2d Materials And Van Der Waals Heterostructures Arxiv

Atomic thin two-dimensional (2D) materials are the thinnest forms of materials to ever occur in nature and have the potential to dramatically alter and revolutionize our material world. Some of the unique properties of these materials including wide photoresponse wavelength, passivated surfaces, strong interaction with incident light, and high mobility have created tremendous interest in photodetector application. This book provides a comprehensive state-of-the-art knowledge about photodetector technology in the range visible to infrared region using various 2D materials including graphene, transition metal dichalcogenides, III-V semiconductor, and so on. It consists of 10 chapters contributed by a team of experts in this exciting field. We believe that this book will provide new opportunities and guidance for the development of next-generation 2D photodetector.

The New Architecture of Science explores how the architecture of advanced nanoscience labs affects the way scientists think, conduct experiments, interact and collaborate. The unique design of the National Graphene Institute in Manchester, UK sheds light on the new generation of 21st century science laboratories. Weaving together two tales of this building, lead scientist and one of the designers, Kostya Novoselov, and architectural anthropologist, Albena Yaneva, combine an analysis of its distinctive design features with ethnographic observation of the practices of scientists, facility managers, technicians, administrators and house service staff. Capturing simultaneously the complex technical infrastructure and the variability of human experiences that it facilitates, contemporary laboratory buildings are shown to be vital settings for the active shaping of new research habits and ways of thinking, ultimately leading to discovery and socio-technical innovations.Related Link(s)

There are only a few discoveries and new technologies in materials science that have the potential to dramatically alter and revolutionize our material world. Discovery of two-dimensional (2D) materials, the thinnest form of materials to ever occur in nature, is one of them. After isolation of graphene from graphite in 2004, a whole other class of atomically thin materials, dominated by surface effects and showing completely unexpected and extraordinary properties, has been created. This book provides a comprehensive view and state-of-the-art knowledge about 2D materials such as graphene, hexagonal boron nitride (h-BN), transition metal dichalcogenides (TMD) and so on. It consists of 11 chapters contributed by a team of experts in this exciting field and provides latest synthesis techniques of 2D materials, characterization and their potential applications in energy conservation, electronics, optoelectronics and biotechnology.

Vollständig überarbeitete Neuauflage des maßgeblichen Grundlagen-Lehrbuchs zur Optik und Photonik - umfassend überarbeitet und mit einem neuen Kapitel zur Metamaterialoptik erweitert Die Optik ist eines der ältesten und faszinierendsten Teilgebiete der Physik und fest in den Curricula des Physikstudiums verankert. Sie beschäftigt sich mit der Ausbreitung von Licht und Phänomenen wie Interferenz, Brechung, Beugung und optischen Abbildungen. Die Photonik umfasst optische Phänomene, die primär auf der Wechselwirkung von (quantisiertem) Licht und Materie beruhen, und befasst sich mit dem Verständnis und der Entwicklung optischer Bauteile und Systeme wie etwa Lasern, LEDs und photonischen Kristallen. In bewährter Weise gibt die vollständig überarbeitete und erweiterte Neuauflage des "Saleh/Teich" eine Einführung in die Grundlagen der Optik und Photonik für Studierende der Physik und verwandter Wissenschaften. Ausführliche Erklärungen, rund 1000 Abbildungen und die zur quantitativen Durchdringung notwendige Mathematik ermöglichen ein tiefes Verständnis aller Teilgebiete der klassischen und modernen Optik. * Umfassend und verständlich: sämtliche Grundlagen der Optik und Photonik in einem Werk vereint * Geschrieben von hervorragenden Didaktikern mit langer Lehrerfahrung: optische Phänomene und deren Physik stehen im Vordergrund, der notwendige mathematische Apparat wird behutsam entwickelt * Überarbeitet und erweitert: alle Kapitel wurden mit Blick auf noch bessere Verständlichkeit kritisch geprüft und aktualisiert * Komplett neu: umfangreiches Kapitel zu Metamaterialoptik "Optik und Photonik" richtet sich an Bachelor- und Master-Studierende der Physik, Materialwissenschaften und Ingenieurwissenschaften.

