Carbon Nanotube And Graphene Device Physics

The Carbon Nanomaterials Sourcebook contains extensive, interdisciplinary coverage of carbon nanomaterials, encompassing the full scope of the field—from physics, chemistry, and materials science to molecular biology, engineering, and medicine—in two comprehensive volumes. Written in a tutorial style, this second volume of the sourcebook: Focuses on nanoparticles, nanocapsules, nanofibers, nanoporous structures, and nanocomposites Describes the fundamental properties, growth mechanisms, and processing of each nanomaterial discussed Explores functionalization for electronic, energy, biomedical, and environmental applications Showcases materials with exceptional properties, synthesis methods, large-scale production techniques, and application prospects Provides the tools necessary for understanding current and future technology developments, including important equations, tables, and graphs Each chapter is dedicated to a different type of carbon nanomaterial and addresses three main areas: formation, properties, and applications. This setup allows for quick and easy search, making the Carbon Nanomaterials Sourcebook: Nanoparticles, Nanocapsules, Nanofibers, Nanoporous Structures, and Nanocomposites a must-have reference for scientists and engineers.
Carbon nanotubes are rolled up graphene sheets with a quasi-one-dimensional structure of nanometer-scale diameter. In these last twenty years, carbon nanotubes have attracted much attention from physicists, chemists, material scientists, and electronic device engineers, because of their excellent structural, electronic, optical, chemical and mechanical properties. More recently, demand for innovative industrial applications of carbon nanotubes is increasing. This book covers recent research topics regarding syntheses techniques of carbon nanotubes and nanotube-based composites, and their applications. The chapters in this book will be helpful to many students, engineers and researchers working in the field of carbon nanotubes.
Carbon Nanotubes (CNT) is the material lying between fullerenes and graphite as a new member of carbon allotropes. The study of CNT has gradually become more and more independent from that of fullerenes. As a novel carbon material, CNTs will be far more useful and important than fullerenes from a practical point of view, in that they will be directly related to an ample field of nanotechnology. This book presents a timely, second-generation monograph covering as far as practical, application of CNT as the newest science of these materials. Most updated summaries for preparation, purification and structural characterisation of single walled CNT and multi walled CNT are given. Similarly, the most recent developments in the theoretical treatments of electronic structures and vibrational structures are covered. The newest magnetic, optical and electrical solid-state properties providing a vital base to actual application technologies are described. Explosive research trends towards application of CNTs, including the prospect for large-scale synthesis, are also introduced. It is the most remarkable feature of

this monograph that it devotes more than a half of the whole volume to practical aspects and offers readers the newest developments of the science and technological aspects of CNTs.

This book provides a complete overview of the field of carbon nanotube electronics. It covers materials and physical properties, synthesis and fabrication processes, devices and circuits, modeling, and finally novel applications of nanotube-based electronics. The book introduces fundamental device physics and circuit concepts of 1-D electronics. At the same time it provides specific examples of the state-of-the-art nanotube devices.

If an appropriate control by different edge atoms is possible, it would be definitely positive. Totally new electronic band structure is obtained by different edge-termination atoms. In addition, only a fraction of impurity atom can also much affect on the material properties of GNR. In order to perform device simulations of non-uniform GNR devices, multiscale simulation scheme can be used in non-equilibrium Green's function (NEGF) formalism and density-functional method.

This book compiles all current information on the different types of functionalization of carbon nanotubes (CNTs) and graphene, both covalent and non-covalent. The book starts with a general overview of the synthesis, characterization and application of functionalized CNTs and graphene. Special attention is dedicated to the characterization of functionalized materials, a topic rarely addressed on the literature. The authors provide a comparison between the functionalization of these two types of carbon materials.

