

NANOTECHNOLOGY

Fundamentals and Applications

Volume 1



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NANOTECHNOLOGY SERIES

VOL. 1: Fundamentals and Applications

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About the Volume

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characteristics of nanomaterials, their broad range of existing applications and future prospects for improved lifestyle. While some of them have also addressed the risk of nanomaterials being hazardous to human and environment owing to its “NANO” nature, making them highly reactive and in some cases even capable of crossing the blood brain barrier. So as it true for any new and “promising” technology; before being used for any human welfare; they should be tested for its non-target harmful effects. This can be achieved by employing risk/safety and management studies of nanomaterials. The target of this volume is to cultivate interest amongst inter disciplinary students, researchers, scientist and professional in academics not limited to the area of physics, chemistry, medicine, biology, defence, civil, energy and environment, information technology, healthcare drug discovery and electronics.

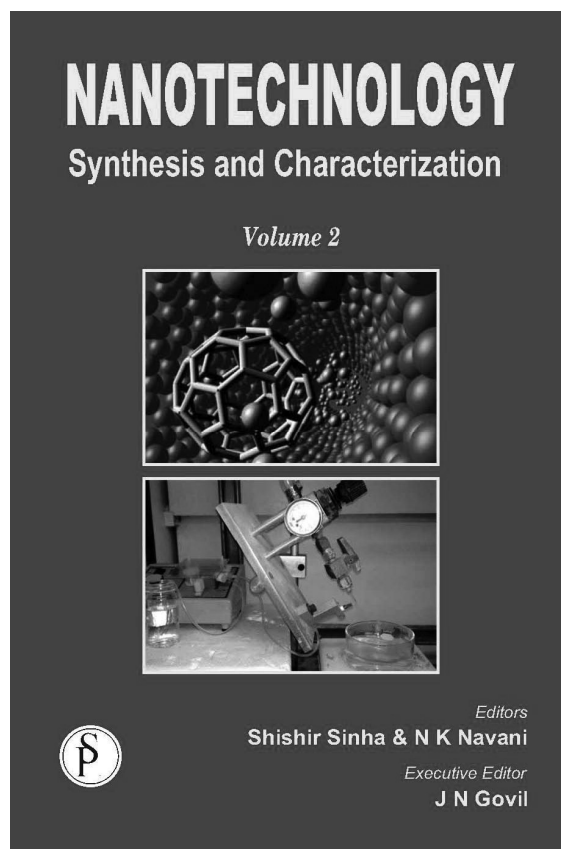
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Preface of Volume 1: Fundamentals and Applications

Nanotechnology is delivering its benefits to society in different sectors like information technology, defence, healthcare, energy and environment, and civil/construction among many others. This volume 1 of a 12 volumes series on nanotechnology comprises articles on fundamentals of nanotechnology and its applications in various areas of life. The volume 1 begins with an introduction to the applications of nanotechnology in the actual technological and scientific world, considering also the theoretical modelling, with which it is possible to test the experimental data of the sector and to predict new features. The chapter 2 presents fundamental concepts and applications of natural and engineered nanomaterials. The chapter covers the fundamentals of nanoscience and nanotechnology, general features of nanomaterials such as size, law of the scales, size dependent properties, brief history of nanotechnology, top-down and bottom-up approaches; an overview of natural nanomaterials, their properties and functions; engineered nanomaterials; applications of the nanomaterials in medicine, environment, electronics and communication technologies; and a brief reflection about nanomaterials and their toxicity in five well structured sections. The chapter 3 is primarily concerned with the applications of nanofluids. Nanofluids are stable solid - liquid mixtures containing suspended solid particles of size less than 100 nm in one dimension. Nanofluids have favorable thermal properties at negligibly small nanoparticle concentrations and, thus, may lead to massive energy savings in heating and cooling applications. The chapter discusses the different issues, like motion of suspended particles and formation of particle clusters that require attention of researchers before successful commercial applications of nanofluids. The chapter 4 discusses the applications of nanomaterials from nanoscale electronics and optics to nanobiological systems and nanomedicine. The chapter also discusses few applications of most significant nanomaterials like gold nanoparticles, iron oxides, quantum dots, fullerenes, carbon nanotubes, nanowires, nanosized metal oxides etc. which are currently under intensive research. The chapter 5 covers a very crucial issue of risk management associated with emission and exposure to these nanomaterials. Risk management of nanomaterials is a field with many uncertainties mainly because of absence of much quantitative information. Still, there are few qualitative tools and methods to assist risk management decisions. The control banding nanotool and

the method design analysis has been discussed in details. The chapter 6 provides an extensive coverage of sciences currently covered by nanotechnology. It also covers various nanotechnology based products currently available in market. Due to their small size, nano-products offer several advantages over conventional products, like effective targeting of difficult-to-reach sites, improved solubility and reduced adverse effects. The possible future developments and safety issues have also been discussed. The chapter 7 presents a detailed discussion on the fabrication, properties and applications of porous anodic alumina (PAA) templates for synthesis of nanostructured materials with big areas, large aspect ratios, and uniform dimensions. The chapter discusses the comparative edge of the technology over the conventional lithographic method. Recent work on the structure of PAA templates and use of PAA to fabricate alumina-based and embedded nanostructures has also been covered. The chapter 8 offers an overview on the current development status of ultra/nanocrystalline diamond films for a variety of applications. The author has summarized various nanodiamond preparation methods, followed by a comparison between the undoped, boron-doped and nitrogen-doped ultra/nanocrystalline diamond films. Finally, the practical applications of these films have been discussed. The chapter 9 focuses on thermal performance of nanofluids applied as a working fluid in a two-phase closed thermosyphon. The theories for investigating nanofluid properties such as the thermal conductivity, rheological behavior, etc. have been highlighted. The chapter 10 provides a review on the basic operation, electrical characterization, and applications of nanomaterials as the active components for non-volatile memory devices. The many impediments that are hindering the growth of such memory devices and the future progress and development of such devices have also been discussed. The chapter 11 describes the growth and modification of various oxide, nitrides, and metal insulator nanocomposite thin films. These nanostructured films have significantly improved the physical properties of 'thin films' and a rapid development has taken place in almost all industrial areas including biology and medicine. Various physical properties emphasizing magnetotransport properties of these films have been discussed in a comprehensive manner. The chapter 12 delves into theory of quasi one-dimensional and two-dimensional polaron structures. V. K. Mukhomorov has shown that specific interpolaron interaction into nano-gap leads to results that are basically different from those observed for electron systems. Quasi one- and two- dimensional electron structures are of applied interest. For example, in one-dimensional nanocapillary electroneutral metal-ammonia systems, electrical conductivity resembles the superconductivity transition with decreasing temperature. In chapter 13, the second order sliding mode control (SOSMC) to coupled multi-input multi-output (MIMO) system is presented. The proposed method can be applied to a large class of nonlinear coupled MIMO processes affected by parameter uncertainties and disturbances. The chapter 14 presents a detailed review on synthesis and applications of electrospun polymer and ceramic nanofibers. These nanofibers have attracted the attention of researchers due to high surface area to volume ratio leading to enhanced micro and nanostructural characteristics. The chapter 15 discusses the role of nanotechnology in agriculture sector by increasing productivity through soil and water conservation. The smaller size, higher specific surface area and reactivity of nano-fertilizers compared to bulk one may increase the solubility, diffusion and hence availability to plants and enhance crop productivity. The environmental risks of nanoparticles demand thorough understanding of the fundamental reaction pathways and proper toxicity study so as to decide their optimum dose to ensure safer and more sustainable use in agriculture. The chapter 16 mainly throws information regarding possible use of nanomaterials in plant tissue culture. Plant tissue culture is playing a vital role in making agriculture an industry. The author argues that in-vitro contamination, uncontrolled exposure of media components, in-vitro imaging tools, delivery of nucleic acids in-vitro are some of the major area where novel tools of nanotechnology could be utilized. This volume gives an introduction of the nano world along with articles on natural and engineered nanomaterials, applications of nanofluids and nanomaterials, risk management and nanomaterials, electrospun nanofibers, and nanotechnology based products. We are much indebted to all contributing academicians and researchers who enthusiastically accepted our request, and made great efforts to write chapters for a wide audience. The length of these chapters varies considerably depending on the topic. Some of them have the appearance of a small book. Their authors deserve special thanks for their painstaking efforts and generosity in choosing to publish their work in this series. We also thank the referees for their hard work to ensure the high quality of the chapters. The **NANOTECHNOLOGY** is a comprehensive compilation of research and review articles that pertain to nanomaterials, from a consideration of their methods of preparation, their novel properties, and areas of their utilization. The series is believed to be of interest to engineers, scientists, and technologists in academic institutions, research laboratories, and industry. It is a befitting introduction of the subject of nanotechnology to the students as well as a mean to provide them an up-to-date review of recent innovations in the field, all in one place.



NANOTECHNOLOGY SERIES

VOL. 2: Synthesis and Characterization

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pumps, nanopropeller, pharmaceutical processes, in space technology, defense and ships, etc.); Life Science (molecular medicine, bioprocessing, agricultural systems, medical surgery, neural surgery, ecotoxicology, molecular imaging, delivery systems, etc). Many scientists and professionals have extensively admired and got inspired by the characteristics of nanomaterials, their broad range of existing applications and future prospects for improved lifestyle. While some of them have also addressed the risk of nanomaterials being hazardous to human and environment owing to its "NANO" nature, making them highly reactive and in some cases even capable of crossing the blood brain barrier. So as it true for any new and "promising" technology; before being used for any human welfare; they should be tested for its non-target harmful effects. This can be achieved by employing risk/safety and management studies of nanomaterials. The target of this volume is to cultivate interest amongst inter disciplinary students, researchers, scientist and professional in academics not limited to the area of physics, chemistry, medicine, biology, defence, civil, energy and environment, information technology, healthcare drug discovery and electronics.

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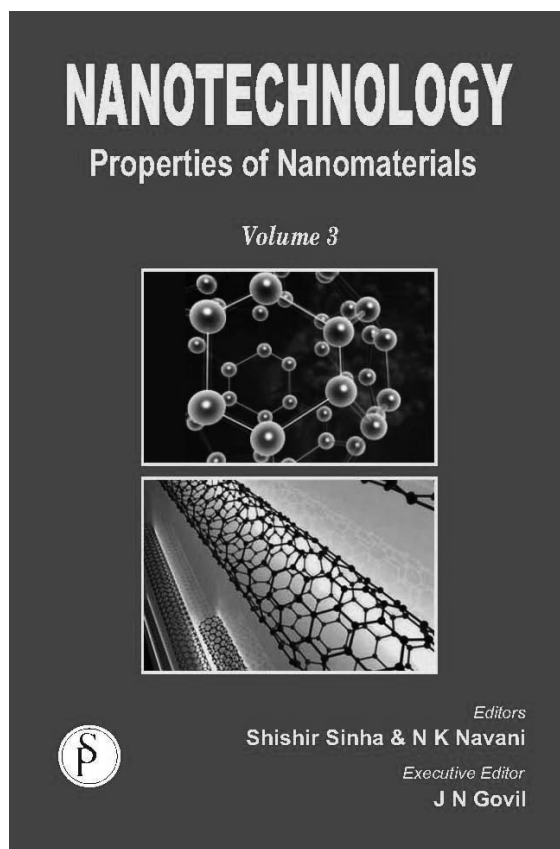
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Preface of Volume 2: Synthesis and Characterization

