Nanoscale Devices

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
This book covers all major aspects of cutting-edge research in the field of neuromorphic hardware engineering involving emerging nanoscale devices.

Special emphasis is given to leading works in hybrid low-power CMOS-Nanodevice design. The book offers readers a bidirectional (top-down and bottom-up) perspective on designing efficient bio-inspired hardware. At the nanodevice level, it focuses on various flavors of emerging resistive memory (RRAM) technology. At the algorithm level, it addresses optimized implementations of supervised and stochastic learning paradigms such as: spike-time-dependent plasticity (STDP), long-term potentiation (LTP), long-term depression (LTD), extreme learning machines (ELM) and early adoptions of restricted Boltzmann machines (RBM) to name a few. The contributions discuss system-level power/energy/parasitic trade-offs, and complex real-world applications. The book is suited for both advanced researchers and students interested in the field. Accurate thermal modeling and the design of microelectronic devices and thin film structures at the micro- and nanoscales poses a challenge to electrical engineers who are less familiar with the basic concepts and ideas in sub-continuum heat transport. This book aims to bridge that gap. Efficient heat removal methods are necessary to increase device performance and device reliability. The authors provide readers with a combination of nanoscale experimental techniques and accurate modeling methods that must be employed in order to determine a device's temperature

profile.
Nanoscale Technology in Biological Systems reviews recent accomplishments in the field of nanobiology and introduces the application of nanoscale matrices to human biology. It focuses on

the applications of nanotechnology fabrication to biomedical devices and discusses new physical methods for cell isolation and manipulation and intracellular commu
Emerging Nanoelectronic

Devices focuses on the future direction of semiconductor and emerging nanoscale device technology. As the dimensional scaling of CMOS approaches its limits, alternate information processing devices and microarchitectures are being explored to sustain increasing functionality at decreasing cost into the indefinite future. This is driving new paradigms of information processing enabled by innovative new devices, circuits, and architectures, necessary to support an increasingly interconnected world through a rapidly evolving internet. This original title provides a fresh perspective on emerging research devices in 26 up to date chapters written by the leading researchers in their respective areas. It supplements and extends the work performed by the Emerging Research Devices working group of the International Technology Roadmap for Semiconductors (ITRS). Key features: Serves as an authoritative tutorial on innovative devices and architectures that populate the dynamic world of “Beyond

CMOS” technologies. Provides a realistic assessment of the strengths, weaknesses and key unknowns associated with each technology. Suggests guidelines for the directions of future development of each technology. Emphasizes physical concepts over mathematical development. Provides an essential resource for students, researchers and practicing engineers.

Brings the latest advances

in nanotechnology and biology to computing This pioneering book demonstrates how nanotechnology can create even faster, denser computing architectures and algorithms. Furthermore, it draws from the latest advances in biology with a focus on bio-inspired computing at the nanoscale, bringing to light several new and innovative applications such as nanoscale implantable biomedical devices and neural networks. Bio-Inspired and Nanoscale Integrated Computing features an expert team of interdisciplinary authors who offer readers the benefit of their own breakthroughs in integrated computing as well as a thorough investigation and analyses of the literature. Carefully edited, the book begins with an introductory chapter providing a general overview of the field. It ends with a chapter setting forth the common themes that tie the chapters together as well as a forecast of emerging avenues of research. Among the important topics addressed in the book are modeling of nano devices, quantum computing, quantum dot cellular automata, dielectrophoretic reconfigurable nano architectures, multilevel and three-dimensional nanomagnetic recording, spin-wave architectures and algorithms, fault-tolerant nanocomputing, molecular computing, self-assembly of supramolecular nanostructures, DNA nanotechnology and computing, nanoscale DNA sequence matching, medical nanorobotics, heterogeneous nanostructures for biomedical diagnostics, biomimetic cortical nanocircuits, bio-applications of carbon nanotubes, and nanoscale image processing. Readers in electrical engineering, computer science, and computational biology will gain new insights into how bio-inspired and nanoscale devices can be used to design the next generation of enhanced integrated

circuits.
Nanoscale DevicesPhysics, Modeling, and Their ApplicationCRC Press
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
Fundamentals and