Electronic devices in which the electrons are confined to fewer than three spatial dimensions are an important tool for physics research and future developments in computing technology. Recently discovered carbon nanotubes (1991) and graphene (2004) are intrinsically low-dimensional materials with remarkable electronic properties. Combined with semiconductor technologies they might be used to fabricate smaller devices with more complex functionality. This thesis addresses two routes towards this goal. The detection of charge transport through quantum dots using a GaAs point contact is a potential tool for quantum computation. This project aimed to fabricate and measure hybrid devices with carbon nanotube quantum dots on top of GaAs point contacts. Dispersion and AFM manipulations of nanotubes on GaAs were studied, revealing comparatively weak binding. Transport measurements indicated that GaAs induces disorder in nanotubes, creating multiple tunnel barriers. Preliminary attempts were made at CVD growth and ink-jet printing of nanotubes directly onto GaAs. Although only one atom thick, graphene is macroscopic in area and must be patterned to confine conduction; room temperature transistor behaviour requires graphene ribbons only a few nanometres wide. This work fabricated such structures using a charged AFM tip, achieving reliable cutting even on single layer graphene and feature sizes as small as 5 nm. The cutting mechanism was found to be chemical oxidation of carbon by a polarised water layer, with an activation energy determined by the energy of dissociation of water at the graphene surface. The critical variables were the voltage difference between the tip and graphene and the atmospheric humidity. An unstable solid oxide intermediate was also observed. Thermal annealing revealed the presence of a layer of water beneath flakes. Finally, EFM measurements were made of graphene at 20 mK, enabling estimates of the local carrier density and revealing spatial variations in the electronic structure on a scale consistent with electron and hole puddles.

Device and sensor miniaturization has enabled extraordinary functionality and sensitivity enhancements over the last decades while considerably reducing fabrication costs and energy consumption. The traditional materials and process technologies used today will, however, ultimately run into fundamental limitations. Combining large-scale directed assembly methods with high-symmetry low-dimensional carbon nanomaterials is expected to contribute toward overcoming shortcomings of traditional process technologies and pave the way for commercially viable device nanofabrication. The purpose of this work is to demonstrate the guided dielectrophoretic integration of individual single-walled carbon nanotube- and graphene-based devices allowing parallel sensor assembly on the example of a piezoresistive pressure sensor. The ultimate goal is to fabricate ultra-small functional devices at high throughput and low costs, which require only minute operation power.

Since the late 20th century, graphene—a one-atom-thick planar sheet of sp2-bonded carbon atoms densely packed in a honeycomb crystal lattice—has garnered appreciable attention as a potential next-generation electronic material due to its exceptional properties. These properties include high current density, ballistic transport, chemical inertness, high thermal conductivity, optical transmittance, and super hydrophobicity at nanometer scale. In contrast to research on its excellent electronic and optoelectronic properties, research on the syntheses of a single sheet of graphene for industrial applications is in its nascent stages. Graphene: Synthesis and Applications reviews the advancement and future directions of graphene research in the areas of synthesis and properties, and explores applications, such as electronics, heat dissipation, field emission, sensors, composites, and energy.

Rare gas adsorption was studied on suspended individual single walled carbon nanotubes and graphene. The devices were fabricated as field effect transistors. Adsorption of N2 and CO, which formed a Root 3 X Root 3 commensurate solid monolayer, produced a dramatic reduction of the two-terminal conductance of graphene by as much as a factor of three. This effect is possibly connected with the opening of a band gap expected to occur in such structures.

Discovery of one-dimensional material carbon nanotubes in 1991 by the Japanese physicist Dr. Sumio Iijima has resulted in voluminous research in the field of carbon nanotubes for numerous applications, including possible replacement of silicon used in the fabrication of CMOS chips. One interesting feature of carbon nanotubes is that these can be metallic or semiconducting with a bandgap depending on their diameter. In search of non-classical devices and related technologies, both carbon nanotube-based field-effect transistors and metallic carbon nanotube interconnects are being explored extensively for emerging logic devices and very large-scale integration. Although various models for carbon nanotube-based transistors and interconnects have been proposed in the literature, an integrated approach to make them compatible with the present simulators is yet to be achieved. This book makes an attempt in this direction for the carbon-based electronics through fundamentals of solid-state physics and devices.

The unique electronic band structure of graphene gives rise to remarkable properties when in contact with a superconducting electrode. In this thesis two main aspects of these junctions are analyzed: the induced superconducting proximity effect and the non-local transport properties in multi-terminal devices. For this purpose specific models are developed and studied using Green function techniques, which allow us to take into account the detailed microscopic structure of the graphene-superconductor interface. It is shown that these junctions are characterized by the appearance of bound states at subgap energies which are localized at the interface region. Furthermore it is shown that graphene-supercondutor-graphene junctions can be used to favor the splitting of Cooper pairs for the generation of non-locally entangled electron pairs. Finally, using similar techniques the thesis analyzes the transport properties of carbon nanotube devices coupled with superconducting electrodes and in graphene superlattices.