Nanotechnology is delivering its benefits to society in every sector of human endeavour, like information technology, defence, healthcare, energy and environment, and civil/construction among many others. One major application of nanotechnology is in development of new materials, particularly nanocomposites due to the unique combination of properties that can be achieved at the nanometre scale. This volume 2 of 12 volumes series on nanotechnology is specialized to synthesis and characterization of nanomaterials. The chapter 1 presents an overview of synthesis, characterization, and applications of multicomponent nanocomposite particles. These particles are supposed to have wider applications in biotechnology, catalysis, electronics, and medicine than monocomponent particles due to their enhanced chemical and physical properties. The chapter 2 discusses the synthesis of mesostructured thin silica films by sol-gel process. Sol-gel silica thin films exhibit a highly ordered hexagonal, cubic, or lamellar structure. The properties of sol-gel nanomaterials can be tailored by incorporating molecules into the matrix. The use of organic additives to change the structure of sol-gel thin films is explained in this chapter. The chapter 3 describes the synthesis of a wide variety of bionanoparticles by bottom-up approach, in the gas as well as in solution phase. Several general methods of nanoparticle synthesis have been described first and

then compared with the method developed by the authors in their laboratory. The authors claim that this new method of nanoparticle synthesis is simple, rapid, versatile, and reproducible, also results in the formation of nanoparticles from a wide variety of materials. The chapter 4 provides a review of the major advances and challenges in the synthesis and characterization of stable nanoparticle suspensions. These fluids have a wide range of scientific and industrial applications due to their enhanced thermophysical properties. The various factors affecting their stability have been identified and the ongoing research focused on each of them is discussed in detail. The chapter 5 reviews the different synthesis techniques and functionalization methods of carbon nanotubes. The potential applications of carbon nanotubes in polymer nanocomposites formation and biomedical field are highlighted. The authors also discuss their research and development efforts in this area. The chapter 6 offers a review on chemical and physical preparation of platinum nanoparticles with operating conditions of various fabrication technologies. The applications of platinum nanoparticles in nano-catalysis, electrical conductivity, optics and nonlinear optics have also been discussed. The chapter 7 is concerned with the synthesis, characterization, and applications of ordered mesoporous oxide films. These films have attracted researchers because of their low density, high specific surface area, and high thermal insulation properties. The structural and thermal properties of the ordered mesoporous oxide films can be controlled by porosity and pore structure. The author focuses on characterization of their structural and thermal properties by control of composition and process variables. The chapter 8 deals with the synthesis and applications of nanostructured forsterite, which is a material of interest to various industries like electronics, refractory, laser, fuel cells, etc. In this chapter, the mechanical activation assisted synthesis of nanostructured forsterite from talc powder in presence of fluorine and chlorine catalysts has been discussed, and finally a comparison of in vitro properties of nanostructured forsterite with micron size forsterite is given. The chapter 9 reveals the surface functionalization of carbon nanotubes using O₂-H₂ gas mixture direct current glow discharge plasma technique for cathode-anode separation of 0.10 ± 0.01 cm. During the glow discharge, *I-V* characteristics of gaseous species were studied at different gas pressures of 1, 2, 3 and 4 mbar. In chapter 10, the author elucidates upon different approaches for fabrication of gold nanowires and gold nanotubes. These nanostructures are promising materials for clinical and diagnosis applications, materials science, and several new areas because of their chemical and physical stability, excellent conductivity, catalytic activity, self-assembly with monolayers, accessibility, and excellent electrochemical performance. The chapter 11 reviews the current status of liquid phase chemical reduction synthesis techniques used for preparation of alloy/bimetallic Ag-Cu nanoparticles. First, the methods used for synthesis of different types of bimetallic/alloy nanostructures are summarized, followed by applications of these preparation recipes for synthesis of Ag-Cu alloy/bimetallic nanostructures. The chapter 12 reports on the fabrication of either nanoporous or nanotubular films onto the iron surface by anodization in the F-containing organic solutions over a wide potential window. Mössbauer, Raman and Energy dispersive X-ray spectroscopies and X-ray diffraction have been used to reveal the composition of these films before and after calcination under various conditions. The possible applications of these materials in solar and fuel cells and Li-ion batteries have also been discussed. The chapter 13 studies the processes for formation of nano-size structures on surface of materials under ion-beam sputtering using an approach based on the Kuramoto-Sivashinsky equation as a generalization of the Bradley-Harper model. Three prototypical cases have been studied, namely homogeneous subbeams, temporally fluctuating homogeneous beams, and spatio-temporal fluctuating beams. Monte-Carlo simulation and continuum approach has been applied to study nano-size surface patterns on silicon surface induced by Ar⁺ ion beam sputtering. The chapter 14 presents a research article on size control and morphology of nano-sized aromatic polyamide particles. The size of the spherical particles depended strongly on the reaction solution composition, chemical structure, and ultrasonic frequency. Although the morphologies of the two types of the polyamide particles were similar, the morphologies of the polybenzimidazoles obtained by heating them were significantly different. The chapter 15 covers the synthesis and applications of organic nano particles (ONP) of porphyrinoids. ONP of porphyrinoids are at the forefront of the research due to their simple methods of preparation and the unique size-dependent properties. Metalloporphyrinoids are better catalysts for the oxidation of a wide range of organic compounds than the component molecules. The chapter 16 reviews the application of positron annihilation spectroscopy (PAS) for investigation of defects and transformations in nanomaterials. The subject of positron annihilation is discussed in details with the principles, experimental methods, data analysis and interpretation to give the reader a bird's-eye view of the subject and to

serve as a guide for the beginners. The chapter aims to fulfill the demand for a comprehensive text book on the subject. The chapter 17 focuses on use of polymer mediated growth (PMG) technique for the synthesis of nanoscale fillers to be used further as additives in polymer composites. PMG technique gives a new route to produce the nanomaterials on large scale in a cost effective manner. The chapter includes a review of the available literature on nano-materials as additives for polymers. The chapter 18 presents a research article on the development of high performance hybrid multi-scale epoxy composites reinforced by conventional microfiber fabrics, electrospun nanofibers, and polymeric resins. The composites were fabricated by vacuum assisted resin transfer molding technique, and the mechanical properties of the resulting composites were improved significantly. The study, however, suggested that electrospun nanofibers are better than other fibers for the development of high performance composites. This volume is devoted to synthesis of nanomaterials such as nanocomposites, sol-gel nanomaterials, bionanoparticles, carbon nanotubes, gold nanowires and nanotubes, platinum nanoparticles, nanofillers, ceramic thin films, and their characterization techniques. We are much indebted to all contributing academicians and researchers who enthusiastically accepted our request, and made great efforts to write chapters for a wide audience. The length of these chapters varies considerably depending on the topic. Some of them have the appearance of a small book. Their authors deserve special thanks for their painstaking efforts and generosity in choosing to publish their work in this series. We also thank the referees for their hard work to ensure the high quality of the chapters. The **NANOTECHNOLOGY** is a comprehensive compilation of research and review articles that pertain to nanomaterials, from a consideration of their methods of preparation, their novel properties, and areas of their utilization. The series is believed to be of interest to engineers, scientists, and technologists in academic institutions, research laboratories, and industry. It is a befitting introduction of the subject of nanotechnology to the students as well as a mean to provide them an up-to-date review of recent innovations in the field, all in one place.



NANOTECHNOLOGY SERIES

VOL. 3: Properties of Nanomaterials

Author: Shishir Sinha, Naveen Kumar Navani & J. N. Govil

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machines (nano engines, nano pumps, nanopropeller, pharmaceutical processes, in space technology, defense and ships, etc.); Life Science (molecular medicine, bioprocessing, agricultural systems, medical surgery, neural surgery, ecotoxicology, molecular imaging, delivery systems, etc). Many scientists and professionals have extensively admired and got inspired by the characteristics of nanomaterials, their broad range of existing applications and future prospects for improved lifestyle. While some of them have also addressed the risk of nanomaterials being hazardous to human and environment owing to its "NANO" nature, making them highly reactive and in some cases even capable of crossing the blood brain barrier. So as it true for any new and "promising" technology; before being used for any human welfare; they should be tested for its non-target harmful effects. This can be achieved by employing risk/safety and management studies of nanomaterials. The target of this volume is to cultivate interest amongst inter disciplinary students, researchers, scientist and professional in academics not limited to the area of physics, chemistry, medicine, biology, defence, civil, energy and environment, information technology, healthcare drug discovery and electronics.

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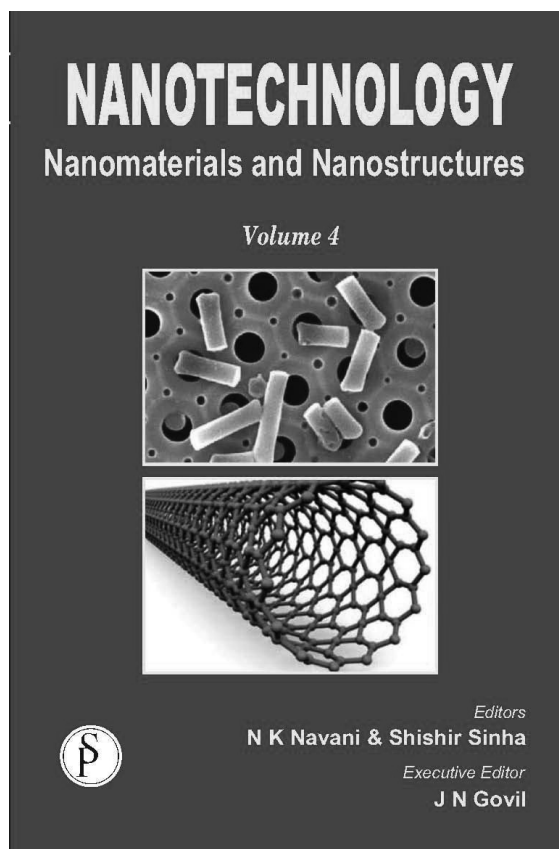
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Preface of Volume 3: Properties of Nanomaterials

Nanotechnology is delivering its benefits to society in every sector of human endeavour, like information technology, defence, healthcare, energy and environment, and civil/construction among many others. Due to their nanoscale dimensions, nanomaterials are known to have many novel properties. This is mainly due to their large surface area to volume ratio, high surface energy, spatial confinement, and reduced imperfections, which do not exist in the corresponding bulk materials. This volume 3 of 12 volumes series contains articles addressing issues related to properties of nanomaterials. The chapter 1 presents an excellent discussion on the two dimensional effective electron mass studies in quantum wells of nonlinear optical, III-V, II-VI, IV-VI, Bismuth and related materials on the basis of a newly formulated electron dispersion laws within the framework of k.p. formalism. The chapter 2 reviews the effect of several variables on the effective thermal conductivity of nanoparticle dispersions. The authors first discuss the thermal conductivity behavior of the two phases that form a nanofluid. Then combine these results to develop an understanding of the behavior of the thermal conductivity of heterogeneous mixtures of metallic or nonmetallic nanoparticles dispersed in liquids. The chapter 3 gives an overview of the wave propagation in carbon nanotubes under initial stresses. The study reveals that the initial stresses present in the