Synthesis, Modelling and Characterization of 2D Materials and Their Heterostructures provides a detailed discussion on the multiscale computational approach surrounding atomic, molecular and atomic-informed continuum models. In addition to a detailed theoretical description, this book provides example problems, sample code/script, and a discussion on how theoretical analysis provides insight into optimal experimental design. Furthermore, the book addresses the growth mechanism of these 2D materials, the formation of defects, and different lattice mismatch and interlayer interactions. Sections cover direct band gap, Raman scattering, extraordinary strong light matter interaction, layer dependent photoluminescence, and other physical properties. Explains multiscale computational techniques, from atomic to continuum scale, covering different time and length scales Provides fundamental theoretical insights, example problems, sample code and exercise problems Outlines major characterization and synthesis methods for different types of 2D materials

Modern materials science builds on knowledge from physics, chemistry, biology, mathematics, computer and data science, and engineering sciences to enable us to understand, control, and expand the material world. Although it is anchored in inquiry-based fundamental science, materials research is strongly focused on discovering and producing reliable and economically viable materials, from super alloys to polymer composites, that are used in a vast array of products essential to today's societies and economies. Frontiers of Materials Research: A Decadal Survey is aimed at documenting the status and promising future directions of materials research in the United States in the context of similar efforts worldwide. This third decadal survey in materials research reviews the progress and achievements in materials research and changes in the materials research landscape over the last decade; research opportunities for investment for the period 2020-2030; impacts that materials research has had and is expected to have on emerging technologies, national needs, and science; and challenges the enterprise may face over the next decade.

November 6-7, 2017 Frankfurt, Germany Key Topics : Graphene and 2D Materials based Nanocomposites, Chemistry and Biology studies of Graphene, Graphene Modification and Functionalisation, Synthesis of Graphene and 2D Materials, Graphene nano In Energy and Storage, Graphene Supercapacitors, Graphene and Graphene oxide , Graphene-like 2D materials , Graphene Application Technology, Emerging Trends in the field of Graphene nano, Advances in Graphene Physics, Carbon nano chips and nanostructures, Graphene Chemistry, Graphite, Graphene & their polymer nano composites, Graphene: Synthesis, Properties & Phenomena, Physics of Graphene, Graphene and Biomaterials for health Care, Nano Medicine & Biotechnology,

The advent of graphene and, more recently, two-dimensional materials has opened new perspectives in electronics, optoelectronics, energy harvesting, and sensing applications. This book, based on a Special Issue published in Nanomaterials –

MDPI covers experimental, simulation, and theoretical research on 2D materials and their van der Waals heterojunctions. The emphasis is the physical properties and the applications of 2D materials in state-of-the-art sensors and electronic or optoelectronic devices.

This book represents a significant advance in our understanding of the synthesis and properties of two-dimensional (2D) materials. The author’s work breaks new ground in the understanding of a number of 2D crystals, including atomically thin transition metal dichalcogenides, graphene, and their heterostructures, that are technologically important to next-generation electronics. In addition to critical new results on the direct growth of 2D heterostructures, it also details growth mechanisms, surface science, and device applications of “epi-grade” 2D semiconductors, which are essential to low-power electronics, as well as for extending Moore’s law. Most importantly, it provides an effective alternative to mechanically exfoliate 2D layers for practical applications.

2D Materials for Nanophotonics presents a detailed overview of the applications of 2D materials for nanophotonics, covering the photonic properties of a range of 2D materials including graphene, 2D phosphorene and MXenes, and discussing applications in lighting and energy storage. This comprehensive reference is ideal for readers seeking a detailed and critical analysis of how 2D materials are being used for a range of photonic and optical applications. Outlines the major photonic properties in a variety of 2D materials Demonstrates major applications in lighting and energy storage Explores the challenges of using 2D materials in photonics

This book shows the electronic, optical and lattice-vibration properties of the two-dimensional materials which are revealed by the Raman spectroscopy. It consists of eleven chapters covering various Raman spectroscopy techniques (ultralow-frequency, resonant Raman spectroscopy, Raman imaging), different kinds of two-dimensional materials (in-plane isotropy and anisotropy materials, van der Waals heterostructures) and their physical properties (double-resonant theory, surface and interface effect). The topics include the theory origin, experimental phenomenon and advanced techniques in this area. This book is interesting and useful to a wide readership in various fields of condensed matter physics, materials science and engineering.

This book focuses on the progress in optoelectronic materials research and technologies, presenting reviews and original works on the theory, fabrication, characterization, and applications of optoelectronic materials. The chapters discuss preparation and properties of several optoelectronic materials, such as ZnO, SnO2, Zn1-XSnXO, BaTiO3, GaAs, GaP, ZnSe, and NaAlSi. The structural, optical, vibrational, and magnetic properties are discussed, in addition to transport and phase transformations.

