

Preface

Technology of making small structures has developed greatly over the last few years from simpler methods for the fabrication of simple structures to the much advanced technologies to design complex devices within the nanoscale dimensions. Due to their peculiar and fascinating properties, as well as applications superior to their bulk counterparts, the nanomaterials have received a lot of interest. To keep pace with modern science and technology, the ability to produce nanomaterials is essential when fabricating new types of nanostructures or reducing the size of the existing microstructures into nanoscale regime. Microelectronics is the most successful example, where “smaller” means greater performance. The direct application of nanotechnology in integrated circuits is in the form of more components per chip, which results in lower cost, faster operation and less power consumption. Miniaturization has become a trend for other developing technologies also. In the area of data storage, there are many efforts to develop magnetic and optical storage components with critical dimensions as small as tens of nanometres. It is also well known that a new phenomenon is associated with nanometre-sized structures, which includes size-dependent excitation of the quantum dot structures and quantization of conductance in the metal contacts. The optical, electrical, magnetic and thermoelectric properties of nanomaterials have been explained with the help of quantum confinement effect. The fabrication of large quantities of nanomaterials from a diversified range of materials at reasonably low cost is desirable for the exploration and development of new technologies.

Since nanomaterials possess unique chemical, physical and mechanical properties, they can be used for a wide variety of applications. These applications include next-generation computer chips, battery insulation materials, phosphors for high-definition TV, low-cost flat-panel displays, tougher and harder cutting tools, elimination of pollutants, high-energy-density batteries, high-power magnets, high-sensitivity sensors, information and communication and medical sciences.

For devices and systems, the present focus of the microelectronics industry is miniaturization, which requires that the circuits, such as transistors, resistors and capacitors, are reduced in size. By achieving a significant reduction in their size, the microprocessors, which contain these components, can run much faster, thereby

enabling computations at far greater speeds. Sol-gel synthesis of nanomaterials results in foam-like structures called aerogels, which are porous and extremely lightweight. Due to the porosity in these nanomaterials, air is trapped at the interstices, providing good insulation. These aerogels are currently being used for insulation in offices, homes, etc. The resolution of a television, or a monitor, depends largely on the size of the pixel. With the reduction in the size of the pixel or the phosphors, the resolution improves dramatically. Nanocrystalline zinc selenide, zinc sulphide, cadmium sulphide, lead telluride and nanophosphors are best materials for improving the resolution of monitors. The use of these nanomaterials is expected to provide the low-cost high-definition televisions (HDTVs) and personal computers. Cutting tools made of nanocrystalline materials, such as tungsten carbide, tantalum carbide and titanium carbide, are much harder, much more wear-resistant, erosion-resistant and last longer than their conventional (large-grained) counterparts. All applications that require electric power use conventional and rechargeable batteries. The energy density (storage capacity) of these batteries is quite low requiring frequent recharging. The life of conventional and rechargeable batteries is also low. Nanocrystalline materials are candidates for separator plates in batteries because of their foam-like (aerogel) structure, which can hold considerably more energy than their conventional counterparts. The coatings of nanomaterials (nanocoating) may be envisioned to have resistance for the attack of pollutants or have self-cleaning properties. There are wide applications of nanomaterials in medical sciences, which include new diagnostic tools; imaging agents and methods; drug delivery systems and pharmaceuticals; therapies; implants and tissue-engineered constructs.

This book presents the latest advancements in nanomaterials with their applications, thereby providing an overview of the current status of this rapidly developing field. This book includes fourteen chapters authored by the experts in nanotechnology. Chapter 1 presents a review of the research work reported on the synthesis and characterization of nanodiamond with future applications. This chapter presents all the major techniques used for the synthesis of nanodiamond particles as well as thin films. Due to its excellent mechanical and optical properties, high surface area, non-toxicity and tenability of its surface structure, nanodiamond has been widely used in various applications. Some interesting applications of nanodiamond, especially the recent ones, have also been included in this chapter. Chapter 2 presents the review on potential two-dimensional material, i.e. carbon nanowalls for field emission and energy-related applications. The growth of CNWs by various methods is discussed in this chapter with an emphasis on plasma-enhanced chemical vapour deposition (PECVD) method. In addition, potential applications of CNWs such as field emitters and energy application including CNWs as negative electrode in lithium-ion batteries, as catalytic supports in fuel cells and solar cells, etc., have also been reviewed in the light of their unique morphology and structure. Chapter 3 highlights the role of nanostructured materials towards remediation of heavy metals/metalloids. This chapter provides a wide-spread analysis on the enduring research and progress activities in the field of remediation of toxic heavy metals/metalloids from contaminated water by using