Applications : Proceedings of the International Symposium
2D Nanoscale Heterostructured Materials
Circuits at the Nanoscale
Emerging Nanoelectronic Devices

The Non-Equilibrium Green's Function Method for Nanoscale Device Simulation
Nanoscale Electronic Devices and Their Applications
Theoretical Foundations of Nanoscale Quantum Devices
Transport in Microfluidic

Devices
Spintronics in Nanoscale Devices
Bio-Inspired and Nanoscale Integrated Computing
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 nano-transmission 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

By exploiting the novel properties of quantum dots and nanoscale Aharonov–Bohm rings together with the electronic and magnetic properties of various semiconductor materials and graphene, researchers have conducted numerous theoretical and computational modeling studies and experimental tests that show promising behavior for spintronics applications. Spin polarization and spin-filtering capabilities and the ability to manipulate the electron spin state through external magnetic or electric fields have demonstrated the promise of workable nanoscale devices for computing and memory applications. This book provides researchers investigating this cutting-edge field with detailed background descriptions of spin-based effects and devices and their theoretical analysis in nanoelectronic circuits.

Nanoscale techniques and devices have had an explosive influence on research in life sciences and bioengineering. Reflecting this influence, Nanopatterning and Nanoscale Devices for Biological Applications provides valuable insight into the latest developments in nanoscale technologies for the study of biological systems. Written and edited by experts in the field, this first-of-its-kind collection of topics: Covers device fabrication methods targeting the substrate on the nanoscale through surface modification Explores the generation of nanostructured biointerfaces and bioelectronics elements Examines microfluidically generated droplets as reactors enabling nanoscale sample preparation and analysis Gives an overview of key biosensors and integrated devices with nanoscale functionalities Discusses the biological applications of nanoscale devices, including a review of nanotechnology in tissue engineering Readers gain a deep understanding of the cutting-edge applications of nanotechnologies in biological engineering, and learn how to apply the relevant scientific concepts to their own research.

Nanopatterning and Nanoscale Devices for Biological Applications is the definitive reference for researchers in engineering, biology, and biomedicine, and for anyone exploring the

newest trends in this innovative field.
Electron and photon confinement in semiconductor nanostructures is one of the most active areas in solid

state research. Written by leading experts in solid state physics, this book provides both a comprehensive review as well as a excellent introduction to fundamental and applied aspects of light-matter coupling in microcavities. Topics covered include parametric amplification and polariton liquids, quantum fluid and non-linear dynamical effects and parametric instabilities, polariton squeezing, Bose-Einstein condensation of microcavity polaritons, spin dynamics of exciton-polaritons, polariton correlation produced by parametric scattering, progress in III-nitride distributed Bragg reflectors using AlInN/GaN materials, high efficiency planar MCLEDs, exciton-polaritons and nanoscale cavities in photonic crystals, and MBE

growth of high finesse microcavities.
Anticipating a limit to the continuous miniaturization (More-Moore), intense research efforts are being made to co-integrate various

functionalities (More-than-Moore) in a single chip. Currently, strain engineering is the main technique used to enhance the performance of advanced semiconductor devices. Written from an engineering applications standpoint, this book encompasses broad areas of semiconductor devices involving the design, simulation, and analysis of Si, heterostructure silicongermanium (SiGe), and III-N compound semiconductor devices. The book provides the background and physical insight needed to understand the new and future developments in the technology CAD (TCAD) design at the nanoscale. Features Covers stressstrain engineering in semiconductor devices, such as FinFETs and III-V Nitride-based devices Includes comprehensive mobility model for strained substrates in global and local strain techniques and their implementation in device simulations Explains the development of strain/stress relationships and their effects on the band structures of strained substrates Uses design of experiments to find the optimum process conditions

Illustrates the use of TCAD for modeling strain-engineered FinFETs for DC and AC performance predictions This book is for graduate students and researchers studying solid-state devices and materials, microelectronics, systems and controls, power electronics, nanomaterials, and electronic materials and devices.