The unique electrical and optical properties of two-dimensional (2D) materials has spurred intense research interest towards development of nanoelectronic devices utilizing these novel materials. The atomically thin form of 2D materials translates to excellent electrostatic gate control even at nanoscale channel length dimensions, near-ideal two-dimensional carrier behavior, and perhaps conventional and novel devices applications. Monolayer transition metal dichalcogenides (TMDs) are novel, gapped 2D materials. Toward device applications, I consider MoS2 layers on dielectrics, in particular in this work, the effect of vacancies on the electronic structure. In density-functional-theory (DFT) simulations, the effects of near-interface oxygen vacancies in the oxide slab, and Mo or S vacancies in the MoS2 layer are considered. Band structures and atom-projected densities of states for each system and with differing oxide terminations were calculated, as well as those for the defect-free MoS2-dielectrics system and for isolated dielectric layers for reference. Among the results, I find that with O-vacancies, both the HfO2-MoS2 and the Al2O3-MoS2 systems appear metallic due to doping of the oxide slab followed by electron transfer into the MoS2, in manner analogous to modulation doping. The n-type doping of monolayer MoS2 by high-k oxides with O-vacancies is confirmed through collaborative experimental work in which back-gated monolayer MoS2 FETs encapsulated by oxygen deficient high-k oxides have been characterized. Van der Waal’s heterostructures allow for novel devices such as two-dimensional-to-two-dimensional tunnel devices, exemplified by interlayer tunnel FETs. These devices employ channel/tunnel-barrier/channel geometries. However, during layer-by-layer exfoliation of these multi-layer materials, rotational misalignment is the norm and may substantially affect device characteristics. In this work, by using density functional theory methods, I consider a reduction in tunneling due to weakened coupling across the rotationally misaligned interface between the channel layers and the tunnel barrier. As a prototypical system, I simulate the effects of rotational misalignment of the tunnel barrier layer between aligned channel layers in a graphene/hBN/graphene system. Rotational misalignment between the channel layers and the tunnel barrier in this van der Waal’s heterostructure can significantly reduce coupling between the channels by reducing, specifically, coupling across the interface between the channels and the tunnel barrier. This weakened coupling in graphene/hBN/graphene with hBN misalignment may be relevant to all such van der Waal’s heterostructures. TMDs are viable alternatives to graphene and hBN as channel and tunnel barrier layers, respectively, for improved performance in interlayer tunnel FET device structures. In particular, I used DFT simulations to study the bilayer-graphene/WSe2/bilayer-graphene heterostructure as well as single and multilayer ReS2-layer systems. Significant roadblocks to the widespread use of TMDs for nanoelectronic devices are the large contact resistance and absence of reliable doping techniques. Hence, I studied substitutional doping of, and evaluated various metal contacts to MoS2 by computing the density of states for the systems. Metal contacts that pin the Fermi level within the desired band are optimal for device applications. My simulation results suggest that monolayer (ML) MoS2 can be doped n-type or p-type by substituting for an S atom in the supercell with a group-17 Cl atom or a group-15 P atom, respectively. My simulations also suggest that Sc and Ti would serve as excellent contacts to n-type ML MoS2 due to the strong bonding and large number of states near the Fermi level. But the theoretical expectations are tempered by the material characteristics, i.e., the extremely reactive nature of Sc and the oxidation prone nature of Ti atoms. I also studied commonly used Ag and Au metal contacts to ML MoS2, which exhibited medium strength bonding to MoS2 and an apparent pinning of the Fermi level nearer to the nominal MoS2 conduction band edge

Two-dimensional materials have had widespread applications in nanoelectronics, catalysis, gas capture, water purification, energy storage and conversion. Initially based around graphene, research has since moved on to looking at alternatives, including transitions metal dichalcogenides, layered topological insulators, metallic mono-chalcogenides, borocarbonitrides and phosphorene. This book provides a review of research in the field of these materials, including investigation into their defects, analysis on hybrid structures focusing on their properties and synthesis, and characterization and applications of 2D materials beyond graphene. It is designed to be a single-point reference for students, teachers and researchers of chemistry and its related subjects, particularly in the field of nanomaterials. Contents: Transition Metal Dichalcogenides and Other Layered Materials (Manoj K Jana and C N R Rao)Topological Valleytronics (Motohiko Ezawa)Two-Dimensional, Layered Materials as Catalysts for Oxygen Reduction Reaction (Debdyuti Mukherjee and S Sampath)Phosphorene (Arpita Paul and Umesh V Waghmare)2D van der Waals Hybrid: Structures, Properties and Devices (Md Ali Aamir, Tanweer Ahmed, Kimberly Hsieh, Saurav Islam, Paritosh Karnatak, Ranjit Kashid, Phanibhusan Singha Mahapatra, Jayanta Mishra, Tathagata Paul, Avradip Pradhan, Kallol Roy, Anindita Sahoo and Arindam Ghosh)Thermoelectric Energy Conversion in Layered Metal Chalcogenides (Satya N Guin, Ananya Banik and Kanishka Biswas)Plasma Chemical and Physical Vapour Deposition Methods and Diagnostics for 2D Materials (Majed A. Alrefae, Nicholas R Glavin, Andrey A Voevodin and Timothy S Fisher)Metal Contacts to MOS2 (Naveen Kaushik, Sameer Grover, Mandar M Deshmukh and Saurabh Lodha)Strain Dependent Properties of 2D MX2 (M = Mo and W; X = S, Se and Te) (Tribhuwan Pandey, Swastibrata Bhattacharyya and Abhishek K Singh)Point Defects, Grain Boundaries and Planar Faults in 2D h-BN and TMX2 Theory and Simulations (Anjali Singh and Umesh V Waghmare) Readership: Students, teachers and researchers of chemistry and its related subjects, particularly in the field of nanomaterials. Keywords:2D Materials;Borocarbonitrides;Phosphorene;Graphene;Catalysis;Nanomaterials;Gas Capture;Water Purification;Dichalcogenides;Topological Insulators;Mono-chalcogenidesReview:0