nanomaterials in order to achieve environmental detoxification, using adsorption process. It also includes the discussion on the essential aspects of heavy metals' problems on environment and their effects on human health through polluted water. Chapter 4 presents the recent trends in the processing and applications of carbon nanotubes and C-MEMS-based carbon nanowires. This chapter includes a review of the processing of carbon nanotubes from the first reported work to the present and covers a myriad of CNT applications. For CNT processing, the three most used techniques, i.e. arc discharge, laser ablation and chemical vapour deposition for both multiwall and single-wall CNTs, are detailed. It is understood that these fabrication techniques often need to be adapted to serve a specific application. The processing techniques for CNT application in gas sensors, biosensors, optical sensors, supercapacitors, micro-/nanoelectronics and in nanoelectromechanical systems have been analysed and discussed in this chapter. Since the poor adhesion between CNTs and substrates often limits their application, a survey the work of researchers who developed surface modification techniques has also been reviewed. Chapter 5 presents an overview of the use of metal nanoparticles for glucose sensors. The most recent as well as conventional fabrication methods are discussed in detail. The linearity range and limit of detection of the glucose sensors are described in detail to justify the fabrication process. The chapter will also provide in-depth review of metal nanoparticles-based glucose sensors which would be beneficial to all researchers, scientists, engineers and students who are in direct contact of developing and using glucose sensors. Chapter 6 is focused on the applications of nanomaterials in civil engineering. In this chapter, the potential use of carbon nanotubes, SiO_2 , TiO_2 , Fe_2O_3 , CuO , ZrO_2 , ZnO_2 , Al_2O_3 , CaCO_3 , Cr_2O_3 and Ag nanoparticles in the construction industry has been explored. The authors have also included some preliminary results on the corrosion behaviour of graphene and nano- TiO_2 -incorporated steel-reinforced cementitious composite.

Chapter 7 focuses on design, development and application of nanocoatings. This chapter discusses the various processing techniques for nanocoatings along with the effect of nanocoatings on structural, mechanical and corrosion behaviour. It is expected that this chapter will provide a better understanding about the designing and developing of nanocoatings for wide industrial applications. Chapter 8 focuses on overview of solid biopolymer electrolytes-based battery and dye-sensitized solar cell. It includes the application of biopolymer electrolytes in battery and dye-sensitized solar cell (DSSC) area. Chapter 9 presents an overview of electronic behaviour of nanocrystalline silicon thin film transistors. The authors have provided a physical insight into the nc-Si TFT device characteristics and device non-idealities which may be an important step for the production of high-performance large area display devices. A review on molecular electronics has been included in Chap. 10. It includes the importance and challenges in molecular electronics. The important fabrication techniques for molecular electronics have also been touched in this review. Chapter 11 presents a review on light-emitting diodes (LEDs). The present chapter deals with introduction and working of both inorganic and organic LEDs. The emphasis has been given on organic LEDs. The present state of the art has been given in detail since its inception. Starting from basic single layer, single colour

OLEDs to present day multilayer, colour tunable OLEDs, author has elaborately discussed the development in the field of OLEDs. The fabrication, relevant characterization techniques and analysis have also been included. Chapter 12 focuses on quantum dot-sensitized solar cells (QDSSCs). It includes the basic strategies of enhanced photovoltaic characteristics that depend on factors like suppressed charge carrier recombination at the interfaces, improved photon absorption and construction of tandem structures. The prevalent challenges which have to overcome in order to develop efficient functioning QDSSC are also discussed in this chapter. Chapter 12 is aimed at understanding the haematological complications and rouleaux formation of blood components (leucocytes and platelet cells) and parameters. It provides detailed and depth knowledge about the haematological complications and rouleaux formation of blood components (leucocytes and platelet cells) and parameters. The purpose of this chapter is to determine the changes in three parameters i.e. cells count, shape of cells and size of cells, prior and after addition of three analytes i.e. sugar, sodium chloride and pure water, for varying concentration of these analytes admixed in blood.

New Delhi, India

Zishan Husain Khan

<http://www.springer.com/978-981-10-6213-1>

Nanomaterials and Their Applications

Khan, Z.H. (Ed.)

2018, XIII, 321 p. 195 illus., 110 illus. in color.,

Hardcover

ISBN: 978-981-10-6213-1