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The book includes seven chapters covering overview of electrons in solids, carbon nanotube devices and their applications, doping techniques, construction and operation details of channel

Engineered MOSFETs, structural and operational details about the spin devices including applications. Structural and operational details of phase change memory (PCM), memristor and Resistive Random-access Memory (ReRAM) are also discussed. Besides, some applications of these phase change devices to logic design have also been presented"--

The primary objective of the NATO Advanced Study Institute (ASI) titled “Functionalized Nanoscale Materials, Devices, and Systems for Chem. -Bio Sensors, Photonics, and

Energy Generation and Storage" was to present a contemporary and comprehensive overview of the field of nanostructured materials and devices and its applications in chem. -bio sensors, nanophotonics, and energy generation and storage devices. The study has become one of the most promising disciplines in science and technology, as it aims at the fundamental understanding of new physical, che- cal, and biological properties of systems and the technological advances arising from their exploration. Such systems are intermediate in size, between the isolated atoms and molecules and bulk material, where the unique transitional characteristics between the two can be understood, controlled, and manipulated. Nanotechnologies refer to the creation and utilization of functional materials, devices, and systems with novel properties and functions that are achieved through the control of matter, atom-by-atom, molecule-by-molecule, or at a micro-mo- cular level. Advances made over the last few years provide new opportunities for scientific and technological developments in nanostructures and nanosystems with new architectures with improved functionality. The field is very actively and rapidly evolving and covers a wide range of disciplines. Recently, various nanoscale materials, devices, and systems with remarkable properties have been developed, with numerous unique applications in chemical and biological sensors, nanophotonics, nano-biotechnology, and in-vivo analysis of cellular processes at the nanoscale. Is Bigger Always Better? Explore the Behavior of Very

Small Devices as Described by Quantum Mechanics Smaller is better when it comes to the semiconductor transistor. Nanoscale Silicon Devices examines the growth of semiconductor device miniaturization and related advances in material, device, circuit, and system design, and highlights the use of device scaling within the semiconductor industry. Device scaling, the practice of continuously scaling down the size of metal-oxide-semiconductor field-effect transistors (MOSFETs), has significantly improved the performance of small computers, mobile phones, and similar devices. The practice has resulted in smaller delay time and higher device density in a chip without an increase in power consumption. This book covers recent advancements and considers the future prospects of nanoscale silicon (Si) devices. It provides an introduction to new concepts (including variability in scaled MOSFETs, thermal effects, spintronics-based nonvolatile computing systems, spin-based qubits, magnetoelectric devices, NEMS devices, tunnel FETs, dopant engineering, and single-electron transfer), new materials (such as high-k dielectrics and germanium), and new device structures in three dimensions. It covers the fundamentals of such devices, describes the physics and modeling of these devices, and advocates further device scaling and minimization of energy consumption in future large-scale integrated circuits (VLSI). Additional coverage includes: Physics of nm scaled devices in terms of quantum mechanics Advanced 3D transistors: tri-gate structure and thermal effects Variability in scaled MOSFET Spintronics on Si platform NEMS devices for switching, memory, and sensor applications The concept of ballistic transport The present status of the transistor variability and more An indispensable resource, Nanoscale Silicon

Devices serves device engineers and academic researchers (including graduate students) in the fields of electron devices, solid-state physics, and nanotechnology.

Physics, Modeling, and Their Application
Device Physics, Modeling and Simulation
Techniques for the Incorporation of Biomolecules Into Nanoscale

Devices
Synthesis, Properties, and Applications
Devices, Circuits and Systems
Science and Engineering Fundamentals

Nanoscale Devices
Nanoscale Technology in Biological Systems
Transport Phenomena in Micro- and Nanoscale Functional Materials and Devices