Carbon Nanotubes and Graphene is a timely second edition of the original Science and Technology of Carbon Nanotubes. Updated to include expanded coverage of the preparation, purification, structural characterization, and common application areas of single- and multi-walled CNT structures, this work compares, contrasts, and, where appropriate, unitizes CNT to graphene. This much expanded second edition reference supports knowledge discovery, production of impactful carbon research, encourages transition between research fields, and aids the formation of emergent applications. New chapters encompass recent developments in the theoretical treatments of electronic and vibrational structures, and magnetic, optical, and electrical solid-state properties, providing a vital base to research. Current and potential applications of both materials, including the prospect for large-scale synthesis of graphene, biological structures, and flexible electronics, are also critically discussed. Updated discussion of properties, structure, and morphology of biological and flexible electronic applications aids fundamental knowledge discovery Innovative parallel focus on nanotubes and graphene enables you to learn from the successes and failures of, respectively, mature and emergent partner research disciplines High-quality figures and tables on physical and mathematical applications expertly summarize key information – essential if you need quick, critically relevant data

As businesses aim to compete internationally, they must be apprised of new methods and technologies to improve their digital marketing strategy in order to remain ahead of their competition. Trends in entrepreneurship that drive consumer engagement and business initiatives, such as social media marketing, yields customer retention and positive feedback. Advanced Methodologies and Technologies in Digital Marketing and Entrepreneurship provides information on emerging trends in business innovation, entrepreneurship, and marketing strategies. While highlighting challenges such as successful social media interactions and consumer engagement, this book explores valuable information within various business environments and industries such as e-commerce, small and medium enterprises, hospitality and tourism management, and customer relationship management. This book is an ideal source for students, marketers, social media marketers, business managers, public relations professionals, promotional coordinators, economists, hospitality industry professionals, entrepreneurs, and researchers looking for relevant information on new methods in digital marketing and entrepreneurship.

Carbon nanotubes (CNTs) are excellent optoelectronic materials and have been investigated for various electronic and optoelectronic device applications, such as light-emitting diodes, photodetectors and photovoltaic cells. This chapter begins with a general discussion on the various types of CNT diodes. It then focuses on a particular type of CNT diode fabricated by a doping-free process, and its application in photovoltaic cells and light-emitting diodes. The chapter ends with an outlook for the use of CNT in further integrated nanoelectronics and optoelectronics.

Carbon nanotubes and graphene have been the subject of intense scientific research since their relatively recent discoveries. This book introduces the reader to the science behind these rapidly developing fields, and covers both the fundamentals and latest advances. Uniquely, this book covers the topics in a pedagogical manner suitable for undergraduate students. The book also uses the simple systems of nanotubes and graphene as models to teach concepts such as molecular orbital theory, tight binding theory and the Laue treatment of diffraction. Suitable for undergraduate students with a working knowledge of basic quantum mechanics, and for postgraduate researchers commencing their studies into the field, this book will equip the reader to critically evaluate the physical properties and potential for applications of graphene and carbon nanotubes.

Presents technologies and key concepts to produce suitable smart materials and intelligent structures for sensing, information and communication technology, biomedical applications (drug delivery, hyperthermia therapy), self-healing, flexible memories and construction technologies. Novel developments of environmental friendly, cost-effective and scalable production processes are discussed by experts in the field.