tube have notable effects on the propagation of waves. The investigations made by authors of this article are quite significant for potential applications and designs of nanoelectronics and nanodevices. The chapter 4 compares the performance characteristics of two different forms of Titanium dioxide, namely Anatase and Rutile, for CO oxidation. Titanium dioxide samples were loaded with gold nanoparticles. Gold is essentially inert in the bulk state, but it is highly active as nanoparticles well dispersed on the support. Samples containing a larger amount of Anatase were found to be more active for CO oxidation and showed lower gold nanoparticle sizes. The chapter 5 examines electromagnetic shielding effectiveness of cotton/polyester woven fabrics coated with γ -Fe₂O₃ and Fe₃O₄ nanoparticles, separately. The widespread use of electronic devices is leading to a higher risk for leukemia and other types of cancer. Therefore, a great deal of efforts is needed to develop the electromagnetic shielding materials. Results showed higher values of shielding effectiveness for Fe₃O₄ nanoparticles compared with γ -Fe₂O₃ nanoparticles. The chapter 6 discusses the application of gold and silver nanoparticles to enhance fluorescence of a variety of organic molecules including biomolecules. Fluorescence is a powerful and sensitive spectroscopic technique that is widely used because of its high sensitivity, simplicity and diversity. The chapter 7 introduces the numerical and theoretical methods for modeling and simulations of fluids flowing in nanochannels and corresponding research findings. The research findings are useful in understanding the behavior of fluids confined in nanochannels and in design of nanofluidic devices. The chapter 8 provides a numerical investigation on the convective heat transfer performance of nanofluid over a permeable stretching sheet in the presence of magnetic field and slip velocity is performed. The similarity equations are solved numerically for metallic nanoparticles such as copper in a water-based fluid to investigate the effect of nanoparticles volume fraction ϕ on the flow and heat transfer characteristic. The chapter 9 elucidates mainly upon current studies on nanoscale field effect transistors (FETs) based on graphene and nanowires. The factors determining the performance of nanoscale graphene FETs are discussed. The electron transport properties of ultrathin Ge, Sn and Si nanowires are presented. Limitations and perspectives of present graphene and nanowire FETs are reviewed. The chapter 10 offers a review on the impact of non-covalent interactions between carbon nanotubes and different dispersing agents. Carbon nanotubes without any covalent surface modifications have been considered, and the special focus is upon π - π stacking. The chapter 11 provides a review of self-assembled nanoemulsion fluids for thermal cooling application. It starts with an introduction of fundamental physics of these fluids, followed by discussion on their formation. Thermophysical properties of several nanoemulsion fluids are discussed. Lastly, the chapter provides an overview of pool boiling and flow boiling of polyalphaolefin (PAO)-based nanoemulsion fluids. The chapter 12 investigates the effects of nano-clay and nano-silica on the rheological characteristics of bio-modified asphalt. It compares the performance characteristics of base asphalt, nanoclay modified asphalt (without bio-binder), and bio-modified asphalt (without nano-particles). The results indicated that the addition of nano-clay to bio-modified asphalt helped significantly improve high temperature performance. The chapter 13 is a research article on the structure and magnetoresistive properties (anisotropic and giant magnetoresistances) of three-layer nanocrystalline film systems CoNi/Ag(Cu)/FeNi in conditions of ultrahigh oil-free vacuum. The chapter 14 is concerned with epitaxial growth process of quantum dots (QD). First, the theoretical description of the process is reviewed. Then, the experimental observations on the QD growth behaviors in the MBE InAs/GaAs (001) system made by the authors are summarized. The author proposes a novel scenario for the QD self-assembling process, inspired by two experimental evidences in the literature and of their own. The chapter 15 reports the computer-assisted studies of silver and water absorption by porous silicon dioxide, (SiO₂)₅₀, nanoparticles. The molecular dynamics method is used to study the absorption of silver atoms and water molecules. Upon absorption of silver atoms, the volume of (SiO₂)₅₀ nanoparticles does not increase, but their power of heat radiation emission is significantly increased. An increase in the number of water molecules in the (SiO₂)₅₀ cluster results in enhancement of IR radiation absorption. The chapter 16 reviews the recent developments in density functional theory studies performed on magnetic nanowires. The focus is on the calculations on magnetic properties, like magnetic moment and magnetic anisotropy energy exhibited by free-standing and substrate supported nanowires. This volume includes chapters

on different properties of nanomaterials like electron mass of nanomaterials, heat transfer characteristics of nanofluids, flow properties in nanochannels, novel nanoemulsion heat transfer fluids, and rheological characteristics of bio-modified nano binders. We are much indebted to all contributing academicians and researchers who enthusiastically accepted our request, and made great efforts to write chapters for a wide audience. The length of these chapters varies considerably depending on the topic. Some of them have the appearance of a small book. Their authors deserve special thanks for their painstaking efforts and generosity in choosing to publish their work in this series. We also thank the referees for their hard work to ensure the high quality of the chapters. The **NANOTECHNOLOGY** is a comprehensive compilation of research and review articles that pertain to nanomaterials, from a consideration of their methods of preparation, their novel properties, and areas of their utilization. The series is believed to be of interest to engineers, scientists, and technologists in academic institutions, research laboratories, and industry. It is a befitting introduction of the subject of nanotechnology to the students as well as a mean to provide them an up-to-date review of recent innovations in the field, all in one place.



NANOTECHNOLOGY SERIES

VOL. 4: Nanomaterials and Nanostructures

Author: Naveen Kumar Navani, Shishir Sinha & J.N. Govil

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About the Volume

This first volume in the nanotechnology series “Fundamentals and Application” gathers and presents the principal concepts of nanotechnology and its diverse and multidisciplinary field of research and emerging applications. The initial chapter bestows us with the introduction to nanoscience and nanobiotechnology which deals with the brief history of naturally existing nanomaterial as an inspiration of nature to design engineered nanomaterials with broad-spectrum properties. Owing to its nano size, this technology has fashioned enormous products offering advantages over the conventional ones; ranging from the materials (nanofuel cells, catalyst, lubricant, aeronautics, automobiles, telecommunications, energy production, mechanics, biology, medicine, etc.); electronics and information technology (nanoelectronics, solar cell, single electron transistors, high sensitivity sensors, etc.); machines (nano engines, nano pumps, nanopropeller, pharmaceutical processes, in space technology, defense and ships, etc.); Life Science

(molecular medicine, bioprocessing, agricultural systems, medical surgery, neural surgery, ecotoxicology, molecular imaging, delivery systems, etc). Many scientists and professionals have extensively admired and got inspired by the characteristics of nanomaterials, their broad range of existing applications and future prospects for improved lifestyle. While some of them have also addressed the risk of nanomaterials being hazardous to human and environment owing to its “NANO” nature, making them highly reactive and in some cases even capable of crossing the blood brain barrier. So as it true for any new and “promising” technology; before being used for any human welfare; they should be tested for its non-target harmful effects. This can be achieved by employing risk/safety and management studies of nanomaterials. The target of this volume is to cultivate interest amongst inter disciplinary students, researchers, scientist and professional in academics not limited to the area of physics, chemistry, medicine, biology, defence, civil, energy and environment, information technology, healthcare drug discovery and electronics.

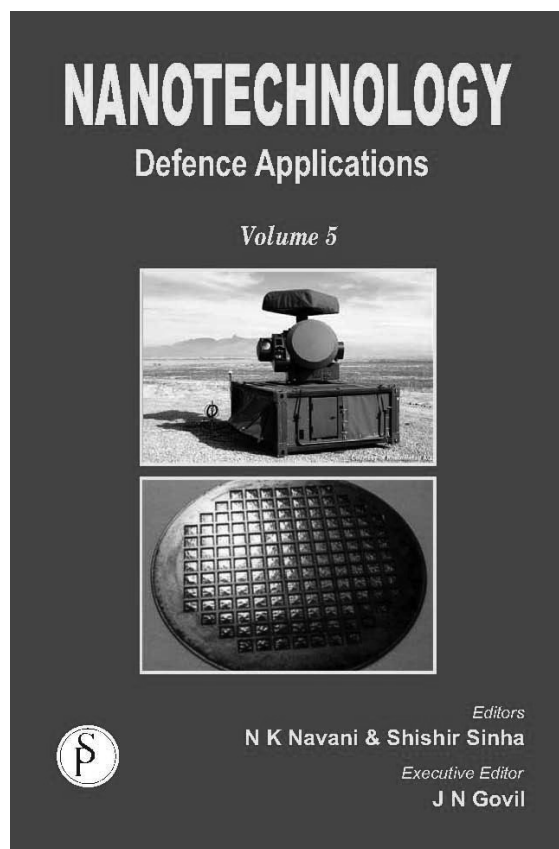
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Preface of Volume 4: Nanomaterials and Nanostructures

Nanotechnology is delivering its benefits to society in every sector of human endeavour, like information technology, defence, healthcare, energy and environment, and civil/construction among many others. Nanotechnology is instrumental in development of materials, where the fundamental properties of materials can be improved without changing the materials’ chemical status. This volume 4 of 12 volumes series on nanotechnology covers synthesis and characterization of some more nanomaterials and nanostructures, in addition to the second volume of the series. The chapter 1 provides an extensive review of the classification, preparation and applications of polymer nanocomposites. Polymer nanocomposites combine the attractive functionalities of both components – polymer and nanoparticles. The potential applications of these nanocomposites are automotive, aerospace, optoelectronic etc. The chapter 2 reviews the mechanical analysis of single walled carbon nano tube (SWCNT). A generalized model which includes external forces acting on the SWCNT and a nonlocal parameter is applied to study their potential applications such as the use of drug delivery and mass sensor. The chapter 3 discusses two diverse approaches for the synthesis of $\text{SiO}_2@Y_2O_3:Eu^{3+}$ particles with core–shell structure. In first approach, different surfactants are applied to enhance the luminescent intensity of core shell particles. In second approach, the polymer shell is obtained by copolymerization of methacryl oxyethyl isocyanate onto silica particles. The grafted polymer acts as template to prepare the luminescent shell. The obtained silica-polymer core-shell particles are dispersed in a solution of Yttrium and Europium nitrates to allow a physical adsorption of the ions by the polymer shell. The polymer shell is removed by thermal treatment to obtain photoluminescent $\text{SiO}_2@Y_2O_3:Eu^{3+}$ core–shell particles. The chapter 4 presents a review article on the synthesis, characterization and applications of advanced organic nanoporous materials. The article discusses the direct and indirect template synthesis, nanoscopic pattern formation, morphology characterization, and the various controlling parameters. In addition, various applications of

nanoporous and nanoscopic materials have also been reviewed. The chapter 5 offers an overview of research conducted by author's on preparation, optical and physico-chemical properties of metallic and nanohybrid materials. Metallic nanoparticles, gold, silver, platinum or their combinations, are the main focus of this review article. These nanoparticles are further functionalized and used as templates for creation of complex and ordered nanomaterials with tailored and tunable structural, optical, catalytic and surface properties. The chapter 6 gives a review study on the coating methods and characterization of nanostructured coatings. Nanostructured coatings have excellent properties, such as high hardness, high wear resistance, low electrical resistivity, good corrosion resistance and high thermal stability. To apply these coatings, Reactive Plasma Spraying, Vacuum Cold Spraying, Plasma Assisted Chemical Vapor Deposition, Active Screen Plasma Nitriding, Ultrasonic Mechanical Coating and Armoring, Magnetron Sputtering and Electrophoretic Deposition and some other methods are used, which have been briefly explained. The chapter 7 covers a review of the current researches on the properties and potential applications of ZnO nanostructures. The studies relating to different types of nanostructures are reviewed in the first part, followed by a detailed review of the properties of the nanostructures. The important feature of this chapter is the inclusion of a comprehensive review of the hydrophobic property of nanocrystalline ZnO film synthesized by nebulized spray pyrolysis. The chapter 8 describes the synthesis of thermo-electric nanofluids and their application in electronic equipments for effective heat transfer management. Thermo-electric nanofluids contain nanoparticles dispersed in a continuous liquid phase and are expected to exhibit superior thermal and electric characteristics. The chapter 9 analyzes the factors influencing the microstructure development in the powder mixtures reacting in the spark plasma sintering (SPS) and conditions responsible for the formation of a fine-grained product, completeness of the reaction and uniformity of composite microstructures. The chapter also discusses the applicability of reactive SPS to the synthesis of nanostructured and nanocomposite materials. The chapter 10 is dedicated to the growth of three group-IV based nanowires: Si, SiGe and SiC nanowires. First, the general properties of these materials have been described, followed by a description of the growth methods. The approach of this chapter comes from a material science point of view. The chapter 11 deals with the different fabrication processes of nanoporous anodic aluminum oxide (AAO) films in details. AAO films with self-organized hexagonal arrays of uniform parallel nanochannels are widely used as the building block to fabricate various functional nanostructures of different morphologies such as nanoparticles, nanowires and nanotubes. These functional nanostructures can be potentially utilized in various applications like magnetic storage media, optoelectronics, bio/chemical sensors, photonics and plasmonics. The chapter 12 also studies the nanoporous alumina templates, like the earlier chapter 11. In the first part of the chapter, the anodisation of alumina templates, as well as the electrochemical process parameters and mechanisms are discussed by means of structural and morphological characterisation. The second part is dedicated to the study of mechanical properties of nanotemplates using nanoindentation. The chapter 13 reports the research work carried out by the authors on fabrication of several types of nanostructures (nanowire, nanoripple, complex nanostructure) on the surface of semiconductor single crystals by laser ablation methods without any furnace, vacuum chamber or additional metal catalyst. By this method, the nanowires grow rapidly and simply on a designed micro pattern. This volume presents topics on nanomaterials and their structures like polymer nanocomposites, core shell materials, advanced organic nanoporous materials, metallic and hybrid nanostructures, nanostructured coatings, thermoelectric nanofluids, and Si, SiGe, and SiC nanowires. We are much indebted to all contributing academicians and researchers who enthusiastically accepted our request, and made great efforts to write chapters for a wide audience. The length of these chapters varies considerably depending on the topic. Some of them have the appearance of a small book. 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NANOTECHNOLOGY SERIES

VOL. 5: Defence Applications

Author: Naveen Kumar Navani, Shishir Sinha & J.N. Govil

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About the Volume

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machines (nano engines, nano pumps, nanopropeller, pharmaceutical processes, in space technology, defense and ships, etc.); Life Science (molecular medicine, bioprocessing, agricultural systems, medical surgery, neural surgery, ecotoxicology, molecular imaging, delivery systems, etc). Many scientists and professionals have extensively admired and got inspired by the characteristics of nanomaterials, their broad range of existing applications and future prospects for improved lifestyle. While some of them have also addressed the risk of nanomaterials being hazardous to human and environment owing to its "NANO" nature, making them highly reactive and in some cases even capable of crossing the blood brain barrier. So as it true for any new and "promising" technology; before being used for any human welfare; they should be tested for its non-target harmful effects. This can be achieved by employing risk/safety and management studies of nanomaterials. The target of this volume is to cultivate interest amongst inter disciplinary students, researchers, scientist and professional in academics not limited to the area of physics, chemistry, medicine, biology, defence, civil, energy and environment, information technology, healthcare drug discovery and electronics.

