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Book Review

Nanomaterials: a guide to fabrication and applications

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The present book is a comprehensive scientific monograph belonging to a rapidly developing area of nanotechnology comprising the research activities on the fabrication and the applications of a rich variety of nanomaterials. It contains 11 chapters.

Chapter 1 with the title 'Top-down meets bottom-up for nanoscale CMOS and MEMS' was written by Arindam Kushagra, Sampath Sutti and V Ramgopal Rao. The content of this chapter is the presentation on the role of self-assembled monolayers (SAMs) in fabricating electronic devices and the role of nanowires grown on microelectromechanical system devices, especially zinc oxide (ZnO) nanowires on cantilevers, and using them for various sensing purpose. It is divided into the following sections:

1. SAMs of Porphyrins
2. Copper Interconnect and Low-k Dielectrics
3. Metal Gate Technologies-Work Function Tuning Requirements
4. Unipolar Graphene Oxide FETs
5. Incorporation of Nanowires in Microelectromechanical System Devices for Sensing Applications

Chapter 2 with the title 'Synthesis and Assembly of Inorganic and Inorganic–Organic Hybrid Nanomaterials by Microreactor-Assisted Chemical Processes' was written by Ki-Joong Kim, Chang-Ho Choi, Seung-Yeol Han and Chih-Hung Chang. The content of this chapter is the presentation on the recent development of microreactor-assisted chemical processes for controlled synthesis and assembly of inorganic and inorganic-organic hybrid nanomaterials, including single-phase nanoparticles (NPs) of unary, binary and ternary materials; core-shell nanoparticles; assembly of nanoparticles, and the deposition of nano- and microstructured thin films. Some of the advantages (or issues) compared to batch chemical reactors are also discussed, along with opportunities for large-scale applications. It is divided into the following sections:

1. Introduction
2. Synthesis of Colloidal NPs
3. Self-Assembly of Nanostructures
4. Fabrication of Metal-Organic Frameworks by Continuous Flow Microreactors
5. Deposition of Nanostructured Thin Films by Continuous Flow Microreactors
6. Conclusion and Outlook

Chapter 3 with the title 'Studying Biologically Templated Materials with Atomic Force Microscopy' was written by Andrew J Lee and Christoph Walti. The content of this chapter is the presentation on the underlying mechanics of the atomic force microscopy (AFM) and the utilization of the direct interaction with the physical probe to extract meaningful topographical and mechanical quantities from biological components and bionanomaterials. This back ground theory is related directly to the ascertainable spatial resolutions, providing insight to systems such as the spatical addressing of DNA nano-architectures with the *Escherichia coli* protein recombinase A (RecA). More recent developments, enabling

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exquisite force sensitivity and improved spatiotemporal resolutions, are discussed and examined in relation to nano-mechanical characterization and real-time observations of biological interactions. Finally, the characteristics of the AFM are related to the direct construction of nano-materials, highlighting the AFM as a versatile nano-manipulator. This chapter divided into the following 7 sections:

1. Introduction
2. Atomic Force Microscope
3. Spatial Resolution
4. Sensing and Controlling Forces
5. Temporal Resolution
6. Direct Manipulation and Construction
7. Conclusions and Perspectives

Chapter 4 with the title 'Environmental Fate and Effects of Nanomaterials in Aquatic Freshwater Environment' was written by Arno C Gutlev, Sébastiene Cambier, Teresa Fernandes, Anastasia Georgantzopoulou, Thomas A J Kuhlbusch, Iseult Lynch, Aibhe Macken, Kahina Mehennaoui, Ruth Moellner, Carmen Nickel, W Peijnenburg and Tomasso Serchi. The potential toxicity of nanomaterials (NMs) is of high societal and scientific interest at present time. The dose reaching a cell or an organism needs thorough evaluation, and the exact localization of NMs is of equally high importance. Both depend on the interaction of NMs with biological molecules that adhere to their surface and alter behaviour, dissolution of ions, uptake and localization. In this chapter the current state of specific quantitative structure-activity relationships for NMs and of grouping of such materials is presented. It contains the following 13 sections:

1. Introduction
2. NPs Entering the Environment and Their Agglomeration and Fate
3. Nanobio Interaction-Nanoenvironmental Interaction
4. Toxicity Testing in Freshwater Species
5. Concentration-Response Curve and Problem of Dosing
6. Ion versus Particle Forms of a Chemical
7. Tissue Distribution, Concentration and Localization
8. Trojan Horse Concept and Legacy Compounds
9. Lack of QSAR Models
10. Grouping
11. Control Materials
12. Regulatory Aspects of NMs
13. Research Needs

Chapter 5 with the title 'Magnetron-Sputtered Hard Nanostructured TiAlN Coatings Strategic Approach toward Potential Improvement' was written by Vishal Khetan, Nathalie Valle, Marie Paule Deplanke and Patrick Choquet. Magnetron sputtered hard nanostructured TiAlN has gained high importance in the field of protective tribological coating. There are several strategies which have been used to improve these coatings in terms of higher oxidation resistance, higher fracture toughness, or better tribological behavious at high temperatures. Most significant among them are adjustment of process parameters during deposition and addition of new elements. This chapter focuses on elaborating of the strategies which would aid in further development of these coatings keeping magnetron sputtering as a technique of choice for their deposition. It contains the following sections:

1. Introduction
2. Ternary Nitrides: TiAlN Coatings
   2.1. Structure
   2.2. Hardness and Elastic Modulus
   2.3. Oxidation Resistance
   2.4. Tribological Properties
3. Influence of Addition of Elements
   3.1. Microstructural Evaluation
   3.2. Oxidation and Tribological Behaviour
4. Summary

Chapter 6 with the title 'Functional Nanoceramics: A Brief Review on Structure Properties Evolutions of Advanced Functional Ceramics Processed Using Microwave and Conventional Technique' was written by Santiranjan Shannigrahi and Mohit Sharma. In modern times, human life is heavily relying on various smart materials and system which can be considered as derivatives of nanomaterials and nanotechnology. A smart material is one that reacts to a change in its environment because of its intrinsic nature and not because of external electronics. Functional materials are considered as a group of smart materials that are distinctly different from structural materials. The physical and chemical properties of functional materials are sensitive to a variety of changes in the environment, such as temperature, pressure, electric field, magnetic field, optical wavelength, adsorbed gas molecules and the pH value. These materials utilize their intrinsic properties to perform intelligent action. This Chapter is a review on related functional materials and consists of the following four sections:

1. Introduction
2. Smart Materials
3. Smart Fluids
4. Smart Ceramics

Chapter 7 with the title 'Design of Magnetic Semiconductors in Silicon' was written by Michal Shaughnessy, Liam Damewood and Ching-Yao Fong. In this chapter the authors present a review of theoretical progress in understanding magnetism in silicon by doping transition metal elements. It contains the following five sections:

1. Introduction
2. Features of the Diamond Structure on the Electronic States of a TM Dopant
3. Mn-Doped Si
4. Mn_xSi_{1-x}
5. Summary

Chapter 8 with the title 'Solution-Based Fabrication of Carbon Nanotube Thin-Film Logic Gate' was written by Yan Duan, Jason Juhala and Wei Xue. In this chapter the authors reported the experimental evaluation of two solution-based approaches for the fabrication of CNT transistor and logic gates. These two approaches result in two different configurations of CNTs: one transistor uses dielectrophoresis-alligned CNTs, whereas the other contains random-network CNTs using layer-by-layer self-assembly. It contains the following sections:

1. Introduction
2. Materials
3. Deposition of CNTs
4. CNT Thin-Film Transistor
5. CNT-Based Voltage Inverter
6. Conclusion

Chapter 9 with the title 'On the Possibility of Observing Tunable Laser-Induced Band Gaps in Graphene' was written by Hernán L Calvo, Horacio M Pastanski, Stephane Roche and Luis E F Foa Torres. In this chapter the authors focus on the possibility of tuning the electronic and transport properties of graphene through illumination with a laser field. It contains the following four sections:

1. Introduction
2. Dirac Fermions: **kp** Approach
3. Tight-Binding Model
4. Conclusion

Chapter 10 with the title 'Applications of Nanocarbons for High-Efficiency Optical Absorbers and High-Performance Nanoelectromechanical Systems' was written by Anupama B Kaul, Jaesung Lee and Philip X-L Feng. In this chapter some key characteristics of carbon-based nanomaterials and the role they play in enabling

high-efficiency optical absorbers and mechanical resonators for nanoelectromechanical systems (NEMSs) are highlighted. It contains the following sections:

1. Introduction
2. Nanocarbons for Optical Absorbers
3. Nanocarbons for NEMS
4. Summary and Conclusion

Chapter 11 with the title 'Carbon Nanostructures from Biomass Waste for Supercapacitor Applications' was written by Ankit Tyagi and Raju Kumar Gupta. This chapter reviews recent advancements for the effective utilization of biomass for the fabrication of carbon nanostructures based electrode materials for energy storage applications in supercapacitors. Biomass is available in large quantity and produced from waste generated from various sources such as agriculture residue, tree leafs, food waste, nutshells, household and industrial activities. They contain celluloses, hemi-celluloses and lignin biopolymers, which can be considered as carbon source and one can get the activated carbon of industrial importance. The basic principles of energy storage devices e.g. supercapacitors, synthesis, characterization and performances of various electrode materials are discussed. This chapter has the following contents:

1. Introduction
2. Comparison of Supercapacitors with Conventional Capacitors, Batteries and Fuel Cells
   2.1. Supercapacitors
   2.2. Types of Supercapacitors
   2.3. Charge Storage Mechanism in Electric Double-Layer Capacitors
   2.4. Models for Charge Storage in Electric Double-Layer Capacitors
   2.5. Charge Storage Mechanism for Pseudocapacitors
   2.6. Components of Supercapacitors
   2.7. Biomass Waste Used for Supercapacitor Applications
3. Conclusion

Reading of this book certainly will be beneficial for a wide range of scientists working in various areas of nanoscience and nanotechnology, including PhD students specialized in materials science.