Graphene and carbon nanotubes are ideal for strain engineering in quantum nanoelectromechanical systems due to their long coherence lengths, mechanical strength, and sensitivity to deformations. Mechanical strain induces scalar ($\Delta \mu_{\varepsilon}$) and vector ($\bm{A}$) potentials, which directly tune the Hamiltonian, providing precise control of the energy, momentum, and quantum state of electrons in these materials. This strain-tunability could be used to completely suppress ballistic transmission in graphene quantum strain transistors (GQSTs), generate large pseudomagnetic fields ($\nabla \times \bm{A}$), or carry quantum information (valleytronics). Thus far, experimental challenges have prevented thorough exploration of quantum transport strain engineering (QTSE). To this end, we have constructed low temperature ($T\sim 1$K?) QTSE instrumentation. Incorporating fabrication methods for ultra-short (~ 10ñm), suspended carbon nanotube and graphene devices, we predict tunable uniaxial strains up to $\approx \text{1--10}\%$ using this instrumentation. We first determined the impact of ultra-short channel lengths on transport by measuring unstrained nanotube devices. These formed t??wo-in-one" quantum transistors with drastically different behaviour for electrons and holes. In a small bandgap nanotube (≈ 50m?eV) we observed ballistic transport for electrons, and quantum dot (QD) behaviour for holes, while in larger bandgap nanotubes(≈ 300m?eV), we measured asymmetric QD behaviour between electrons and holes. We showed that this transport asymmetry is caused by electron doping in the nanotube contacts, and is greatly enhanced in ultra-short devices. With these contact effects in mind, we developed a realistic applied theoretical model for transport in uniaxially strained ballistic GQSTs. We calculated conductivity for strained ballistic graphene, and found four transport signatures: gate-shifting of the data from the scalar potential, and strong suppression of conductivity, modification of electron-hole conductivity asymmetry, and a rich resonance spectrum from the vector potential. We calculated high on/off ratios $>104?$ in realistically achievable GQSTs at sufficient strains. Using our strain instrumentation, we measured transport in strained graphene, observing unambiguously the effects of strain-induced vector and scalar potentials. In graphene QDs, we observed gate-shifting of the charge states with strain, consistent with strong, strain-tunable pseudomagnetic fields. In a strained ballistic graphene device, we observed the four expected transport signatures discussed above, and using our model, we found good semi-quantitative agreement between theory and experiment.

This is introductory book for researchers, scientists and students in the area of organic and inorganic composite materials. This book has addressed timely the innovative topic "chalcogenide-multiwalled carbon nanotubes and chalcogenide-bilayer graphene" composite materials under a glassy regime. This book will give a clear idea on the concepts of the newly established composite materials area, by providing interpretations of inside physio-chemical mechanism. The remarkable landmark innovations related to this newly introduced research field are included in this book. Additionally, the possible futuristic applications in the area of nanoelectronics, optoelectronics, biomedical etc are also addressed.

The papers included in this issue of ECS Transactions were originally presented in the symposium ¿Low-Dimensional Nanoscale Electronic and Photonic Devices 4¿, held during the 218th meeting of The Electrochemical Society, in Las Vegas, Nevada from October 10 to 15, 2010.

Carbon nanotubes, with their extraordinary mechanical and unique electronic properties, have garnered much attention in the past five years. With a broad range of potential applications including nanoelectronics, composites, chemical sensors, biosensors, microscopy, nanoelectromechanical systems, and many more, the scientific community is more motivated than ever to move beyond basic properties and explore the real issues associated with carbon nanotube-based applications. Taking a comprehensive look at this diverse and dynamic subject, Carbon Nanotubes: Science and Applications describes the field's various aspects, including properties, growth, and processing techniques, while focusing on individual major application areas. Well-known authors who practice the craft of carbon nanotubes on a daily basis present an overview on structures and properties, and discuss modeling and simulation efforts, growth by arc discharge, laser ablation, and chemical vapor deposition. Applications become the focal point in chapters on scanning probe microscopy, carbon nanotube-based diodes and transistors, field emission, and the development of chemical and physical sensors, biosensors, and composites. Presenting up-to-date literature citations that express the current state of the science, this book fully explores the development phase of carbon nanotube-based applications. It is a valuable resource for engineers, scientists, researchers, and professionals in a wide range of disciplines whose focus remains on the power and promise of carbon nanotubes. Editor Meyya Meyyappan will receive the Pioneer Award in Nanotechnology from the IEEE Nanotechnology Council at the IEEE Nano Conference in Portland, Oregon in August, 2011