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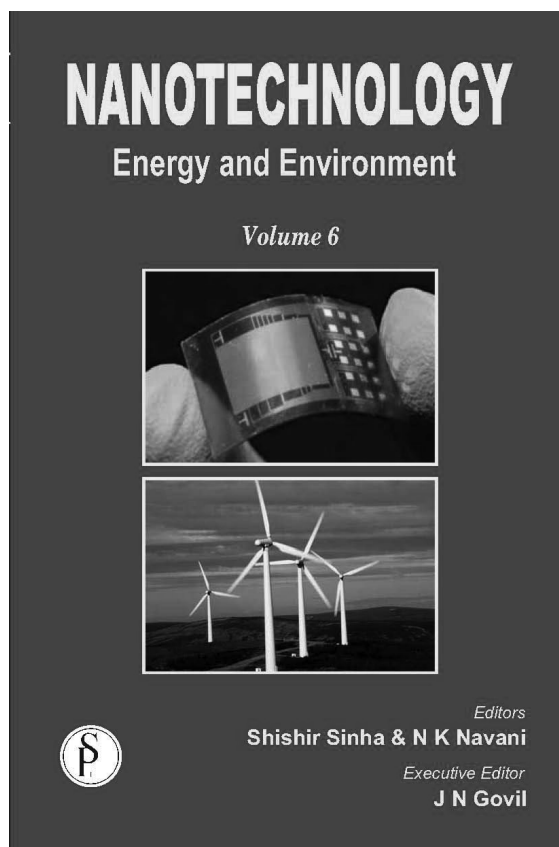
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Preface of Volume 5: Defence Applications

Nanotechnology is delivering its benefits to society in different sectors like information technology, defence, healthcare, energy and environment, and civil/construction among many others. Nanotechnology promises revolutionary technological changes for a wide range of military applications, like development of smart fabrics, armor structures and materials, fuel economy of vehicles, military personnel health, defense against chemical and biological warfare, nanosensors, nano air vehicles, power generation and management, and many more. This volume 5 of 12 volumes series is a collection of some best articles discussing various aspects of nanotechnology for defence applications. The chapter 1 gives an introduction of nanotechnology for military applications. The potential changes in properties of nano-materials by introducing new and enhanced characteristics will have critical impact on future military personnel, hardware and the nature of warfare on the whole. The chapter describes the applications of nanotechnology in defence, ranging from development of sensors for chemical, biological, radiological, nuclear, and explosive materials; smart armor, camouflage, medical aid, nanorobotics, etc. The chapter 2 examines the recent developments in nanotechnology and their potential applicability within military and defense context. Applications of nano-engineered materials and technologies can lend a hand to the

soldiers-as-systems in reducing weight, increasing comfort, along with improved chemical, biological and ballistic protection. The nanotechnology is expected to deliver revolutionary effects in future war fighting strategies. The chapter 3 reviews the recent advances of nanomaterials in general and their defence applications in particular. It also brings out the futuristic applications of nanomaterials which are either conceptualized or being evaluated for their performances. There is a paradigm shift in the concept of conventional war due to availability of nanomaterials and their applications. The chapter 4 covers a brief overview of the use of optical chemical sensors and probes based on nanomaterials for defence applications. The emphasis is on the detection of explosives and chemical warfare agents. The detection transduction schemes that are used in optical nanosensors are overviewed along with discussion on recently published works. The chapter 5 presents a research article on optimization of fiber electrospinning technique to prepare polyacrylonitrile (PAN) fibers involving $\text{Cr}(\text{NO}_3)_3/\text{Zn}(\text{CH}_3\text{COO})_2$ /Ionic liquids additives with diameters in the nanoscale and micron range. The objective of this research is to develop new radar absorbing materials (RAM) for military applications. RAM is used to cover the surface of targets, which include different types of equipment, land vehicles, aircraft and ships. The chapter 6 analyzes the role of remote sensing and nanotechnology in three major areas, viz, natural resources, social and human conditions, and environmental security. The authors propose a fusion of remote sensing and nanotechnology, with example of three case studies and suggest the ways of replicating such experiments in the Indian context. The chapter 7 reviews the technological developments taking place in miniaturization of high performance thin films solid oxide fuel cells (TFSOFCs). These cells are attractive for defense applications, like micro unmanned aerial vehicles (MAVs) and remote sensors, for their high energy conversion efficiency, fuel flexibility, and potential for low audible signature. The chapter 8 compares the performance of quantum dot infrared photodetectors (QDIP) with other competitive infrared photodetectors. The emphasis is on the material properties, device structure, and their impact on the device performance, especially in long wavelength infrared (LWIR) spectral regions. The chapter 9 investigates the influence of ionic liquids on the growth of nanofillers for the development of electromagnetic wave absorbing materials in the frequency region of 5 - 12 GHz. To improve performance of electromagnetic wave absorbing materials, the focus is on the morphology and size control of materials synthesized on the micro- and nano-scale. The chapter 10 studies the development of nanomaterials for radar absorbing structures in stealth aerial vehicles. Radar can detect the aerial vehicles from the farthest distance and so the range of detections is more. A brief overview of the radar cross-section is discussed first to understand how the nanomaterials will help in reducing the radar cross-section. Then various concepts of radar cross-section reduction via use of radar absorbing structures have been discussed, while keeping the main emphasis on nanomaterials. The chapter 11 delves into the role and influence of nano-sized ingredients in high energy materials, namely propellants, explosives and pyrotechnics, for enhancing performance through optimized burning rate, propagation velocity, ignition delay, flame temperature, peak pressure in closed vessel, and detonation pressure, etc. The chapter also discusses various ingredients and methods of their synthesis and characterization in nano-sizes. The chapter 12 provides a brief introduction to microwave and need to develop a material that can absorb microwave in the range of 2 GHz to 24 GHz or even higher. Microwave absorption has direct application in defence for blocking the recognition of planes entering the enemy territory. The chapter has been written to make readers get the feel of the subject without going into much of mathematical treatments. Application of carbon materials and some of the results obtained with carbon materials are also presented in this chapter. The chapter 13 focuses on the current status of development of smart multifunctional self healing coatings for aerospace alloy AA2024-T3. The authors have discussed their own research efforts of development of sol-gel based self healing coatings, doped with inhibitors lodged in polyelectrolyte based nano containers/tubes for controlled release of the inhibitors. Polyelectrolyte has a dual advantage of pH sensitivity and self healing ability. The chapter 14 discusses the recent developments in plasmonic nanoparticles (AuNP, AgNP) based sensors for the detection of chemical warfare agents. The rapid detection and identification of chemical warfare agents (blister agent, nerve agent, sulfur mustard, nitrogen mustard, and lewisite), either in soil, water, or food to spread terrorism causing diseases or

death to humans, animals and plants, is a major challenge to any government. Plasmonic nanoparticles based acetylcholinesterase assay shows promising sensitivity and detection selectivity towards chemical warfare agents. The chapter 15 offers a state-of-the-art review of low dimensional material systems for fabrication of new generation infrared detectors, such as quantum well infrared photodetectors (QWIPs), quantum dot infrared photodetectors (QDIPs), and type-II superlattice photodiodes. These devices are sufficiently advanced with the possibility of their being incorporated in high-performance integrated circuits. This volume addresses the defence applications of nanotechnology and contains chapters on introduction of nanotechnology in defence sector, recent advances in nanomaterials and nanotechnology, nanomaterials for radar absorbing structures, nano-sized ingredients of propellants and explosives, and self - healing anti corrosion coatings for aerospace applications. We are much indebted to all contributing academicians and researchers who enthusiastically accepted our request, and made great efforts to write chapters for a wide audience. The length of these chapters varies considerably depending on the topic. Some of them have the appearance of a small book. Their authors deserve special thanks for their painstaking efforts and generosity in choosing to publish their work in this series. We also thank the referees for their hard work to ensure the high quality of the chapters. The **NANOTECHNOLOGY** is a comprehensive compilation of research and review articles that pertain to nanomaterials, from a consideration of their methods of preparation, their novel properties, and areas of their utilization. The series is believed to be of interest to engineers, scientists, and technologists in academic institutions, research laboratories, and industry. It is a befitting introduction of the subject of nanotechnology to the students as well as a mean to provide them an up-to-date review of recent innovations in the field, all in one place.



NANOTECHNOLOGY SERIES

VOL. 6: Energy and Environment

Author: Shishir Sinha, Naveen Kumar Navani & J. N. Govil

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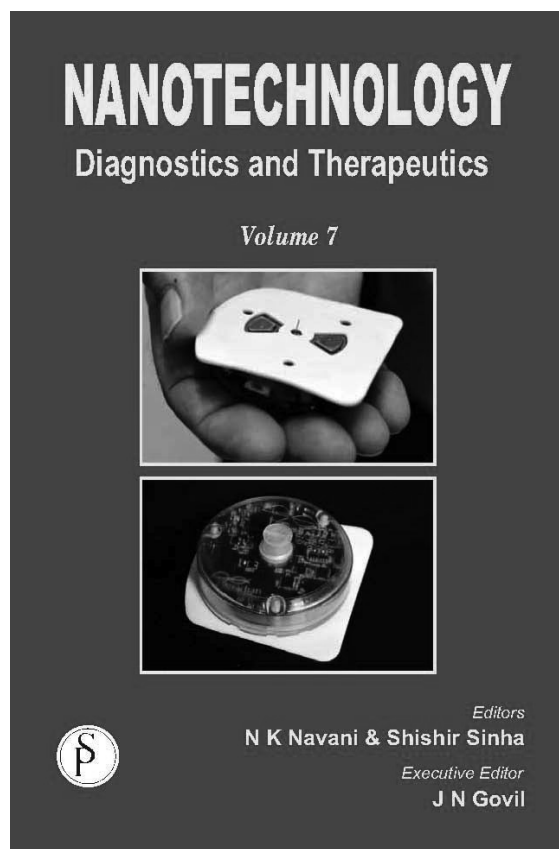
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Preface of Volume 6: Energy and Environment

