Preface

Evolution is an ongoing process that replaces what is existing gradually with something better. With the rapid development in the field of nanomaterials, it would not be wrong if we call this time of rapid evolution, the Nano Era. Nanomaterials are one of the most significant research areas to emerge in the past decade or so. It is an interdisciplinary field that draws on knowledge and expertise and covers a vast and diverse array of devices derived from engineering, physics, chemistry, and biology. As the research on nanomaterials matures, an increasing number of applications become commercially viable. Numerous approaches have been utilized in successfully developing different types of nanomaterials, and it is expected that with advancement of technology, new approaches may also emerge. The approaches employed thus far have generally been dictated by the technology available and the background experience of the researchers involved. It is a truly multidisciplinary field involving chemistry, physics, biology, engineering, electronics, and social sciences, which need to be integrated together in order to generate the next level of development in nanomaterials research. The "top-down" approach involves fabrication of nanomaterials via monolithic processing on the nanoscale and has been used with spectacular success in the semiconductor devices used in consumer electronics. The "bottom-up" approach involves the fabrication of nanomaterials via systematic assembly of atoms, molecules, or other basic units of matter. This is the approach nature uses to repair cells, tissues, and organ systems in living things and indeed for life processes such as protein synthesis. Tools are evolving which will give scientists more control over the synthesis and characterization of novel nanostructures yielding a range of new products in the near future. There are many applications of nanomaterials which are still in the realm of scientific fiction and will be made possible in the near future. Every day, the research on nanomaterials is enriched with new innovations/discoveries and scientists are putting serious efforts in bringing out more advancement to this research field.

This book includes some of the latest advancements and applications in the field of nanomaterials. It provides an overview of the present status of this rapidly developing field. The book includes twelve chapters authored by the experts in the field of nanomaterials and applications. Chapter 1 is an introductory chapter and presents an introduction of nanomaterials. It presents an overview of nanomaterials, their classification, different methods of synthesis of nanomaterials, and potential applications. Chapter 2 shows the significant progress made in the field of carbon nanomaterials specifically carbon nanotubes (CNTs). This chapter summarizes various fabrication techniques, characterization, and potential applications of carbon nanomaterials. It includes various methods to fabricate CNT fibers or yarns via spinning from CNT solutions, spinning from vertically aligned CNT arrays on substrates, direct spinning from CNT aerogels synthesized in chemical vapor deposition (CVD) chambers, spinning from cotton-like precursors, spinning with dielectrophoresis and rolling from CNT films/sheets. The chapter also provides the difference among thin films composed of free standing CNTs of different thicknesses known as membranes, sheets, buckypapers or papers. It also presents a brief discussion about 3D nanomaterials based on CNTs that include bulks, foams, and gels.

Chapter 3 summarizes the significant development in theoretical and experimental study of doped graphenes. The chapter discusses various doping methods, doping levels, heteroatom sources, chemical bond structures between heteroatom and graphene, their synthesis by several techniques such as thermal CVD, arc discharge approach, graphite oxide post-treatment, and plasma treatment synthesis. It also includes important properties such as electrical stability, quality of doped material, and technological applications.

Chapter 4 discusses the effect of varying size from chalcogenides to nanoscale chalcogenides, i.e., nanochalcogenides on physical properties of chalcogenides. It presents a brief discussion of methods for preparation of chalcogenide thin films via physical vapor condensation, sputtering, pulsed laser deposition, and chemical vapor deposition. Various models such as CFO model and Davis–Mott model for describing the electrical properties of nanochalcogenides have been discussed briefly in this chapter. It also includes the optical and thermal properties of nanochalcogenides. The applications of chalcogenides in memories based on phase change and electrical switching has also been discussed in detail in this chapter.

Chapter 5 presents a review on metal oxide nanostructures, their growth, and applications. The chapter includes the introduction of metal oxide nanostructures with chemical growth process CVD technique. The growth of indium oxide nanostructures with effect of ambient conditions such as tunable growth of nanowires, nanotubes, and octahedrons, effect of time, pressure, gas flow dynamics has been discussed in this chapter. This chapter also includes the growth of 3-D indium zinc oxide and gallium oxide nanostructures. Finally, the applications of metal oxide nanostructures such as environmental sensors and photodetector have been discussed in detail at the end of this chapter.

Chapter 6 gives an overview on metal matrix nanocomposites and their applications in corrosion control. The chapter includes the introduction of nanocomposites, its various types such as CMNCs, MMNCs, and PMNSCs. Solid- and liquid-state methods for synthesizing routes for fabrication of nanocomposites have been described in this chapter. This chapter also discusses major application of nanocomposites mainly corrosion and its various forms, mechanism, calculation, and control of corrosion.

Chapter 7 describes the process of diamond nanogrinding. The chapter includes the principle of the process of nanogrinding using coated piezoelectric materials. The chapter also discusses about the bonds in porous tools engineered to minimize abrasive grain loss and the ways to process the vitrified bonding bridges using a laser to form extremely sharp nanoscale cutting wedges.

Chapter 8 presents the epitaxial growth of GaN layer by using laser molecular beam epitaxy technique. It includes the structural and optical properties of the epitaxial GaN layers by using HRXRD, AFM, FTRAMAN, SIMS, and Pl spectroscopy techniques.

Chapter 9 presents a review on aperiodic SiNWs array fabrication by silver-assisted wet chemical etching method. The chapter includes the light trapping properties of aperiodic SiNWs array and PV applications with emphasis on SiNWs array-based solar cells. This chapter also discusses the challenges in use of SiNWs arrays in PV devices and its future perspective.

Chapter 10 presents the recent trends in gelatin nanoparticles (GNPs) and its biomedical applications. It includes chemical structure, methods used to synthesize GNPs and the characterization of these GNPs by SEM, AFM, and HRTEM. The use of GNPs for target delivery of drug and gene for a range of diseases such as cancer, malaria, and infectious diseases has also been included in this chapter. It also discusses ocular, pulmonary drugs delivery as well as nutraceutical, proteins, peptides delivery and their application in tissue engineering.

Chapter 11 presents the studies on graphene and its application in drug delivery. The chapter gives a brief introduction of method of synthesis and functionalization of graphene and deals with the applications of graphene in medicine and biomedical.

Chapter 12 describes the optical coherence tomography (OCT) as glucose sensor in blood. The chapter includes basic principle of OCTs and application of OCT for glucose monitoring. This chapter describes the use of OCT technique for measuring glucose in liquid phantoms, whole blood (in vitro *and* in vivo) based on temporal dynamics of light scattering.

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