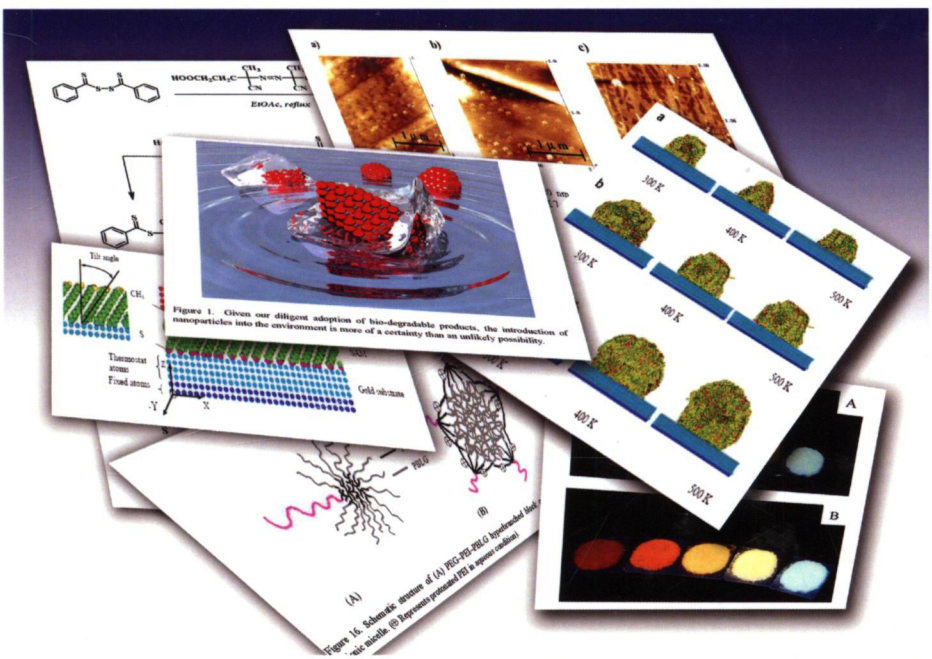
ADVANCES IN NANOTECHNOLOGY

Volume 20



Zacharie Bartul
Jérôme Trenor
Editors

NOVA

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Contributors

Malik Anjelh Baqiya
Munasir
Mochamad Zainuri
Zaenal Arifin
Mashuri
Triwikantoro
Suminar Pratapa
Darminto
Ibrahim M. Alarifi
Waseem S. Khan
Muhammad M. Rahman
Ramazan Asmatulu
V. N. Tseluikin
I. V. S. Yashwanth
I. Gurrappa
J. S. Burnell-Gray
Raminder Kaur
Jobanpreet Singh
Balraj Singh Saini
Kelvii Wei Guo
Chuan-Pei Leea
A. L. Stepanov
V. V. Vorobev
V. I. Nuzhdin
V. F. Valeev
A. M. Rogov
Y. N. Osin

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ZACHARIE BARTUL
AND
JÉRÔME TRENOR
EDITORS

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PREFACE

In this compilation, the authors discuss nanopowders, or powders with a particle size of less than 100 nanometers. Several nanopowder types have effectively been synthesized with potential applications as follows: Fe3O4 and BaFe6O19 (as magnetic materials, microwave absorbent, magnetic fluid and gel), SiO2 (as fillers to enhance mechanical strength), and CaCO3 (as coating for corrosive protection, food additives, cosmetics and drugs). This method allows for the production of high purity nanopowders with a moderately narrow crystal size distribution and unique morphology. Next, the innovative approaches to address the lightning strikes and EMI shielding effects on composite aircraft are examined, noting that composite aircraft protection against lightning is more complex due to the anisotropic nature of composite structure and high resistance of carbon in epoxy resins. The authors go on to present results of studies of composite electrochemical coatings modified by nano- and microparticles of various natures are presented, considering the operational properties and structural features of main types of composite coatings. Later, recent advances in synthesising highly ordered Titana nanotubes are explored, with regard to selection of suitable titanium based substrate and electrolyte apart from process parameters. These parameters include temperature, pH, voltage and applications in the areas of global warming, solar energy, photocatalytic applications, biomedical starting from implants to drug-

eluding stents, sensors, and hydrogen storage. A chapter is presented on practical ways for fabricating cost-effective equipment for deposition of nanofilms, covering the most versatile techniques of sol-gel deposition and sputter-coating. The authors maintain that by applying individual ingenuity to the described frugal techniques, the reader should be able to form nanofilms of various materials with properties tailored to suit the intended application. Afterwards, the authors describe the soft, hard templated, and hierarchically ordered strategies concerning nanotechnology applied to fabricate porous carbon materials. Additionally, relevant advantages and disadvantages aim to provide the vital information about the growing field for future energy to minimize the potential environmental risks. Moving on, the authors introduce new research and related literature concerning the synthesis of cobalt diselenide (CoSe2) nanoneedle arrays for efficient hydrogen evolution electrolysis. Future aspects for improving the performance of transition metal dichalcogenide-based electrocatalytic electrodes are also examined. Lastly, a study on formation of nanoporous silicon and germanium layers with silver nanoparticles by low-energy high-dose ion implantation is presented. The authors suggest ion implantation for the formation of nanoporous semiconductor thin layers, which could be easily combined with the crystalline matrix for various applications.