Nanotechnology is delivering its benefits to society in every sector of human endeavour, like information technology, defence, healthcare, energy and environment, and civil/construction among many others. Nanotechnology is opening up new avenues of research in energy and environment by development of less expensive nanostructured solar cells, better catalysts for improved fuel production efficiency, increased fuel consumption efficiency in vehicles and power plants, strong and light weight materials for windmill blades, and nanostructured filters to provide drinking water form salt water or polluted water. This volume 6 of 12 volumes series on nanotechnology looks into development of nanomaterials for clean and green energy technologies to achieve a more sustainable society with adequate energy usage and less environmental pollution. The chapter 1 reviews the recent advances in research for energetic materials that can store higher amounts of energy for a given volume and lead to higher amounts of impulse management. Aluminum nanoparticles have been studied extensively in recent years, with Boron and Carbon as possibilities in the future. However, there are many challenges still faced, including the synthesis, safe-handling, storage, and lifecycle analysis. The chapter 2 presents a comprehensive review of renewable energy sources that do not produce air pollution or greenhouse gases, and provide comfortable coexistence of human, livestock, and plants. It also includes potential renewable energy technologies, efficient energy systems, energy savings techniques and other mitigation measures necessary to reduce climate changes. The chapter 3 offers a discussion on the plants responsible for the biological synthesis of silver (Ag), gold (Au), palladium (Pd), platinum (Pt) and metal oxide nanoparticles along with the possible mechanism of action. Terrestrial and aquatic plants, especially their extracts, are able to produce metal nanoparticles even in energetically

unfavorable room temperatures. Control over the shape and size of nanoparticles seems to be very easy with the use of plants. The chapter 4 introduces the nanotoxicology in engineering and built environment, serving as a health implication for the myriad potentials and opportunities in the development of advanced nano-materials in building and construction. A critical review of the current toxic nano-products indicates that the emerging nano-toxicology is able to address the potential hazards as well as to support the research into safe design, production, use and disposal practices that enhance the sustainability of both the nanotechnology and construction industry. The chapter 5 analyzes the thermodynamic, physical and nanotechnological aspects of the graphene/graphane problem in connection with developing a much simpler and efficient method of producing a high density solid molecular hydrogen carrier. It is achieved by hydrogen intercalation in closed multigraphane nanostructures of the over-megabar strength properties. The volumetric hydrogen capacity is of $\sim 0.2 \text{ g/cm}^3$, and the gravimetric one being 15 wt % (H_2). The chapter 6 provides a brief summary of recent research progress on carbon nanotubes and graphenes in energy storage and catalysis field. Carbon nanotubes and graphenes have emerged as promising materials for next generation hydrogen storage materials, supercapacitors and as catalysts due to their unique properties. The chapter 7 summarizes the results of research done over the last decade to study the feasibility of the construction and use of solid-state hydrogen accumulators, namely nanoporous carbon and metal-organic framework structures, Mg-based and complex hydrides and nanoporous materials. The chapter 8 discusses the possibility of aluminum based anodes for advanced lithium-ion batteries. The traditionally employed graphite is unable to fulfill the new requirements of high energy and power density. Aluminum is characterized by high theoretical specific capacity, low expansion during the cycling and strong intention to form a surface oxide layer and, therefore, is one of most promising anode materials. The chapter 9 investigates the designing of different classes of molecular materials for hydrogen storage applications on the basis of conceptual density functional theory and its allied reactivity descriptors and nucleus independent chemical shift measures. The hydrogen binding capability of a given template species depends on the formal charge carried by a given active site and application of an external electric field. The chapter 10 examines the factors responsible for proper application development of silver nanoparticles in real environment. The effective control of the processes of dissolution, aggregation and reactivity in relation to medium composition leads to optimization of the application. The Gibbs energy for the aggregation process and its dependence on the medium composition contains all the information needed to control the fate of silver nanoparticles in real environments. The chapter 11 gives a brief account on the development of photovoltaic solar cell covering the types of solar cell devices, material aspects, and the efforts made to reduce the cost of solar cell. The efforts made to utilize carbon nano materials in solar cell have also been discussed. A homojunction carbon solar cell giving an efficiency of 2.28% is explained. The chapter 12 reports on various types of Schottky solar cells for thin films, nanostructures and transparent conductors. A nanostructured solar cell has not yet been achieved due to the difficult architecture and complex doping processes. Schottky type cells are an alternative approach to resolve the hurdles of conventional p/n type nanostructure solar cells. The chapter 13 studies the nanostructured manganese oxide materials for energy and environmental applications. Manganese oxide can be operated in a wide temperature range with long life cycle. Here, three significant applications of manganese oxide materials - capacitance, support material for fuel cell catalyst and environmental usages are reviewed. The chapter 14 is focused on the synthesis, characterization, and application of nanosized zero valent iron (nZVI) for polluted groundwater remediation. nZVI supported by clay minerals has been recognized as a promising removal agent in permeable barriers to effectively treat nitroaromatic compounds, halogenated hydrocarbons, trace metals, and inorganic anions in soil and subsurface water for several decades. The chapter 15 stresses on need for detailed failure analysis of nanomaterials to quantify their advantages and shortcomings. Nanomaterials are increasingly being used in numerous industries to improve the performance/cost ratio, while reducing utilization of raw materials and environmental impact. A detailed material science and engineering investigation will allow better understanding of the relationship between the composition and structure, and functional properties of nanostructured materials. This volume is more or less specialized to energy and environment issues. The chapters in this volume address issues related to nanoenergetic materials, clean and green energy technologies, carbon nanotubes and graphenes in energy storage, nanocrystalline and nanoporous hydrogen storages, silver nanoparticles in real environments, nanostructures for schottky solar cells, and nanostructured materials for sustainable solutions. We are much indebted to all contributing academicians and

researchers who enthusiastically accepted our request, and made great efforts to write chapters for a wide audience. The length of these chapters varies considerably depending on the topic. Some of them have the appearance of a small book. Their authors deserve special thanks for their painstaking efforts and generosity in choosing to publish their work in this series. We also thank the referees for their hard work to ensure the high quality of the chapters. The **NANOTECHNOLOGY** is a comprehensive compilation of research and review articles that pertain to nanomaterials, from a consideration of their methods of preparation, their novel properties, and areas of their utilization. The series is believed to be of interest to engineers, scientists, and technologists in academic institutions, research laboratories, and industry. It is a befitting introduction of the subject of nanotechnology to the students as well as a mean to provide them an up-to-date review of recent innovations in the field, all in one place.



NANOTECHNOLOGY SERIES

VOL. 7: Diagnostics and Therapeutics

Author: Naveen Kumar Navani, Shishir Sinha & J.N. Govil

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About the Volume

This first volume in the nanotechnology series “Fundamentals and Application” gathers and presents the principal concepts of nanotechnology and its diverse and multidisciplinary field of research and emerging applications. The initial chapter bestows us with the introduction to nanoscience and nanobiotechnology which deals with the brief history of naturally existing nanomaterial as an inspiration of nature to design engineered nanomaterials with broad-spectrum properties. Owing to its nano size, this technology has fashioned enormous products offering advantages over the conventional ones; ranging from the materials (nanofuel cells, catalyst, lubricant, aeronautics, automobiles, telecommunications, energy production, mechanics, biology, medicine, etc.); electronics and information technology (nanoelectronics, solar cell, single electron transistors, high sensitivity sensors, etc.); machines (nano engines, nano pumps, nanopropeller, pharmaceutical processes, in space technology, defense and ships, etc.); Life Science

(molecular medicine, bioprocessing, agricultural systems, medical surgery, neural surgery, ecotoxicology, molecular imaging, delivery systems, etc). Many scientists and professionals have extensively admired and got inspired by the characteristics of nanomaterials, their broad range of existing applications and future prospects for improved lifestyle. While some of them have also addressed the risk of nanomaterials being hazardous to human and environment owing to its “NANO” nature, making them highly reactive and in some cases even capable of crossing the blood brain barrier. So as it true for any new and “promising” technology; before being used for any human welfare; they should be tested for its non-target harmful effects. This can be achieved by employing risk/safety and management studies of nanomaterials. The target of this volume is to cultivate interest amongst inter disciplinary students, researchers, scientist and professional in academics not limited to the area of physics, chemistry, medicine, biology, defence, civil, energy and environment, information technology, healthcare drug discovery and electronics.

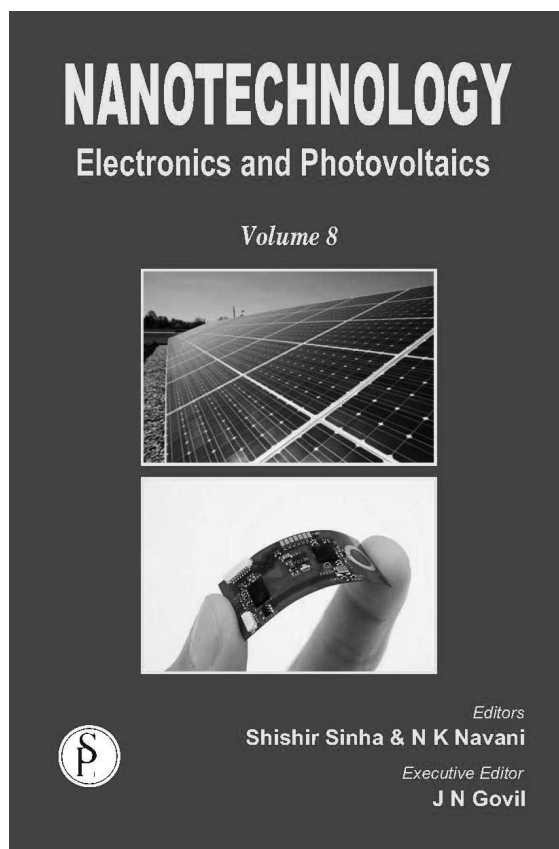
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Preface of Volume: Diagnostics and Therapeutics

Nanotechnology is delivering its benefits to society in every sector of human endeavour, like information technology, defence, healthcare, energy and environment, and civil/construction among many others. Nanotechnology has the real potential to revolutionize the entire medical sector by synthesis and use of nanostructures, applications of nanotechnology in therapy, biomimetic nanostructures which are synthetic products developed from an understanding of biological systems, biological nanostructures, devices for early detection of disease, nanotechnology for tissue engineering, etc. This volume 7 of 12 volumes series analyzes the research efforts and the progress made so far by nanotechnology in healthcare sector. The chapter 1 highlights the recent advances in use of nanomaterials for diagnostics and therapeutics. Small size, large surface area and high reactivity allow the nanoparticles to easily translocate into the specific cell leading to targeted delivery of drugs, vaccines and other biomolecules. Metallic nanomaterials have superior optical and electrical properties making them ideal for imaging, diagnosis and thermal ablation of the diseased tissue. The chapter 2 reviews the merits of nanotechnology in terms of their medical applications. The basic physical and medical concepts of biomaterials and their therapeutic and diagnostic applications at nanoscale are reviewed as well. Special attention is given to the use of noble nanoparticles in biomimetic coating of metallic implants. The chapter 3 deals with the synthesis and characterization of magnetite and magnetite based nanomaterials for biomedical applications like drug delivery and antitumoral treatments. The good compatibility of these materials with other components allows the synthesis of multifunctional materials with tailored properties. The chapter 4 emphasizes on the applications of nanotechnology in the medicine field for the treatment of killer diseases like cancer, HIV and disorders like diabetes, cardiac diseases, etc. and the basic ethical issues in the development of nanomedicine. The chapter 5 comprises a discussion on synthetic biomimetic nanostructured hydroxyapatite nano and micro crystals, and compares them with natural biogenic materials. The authors argue that the high degree of miniaturization, efficiency, reliability, and adaptability of natural materials can be only partially obtained in manmade materials by the present conventional processes. Biomimeticism represents an important tool for the design and synthesis of innovative materials and devices. Biomimetic nanostructured hydroxyapatite can not only mimic biogenic materials in their functionalities, but can also be used to release drugs and bioactive molecules by a predetermined stimuli responsive kinetics. The chapter 6 discusses about multifunctional nanomedicines for cancer therapy. The successful treatment of cancer requires simultaneous detection and therapy using smart multifunctional nanomedicines. These all in one nanosystems contain targeting, imaging and therapeutic agents that can provide superior pharmacokinetic properties with maximum impact on diseased cancer cells. The chapter 7 introduces readers to a new branch of science called nanooncology where nano technology is used to find more effective and efficient methodologies to fight and cure cancer. The cancer is a chronic disease that has increased over twice in last 30 years. Nanotechnology can play a significant role in fight against cancer if some innovative technological methodologies could be designed to delineate the tumor margins, separate cancer cells from the normal, also identifying micrometastasis and determine if the tumor has completely removed. The chapter 8 presents a discussion on drug delivery applications of the magnetic nanoparticles. Magnetic nanoparticles are a major class of nanoscale materials. They have potential for diagnostic and therapeutic techniques due to their unique physical properties and ability to function at the cellular and molecular level of biological interactions. The chapter 9 highlights the various features of inorganic nanomaterials that can form building blocks for the future drug delivery systems. Inorganic nanomaterials have attracted great attention in the field of drug delivery as they offer functions for enhanced solubility of the drugs, improved targeted delivery of drugs across tight epithelial and endothelial barriers, increased bioavailability, controlled release of one or more drugs, and design of effective multi-functional therapeutic agents. The chapter 10 offers a more elaborative discussion on main biomedical applications of magnetic nanoparticles, namely, hyperthermia, drug delivery, and image contrast particularly in cancer therapy. Self controlled magnetic nanoparticles can automatize heat in tumor cells without damaging the healthy tissues. The carrying of drugs by nanoparticulates is another valuable technique in which the largest fraction of the drug interacts exclusively with the target tissue. Magnetic nanoparticles can also be used as image contrast agent to monitor the accuracy of delivering therapeutic agents. The chapter 11 focuses on experience with nanoparticles in magnetic resonance imaging (MRI) and computed tomography (CT) imaging in preclinical and clinical approaches and describes the means of their utilization in image-guided minimal-invasive procedures. Magnetic nanoparticles were introduced in diagnostic radiology around 20 years ago. They have the potential to improve image-based detection of pathological abnormalities on the anatomical, cellular and molecular level. The chapter 12 reviews bioconjugation of cytotoxic drugs with macromolecules and nanostructures for enhanced drug delivery to cancer cells. The peptides, proteins, monoclonal antibodies, and aptamers have attracted attention of researchers as drug vehicles on account of their good biological stability, biodegradability and safety. The chapter also discusses the chemistry of these conjugates and different coupling techniques cited in the literature. The chapter