Since the great success of graphene, atomically thin-layered nanomaterials, called two dimensional (2D) materials, have attracted tremendous attention due to their extraordinary physical properties. Specifically, van der Waals heterostructured architectures based on a few 2D materials, named atomic-scale Lego, have been proposed as unprecedented platforms for the implementation of versatile devices with a completely novel function or extremely high-performance, shifting the research paradigm in materials science and engineering. Thus, diverse 2D materials beyond existing bulk materials have been widely studied for promising electronic, optoelectronic, mechanical, and thermoelectric applications. Especially, this Special Issue included the recent advances in the unique preparation methods such as exfoliation-based synthesis and vacuum-based deposition of diverse 2D materials and also their device applications based on interesting physical properties. Specifically, this Editorial consists of the following two parts: Preparation methods of 2D materials and Properties of 2D materials

Learn about the most recent advances in 2D materials with this comprehensive and accessible text. Providing all the necessary materials science and physics background, leading experts discuss the fundamental properties of a wide range of 2D materials, and their potential applications in electronic, optoelectronic and photonic devices. Several important classes of materials are covered, from more established ones such as graphene, hexagonal boron nitride, and transition metal dichalcogenides, to new and emerging materials such as black phosphorus, silicene, and germanene. Readers will gain an in-depth understanding of the electronic structure and optical, thermal, mechanical, vibrational, spin and plasmonic properties of each material, as well as the different techniques that can be used for their synthesis. Presenting a unified perspective on 2D materials, this is an excellent resource for graduate students, researchers and practitioners working in nanotechnology, nanoelectronics, nanophotonics, condensed matter physics, and chemistry.

This thesis deals with the development and in-depth study of a new class of optoelectronic material platform comprising graphene and MoS_2, in which MoS_2 is used essentially to sensitize graphene and lead to unprecedently high gain and novel opto-electronic memory effects. The results presented here open up the possibility of designing a new class of photosensitive devices which can be utilized in various optoelectronic applications including biomedical sensing, astronomical sensing, optical communications, optical quantum information processing and in applications requiring low intensity photodetection and number resolved single photon detection.

This book, Condensed Matter and Material Physics, incorporates the work of multiple authors to enhance the theoretical as well as experimental knowledge of materials. The investigation of crystalline solids is a growing need in the electronics industry. Micro and nano transistors require an in-depth understanding of semiconductors of different groups. Amorphous materials, on the other hand, as non-equilibrium materials are widely applied in sensors and other medical and industrial applications. Superconducting magnets, composite materials, lasers, and many more applications are integral parts of our daily lives. Superfluids, liquid crystals, and polymers are undergoing active research throughout the world. Hence profound information on the nature and application of various materials is in demand. This book bestows on the reader a deep knowledge of physics behind the concepts, perspectives, characteristic properties, and prospects. The book was constructed using 10 contributions from experts in diversified fields of condensed matter and material physics and its technology from over 15 research institutes across the globe.

Ever since the discovery of graphene, two-dimensional layered materials (2DLMs) have been the central tool of the materials research community. The reason behind their importance is their superlative and unique electronic, optical, physical, chemical and mechanical properties in layered form rather than in bulk form. The 2DLMs have been applied to electronics, catalysis, energy, environment, and biomedical applications. The following topics are discussed in the book’s fifteen chapters: • The research status of the 2D metal-organic frameworks and the different techniques used to synthesize them. • 2D black phosphorus (BP) and its practical application in various fields. • Reviews the synthesis methods of MXenes and provides a detailed discussion of their structural characterization and physical, electrochemical and optical properties, as well as applications in catalysis, energy storage, environmental management, biomedicine, and gas sensing. • The carbon-based materials and their potential applications via the photocatalytic process using visible light irradiation. • 2D materials like graphene, TMDCs, few-layer phosphorene, MXene in layered form and their heterostructures. • The structure and applications of 2D perovskites. • The physical parameters of pristine layered materials, ZnO, transition metal dichalcogenides, and heterostructures of layered materials are discussed. • The coupling of graphitic carbon nitride with various metal sulfides and oxides to form efficient heterojunction for water purification. • The structural features, synthetic methods, properties, and different applications and properties of 2D zeolites. • The methods for synthesizing 2D hollow nanostructures are featured and their structural aspects and potential in medical and non-medical applications. • The characteristics and structural aspects of 2D layered double hydroxides (LDHs) and the various synthesis methods and role of LDH in non-medical applications as adsorbent, sensor, catalyst, etc. • The synthesis of graphene-based 2D layered materials synthesized by using top-down and bottom-up approaches where the main emphasis is on the hot-filament thermal chemical vapor deposition (HFTCVD) method. • The different properties of 2D h-BN and borophene and the various methods being used for the synthesis of 2D h-BN, along with their growth mechanism and transfer techniques. • The physical properties and current progress of various transition metal dichalcogenides (TMDC) based on photoactive materials for photoelectrochemical (PEC) hydrogen evolution reaction. • The state-of-the-art of 2D layered materials and associated devices, such as electronic, biosensing, optoelectronic, and energy storage applications.