Chapter 1 - Nanopowders are defined as powders having a particle size less than 100 nanometers. Due to the specific surface effect, they have unique and different properties from powders with larger particle sizes. The quality of nanopowders extremely depends on the purity and homogeneity of the grain/crystallite size. These factors are associated with the complexity of how the nanopowders are prepared. Nanopowders are widely available in the form of ceramic compounds, which are generally oxides, carbonates, sulfates, and carbides. The metal-oxide ceramic nanopowders can be prepared by simple coprecipitation. This method not only can produce high purity nanopowders, but also with a relatively narrow crystal size distribution and unique morphology. Those are very crucial for any kind of application. To cite some examples, a number of nanopowder types have successfully been synthesized with potential

applications as follows: Fe_3O_4 and $BaFe_6O_{19}$ (as magnetic materials, microwave absorbent, magnetic fluid and gel), SiO_2 (as fillers to enhance mechanical strength), and $CaCO_3$ (as coating for corrosive protection, food additives, cosmetics and drugs).

Chapter 2 - This chapter reports the current state-of-the-art systems on lightning strikes, their effects on composite aircraft, and new techniques available to engineers and operators to safeguard against detrimental effects of lightning strikes. Designing and manufacturing of composite aircraft need advanced strategies to sustain the same degree of safety and shelter as achieved by conductive aluminum skinned aircrafts. Researchers and scientists have been investigating new ideas to support the development of new mitigation, diagnosis and prognosis techniques to overcome the increased challenges associated with lightning protection on composite aircraft. Lightning protection of composite aircraft is more complex due to the anisotropic nature of composite structure and high resistance of carbon in epoxy resins. A wide variety of solutions have been available for composite aircraft against lightning strike as composite materials have been expanded extensively in aircraft manufacturing during last three decades. Generally, electrically and thermally conductive materials, such as metallic foils, metal mesh, ply-integrated interwoven wires, continuous conductive path of low resistance materials and highly conductive nanoparticles and nanofilms are used to dissipate the high density current, shockwave and heat generated during the lightning strikes. This chapter deals with all the newer approaches to address the lightning strikes and EMI shielding effects on composite aircraft.

Chapter 3 - The results of studies of composite electrochemical coatings modified by nano- and microparticles of various natures are presented. Operational properties (hardness, friction coefficient, wear- and corrosion resistance, etc.) and structural features of main types of composite coatings are considered.

Chapter 4 - The chapter discusses the recent advances in synthesising highly ordered Titana nanotubes with respect to selection of suitable titanium based substrate and electrolyte apart from process parameters such as temperature, pH, voltage and also their applications in the areas of

global warming, solar energy, photocatalytic applications, biomedical starting from implants to drug-eluding stents, sensors and hydrogen storage. The superiority of electrodeposition technique over other techniques is presented. Subsequently, the chapter explains the efforts made in designing and developing titania nanotubes with considerably improved properties on different structural alloys used in aerospace applications by electrochemical anodization technique.

Chapter 5 - Nanofilms come under the category of two-dimensional nanomaterials, whose thickness lies in the range of 1nm to 100nm. Owing to their small thickness, they do not cause any appreciable change in physical dimensions or weight of the underlying substrate, but facilitate a dramatic change in its interaction with the environment. Advances in nanofilm deposition techniques have heralded breakthroughs in various areas, such as optical coatings for energy conversion and conservation, fabrication of semiconductor devices, sensors, displays and so on. Apart from their practical applications, it is only in this two-dimensional form, that the functionality of nanomaterials can be studied at a macroscopic scale, while the nanometer scale of thickness facilitates investigation of the effects of quantum confinement on various materials.

The need for exercising precise control over various process parameters generally calls for elaborate equipment for depositing nanofilms. In addition to being expensive, the deposition equipment is often optimized for some particular application and so, does not allow much room for experimentation with various parameters. This chapter describes practical ways for fabricating cost-effective equipment for deposition of nanofilms, covering the most versatile techniques of sol-gel deposition and sputter-coating. By applying individual ingenuity to the frugal techniques described in this chapter, the reader should be able to form nanofilms of various materials with properties tailored to suit the intended application.

Chapter 6 - Carbon materials mostly involved in new alternative clean and sustainable energy technologies have been playing more and more significant role in energy storage and conversion systems, especially for the carbon porous materials, because carbon porous materials with

structures can provide large surface areas for reaction, interfacial transport, or dispersion of active sites at different length scales of pores and shorten diffusion paths or reduce diffusion effect. Therefore, the soft, hard templated and hierarchically ordered strategies with nanotechnology employed to fabricate porous carbon materials are marked along with the relevant advantages and disadvantages aim to provide the vital information about the growing field for future energy to minimize the potential environmental risks.