An Alternative to Copper-Based Interconnect Technology With an increase in demand for more circuit components on a single chip, there is a growing need for nanoelectronic devices and their interconnects (a physical connecting medium made of thin metal films between several electrical nodes in a semiconducting chip that transmit signals from one point to another without any distortion). Carbon Nanotube and Graphene Nanoribbon Interconnects explores two new important carbon nanomaterials, carbon nanotube (CNT) and graphene nanoribbon (GNR), and compares them with that of copper-based interconnects. These nanomaterials show almost 1,000 times more current-carrying capacity and significantly higher mean free path than copper. Due to their remarkable properties, CNT and GNR could soon replace traditional copper interconnects. Dedicated to proving their benefits, this book covers the basic theory of CNT and GNR, and provides a comprehensive analysis of the CNT- and GNR-based VLSI interconnects at nanometric dimensions. Explore the Potential Applications of CNT and Graphene for VLSI Circuits The book starts off with a brief introduction of carbon nanomaterials, discusses the latest research, and details the modeling and analysis of CNT and GNR interconnects. It also describes the electrical, thermal, and mechanical properties, and structural behavior of these materials. In addition, it chronicles the progression of these fundamental properties, explores possible engineering applications and growth technologies, and considers applications for CNT and GNR apart from their use in VLSI circuits. Comprising eight chapters this text: Covers the basics of carbon nanotube and graphene nanoribbon Discusses the growth and characterization of carbon nanotube and graphene nanoribbon Presents the modeling of CNT and GNR as future VLSI interconnects Examines the applicability of CNT and GNR in terms of several analysis works Addresses the timing and frequency response of the CNT and GNR interconnects Explores the signal integrity analysis for CNT and GNR interconnects Models and analyzes the applicability of CNT and GNR as power interconnects Considers the future scope of CNT and GNR Beneficial to VLSI designers working in this area, Carbon Nanotube and Graphene Nanoribbon Interconnects provides a complete understanding of carbon-based materials and interconnect technology, and equips the reader with sufficient knowledge about the future scope of research and development for this emerging topic.

Explaining the properties and performance of practical nanotube devices and related applications, this is the first introductory textbook on the subject. All the fundamental concepts are introduced, so that readers without an advanced scientific background can follow all the major ideas and results. Additional topics covered include nanotube transistors and interconnects, and the basic physics of graphene. Problem sets at the end of every chapter allow readers to test their knowledge of the material covered and gain a greater understanding of the analytical skill sets developed in the text. This is an ideal textbook for senior undergraduate and graduate students taking courses in semiconductor device physics and nanoelectronics. It is also a perfect self-study guide for professional device engineers and researchers

The brief primarily focuses on the performance analysis of CNT based interconnects in current research scenario. Different CNT structures are modeled on the basis of transmission line theory. Performance comparison for different CNT structures illustrates that CNTs are more promising than Cu or other materials used in global VLSI interconnects. The brief is organized into five chapters which mainly discuss: (1) an overview of current research scenario and basics of interconnects; (2) unique crystal structures and the basics of physical properties of CNTs, and the production, purification and applications of CNTs; (3) a brief technical review, the geometry and equivalent RLC parameters for different single and bundled CNT structures; (4) a comparative analysis of crosstalk and delay for different single and bundled CNT structures; and (5) various unique mixed CNT bundle structures and their equivalent electrical models.

This book describes various carbon nanomaterials and their unique properties, and offers a detailed introduction to graphene–carbon nanotube (CNT) hybrids. It demonstrates strategies for the hybridization of CNTs with graphene, which fully utilize the synergistic effect between graphene and CNTs. It also presents a wide range of applications of graphene–CNT hybrids as novel materials for energy storage and environmental remediation. Further, it discusses the preparation, structures and properties of graphene–CNT hybrids, providing interesting examples of three types of graphene–CNT hybrids with different nanostructures. This book is of interest to a wide readership in various fields of materials science and engineering.

Carbon nanotubes and graphene are promising and widely explored materials for the development of high performance lithium ion batteries that can operate at a wide range of temperatures. This book deals with carbon nanotube and graphene composite materials for both electrodes and electrolytes in lithium ion battery applications.

Graphene, Carbon Nanotubes, and Nanostructures: Techniques and Applications offers a comprehensive review of groundbreaking research in nanofabrication technology and explores myriad applications that this technology has enabled. The book examines the historical evolution and emerging trends of nanofabrication and supplies an analytical understanding of some of the most important underlying nanofabrication technologies, with an emphasis on graphene, carbon nanotubes (CNTs), and nanowires. Featuring contributions by experts from academia and industry around the world, this book presents cutting-edge nanofabrication research in a wide range of areas. Topics include: CNT electrodynamics and signal propagation models Electronic structure calculations of a graphene–hexagonal boron nitride interface to aid the understanding of experimental devices based on these heterostructures How a laser field would modify the electronic structure and transport response of graphene, to generate bandgaps The fabrication of transparent CNT electrodes for organic light-emitting diodes Direct graphene growth on dielectric substrates, and potential applications in electronic and spintronic devices CNTs as a promising candidate for next-generation interconnect conductors CMOS–CNT integration approaches, including the promising localized heating CNT synthesis method CNTs in electrochemical and optical biosensors The synthesis of diamondoids by pulsed laser ablation plasmas generated in supercritical fluids, and possible applications The use of DNA nanostructures in lithography CMOS-compatible silicon nanowire biosensors The use of titanium oxide-B nanowires to detect explosive vapors The properties of protective layers on silver nanoparticles for ink-jet printing Nanostructured thin-film production using microreactors A one-stop reference for professionals, researchers, and graduate students working in nanofabrication, this book will also be useful for investors who want an overview of the current nanofabrication landscape.