13 reports on the fabrication of novel magnetic fibrin hydrogel scaffolds enriched with growth factors conjugated to fluorescent $\gamma\text{-Fe}_2\text{O}_3$ nanoparticles. The $\gamma\text{-Fe}_2\text{O}_3$ nanoparticles are of particular importance due to their high surface area to volume ratio, magnetic properties, biocompatibility, relative non-toxicity and biodegradability. These scaffolds containing the bioactive nanoparticles provide a highly efficient supporting environment for massive 3D growth and proliferation of various cells that may be useful in the future as potential therapeutic nanocomposite implants to guide tissue development for various tissue engineering applications. The chapter 14 studies the synthesis of highly stable silver nanoparticles using the aqueous extract of Lemon leaves which acts as reducing agent (Ag^+ ion to Ag^0) and encapsulating cage for the silver nanoparticles. These silver nanoparticles show good antifungal activity on cotton and silk fabric due to synergistic effect of silver and essential oil components of lemon leaves. The chapter 15 investigates the cooperative magnetophoresis behavior of silica-coated iron oxide nanoparticles and non-cooperative magnetophoresis behavior of the Sodium Dodecyl Sulfate surface modified iron oxides nanoparticles. For cooperative magnetophoresis, the effects of the electrostatic stabilizing energy on the magnetic separation times have been shown. A brief description of the samples preparation and characterization is also given. The chapter 16 examines the potential biological activities of biologically synthesized silver, silica, and zero valent iron nanoparticles. The non targeted effects of these nanoparticles on soil parameters were studied, while the plant growth parameters were analyzed with green gram (*Vigna mungo*). Bio safety study revealed that all the tested nanoparticles did not cause any toxic effect on soil parameters and on plant growth parameters of *Vigna mungo*. The chapter 17 elucidates upon nanomaterials that can specifically deliver therapeutic molecules into tumor cells, and respond to their cellular environments. The nanomaterials contain target cell-specific promoters that recognize low pH in endosomes and/or lysosomes, ligands that recognize target hyperactivated receptors, and protein kinase- or protease- specific proteins and peptides. These nanomaterials have shown better results in the efficient diagnosis and therapy of tumor cells. The chapter 18 delves into the application of inorganic nanoparticles for making new textiles with super hydrophobic outer surface and antibacterial properties especially for medical textiles. The super hydrophobicity of a material is attributed to roughness and low surface free energy, and both of them can be covered by utilizing the nanoparticles on textiles. Likewise, the silver and copper nanoparticles can be used to endow antibacterial properties on textile substrate. The chapter 19 describes the synthesis and characterization of magnetite nanoparticles, and their antimicrobial and quorum sensing inhibitory activities using experimental models for the in vitro development of bacterial and fungal biofilms. The studies suggested that the hybrid nanobiosystems have an improved antibiofilm activity, highlighting their potential for the development of efficient antibiofilm strategies. The chapter 20 provides a detailed discussion on applications of nanotechnology in textiles. Nanotechnology can impart multiple functionalities in textiles, including antimicrobial action, water- and stain-repellency, self cleaning, anti odor, ultra violet light protection, and flame proofing without impairing existing properties. The areas of application include medical textiles, protective clothing, aerospace and automotive industries, outdoor and home textiles and apparel. This volume is concentrated around biomedical applications of nanotechnology. Three applications of nanotechnology are particularly suited to biomedicine, namely diagnostic techniques, drugs, and prostheses and implants. Other issues like treatment of cancer with nanomedicines, and nanotechnology in development of antimicrobial fabrics have been addressed. We are much indebted to all contributing academicians and researchers who enthusiastically accepted our request, and made great efforts to write chapters for a wide audience. The length of these chapters varies considerably depending on the topic. Some of them have the appearance of a small book. Their authors deserve special thanks for their painstaking efforts and generosity in choosing to publish their work in this series. We also thank the referees for their hard work to ensure the high quality of the chapters. The **NANOTECHNOLOGY** is a comprehensive compilation of research and review articles that pertain to nanomaterials, from a consideration of their methods of preparation, their novel properties, and areas of their utilization. The series is believed to be of interest to engineers, scientists, and technologists in academic institutions, research laboratories, and industry. It is a befitting introduction of the subject of nanotechnology to the students as well as a mean to provide them an up-to-date review of recent innovations in the field, all in one place.



NANOTECHNOLOGY SERIES

VOL. 8: Electronics and Photovoltaics

Author: Shishir Sinha, Naveen Kumar Navani & J. N. Govil

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About the Volume

This first volume in the nanotechnology series “Fundamentals and Application” gathers and presents the principal concepts of nanotechnology and its diverse and multidisciplinary field of research and emerging applications. The initial chapter bestows us with the introduction to nanoscience and nanobiotechnology which deals with the brief history of naturally existing nanomaterial as an inspiration of nature to design engineered nanomaterials with broad-spectrum properties. Owing to its nano size, this technology has fashioned enormous products offering advantages over the conventional ones; ranging from the materials (nanofuel cells, catalyst, lubricant, aeronautics, automobiles, telecommunications, energy production, mechanics, biology, medicine, etc.); electronics and information technology (nanoelectronics, solar cell, single electron transistors, high sensitivity sensors, etc.); machines (nano engines, nano

pumps, nanopropeller, pharmaceutical processes, in space technology, defense and ships, etc.); Life Science (molecular medicine, bioprocessing, agricultural systems, medical surgery, neural surgery, ecotoxicology, molecular imaging, delivery systems, etc). Many scientists and professionals have extensively admired and got inspired by the characteristics of nanomaterials, their broad range of existing applications and future prospects for improved lifestyle. While some of them have also addressed the risk of nanomaterials being hazardous to human and environment owing to its "NANO" nature, making them highly reactive and in some cases even capable of crossing the blood brain barrier. So as it true for any new and "promising" technology; before being used for any human welfare; they should be tested for its non-target harmful effects. This can be achieved by employing risk/safety and management studies of nanomaterials. The target of this volume is to cultivate interest amongst inter disciplinary students, researchers, scientist and professional in academics not limited to the area of physics, chemistry, medicine, biology, defence, civil, energy and environment, information technology, healthcare drug discovery and electronics.

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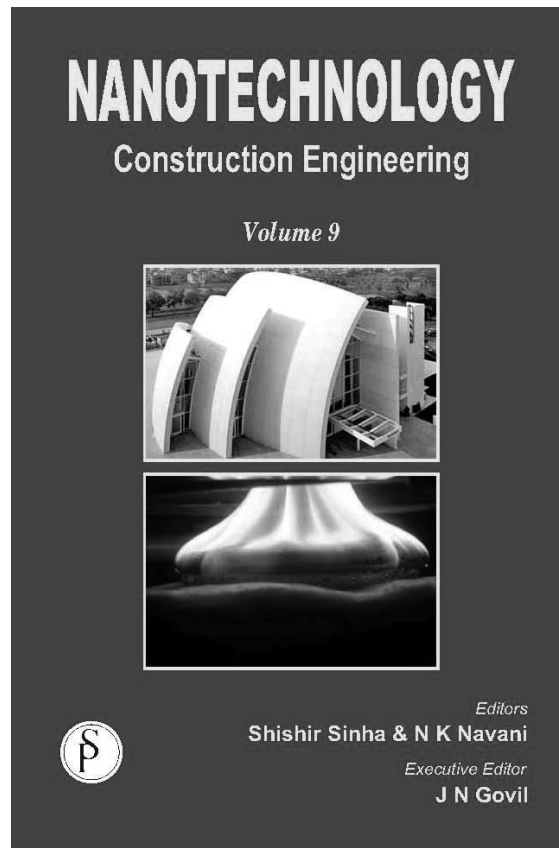
VOLUME 8: ELECTRONICS AND PHOTOVOLTAICS: 1. Changing Trends in Silicon Nanotechnology: MD. AHAMAD MOHIDDON, ANSHU AND M. GHANASHYAM KRISHNA (INDIA, ITALY); 2. Advanced Nanostructured Electrodes for Li-Ion Batteries: JUN LIU, YANLING WAN, WEI LIU, SHAOMIN JI AND YICHUN ZHOU (CHINA); 3. Nanotechnology in Photovoltaics: HARJEET SINGH (INDIA); 4. Luminescent Nanoparticles for Applications in Lighting, Display and Solar Cell Energy Harvesting: SANTA CHAWLA (INDIA); 5. Topological Insulator Nanostructures: NICHOLAS MEYER, LIHONG BAO AND FAXIAN XIU (USA); 6. Quantum Light Sources Based on Nano-Materials: CHI-TSU YUAN AND JAU TANG (TAIWAN); 7. Ultrafast Spectroscopy and Technological Application of Light Harvesting Nanomaterials: SOUMIK SARKAR, ABHINANDAN MAKHAL AND SAMIR KUMAR PAL (INDIA); 8. Applications of Various TiO₂ Nanostructures: DINESH PRATAP SINGH (REPUBLIC OF CHILE); 9. Multi-nanolayered Ohmic Metallizations for Sub-microelectronics: LILYANA KOLAKLIEVA AND ROUMEN KAKANAKOV (BULGARIA); 10. Magnetic Tunnel Junction Based Molecular Spintronics Devices: PAWAN TYAGI (USA); 11. Optical Injection Looking of Quantum-Dot Semiconductor Lasers: BASIM ABDULLATTIF GHALIB, SABRI J. AL-OBAIDI AND AMIN H. AL-KHURSAN (IRAQ); 12. Hybrid Nanocrystal/Polymer Bulk Heterojunction Photovoltaic Cells: AIWEI TANG, FENG TENG, YU WANG AND YANBING HOU (CHINA); 13. GaN-based Light-Emitting Diodes with Nanostructure: LUNG-CHIEN CHEN (TAIWAN); 14. Advanced Radial *pn* Junction Solar Cells Constructed on Silicon Nanowire Arrays: YALI LI, QIANG CHEN, DEYAN HE AND JUNSHUAI LI (CHINA, JAPAN); **Appendix-I:** *Table of Contents of Other Volumes of the Series Vols. 1 to 7 & 9 to 10;* **Subject Index:**