Micro/nano-mechanical systems are a crucial part of the modern world providing a plethora of sensing and actuation functionalities used in everything from the largest cargo ships to the smallest hand-held electronics; from the most advanced scientific and medical equipment to the simplest household items. Over the past few decades, the processes used to produce these devices have improved, supporting dramatic reductions in size, but there are fundamental limits to this trend that require a new production paradigm. The 2004 discovery of graphene ushered in a new era of condensed matter physics research, that of two-dimensional materials. Being only a few atomic layers thick, this new class of materials exhibit unprecedented mechanical strength and flexibility and can couple to electric, magnetic and optical signals. Additionally, they can be combined to form van der Waals heterostructures in an almost limitless number of ways. They are thus ideal candidates to reduce the size and extend the capabilities of traditional micro/nano-mechanical systems and are poised to redefine the technological sphere. This thesis attempts to develop the framework and protocols required to produce and characterise micro/nano-mechanical devices made from two-dimensional materials. Graphene and its insulating analogue, hexagonal boron nitride, are the most widely studied materials and their heterostructures are used as the test-bed for potential device architectures and capabilities. Interlayer friction, electro-mechanical actuation and surface reconstruction are some of the key phenomena investigated in this work.

Major developments in the semiconductor industry are on the horizon through the use of two-dimensional (2D) materials, such as graphene and transition metal dichalcogenides, for integrated circuits (ICs). 2D Materials for Nanoelectronics is the first comprehensive treatment of these materials and their applications in nanoelectronic devices. Comprised of chapters authored by internationally recognised researchers, this book: Discusses the use of graphene for high-frequency analog circuits Explores logic and photonic applications of molybdenum disulfide (MoS_2) Addresses novel 2D materials including silicene, germanene, stanene, and phosphorene Considers the use of 2D materials for both field-effect transistors (FETs) and logic circuits Provides background on the simulation of structural, electronic, and transport properties from first principles 2D Materials for Nanoelectronics presents extensive, state-of-the-art coverage of the fundamental and applied aspects of this exciting field.

This book is a printed edition of the Special Issue "Integration of 2D Materials for Electronics Applications" that was published in Crystals

Fundamentals and Sensing Applications of 2D Materials provides a comprehensive understanding of a wide range of 2D materials. Examples of fundamental topics include: defect and vacancy engineering, doping and advantages of 2D materials for sensing, 2D materials and composites for sensing, and 2D materials in biosystems. A wide range of applications are addressed, such as gas sensors based on 2D materials, electrochemical glucose sensors, biosensors (enzymatic and non-enzymatic), and printed, stretchable, wearable and flexible biosensors. Due to their sub-nanometer thickness, 2D materials have a high packing density, thus making them suitable for the fabrication of thin film based sensor devices. Benefiting from their unique physical and chemical properties (e.g. strong mechanical strength, high surface area, unparalleled thermal conductivity, remarkable biocompatibility and ease of functionalization), 2D layered nanomaterials have shown great potential in designing high performance sensor devices. Provides a comprehensive overview of 2D materials systems that are relevant to sensing, including transition metal dichalcogenides, metal oxides, graphene and other 2D materials system Includes information on potential applications, such as flexible sensors, biosensors, optical sensors, electrochemical sensors, and more Discusses graphene in terms of the lessons learned from this material for sensing applications and how these lessons can be applied to other 2D materials

2D Materials for Photonic and Optoelectronic Applications introduces readers to two-dimensional materials and their properties (optical, electronic, spin and plasmonic), various methods of synthesis, and possible applications, with a strong focus on novel findings and technological challenges. The two-dimensional materials reviewed include hexagonal boron nitride, silicene, germanene, topological insulators, transition metal dichalcogenides, black phosphorous and other novel materials. This book will be ideal for students and researchers in materials science, photonics, electronics, nanotechnology and condensed matter physics and chemistry, providing background for both junior investigators and timely reviews for seasoned researchers. Provides an in-depth look at boron nitride, silicene, germanene, topological insulators, transition metal dichalcogenides, and more Reviews key applications for photonics and optoelectronics, including photodetectors, optical signal processing, light-emitting diodes and photovoltaics Addresses key technological challenges for the realization of optoelectronic applications and comments on future solutions