Neuromorphic Circuits for Nanoscale Devices

Nanoscale Fabrication, Optimization, Scale-up and Biological Aspects of Pharmaceutical Nanotechnology focuses on the fabrication, optimization, scale-up and biological aspects of pharmaceutical nanotechnology. In particular, the following aspects of nanoparticle preparation methods are discussed: the need for less toxic reagents, simplification of the procedure to allow economic scale-up, and optimization to improve yield and entrapment efficiency. Written by a diverse range of international researchers, the chapters examine characterization and manufacturing of nanomaterials for pharmaceutical applications. Regulatory and policy aspects are also discussed. This book is a valuable reference resource for researchers in both academia and the pharmaceutical industry who want to learn more about how nanomaterials can best be utilized. Shows how nanomanufacturing techniques can help to create more effective, cheaper pharmaceutical products Explores how nanofabrication techniques developed in the lab have been translated to commercial applications in recent years Explains safety and regulatory aspects of the use of nanomanufacturing processes in the pharmaceutical industry

A variety of new processes and materials for nanoscale magnetic devices has been developed under this 5-year program, with application to non-volatile magnetic memories and GMR/spin-valve heads. The demonstration of ultra-high density patterning techniques and magnetic dot arrays were highlights of the program.

This self-contained text describes the underlying theory and approximate quantum models of real nanodevices for nanotechnology applications.

The second half of the twentieth century and the beginning of the twenty ?rst have been characterized by the most impressive industrial revolution ever seen. In - proximately 40years, the complexity of integrated circuits (ICs) has increased by a 9 factor of 10 , with a corresponding reduction of the cost per bit by eight orders of magnitude. Not only has this evolution allowed dramatic progress in allscienti?c ?elds (large computers, space probes, etc.), but also has fueled the economic development with the raise of new markets (personal computers, cellular phones, etc.) and even social revolutions (world wide web, global village, etc.). In last years, however, the situation has signi?cantly changed: the continuous scaling down of device size has eventually brought the IC major technique, p- tolithography, to its limits. Overcoming its original limits has been proved to be possible, but the price to pay for that has changed the playing rules – while at the beginning of the IC history the evolution was driven by

technology, now it is driven by economy, the cost of a medium size production plant being in the range of a few billion dollars.
Nanoscale devices differ from larger microscale devices because they depend on the physical phenomena

and effects that are central to their operation. This textbook illuminates the behavior of nanoscale devices by connecting them to the electronic, as well as magnetic, optical and mechanical properties, which fundamentally affect nanoscale devices in fascinating ways. Their small size means that an understanding of the phenomena measured is even more important, as their effects are so dominant and the changes in scale of underlying energetics and response are significant. Examples of these include classical effects such as single electron effects, quantum effects such as the states accessible as well as their properties; ensemble effects ranging from consequences of the laws of numbers to changes in properties arising from different magnitudes of the interactions, and others. These interactions, with the limits on size, make their physical behavior interesting, important and useful. The collection of four textbooks in the Electroscience

Series culminates in a comprehensive understanding of nanoscale devices — electronic, magnetic, mechanical and optical — in the 4th volume. The series builds up to this last subject with volumes devoted to underlying semiconductor and solid-state physics.

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 transport 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 spincaloritronics. 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 dots as nanomaterials have been extensively investigated in the past several decades from growth to characterization to applications. As the basis of future developments in the field, this book collects a series of state-of-the-art chapters on the current status of quantum dot devices and how these devices take advantage of quantum features. Written by 56 leading experts from 14 countries, the chapters cover numerous quantum dot applications, including lasers, LEDs, detectors, amplifiers, switches, transistors, and solar cells. Quantum Dot Devices is appropriate for researchers of all levels of experience with an interest in epitaxial and/or colloidal quantum dots. It provides the beginner with the necessary overview of this exciting field and those more experienced with a comprehensive

reference source.
It is generally acknowledged that modeling and simulation are preferred alternatives to trial and error approaches to semiconductor fabrication in the present environment, where the cost of

process runs and associated mask sets is increasing exponentially with successive technology nodes. Hence, accurate physical device simulation tools are essential to accurately predict device and circuit performance. Accurate thermal modelling and the design of microelectronic devices and thin film structures at the micro- and nanoscales poses a challenge to electrical engineers who are less familiar with the basic concepts and ideas in sub-continuum heat transport. This book aims to bridge that gap. Efficient heat removal methods are necessary to increase device performance and device reliability. The authors provide readers with a combination of nanoscale experimental techniques and accurate modelling methods that must be employed in order to determine a device's temperature profile.