Because of their estimated ultra-high third-order nonlinearity, single-walled carbon nanotubes (CNTs) can be regarded as a potential new material for optical nonlinearity. The nonlinearity of CNTs is believed to originate from the inter-band transitions of the ?-electrons, causing nonlinear polarization. In this respect, CNTs are similar to other organic optical materials that exhibit extremely high nonlinearity. CNT-based photonics devices offer several key advantages, including ultrafast response, robustness, tunability of wavelength, and compatibility to fibers. This chapter will describe the design and fabrication of CNT-based nonlinear photonic devices. CNTs with suitable diameters – and thus suitable operational wavelengths – are deposited or grown directly on different types of fibers or waveguides to ensure effective CNT–light interaction. Optical nonlinear effects including four-wave mixing (FWM), cross-phase modulation (XPM), and self-phase modulation (SPM) have been observed experimentally using fabricated CNT-based devices. Corresponding wavelength conversion and optical signal regeneration applications based on various nonlinear effects are discussed.

This chapter discusses the background knowledge and provides a literature review of carbon-nanotubes-based metamaterials and other nanophotonic devices we present in the chapter. The materials properties of carbon nanotubes are discussed, along with their possible application in producing metamaterials which display artificial optical properties. A detailed analysis of different types of metamaterials is presented, along with their theory and applications. The utilization of silicon nanopillars for producing photonic crystals and the enhanced reflection effects are discussed. Lastly, the theoretical background and designing of carbon nanotube forests-based Fresnel lenses are presented.

The optical properties of carbon nanotubes and graphene make them potentially suitable for a variety of photonic applications. Carbon nanotubes and graphene for photonic applications explores the properties of these exciting materials and their use across a variety of applications. Part one introduces the fundamental optical properties of carbon nanotubes and graphene before exploring how carbon nanotubes and graphene are synthesised. A further chapter focusses on nonlinearity enhancement and novel preparation approaches for carbon nanotube and graphene photonic devices. Chapters in part two discuss carbon nanotubes and graphene for laser applications and highlight optical gain and lasing in carbon nanotubes, carbon nanotube and graphene-based fiber lasers, carbon-nanotube-based bulk solid-state lasers, electromagnetic nonlinearities in graphene, and carbon nanotube-based nonlinear photonic devices. Finally, part three focusses on carbon-based optoelectronics and includes chapters on carbon nanotube solar cells, a carbon nanotube-based optical platform for biomolecular detection, hybrid carbon nanotube-liquid crystal nanophotonic devices, and quantum light sources based on individual carbon nanotubes. Carbon nanotubes and graphene for photonic applications is a technical resource for materials scientists, electrical engineers working in the photonics and optoelectronics industry and academics and researchers interested in the field. Covers the properties and fabrication of carbon nanotubes and graphene for photonic applications Considers the uses of carbon nanotubes and graphene for laser applications Explores numerous carbon-based light emitters and detectors

This book presents a comprehensive review of research on applications of carbon nanotubes (CNTs) and graphene to electronic devices. As nanocarbons in general, and CNTs and graphene in particular, are becoming increasingly recognized as the most promising materials for future generations of electronic devices, including transistors, sensors, and interconnects, a knowledge gap still exists between the basic science of nanocarbons and their feasibility for cost-effective product manufacturing. The book highlights some of the issues surrounding this missing link by providing a detailed review of the nanostructure and electronic properties, materials, and device fabrication and of the structure–property–application relationships.

