and accumulation layers quantum well HD superlattices and nipi structures under different physical conditions is discussed in detail This monograph contains 100 open research problems which form the integral part of the text and are useful for both Ph D aspirants and researchers in the fields of condensed matter physics solid state sciences materials science nano science and technology and allied fields Quantum Effects, Heavy Doping, And The Effective Mass Kamakhya Prasad Ghatak,2016-12-08 The importance of the effective mass EM is already well known since the inception of solid state physics and this first of its kind monograph solely deals with the quantum effects in EM of heavily doped HD nanostructures The materials considered are HD quantum confined nonlinear optical III V II VI IV VI GaP Ge PtSb2 stressed materials GaSb Te II V Bi2Te3 lead germanium telluride zinc and cadmium diphosphides and quantum confined III V II VI IV VI and HgTe CdTe super lattices with graded interfaces and effective mass super lattices The presence of intense light waves in optoelectronics and strong electric field in nano devices change the band structure of semiconductors in fundamental ways which have also been incorporated in the study of EM in HD quantized structures of optoelectronic compounds that control the studies of the HD quantum effect devices under strong fields The importance of measurement of band gap in optoelectronic materials under intense external fields has also been discussed in this context The influences of magnetic quantization crossed electric and quantizing fields electric field and light waves on the EM in HD semiconductors and super lattices are discussed The content of this book finds twenty eight different applications in the arena of nano science and nano technology This book contains 200 open research problems which form the integral part of the text and are useful for both PhD aspirants and researchers in the fields of condensed matter physics materials science solid state sciences nano science and technology and allied fields in addition to the graduate courses in semiconductor nanostructures The book is written for post graduate students researchers engineers and professionals in the fields of condensed matter physics solid state sciences materials science nanoscience and technology and nanostructured materials in general Photoemission from Optoelectronic Materials and their Nanostructures Kamakhya Prasad Ghatak,Sitangshu Bhattacharya,Debashis De,2010-03-14 In recent years with the advent of fine line lithographical methods molecular beam epitaxy organometallic vapour phase epitaxy and other experimental techniques low dimensional structures having quantum confinement in one two and three dimensions such as ultrathin films inversion layers accumulation layers quantum well superlattices quantum well wires quantum wires superlattices magneto size quantizations and quantum dots have attracted much attention not only for their potential in uncovering new phenomena in nanoscience and technology but also for their interesting applications in the areas of quantum effect devices In ultrathin films the restriction of the motion of the carriers in the direction normal to the film leads to the quantum size effect and such systems find extensive applications in quantum well lasers field effect transistors high speed digital networks and also in other quantum effect devices In quantum well wires the carriers are quantized in two transverse directions and only one dimensional motion of the carriers is allowed *Einstein's Photoemission* Kamakhya Prasad Ghatak,2014-11-19 This monograph solely investigates the Einstein s Photoemission EP from Heavily Doped HD Quantized Structures on the basis of newly formulated electron dispersion laws The materials considered are quantized structures of HD non linear optical III V II VI Ge Te Platinum Antimonide stressed materials GaP Gallium Antimonide II V Bismuth Telluride together with various types of HD superlattices and their Quantized counterparts respectively The EP in HD opto electronic materials and their nanostructures is studied in the presence of strong light waves and intense electric fields that control the studies of such quantum effect devices The suggestions for the experimental determinations of different important physical quantities in HD 2D and 3D materials and the importance of measurement of band gap in HD optoelectronic materials under intense built in electric field in nano devices and strong external photo excitation for measuring physical properties in the presence of intense light waves which alter the electron energy spectra have also been discussed in this context The influence quantizing magnetic field on the EP of the different HD quantized structures quantum wells quantum well HD superlattices and nipi structures under different physical conditions has been investigated This monograph contains 100 open research problems which form the integral part of the text and are useful for both Ph D aspirants and researchers in the fields of materials science condensed matter physics solid state sciences nano science and technology and allied fields in addition to the graduate courses in modern semiconductor nanostructures offered in different Universities and Institutes Elastic Constants In Heavily Doped Low Dimensional Materials Kamakhya Prasad Ghatak,Madhuchhanda Mitra,2021-03-15 The elastic constant EC is a very important mechanical property of the these materials and its significance is already well known in literature This first monograph solely deals with the quantum effects in EC of heavily doped HD low dimensional materials The materials considered are HD quantum confined nonlinear optical III V II VI IV VI GaP Ge PtSb stressed materials GaSb Te II V Bi Te lead germanium telluride zinc and cadmium diphosphides and quantum confined III V II VI IV VI and HgTe CdTe super lattices with graded interfaces and effective mass super lattices The presence of intense light waves in optoelectronics and strong electric field in nano devices changes the band structure of semiconductors in fundamental ways which have also been incorporated in the study of EC in HD low dimensional optoelectronic compounds that control the studies of the HD quantum effect devices under strong fields The importance of measurement of band gap in optoelectronic materials under intense external fields has also been discussed in this context

The influences of magnetic quantization crossed electric and quantizing fields electric field and light waves on the EC in HD semiconductors and super lattices are discussed The content of this book finds twenty five different applications in the arena of nano science and nano technology We The authors have discussed the experimental methods of determining the Einstein Relation screening length and EC in this context This book contains circa 200 open research problems which form the integral part of the text and are useful for both PhD aspirants and researchers in the fields of condensed matter physics materials science solid state sciences nano science and technology and allied fields in addition to the graduate courses in semiconductor nanostructures Magneto Thermoelectric Power In Heavily Doped Quantized Structures Kamakhya Prasad Ghatak,2016-01-28 This pioneering monograph solely deals with the Magneto Thermoelectric Power MTP in Heavily Doped HD Quantized Structures The materials considered range from HD quantum confined nonlinear optical materials to HgTe CdTe HD superlattices with graded interfaces and HD effective mass superlattices under magnetic quantization An important concept of the measurement of the band gap in HD optoelectronic materials in the presence of external photo excitation has been discussed in this perspective The influences of magnetic quantization crossed electric and quantizing fields the intense electric field on the TPM in HD semiconductors and superlattices are also discussed This book contains 200 open research problems which form the integral part of the text and are useful for both PhD aspirants and researchers in the various fields for which this particular series is dedicated

The book delves into Nanoscale Transistors Device Physics Modeling And Simulation. Nanoscale Transistors Device Physics Modeling And Simulation is a crucial topic that needs to be grasped by everyone, ranging from students and scholars to the general public. This book will furnish comprehensive and in-depth insights into Nanoscale Transistors Device Physics Modeling And Simulation, encompassing both the fundamentals and more intricate discussions.

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    - Chapter 5: Conclusion
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