Modeling Self-heating Effects in Nanoscale Devices

Communications, Imaging, and

Sensing
Nanoscale Devices, Materials, and Biological Systems
Nanoscale Devices for Optical Detection and Spectroscopy of Single Molecules
Physics of Semiconductor

Microcavities
Nanoscale Silicon Devices
Nanoscale Fabrication, Optimization, Scale-up and Biological Aspects of Pharmaceutical Nanotechnology
Micro- and Nanoscale Fluid

This book collects papers on the

fundamentals and applications of nanoscale devices, first presented at the NATO Advanced Research Workshop on Nanoscale Devices – Fundamentals and Applications held in Kishinev, Moldova, in September 2004. The focus is on the synthesis and *characterization of nanoscale magnetic materials; fundamental physics and materials aspects of solid-state nanostructures; development of novel device concepts and design principles for nanoscale devices; and on applications in electronics with* *emphasis on defence against the threat of terrorism.*

For modeling the transport of carriers in nanoscale devices, a Green-function formalism is the most accurate approach. Due to the complexity of the formalism, one should have a deep *understanding of the underlying principles and use smart approximations and numerical methods for solving the kinetic equations at a reasonable computational time. In this book the required concepts from quantum and statistical mechanics and* *numerical methods for calculating Green functions are presented. The Green function is studied in detail for systems both under equilibrium and under nonequilibrium conditions. Because the formalism enables rigorous modeling of different* *scattering mechanisms in terms of self-energies, but an exact evaluation of self-energies for realistic systems is not possible, their approximation and inclusion in the quantum kinetic equations of the Green functions are elaborated. All the elements of the* *kinetic equations, which are the device Hamiltonian, contact self-energies and scattering self-energies, are examined and efficient methods for their evaluation are explained. Finally, the application of these methods to study novel electronic devices such as* *nanotubes, graphene, Si-nanowires and low-dimensional thermoelectric devices and photodetectors are discussed.*

Nanotechnology is a vital new area of research and development addressing the control, modification and *fabrication of materials, structures and devices with nanometre precision and the synthesis of such structures into systems of micro- and macroscopic dimensions. Future applications of nanoscale science and technology include motors smaller than the* *diameter of a human hair and single-celled organisms programmed to fabricate materials with nanometer precision. Miniaturisation has revolutionised the semiconductor industry by making possible inexpensive integrated electronic* *circuits comprised of devices and wires with sub-micrometer dimensions. These integrated circuits are now ubiquitous, controlling everything from cars to toasters. The next level of miniaturisation, beyond sub-micrometer dimensions into nanoscale* *dimensions (invisible to the unaided human eye) is a booming area of research and development. This is a very hot area of research with large amounts of venture capital and government funding being invested worldwide, as such Nanoscale Science* *and Technology has a broad appeal based upon an interdisciplinary approach, covering aspects of physics, chemistry, biology, materials science and electronic engineering. Kelsall et al present a coherent approach to nanoscale sciences, which will be* *invaluable to graduate level students and researchers and practising engineers and product designers. Nanoscale science and technology, often referred to as "nanoscience" or "nanotechnology," are science and engineering enabled by our relatively* *new ability to manipulate and characterize matter at the level of single atoms and small groups of atoms. This capability is the result of many developments in the last two decades of the 20th century, including inventions of scientific instruments like* *the scanning tunneling microscope. Using such tools, scientists and engineers have begun controlling the structure and properties of materials and systems at the scale of 10?9 meters, or 1/100,000 the width of a human hair. Scientists and engineers* *anticipate that nanoscale work will enable the development of materials and systems with dramatic new properties relevant to virtually every sector of the economy, such as medicine, telecommunications, and computers, and to areas of national* *interest such as homeland security. Indeed, early products based on nanoscale technology have already found their way into the marketplace and into defense applications. In 1996, as the tremendous scientific and economic potential of nanoscale* *science and technology was beginning to be recognized, a federal interagency working group formed to consider creation of a national nanotechnology initiative (NNI). As a result of this effort, around $1 billion has been directed toward NNI research since the* *start of FY 2001. At the request of officials in the White House National Economic Council and agencies that are participating in NNI, the National Research Council (NRC) agreed to review the NNI. The Committee for the Review of the National*