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

This book shows the recent advances of the applications of carbon nanotubes (CNTs), in particular, the polymer functionalized carbon nanotubes. It also includes a comprehensive description of carbon nanotubes' preparation, properties, and characterization. Therefore, we have attempted to provide detailed information about the polymer-carbon nanotube composites. With regard to the unique structure and properties of carbon nanotubes, a series of important findings have been reported. The unique properties of carbon nanotubes, including thermal, mechanical, and electrical properties, after polymer functionalization have been documented in detail. This book comprises 18 chapters. The chapters include different applications of polymer functionalization CNTs, e.g. photovoltaic, biomedical, drug delivery, gene delivery, stem cell therapy, thermal therapy, biological detection and imaging, electroanalytical, energy, supercapacitor, and gas sensor applications.

Carbon Nanotube- and Graphene Based Devices, Circuits and Sensors for VLSI Design.

In recent decades, graphene composites have received considerable attention due to their unique structural features and extraordinary properties. 2D and 3D graphene hybrid structures are widely used in memory, microelectronic, and optoelectronic devices; energy- and power-density supercapacitors; light-emitting diodes; and sensors, batteries, and solar cells. This book covers the fundamental properties of the latest graphene-based 2D and 3D composite materials. The book is a result of the collective work of many highly qualified specialists in the field of experimental and theoretical research on graphene and its derivatives. It describes experimental methods for obtaining and characterizing samples of chemically modified graphene, details conceptual foundations of popular methods for computer modeling of graphene nanostructures, and compiles original computational techniques developed by the chapter authors. It discusses the potential application areas and modifications of graphene-based 2D and 3D composite materials and interprets the interesting physical effects discovered for the first time for graphene materials under consideration. The book is useful for graduate students and researchers as well as specialists in industrial engineering. It will also appeal to those involved in materials science, condensed matter physics, nanotechnology, physical electronics, nano- and optoelectronics.

Carbon nanotubes belong to new nanomaterials and have been known for almost 20 years, but their history is somewhat lengthier. They have been identified as promising candidates for various applications.High-temperature preparation techniques are conventional techniques for the synthesis of carbon nanotubes using arc discharge or laser ablation, but today these methods are being replaced by low-temperature vapor deposition techniques, since orientation, alignment, nanotube length, diameter, purity, and density of carbon nanotubes can be precisely controlled. The synthesis of carbon nanotubes by chemical vapor deposition on catalyst arrays leads to nanotube models grown from specific sites on surfaces. The controlled synthesis of nanotubes opens up interesting possibilities in nanoscience and nanotechnologies, including electrical, mechanical and electromechanical properties and devices, chemical functionalization, surface chemistry and photochemistry, molecular sensors, and interfacing with moderate biological systems.Carbon nanotubes are used in many applications due to their unique electrical, mechanical, optical, thermal, and other properties. Conductive and high-strength composite materials, energy saving and energy conversion devices, sensors, visualization of field emissions and sources of radiation, means for storing hydrogen, and nanoscale semiconductor devices, probes, and interconnections are some of the many applications of carbon nanotubes.

Graphene is the first example of two-dimensional materials and is the most important growth area of contemporary research. It forms the basis for new nanoelectronic applications. Graphene, which comprises field-effect structures, has remarkable physical properties. This book focuses on practical applications determined by the unique properties of graphene. Basic concepts are elucidated by end-of-chapter problems, the answers to which are provided in the accompanying solutions manual. The mechanisms of electric and thermal transport in the gated graphene, interface phenomena, quantum dots, non-equilibrium states, scattering and dissipation, as well as coherent transport in graphene junctions are considered in detail in the book. Detailed analyses and comparison between theory and experiments is complemented with a variety of practical examples. The book has evolved from the author’s own research experience and from his interaction with other scientists at tertiary institutions and is targeted at a wide audience ranging from graduate students and postdoctoral fellows to mature researchers and industrial engineers.

With their nano-scaled dimensions and extremely elevated optical nonlinearity, carbon nanostructures including single-walled carbon nanotubes and graphene have played a critical role in generating ultrafast optical pulses. The pulsation relies on passive mode-locking of the nanostructures, and has been enhanced by employing an evanescent field interaction scheme that guarantees the all-fiber high-power operation. Preparation schemes for pulsating devices have been evolving via the development of elegant processes such as optical deposition, electrospray, and aerosol deposition of carbon nanostructures, ensuring the dramatic increase of process efficiency. In this chapter, details of the technical achievements are addressed.