Preface of Volume 8: Electronics and Photovoltaics

Nanotechnology is delivering its benefits to society in every sector of human endeavour, like information technology, defence, healthcare, energy and environment, and civil/construction among many others. Nanotechnology is already around us as organic light emitting diode screens in televisions, laptops, cell phones, digital cameras; flash memory chips in iPod nanos; ultrasensitive hearing aids; antimicrobial/antibacterial coatings on mouse/keyboard/cell phone casings; conductive inks for printed electronics; more life-like video games; flexible displays for e-book readers; inexpensive high efficiency sensors; and nanostructured solar cells. This volume 8 of 12 volumes series on nanotechnology looks into the current developments, expectations for time-to-market and several future concepts for electronics and photovoltaics applications. The chapter 1 offers a discussion on synthesis of nanocrystalline silicon and their biological applications. In the first part of the chapter, the chemical vapor deposition, liquid phase condensation, metal induced crystallization, and laser induced crystallization methods of nano structured silicon synthesis have been discussed. In the next part of the chapter, the applications of silicon nanowires along with their top-down and bottom-up synthesis method are discussed. The biological applications of porous silicon in the drug delivery, cell culture and detection of analytes are discussed at the end of the chapter. The chapter 2 reviews the use of advanced nanostructured electrode materials for rechargeable Li-ion batteries, including various insertion-type, conversion-type, and alloying-type electrode materials. The major goal of the chapter is to highlight the recent progress made in use of these nanostructured materials as cathode and anode to develop high capacity Li-ion batteries with excellent cycling stability. The chapter 3 summarizes recent developments in novel properties of nanomaterials and nanostructures for using them in solar cell devices to enhance efficiency and cut overall cost. A brief introduction of basic photovoltaics (PV) is followed by growth and development of nanotech-photovoltaics, present PV market scenario, economics and future prospects, while focusing primarily on research

and developmental aspects of nanotechnology in PV. Some new concept cells such as multiple exciton generation enabled solar cells, and hot carrier solar cells have also been included. The chapter 4 describes the phenomenon of luminescence, and important parameters and processes for development of luminescent nanoparticles. Luminescent nanoparticles play important role in solid state lighting, display in plasma display panels, and efficient energy harvesting by solar cells. The chapter 5 discusses the properties of topological insulators, their potential applications, growing attention of researchers in topological insulator nanostructures, and few methods for their production and characterization. Topological insulators are materials of interest for engineering applications due to electrically insulating bulk states, and highly conducting and massless spin-helical surface states that are protected by time-reversal symmetry. The chapter 6 introduces the fundamental concepts and potential applications of semiconductor nanocrystals, usually referred as colloidal quantum dots. Quantum properties of light have great potential for achieving various promising applications in quantum optics, such as quantum cryptography and optical quantum computing. A further understanding of the basic mechanism will help in generation of high performance quantum light sources operating at room temperature that are based on low cost colloidal quantum dots. The chapter 7 investigates the key ultrafast processes in the light harvesting dynamics of Zinc Oxide (ZnO) - based nanomaterials. The light harvesting studies of the ZnO nanoparticles with Oxazine 1 in the near-infrared region of $\lambda = 550$ nm show a very high efficiency of $>90\%$ for the Förster Resonance Energy Transfer (FRET) in the nanoparticle-dye system, while the ZnO nanorods have an efficiency of only about $\sim 40\%$, much less compared to the nanoparticles. Further studies demonstrate that the overall efficiency of a ZnO nanoparticle based solar cell significantly depends on the presence of high energy photons in the solar radiation. The chapter 8 delves into various applications of Titanium dioxide (TiO_2) based nanostructures. Due to its specific semiconductive properties, TiO_2 has attracted considerable attention for a plethora of applications, such as solar cells, photocatalysis, hydrogen production, lithium ion battery, sensors, electronic devices, self-cleaning coatings, purification of water and air, etc. The chapter 9 presents a discussion on (i) Al-based multi-nanolayered metallizations with Ti and Mo barrier layers, and (ii) Al-free multi-nanolayered metallizations of GaN/AlGaIn/GaN heterostructures suitable for use as ohmic contacts in high electron mobility transistors (HEMTs). The edge termination, thermal stability, surface morphology, and ohmic properties have been discussed in view of their application in sub-micron devices. The chapter 10 focuses on the main features of magnetic tunnel junction (MTJ) based molecular spin devices from various perspectives. The development of molecular spintronics devices continues to be a big challenge. Although spintronics is already providing memory devices with gigabyte storage for the present day computers and iPod like electronics items, but spintronics devices are now being researched for the development of next generation of memory and logic devices. The chapter 11 states a model to study the effects of optical injection locking on quantum dot semiconductor lasers. Injection-locking is a very useful tool for stabilizing the laser. The proposed model recognizes between electrons and holes. It shows that electrons in the quantum dot ground state are depleted at high injection, where their contribution to dynamics is higher than that of holes. The chapter 12 comprises a discussion on hybrid nanocrystal/polymer Bulk Hetero Junction (BHJ) photovoltaic cells. Hybrid nanocrystal/polymer BHJ photovoltaic cells have attracted much attention due to their low-cost and cheap fabrication in the past few decades. In this chapter, first the general fabrication techniques and working principles of these cells are discussed. Then, their recent developments based on different types of semiconductor nanocrystals (electron acceptors) and conjugated polymers (electron donors) have been discussed followed by a future outlook for these cells. The chapter 13 reports on the progress of Gallium nitride (GaN) based light emitting diodes (LEDs) with state-of-the-art nanostructures for future applications. The chapter focuses upon various nanostructures including nano-patterned sapphire substrate (NPSS), nanoporous aluminum nitride (AlN) buffer layer, 2-D photonic crystal on the surface of the LEDs, ZnO nanorods on the surface of the LEDs, surface roughing, and GaN/ZnO coaxial nanotube heterostructure arrays. The chapter 14 gives an elaborate summary on progress of solar cells based on Silicon nanowire arrays. The chapter starts with an introduction of the optical and electrical properties of Si nanowire arrays. Then the solar cells prepared using the aforementioned two paradigms are summarized followed by a discussion on the further improvement of cell performance. The other advanced solar cells employing Si nanowire arrays are also briefly discussed. This volume takes into account the applications of nanotechnology in electronics and photovoltaics. This volume includes chapters on advanced nanostructured electrodes for Li-ion batteries, topological insulator nanostructures,

applications of various TiO₂ nanostructures, hybrid nanocrystal/polymer bulk heterojunction photovoltaic cells, and advanced radial *pn* junction solar cells constructed on silicon nanowire arrays. We are much indebted to all contributing academicians and researchers who enthusiastically accepted our request, and made great efforts to write chapters for a wide audience. The length of these chapters varies considerably depending on the topic. Some of them have the appearance of a small book. Their authors deserve special thanks for their painstaking efforts and generosity in choosing to publish their work in this series. We also thank the referees for their hard work to ensure the high quality of the chapters. The **NANOTECHNOLOGY** is a comprehensive compilation of research and review articles that pertain to nanomaterials, from a consideration of their methods of preparation, their novel properties, and areas of their utilization. The series is believed to be of interest to engineers, scientists, and technologists in academic institutions, research laboratories, and industry. It is a befitting introduction of the subject of nanotechnology to the students as well as a mean to provide them an up-to-date review of recent innovations in the field, all in one place.



NANOTECHNOLOGY SERIES

VOL. 9: Construction Engineering

Author: Shishir Sinha, Naveen Kumar Navani & J. N. Govil

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About the Volume

This first volume in the nanotechnology series “Fundamentals and Application” gathers and presents the principal concepts of nanotechnology and its diverse and multidisciplinary field of research and emerging applications. The initial chapter bestows us with the introduction to nanoscience and nanobiotechnology which deals with the brief history of naturally existing nanomaterial as an inspiration of nature to design engineered nanomaterials with broad-spectrum properties. Owing to its nano size, this technology has fashioned enormous products offering advantages over the conventional ones; ranging from the materials (nanofuel cells, catalyst, lubricant, aeronautics, automobiles, telecommunications, energy production, mechanics, biology, medicine, etc.); electronics and information technology (nanoelectronics, solar cell, single electron transistors, high sensitivity sensors, etc.); machines (nano engines, nano pumps, nanopropeller, pharmaceutical processes, in space technology, defense and ships, etc.); Life Science

(molecular medicine, bioprocessing, agricultural systems, medical surgery, neural surgery, ecotoxicology, molecular imaging, delivery systems, etc). Many scientists and professionals have extensively admired and got inspired by the characteristics of nanomaterials, their broad range of existing applications and future prospects for improved lifestyle. While some of them have also addressed the risk of nanomaterials being hazardous to human and environment owing to its “NANO” nature, making them highly reactive and in some cases even capable of crossing the blood brain barrier. So as it true for any new and “promising” technology; before being used for any human welfare; they should be tested for its non-target harmful effects. This can be achieved by employing risk/safety and management studies of nanomaterials. The target of this volume is to cultivate interest amongst inter disciplinary students, researchers, scientist and professional in academics not limited to the area of physics, chemistry, medicine, biology, defence, civil, energy and environment, information technology, healthcare drug discovery and electronics.

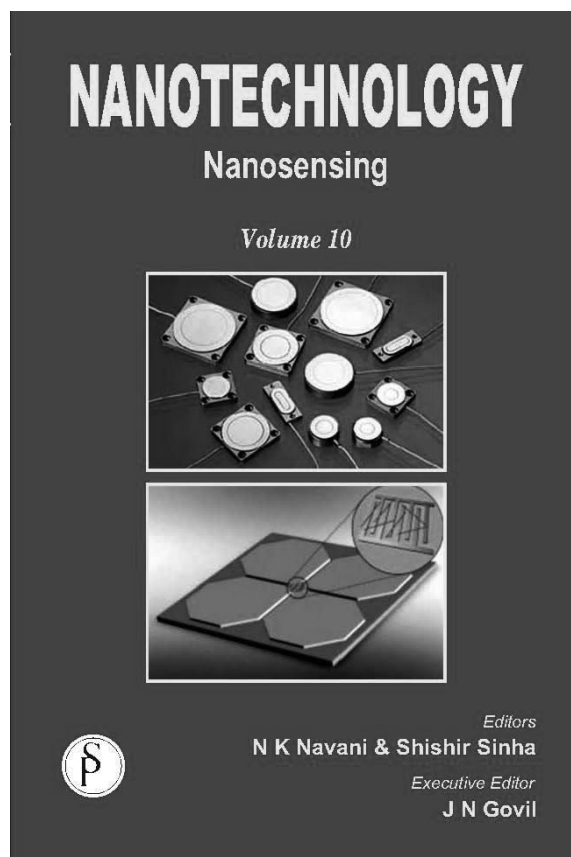
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Preface of Volume 9: Construction Engineering

Nanotechnology is delivering its benefits to society in every sector of human endeavour, like information technology, defence, healthcare, energy and environment, and civil/construction among many others. Nanotechnology is being applied in civil/construction industry mainly due to availability of the following nanotechnology based products: high mechanical strength metals and composites, wear and tear resistance composites, self cleaning glass, antimicrobial surfaces, flame retardant and scratch resistant coatings, hydrophobic and ultra violet radiation stable facade paint, thermal insulation, Li-Fe-nanophosphate battery, fuel cells, more efficient solar cells, etc. This volume 9 of 12 volumes series is devoted to applications of nanotechnology to civil and construction sector. The chapter 1 presents an overview of the development of high performance construction materials by integration of nanotechnology. Nanotechnology is likely to make possible the production of high performance materials, functional paints and coatings, heat-insulating self-cleaning antifogging windows, and high-resolution sensing devices for construction industry as a mean to improve the quality of our life. The chapter 2 focuses on the revolutionary changes that nanotechnology might bring to the construction world by improved strength and durability of the concrete, anticorrosive materials, architectural paints, scratch proof coatings, insulation coatings, ultra violet rays protective windows, etc. The author, however, argues for setting of ethical set of guidelines to insure that the nanotechnology is not used to invade the privacy of inmates by way of sensors, variable transparency of interior partitions, or other developed products. The chapter 3 analyzes the role of nanotechnology in construction sector from the perspective of improved energy efficiency, sustainability and adaptability to changing environment. The present energy situation warrants the adoption of low energy production processes and use of energy efficient advanced materials in construction sector. Such a situation can be greatly met by using nanostructured concrete and cement, multifunctional coatings, phase change and self healing materials, sensors for