Nanotechnology Initiative was formed by the NRC and asked to consider topics such as the current research portfolio of the NNI, the suitability of federal investments, and interagency coordination efforts in this area. Advances in design methods and *process technologies have resulted in a continuous increase in the complexity of integrated circuits (ICs). However, the increased complexity and nanometer-size features of modern ICs make them susceptible to manufacturing defects, as well as* *performance and quality issues. Testing for Small-Delay Defects in Nanoscale CMOS Integrated Circuits covers common problems in areas such as process variations, power supply noise, crosstalk, resistive opens/bridges, and design-for-*

manufacturing (DfM)-related rule violations. The book also addresses testing for small-delay defects (SDDs), which can cause immediate timing failures on both critical and non-critical paths in the circuit. Overviews semiconductor industry test challenges *and the need for SDD testing, including basic concepts and introductory material Describes algorithmic solutions incorporated in commercial tools from Mentor Graphics Reviews SDD testing based on "alternative methods" that explores new metrics,* *top-off ATPG, and circuit topology-based solutions Highlights the advantages and disadvantages of a diverse set of metrics, and identifies scope for improvement Written from the triple viewpoint of university researchers, EDA tool developers, and* *chip designers and tool users, this book is the first of its kind to address all aspects of SDD testing from such a diverse perspective. The book is designed as a one-stop reference for current industrial practices, research challenges in the domain of SDD* *testing, and recent developments in SDD solutions.*

This text focuses on the physics of fluid transport in micro- and nanofabricated liquid-phase systems, with consideration of gas bubbles, solid particles, and macromolecules. This *text was designed with the goal of bringing together several areas that are often taught separately - namely, fluid mechanics, electrodynamics, and interfacial chemistry and electrochemistry - with a focused goal of preparing the modern microfluidics* *researcher to analyse and model continuum fluid mechanical systems encountered when working with micro- and nanofabricated devices. This text serves as a useful reference for practising researchers but is designed primarily for classroom instruction.*

Worked sample problems are included throughout to assist the student, and exercises at the end of each chapter help facilitate class learning.
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*

Nanoscale devices attracted significant research effort from the industry and academia due to their operation principals being based on different physical properties which provide advantages in the design of certain classes of circuits over conventional

CMOS transistors. Neuromorphic Circuits for Nanoscale Devices contains recent research papers presented in various international conferences and journals to provide insight into how the operational principles of the nanoscale devices can *be utilized for the design of neuromorphic circuits for various applications of non-volatile memory, neural network training/learning, and image processing. The topics discussed in the book include: Nanoscale Crossbar Memory Design Q-Learning* *and Value Iteration using Nanoscale Devices Image Processing and Computer Vision Applications for Nanoscale Devices Nanoscale Devices-based Cellular Nonlinear/Neural Networks*

Nanoelectronics

Systems Engineering for Microscale and Nanoscale Technologies
Stress and Strain Engineering at Nanoscale in Semiconductor Devices
Small Wonders, Endless Frontiers
Nanopatterning and Nanoscale

Devices for Biological Applications
Modeling Self-Heating Effects in Nanoscale Devices
Quantum Dot Devices
Nanoscale Devices and Novel Engineered Materials
Fabrication, Functionalization, and