This book presents the first established experimental results of an emergent field: 2-dimensional materials as platforms for quantum technologies, specifically through the optics of quantum-confined excitons. It also provides an extensive review of the literature from a number of disciplines that informed the research, and introduces the materials of focus – 2d Transition Metal Dichalcogenides (2d-TMDs) – in detail, discussing electronic and chemical structure, excitonic behaviour and response to strain. This is followed by a brief overview of quantum information technologies, including concepts such as single-photon sources and quantum networks. The methods chapter addresses quantum optics techniques and 2d-material processing, while the results section shows the development of a method to deterministically create quantum dots (QDs) in the 2d-TMDs, which can trap single-excitons; the fabrication of atomically thin quantum light-emitting diodes to induce all-electrical single-photon emission from the QDs, and lastly, the use of devices to controllably trap single-spins in the QDs –the first step towards their use as optically-addressable matter qubits.

Graphene is probably the most fascinating material discovered in this century. A group of 2D materials can be called graphene derivatives, and these have attracted tremendous interest. This includes materials that are one or a few atoms thick. They have outstanding optical/electrical properties, and, most importantly, they are flat and thin—they can be processed with existing semiconductor technologies. Therefore, they have great potential in nanoelectronics and optoelectronics, playing a revolutionary role in these fields via their integration with other bulk materials. Of course, there are still challenges, such as large-scale production, as well as the mechanical transfer of these atomically thin sheets. These are the fields where scientists are now actively doing research. In this book, some leading scientists in the area share their most recent results on the material growth, device physics/processing, and system integration of 2D materials and devices. This book can serve as a starting point for young students to get familiar with the field, and should also be valuable to established device physicists and engineers who would like to explore the potential applications of 2D materials in electronics.

2D Semiconductor Materials and Devices reviews the basic science and state-of-art technology of 2D semiconductor materials and devices. Chapters discuss the basic structure and properties of 2D semiconductor materials, including both elemental (silicene, phosphorene) and compound semiconductors (transition metal dichalcogenide), the current growth and characterization methods of these 2D materials, state-of-the-art devices, and current and potential applications. Reviews a broad range of emerging 2D electronic materials beyond graphene, including silicene, phosphorene and compound semiconductors Provides an in-depth review of material properties, growth and characterization aspects—topics that could enable applications Features contributions from the leading experts in the field

Spintronic 2D Materials: Fundamentals and Applications provides an overview of the fundamental theory of 2D electronic systems that includes a selection of the most intensively investigated 2D materials. The book tells the story of 2D spintronics in a systematic and comprehensive way, providing the growing community of spintronics researchers with a key reference. Part One addresses the fundamental theoretical aspects of 2D materials and spin transport, while Parts Two through Four explore 2D material systems, including graphene, topological insulators, and transition metal dichalcogenides. Each section discusses properties, key issues and recent developments. In addition, the material growth method (from lab to mass production), device fabrication and characterization techniques are included throughout the book. Discusses the fundamentals and applications of spintronics of 2D materials, such as graphene, topological insulators and transition metal dichalcogenides Includes an in-depth look at each materials system, from material growth, device fabrication and characterization techniques Presents the latest solutions on key challenges, such as the spin lifetime of 2D materials, spin-injection efficiency, the potential proximity effects, and much more

2D Materials for Infrared and Terahertz Detectors provides an overview of the performance of emerging detector materials, while also offering, for the first time, a comparison with traditional materials used in the fabrication of infrared and terahertz detectors. Since the discovery of graphene, its applications to electronic and optoelectronic devices have been intensively researched. The extraordinary electronic and optical properties allow graphene and other 2D materials to be promising candidates for infrared (IR) and terahertz (THz) photodetectors, and yet it appears that the development of new detectors using these materials is still secondary to those using traditional materials. This book explores this phenomenon, as well as the advantages and disadvantages of using 2D materials. Special attention is directed toward the identification of the most-effective hybrid 2D materials in infrared and terahertz detectors, as well as future trends. Written by one of the world’s leading researchers in the field of IR optoelectronics, this book will be a must-read for researchers and graduate students in photodetectors and related fields. Features • Offers a comprehensive overview of the different types of 2D materials used in fabrication of IR and THz detectors, and includes their advantages/disadvantages • The first book to compare new detectors to a wide family of common, commercially available detectors that use traditional materials.