structural health monitoring, nano modified steel, self cleaning glass and ceramics, etc. The chapter 4 elucidates upon different sustainable materials that could be used in the design of energy efficient **green building** for fire protection, waste-water treatment, rainwater harvesting, sludge treatment, day lighting, electrical lighting, etc. The cost of a green building is necessarily greater than the conventional building, but it can not be overlooked owing to benefits of reduced operating and maintenance bills, energy usages, and prolonged life period. The chapter 5 briefly reviews various synthesis techniques for ceramic nanopowders and their advantages and disadvantages. General discussion is supported with the specific examples derived from author's own research and the research work carried out in various laboratories worldwide. The chapter 6 highlights the most recent studies carried out on the influence of layered nanoparticles, particularly the silicate nanoclays and layered double hydroxides, on the mechanical and flame retardancy properties of polymer foams, with the final goal of developing multifunctional lightweight materials with improved properties for applications in sectors such as construction or automotive. The chapter 7 provides a general overview of micro-electro-mechanical systems (MEMS) and its potential applications for real-time structural health monitoring of civil and transportation infrastructure systems. The focus is on the applications such as bridge, pavement, and traffic engineering. Both technological and theoretical issues are discussed. The chapter 8 introduces research on the nanotip-induced ultrahigh pressure-sensitive cement-based composites/sensors, with attention on fabrication of the composites, measurement of pressure sensitivity of the composites, origin of pressure-sensitivity of the composites, effect of filler content level and particle size on pressure-sensitivity of the composites, pressure-sensitive characteristic model of the composites, performance of the sensors and application of the sensors in vehicle detection. Future challenges in the development and applications have also been discussed. The chapter 9 evaluates both the positive and negative aspects of applying nanotechnology within concrete materials and structures. The chapter begins with information on current applications of nanotechnology enabled products within the construction industry, followed by a summary of recent research and review articles related to the application of nanomaterials in concrete technology. The subsequent sections present an overview of the potential environmental impacts of nanotechnologies in terms of the release of particulate pollutants, including nanoparticles, during the construction, demolition and refurbishment activities. The chapter 10 investigates into nano-structured ceramic and glass surfaces as a low-cost, environment friendly and sustainable technology to achieve the "zero polluting standard" target for indoor/outdoor air and water quality. The results indicate that functional substrates based on TiO₂, doped TiO₂ and silver nanostructures could have interesting industrial application in building materials for de-pollution of indoor and outdoor environment and pollutants in water/wastewater. The chapter 11 looks into various parameters that control blast-induced damage and overbreak. In dimension stone blasting, the development of cracks in *insitu* or splitted rock mass deteriorates the economic value of dimension stone and raises the cost of operation and wastes. The controlled blasting technique increases cost of operation by two to five folds by increasing the amount of specialized drilling and explosive quality. But this technique is more acceptable as it causes minimum damage and overbreak and produce well fragmented rock mass and leave a stable highwall or foot-wall for subsequent operation. This volume incorporates chapters on role of nanotechnology in civil/construction industry. The chapters in this volume discusses the issues like fundamental changes brought in construction world by the use of nanotechnology, sustainable materials for energy efficient building design, synthesis of ceramic nanoparticle, application of layered nanoparticles in the micromechanical reinforcement and flame retardancy of polymer foams, and smart nanosurfaces in ceramic and glass for de-pollution of indoor and outdoor environment. We are much indebted to all contributing academicians and researchers who enthusiastically accepted our request, and made great efforts to write chapters for a wide audience. The length of these chapters varies considerably depending on the topic. Some of them have the appearance of a small book. Their authors deserve special thanks for their painstaking efforts and generosity in choosing to publish their work in this series. We also thank the referees for their hard work to ensure the high quality of the chapters. 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NANOTECHNOLOGY SERIES

VOL. 10: Nanosensing

Author: Naveen Kumar Navani, Shishir Sinha & J.N. Govil

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This first volume in the nanotechnology series “Fundamentals and Application” gathers and presents the principal concepts of nanotechnology and its diverse and multidisciplinary field of research and emerging applications. The initial chapter bestows us with the introduction to nanoscience and nanobiotechnology which deals with the brief history of naturally existing nanomaterial as an inspiration of nature to design engineered nanomaterials with broad-spectrum properties. Owing to its nano size, this technology has fashioned enormous products offering advantages over the conventional ones; ranging from the materials (nanofuel cells, catalyst, lubricant, aeronautics, automobiles, telecommunications, energy production, mechanics, biology, medicine, etc.); electronics and information technology (nanoelectronics, solar cell, single electron transistors, high sensitivity sensors, etc.); machines (nano engines, nano pumps, nanopropeller, pharmaceutical processes, in space technology, defense and ships, etc.); Life Science (molecular medicine, bioprocessing, agricultural systems, medical surgery, neural surgery, ecotoxicology, molecular

imaging, delivery systems, etc). Many scientists and professionals have extensively admired and got inspired by the characteristics of nanomaterials, their broad range of existing applications and future prospects for improved lifestyle. While some of them have also addressed the risk of nanomaterials being hazardous to human and environment owing to its “NANO” nature, making them highly reactive and in some cases even capable of crossing the blood brain barrier. So as it true for any new and “promising” technology; before being used for any human welfare; they should be tested for its non-target harmful effects. This can be achieved by employing risk/safety and management studies of nanomaterials. The target of this volume is to cultivate interest amongst inter disciplinary students, researchers, scientist and professional in academics not limited to the area of physics, chemistry, medicine, biology, defence, civil, energy and environment, information technology, healthcare drug discovery and electronics.

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Preface of Volume 10: Nanosensing

Nanotechnology is delivering its benefits to society in every sector of human endeavour, like information technology, defence, healthcare, energy and environment, and civil/construction among many others. The scale of nanotechnology could well mean the development of nanosensors and other devices capable of providing cost effective continuous structural monitoring of the bridges, tunnels, rails, parking structures, and pavements; identification of harmful chemical or biological agents in the air and soil with higher sensitivity, an enhanced transportation infrastructure that can help drivers maintain lane position, avoid collisions, adjust travel routes to avoid congestion; early detection of diseases in healthcare; detection of radioactive materials or toxins like anthrax in the field of national security; and monitoring of the physical and mental condition of a soldier in combat area by providing health information, like heart rate and its variability, activity level and body temperature, respiration rate, blood pressure, and hydration level, etc. This volume 10 of 12 volumes series provides a set of fifteen articles on nanosensors for a wide array of applications ranging from daily life to battle field. The chapter 1 contains a brief review on the mechanism of one-dimensional nanostructure based chemiresistor sensors. A chemiresistor sensor is an electronic device whose operation relies on at least one of the physical and chemical properties arising due to nanoscale dimensions of the material. These nanosensors have a number of salient characteristics that set them apart from other sensing devices. The chapter 2 presents author’s research work on the synthesis of semiconductor nanomaterials based chemical sensors and their application for the detection of toxic chemicals in solution phase. Here, low dimension iron oxide nanoparticles were synthesized by solvo-thermal method in alkaline medium and

applied as chemical sensors for the detection of chloroform in solution phase using simple and reliable I-V techniques. The analytical performances of the proposed sensor using low dimensional β -Fe₂O₃ nanoparticles film was excellent in terms of sensitivity, lower detection limit, large linear dynamic ranges, short response time, and reproducibility. The chapter 3 reviews the recent developments on aptamer nanostructures as signaling molecular switches for biosensor applications. The hairpin-structured electrochemical molecular beacons containing an aptamer sequence are the simplest form of target-induced signaling probe and have the greater acceptance for their use as “smart” molecular switches. The chapter 4 summarizes the exploitation of nanoparticles for the development of sensors to detect xenobiotics, environmental pollutants such as heavy metals, pesticides and other small molecules of significance to environment and human health. Nanoparticles, specifically gold, silver, and quantum dots possess several distinctive physical and chemical attributes that make them promising synthetic scaffolds particularly for sensing applications. The chapter 5 first discusses all available technologies from old conventional plating method to modern aptamer and nanotechnology based bacterial approaches for detection of microbial contamination in food and water. The chapter then focuses on an aptamer-gold nanoparticles based rapid, colorimetric detection system capable of detecting bacteria in both qualitative and quantitative fashion. This method can complement the existing technology and give a new dimension to the field of bacterial detection. The chapter 6 reports on the impacts of oligonucleotide (ON) aptamers in bio-sensing and targeting approaches. Owing to their high affinity towards a wide range of ligands with a simple chemistry and easy process, ON aptamers are considered as suitable probe for targeting and detection of a wide variety of substances, such as chemicals, drugs, amino acids, toxins, pathogens, biomarkers, etc. making them a promising tool for diagnosis and treatment of various diseases. The chapter 7 is devoted to Deoxyribonucleic acid (DNA) based bionanocatalysts. DNA-based bionanocatalysts are of intense interest in materials science because of the unique properties of DNA coupled with the novel properties of nanomaterials to produce systems with unprecedented control over their properties. In this article, the very first examples of DNA/enzyme/inorganic hybrid bionanocatalysts are discussed from author’s own research findings. The chapter 8 studies the nanocluster synthesis using the inert gas condensation technique. The effect of the different synthesis parameters that control the size and number of produced nanoclusters are discussed in details. Recent progress in nanocluster utilization in the gas sensor applications is summarized, with focus on palladium nanoclusters as sensing elements. The chapter 9 comprises discussion on some important metal nanoparticles used in amperometric biosensors. Metal nanoparticles are employed for developing amperometric and electrochemical sensors based on molecular/polymer functionalized nanoparticles sensing interfaces, and for the construction of different biosensors. The chapter 10 highlights recent and important progress in the field of humidity sensors based on nano-hybrid materials. The transformation of hybrid composite dimensions in nano-metric-size level display great improvements in their properties, such as humidity sensing, small hysteresis, lower impedance, linearity, etc. The chapter 11 analyzes that charge transfer associated with chemisorption leads to an increase in the nanowire depletion layer width, thereby decreasing surface conductivity and forming the basis of molecular sensing capability of the nanowires. Based on these studies, a novel sensor capable of detecting ¹³⁷Cs γ -radiation using SnO₂ nanowires is fabricated, thus fulfilling the need for an inexpensive and uncooled nuclear sensor. The chapter 12 gives a brief review of recent experimental and theoretical work on the graphene and carbon nanotube quantum dot sensors of the THz waves. The graphene and carbon nanotube based THz detectors show a strong potential for variety of applications including defense, security, nanoelectronics, chemistry, industry, and medicine. The chapter 13 examines that, although, persistent organic pollutants such as PentaChlorinated Biphenyl (PCB) are difficult to detect at trace amount, they can be detected and recognized rapidly via the Surface-enhanced Raman Scattering (SERS) technique. Ag nano-structured SERS substrates prepared by the glancing angle deposition method are excellent at detection and their sensitivity can be further improved by tuning the thin under layer films. These studies provide a potential method for detection of several other organic pollutants at trace level via silver nanostructure. The chapter 14 describes the biosynthesis of silica nanoparticles and their biological applications in different systems. Biological methods of synthesis of nanoparticles using microorganism, enzymes, and plants or plant extracts have been suggested as possible ecofriendly alternatives to chemical and physical methods. The biologically activated silica nanoparticles have wide applications in clinical diagnostics, food quality control, and drug delivery systems. The chapter 15 provides a feasibility study to test the suitability of near infra-red (NIR)

fluorescent HSA nanoparticles for optical detection of colonic cancer. The main advantage of these particles is their fluorescence in the NIR region of the electromagnetic spectrum, allowing in vivo imaging with low tissue absorbance, increased tissue penetration and low auto fluorescence of bodily tissues, which allows for early specific detection of neoplasms in the gastrointestinal tract. This volume refers to the use of nanotechnology for the development of nanoscale sensors and devices. These devices may be used for various medicinal purposes, for cost effective monitoring of public systems, and to build other nanoproducts such as computer chips. This volume includes chapters on nanostructure based chemical sensors and their applications, aptasensors for specific sensing and detection, gas sensors, humidity nano sensors, detection of organic pollutants via nanostructures. We are much indebted to all contributing academicians and researchers who enthusiastically accepted our request, and made great efforts to write chapters for a wide audience. The length of these chapters varies considerably depending on the topic. Some of them have the appearance of a small book. Their authors deserve special thanks for their painstaking efforts and generosity in choosing to publish their work in this series. We also thank the referees for their hard work to ensure the high quality of the chapters. The **NANOTECHNOLOGY** is a comprehensive compilation of research and review articles that pertain to nanomaterials, from a consideration of their methods of preparation, their novel properties, and areas of their utilization. The series is believed to be of interest to engineers, scientists, and technologists in academic institutions, research laboratories, and industry. It is a befitting introduction of the subject of nanotechnology to the students as well as a mean to provide them an up-to-date review of recent innovations in the field, all in one place.