Accessibility from the Macroscopic World
Circuits for Emerging Technologies Beyond CMOS
New exciting opportunities are abounding in the field of body area networks,

wireless communications, data networking, and optical imaging. In response to these developments, top-notch international experts in industry and academia present Circuits at the Nanoscale: Communications, Imaging, and Sensing. This volume, unique in both its scope and its focus, addresses the state-of-the-art in integrated circuit design in the context of emerging systems. A must for anyone serious about circuit design for future technologies, this book discusses emerging materials that can take system performance beyond standard CMOS. These include Silicon on Insulator (SOI), Silicon Germanium (SiGe), and Indium Phosphide (InP). Three-dimensional CMOS integration and co-integration with Microelectromechanical (MEMS) technology and radiation sensors are described as well. Topics in the book are divided into comprehensive sections on emerging design techniques, mixed-signal CMOS circuits, circuits for communications, and circuits for imaging and sensing. Dr. Krzysztof Iniewski is a director at CMOS Emerging Technologies, Inc., a consulting company in Vancouver, British Columbia. His current research interests are in VLSI ciruits for medical applications. He has published over 100 research papers in international journals and conferences, and he holds

18 international patents granted in the United States, Canada, France, Germany, and Japan. In this volume, he has assembled the contributions of over 60

world-reknown experts who are at the top of their field in the world of circuit design, advancing the bank of knowledge for all who work in this exciting and burgeoning

area.
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. Furthermore, the book develops a strong foundation to understand the need for moving from conventional MOSFET to novel devices, including, how the device physics and transport phenomenon changes with reduction in the device size to a nanoscale regime. Details about the simulation technique and/or fabrication process flow of the various nanoscale devices is included along with simulated results of device performance parameters. The numerical and theoretical methods

are used to describe the related concepts.
To realize the full potential of micro- and nanoscale devices in system building, it is critical to develop

systems engineering methodologies that successfully integrate stand-alone, small-scale technologies that can effectively interface with the macro world. So how do we accomplish this? Systems Engineering for Microscale and Nanoscale Technologies is perhaps the first handbook to concentrate on the use of systems engineering at the micro and nano levels. One major roadblock to this process is a generally limited understanding of exactly how to apply systems engineering principles and management processes to the integration of newer, small-scale technologies. Focusing on this problem of consolidating disciplines, contributors illustrate the interdependence between nanotechnology and systems engineering, making it easier for experts from these two distinct fields to understand and optimize their application of the

other. To help readers
from these different
domains successfully
combine heterogeneous,
mixed-scale elements,
contributors assess the
evolution of micro- and

nanoscale technology development and its impact on everything from laboratory concepts to actualized products in health, automotive, aerospace, communication, and many other fields. The book outlines new approaches to developing smart systems. It also clarifies the capabilities of micro- and nanotechnologies, including how they interface with each other and with macro systems. Edited by highly regarded technologists, this introductory resource includes insightful contributions from leading minds in areas including nanotechnology, physics, systems engineering, materials science, chemistry, electrical engineering, and futurism, among others. The result is a masterfully designed, interrelated collection of multidisciplinary expertise to help readers optimize future technologies. About the

Editors: M. Ann Garrison Darrin is managing executive of the Space Department at the Applied Physics Laboratory at The Johns Hopkins University. Janet L. Barth is chief of

the Electrical Engineering Division (EED) at NASA’s Goddard Space Flight Center (GSFC).
2D Nanoscale Heterostructured Materials: Synthesis,

Properties, and Applications assesses the current status and future prospects for 2D materials other than graphene (e.g., BN nanosheets, MoS_2, $NbSe_2$, WS_2, etc.) that have already been contemplated for both low-end and high-end technological applications. The book offers an overview of the different synthesis techniques for 2D materials and their heterostructures, with a detailed explanation of the many potential future applications. It provides an informed overview and fundamentals properties related to the 2D Transition metal dichalcogenide materials and their heterostructures. The book helps researchers to understand the progress of this field and points the way to future research in this area. Explores synthesis techniques of newly evolved 2D materials and their heterostructures

with controlled properties
Offers detailed analysis
of the fundamental
properties (via various
experimental process and
simulations techniques) of
2D heterostructures

materials Discusses the applications of 2D heterostructured materials in various high-performance devices
Nanoscale Devices - Fundamentals and

Applications
Nanoscale Science and
Technology
Nanoscale Transistors
From Fundamentals to
Nanoscale Devices
A Review of the National

Devices