2D Materials and Van der Waals HeterostructuresPhysics and ApplicationsMDPI

Spintronics Handbook, Second Edition offers an update on the single most comprehensive survey of the two intertwined fields of spintronics and magnetism, covering the diverse array of materials and structures, including silicon, organic semiconductors, carbon nanotubes, graphene, and engineered nanostructures. It focuses on seminal pioneering work, together with the latest in cutting-edge advances, notably extended discussion of two-dimensional materials beyond graphene, topological insulators, skyrmions, and molecular spintronics. The main sections cover physical phenomena, spin-dependent tunneling, control of spin and magnetism in semiconductors, and spin-based applications. Features: Presents the most comprehensive reference text for the overlapping fields of spintronics (spin transport) and magnetism. Covers the full spectrum of materials and structures, from silicon and organic semiconductors to carbon nanotubes, graphene, and engineered nanostructures. Extends coverage of two-dimensional materials beyond graphene, including molybdenum disulfide and study of their spin relaxation mechanisms Includes new dedicated chapters on cutting-edge topics such as spin-orbit torques, topological insulators, half metals, complex oxide materials and skyrmions. Discusses important emerging areas of spintronics with superconductors, spin-wave spintronics, benchmarking of spintronics devices, and theory and experimental approaches to molecular spintronics. Evgeny Tsymbal's research is focused on computational materials science aiming at the understanding of fundamental properties of advanced ferromagnetic and ferroelectric nanostructures and materials relevant to nanoelectronics and spintronics. He is a George Holmes University Distinguished Professor at the Department of Physics and Astronomy of the University of Nebraska-Lincoln (UNL), Director of the UNL’s Materials Research Science and Engineering Center (MRSEC), and Director of the multi-institutional Center for NanoFerroic Devices (CNFD). Igor Žuti? received his Ph.D. in theoretical physics at the University of Minnesota. His work spans a range of topics from high-temperature superconductors and ferromagnetism that can get stronger as the temperature is increased, to prediction of various spin-based devices. He is a recipient of 2006 National Science Foundation CAREER Award, 2005 National Research Council/American Society for Engineering Education Postdoctoral Research Award, and the National Research Council Fellowship (2003-2005). His research is supported by the National Science Foundation, the Office of Naval Research, the Department of Energy, and the Airforce Office of Scientific Research.

Ambipolar materials represent a class of materials where positive and negative charge carriers can both transport concurrently. In recent years, a diverse range of materials have been synthesized and utilized for implementing ambipolar charge transport, with applications in high?density data storage, field effect transistors, nanotransitors, photonic memory, biomaterial-based memories and artificial synapses. This book highlights recent development of ambipolar materials involving materials design, fundamental principles, interface modifications, device structures, ambipolar characteristics and promising applications. Challenges and prospects for investigating ambipolar materials in electronics and optoelectronics are also discussed. With contributions from global leaders in the field, this title will appeal to graduate students and researchers who want to understand the design, materials characteristics, device operation principles, specialized device application and mechanisms of the latest ambipolar materials.

Most reference texts covering two-dimensional materials focus specifically on graphene, when in reality, there are a host of new two-dimensional materials poised to overtake graphene. This book provides an authoritative source of information on twodimensional materials covering a plethora of fields and subjects and outlining all two-dimensional materials in terms of their fundamental understanding, synthesis, and applications.

This book brings together innovative methodologies and strategies adopted in the research and developments of Advanced 2D Materials. Well-known worldwide researchers deliberate subjects on (1) Synthesis, characterizations, modeling and properties, (2) State-of-the-art design and (3) innovative uses of 2D materials including: Two-dimensional layered gallium selenide Synthesis of 2D boron nitride nanosheets The effects of substrates on 2-D crystals Electrical conductivity and reflectivity of models of some 2D materials Graphene derivatives in semicrystalline polymer composites Graphene oxide based multifunctional composites Covalent and non-covalent polymer grafting of graphene oxide Graphene-semiconductor hybrid photocatalysts for solar fuels Graphene based sensors Graphene composites from bench to clinic Photocatalytic ZnO-graphene hybrids Hydroxyapatite-graphene bioceramics in orthopaedic applications

This book is for senior undergraduates, graduate students and researchers interested in understanding the physical and chemical interactions of organic semiconductors on emergent two-dimensional (2D) materials. Molecular electronics has come of age, and there is now a pressing need to understand molecule-2D material heterointerfaces at the nanoscale. The purpose of this book is to present a coherent coverage of these heterointerfaces for next generation molecular memories, switches, bio-sensors and magnetic quantum devices. In this interdisciplinary collection, advances in the application of scanning probe and high-resolution synchrotron techniques are illustrated.