Carbon porous materials with attractive structures as ideal candidates for the versatility and feasibility of application to energy storage and conversion should not only be realized, but also much effort has to be devoted to systematic studies on the relationship between physicochemical properties of these materials and their performances in energy conversion and storage to more efficiently stimulate further developments in this fascinating area, alongside eco-technologies that will ensure minimal environmental impact.

Chapter 7 - Hydrogen is a clean, storable, and high-energy density energy carrier, which has been considered as a promising sustainable energy alternative for meeting the global energy demand and achieving an environmentally friendly fuel economy. Whereas water splitting is one of the most promising approaches for hydrogen fuel production. As alternatives to noble metal catalyst, e.g., platinum, for the use in hydrogen evolution reaction of water splitting, transition metal dichalcogenides have shown highly potential. Furthermore, nanostructuring is an efficient method to improve the activity of heterogeneous catalysts and the performance of the electrocatalytic electrodes. Thus, this chapter aims to introduce the authors' recent research about the synthesis of cobalt diselenide ($CoSe_2$) nanoneedle arrays for efficient hydrogen evolution electrolysis, and the related literatures are briefly discussed. Finally, the future aspects for improving the performance of transition metal dichalcogenide-based electrocatalytic electrodes are also mentioned in the end of this chapter.

Chapter 8 - Experiments on formation of nanoporous silicon and germanium layers with silver nanoparticles by low-energy high-dose ion

implantation are observed. For this task Ag^+-ion implantation into monocrystalline silicone and germanium substrates at energy 30 keV with doses from $7.5 \cdot 10^{16}$ to $1.5 \cdot 10^{17}$ ion/cm2 was realized. Surface nanoporous semiconductor structures were studied by scanning electron microscopy, imaging and energy-dispersive X-ray analysis. It is demonstrated that nanoporous silicon and germanium with silver nanoparticles could be fabricated by Ag-ion implantation. The average sizes of porous holes and thickness of walls between porous in silicon are about 110-130 and 30-60 nm, respectively. In germanium regular holes were not observed but silver nanoparticles were smaller sizes. Thus, ion implantation is suggested to be used for a formation of naoporous semiconductor thin layers for industry, which could be easily combined with the crystalline matrix for various applications.

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Chapter 1

NANOPOWDERS PRODUCED FROM NATURAL SOURCES USING THE SIMPLE COPRECIPITATION METHOD

Malik Anjelh Baqiya[1], Munasir[2], Mochamad Zainuri[1], Zaenal Arifin[1], Mashuri[1], Triwikantoro[1], Suminar Pratapa[1] and Darminto[1,*]

[1]Department of Physics, Faculty of Mathematics and Sciences, Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia
[2]Department of Physics, Faculty of Mathematics and Sciences, Universitas Negeri Surabaya (UNESA), Surabaya, Indonesia

ABSTRACT

Nanopowders are defined as powders having a particle size less than 100 nanometers. Due to the specific surface effect, they have unique and different properties from powders with larger particle sizes. The quality

* Corresponding Author Email: darminto@physics.its.ac.id.

of nanopowders extremely depends on the purity and homogeneity of the grain/crystallite size. These factors are associated with the complexity of how the nanopowders are prepared. Nanopowders are widely available in the form of ceramic compounds, which are generally oxides, carbonates, sulfates, and carbides. The metal-oxide ceramic nanopowders can be prepared by simple coprecipitation. This method not only can produce high purity nanopowders, but also with a relatively narrow crystal size distribution and unique morphology. Those are very crucial for any kind of application. To cite some examples, a number of nanopowder types have successfully been synthesized with potential applications as follows: Fe_3O_4 and $BaFe_6O_{19}$ (as magnetic materials, microwave absorbent, magnetic fluid and gel), SiO_2 (as fillers to enhance mechanical strength), and $CaCO_3$ (as coating for corrosive protection, food additives, cosmetics and drugs).

Keywords: nanopowders, natural sources, coprecipitation method, Fe_3O_4, SiO_2, $CaCO_3$

INTRODUCTION

In the past few decades, many efforts have been made to investigate the structures and applications of both magnetic and non-magnetic nanomaterials. Nanomaterial has a unique feature which is different from the bulk form due to its specific surface effect. As the particle size of a nanomaterial decreases, the surface-to-volume ratio increases. Consequently, it affects the whole physical and chemical properties of the materials. For instance, the superior physical properties of nanomaterials include the improvement of mechanical, optical, electrical, and magnetic properties.

The properties of nanomaterials are generally influenced by many factors, such as particle size and shape, particle distribution and morphologies, and particle interaction with the surrounding and neighboring substances. It has been found that these factors can be modified and improved through the synthesis route, how they can be prepared. The synthesis method for obtaining nano-sized magnetic particles have been developed in various sizes and shapes [1-3]. Magnetic