In-depth overview of two-dimensional semiconductors from theoretical studies, properties to emerging applications! Two-dimensional (2D) materials have attracted enormous attention due to their exotic properties deriving from their ultrathin dimensions. 2D materials, such as graphene, transition metal dichalcogenides, transition metal oxides, black phosphorus and boron nitride, exhibit versatile optical, electronic, catalytic and mechanical properties, thus can be used in a wide range of applications, including electronics, optoelectronics and optical applications. Two-Dimensional Semiconductors: Synthesis, Physical Properties and Applications provides an in-depth view of 2D semiconductors from theoretical studies, properties to applications, taking into account the current state of research and development. It introduces various preparation methods and describes in detail the physical properties of 2D semiconductors including 2D alloys and heterostructures. The covered applications include, but are not limited to, field-effect transistors, spintronics, solar cells, photodetectors, light-emitting diode, sensors and bioelectronics. Highly topical: 2D materials are a rapidly advancing field that attracts increasing attention Concise overview: covers theoretical studies, preparation methods, physical properties, potential applications, the challenges and opportunities Application oriented: focuses on 2D semiconductors that can be used in various applications such as field-effect transistors, solar cells, sensors and bioelectronics Highly relevant: newcomers as well as experienced researchers in the field of 2D materials will benefit from this book Two-Dimensional Semiconductors: Synthesis, Physical Properties and Applications is written for materials scientists, semiconductor and solid state physicists, electrical engineers, and readers working in the semiconductor industry.

Biomedical Innovations to Combat COVID-19: Mechanics, Biology, and Numerical Modeling provides an updated overview on the development of vaccines, monoclonal antibodies, antiviral materials, and diagnostic methods for the fight against COVID-19. Perspectives on the bioinformatics applications are identified, discussed and enriched with figures and information trees for easy understanding and applicability. The book is split into 4 sections: introduction, presenting basic virologic and epidemiological aspects of COVID-19; vaccines against COVID-19, discussing their different types and applications used to develop them; antibodies targeting COVID-19, encompassing the use of convalescent plasma, camelid and hybridoma-based antibodies; and diagnostic approaches, covering conventional serologic and immunodiagnostic tests and next generation biosensors. It is a valuable source for bioinformaticians, biotechnologists and members of biomedical field interested in learning more about how novel technologies can be applied to fasten the eradication of the COVID-19 and similar pandemics. Presents updated literature coverage summarizing the most relevant information on COVID-19 Written by experts from diverse scientific domains in order to provide readers with a thorough view on the subject Encompasses tables, figures and information trees especially developed for the book in order to condense and highlight key points for quick reference

2D Materials contains the latest information on the current frontier of nanotechnology, the thinnest form of materials to ever occur in nature. A little over 10 years ago, this was a completely unknown area, not thought to exist. However, since then, graphene has been isolated and acclaimed, and a whole other class of atomically thin materials, dominated by surface effects and showing completely unexpected and extraordinary properties has been created. This book is ideal for a variety of readers, including those seeking a high-level overview or a very detailed and critical analysis. No nanotechnologist can currently overlook this new class of materials. Presents one of the first detailed books on this subject of nanotechnology Contains contributions from a great line-up of authoritative contributors that bring together theory and experiments Ideal for a variety of readers, including those seeking a high-level overview or a very detailed and critical analysis

Inorganic 2D nanomaterials, or inorganic graphene analogues, are gaining great attention due to their unique properties and potential energy applications. They contain ultrathin nanosheet morphology with one-dimensional confinement, but unlike pure carbon graphene, inorganic two-dimensional nanomaterials have a more abundant elemental composition and can form different crystallographic structures. These properties contribute to their unique chemical reaction activity, tunable physical properties and facilitate applications in the field of energy conversion and storage. Inorganic Two-dimensional Nanomaterials details the development of the nanostructures from computational simulation and theoretical understanding to their synthesis and characterization. Individual chapters then cover different applications of the materials as electrocatalysts, flexible supercapicitors, flexible lithium ion batteries and thermoelectrical devices. The book provides a comprehensive overview of the field for researchers working in the areas of materials chemistry, physics, energy and catalysis.

Non-covalent Interactions in Quantum Chemistry and Physics: Theory and Applications provides an entry point for newcomers and a standard reference for researchers publishing in the area of non-covalent interactions. Written by the leading experts in this field, the book enables experienced researchers to keep up with the most recent developments, emerging methods, and relevant applications. The book gives a comprehensive, in-depth overview of the available quantum-chemistry methods for intermolecular interactions and details the most relevant fields of application for those techniques. Theory and applications are put side-by-side, which allows the reader to gauge the strengths and weaknesses of different computational techniques. Summarizes the state-of-the-art in the computational intermolecular interactions field in a comprehensive work Introduces students and researchers from related fields to the topic of computational non-covalent interactions, providing a single unified source of information Presents the theoretical foundations of current quantum mechanical methods alongside a collection of examples on how they can be applied to solve practical problems