

## Editorial

# Multifunctionalization of Nanostructured Metal Oxides

Zijie Yan,<sup>1</sup> Yu Wang,<sup>2</sup> Dawen Zeng,<sup>3</sup> Douglas B. Chrisey,<sup>4</sup> and Min Liu<sup>5</sup>

<sup>1</sup>Department of Chemical & Biomolecular Engineering, Clarkson University, Potsdam, NY 13699, USA

<sup>2</sup>School of Materials Science and Engineering, Nanchang University, Nanchang 330029, China

<sup>3</sup>Department of Materials Science and Engineering, Huazhong University of Science and Technology, Wuhan 430074, China

<sup>4</sup>Department of Physics and Engineering Physics, Tulane University, New Orleans, LA 70008, USA

<sup>5</sup>Department of Electrical and Computer Engineering, The University of Toronto, Toronto, ON, Canada M5S 3G4

Correspondence should be addressed to Zijie Yan; [zyan@clarkson.edu](mailto:zyan@clarkson.edu)

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Metal oxides are a rich family of materials that have nourished many research areas. From colossal magnetoresistance to multiferroicity and from catalysts to wearable devices, metal oxides never lack new materials with fascinating properties and great potential for device applications. The ability to control materials at the nanometric level has further broadened the landscape of research for metal oxides. With rational control of sizes, structures, compositions, and morphologies, nanostructured metal oxides can possess novel optical, electronic, magnetic, and/or mechanical properties that do not exist in bulk forms. These properties have enabled applications of metal oxides in various areas, including electronics, photonics, sensors, catalysis, photovoltaics, and batteries. A better understanding of the origin of novel metal oxide properties promises further improvements that are waiting to be discovered, yet difficulties still exist for applications that require integrating or balancing multiple aspects of the material properties. The integration of metal oxides in prototype devices needs innovations in synthesis, functionalization, assembly, and characterization of nanostructures, which in turn will inspire new applications of metal oxides.

This special issue features articles that address these challenges. The authors report here their achievements in the design, fabrication, modification, and characterization of multifunctional metal oxide nanostructures. It is worth noting that  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$  (YBCO) is a well-known material for “high temperature superconductivity.” However, in the paper entitled “Photocatalytically Active  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$  Nanoparticles Synthesized via a Soft Chemical Route,” Z. Shen et al. explored the chemical properties of YBCO

and found that YBCO nanoparticles could show excellent photocatalytic effects without compromising their normal superconductivity properties. This work provides a good example of obtaining multifunctional metal oxides based on the surface effects of nanostructures.

In another article entitled “Nanoscale Ferroelectric Switchable Polarization and Leakage Current Behavior in  $(\text{Ba}_{0.50}\text{Sr}_{0.50})(\text{Ti}_{0.80}\text{Sr}_{0.20})\text{O}_3$  Thin Films Prepared Using Chemical Solution Deposition,” V. S. Puli et al. investigated the ferroelectric/piezoelectric effects of  $(\text{Ba}_{0.50}\text{Sr}_{0.50})(\text{Ti}_{0.80}\text{Sr}_{0.20})\text{O}_3$  (BSTS) thin films at the nanoscale level using piezoresponse force microscopy and revealed the nanoscale switchability of ferroelectric polarization in these chemical solution deposited BSTS thin films. This observation opens up the possibility of further optimizing physical and electrical properties of BSTS films for practical applications, including nonvolatile ferroelectric memories, data-storage media, piezoelectric actuators, and electric energy storage capacitors.

The guest editors hope that the special issue will draw attention to the multifunctionalization of nanostructured metal oxides and stimulate not only the discovery of new multifunctional metal oxides, but also the detection of new properties in traditional metal oxides via the state-of-the-art nanotechnology.

Zijie Yan  
Yu Wang  
Dawen Zeng  
Douglas B. Chrisey  
Min Liu

**Nanostructured Metal Oxides For Advanced Applications**  
**Volume 1552 Mrs Proceedings By 2013 12**

**M. K. Jayaraj**



## **Nanostructured Metal Oxides For Advanced Applications Volume 1552 Mrs Proceedings By 2013 12 :**

**Nanostructured Metal Oxides for Advanced Applications: Volume 1552** Alberto Vomiero, Federico Rosei, Xiao Wei Sun, Juan Ramon Morante, 2013-12-02 Symposium S Nanostructured Metal Oxides for Advanced Applications was held April 15 at the 2013 MRS Spring Meeting in San Francisco California Metal oxides represent an appealing and assorted class of materials whose properties cover the entire range from metals to semiconductors to insulators and almost all aspects of material science chemistry and physics in a very broad application area In the past few years progress has been made on the synthesis structural physical and chemical characterization of self assembled and hierarchically assembled metal oxide nanostructures that exhibit size dependent properties In these proceedings attention is paid to the synthesis structural and functional characterization of self assembled nanostructures and architectures of all metal oxides with application potentials with particular consideration given to the capability to tailor and control material properties via surface and structural modifications Nanostructured Metal Oxides for Advanced Applications Alberto Vomiero, Materials Research Society. Spring Meeting Symposium S., 2013 *Functional Metal-Oxide Nanostructures: Volume 1406* Alberto Vomiero, Sanjay Mathur, Zhong Lin Wang, Eric Wei-Guang Diao, 2012-07-09 Symposium Z Functional Metal Oxide Nanostructures was held November 27 December 2 during the 2011 MRS Fall Meeting in Boston Massachusetts Metal oxides represent an assorted and appealing class of materials whose properties cover the entire range from metals to semiconductors to insulators and almost all aspects of material science and physics in areas including superconductivity and magnetism In the past few years a great deal of progress has been made in the field of metal oxide nanostructures particularly with regard to innovative synthetic pathways as well as the structural physical and chemical characterization modification and assembly of nanostructured oxides to exploit their nanoscopic properties and their size dependent modulation These proceedings captures some of the most recent developments in the field of synthesis structural and functional characterization of self assembled metal oxides nanostructures and heterostructures thereof to illustrate their application potential as functional materials **Functional Metal-Oxide Nanostructures:** Junqiao Wu, Wei-Qiang Han, Anderson Janotti, Ho-Cheol Kim, 2014-06-05 Metal oxides and their nanostructures have emerged as an important class of materials with a rich spectrum of properties and great potential for device applications These include transparent electrodes high electron mobility transistors gas sensors photovoltaic and photonic devices energy harvesting devices with multiferroic oxides nonvolatile memories with defective oxides etc The book addresses fundamental challenges related to synthesis characterization assembly and device applications of oxide nanostructures as well as the most recent progress in these fields Topics include physics and applications of phase transitions strain and interfaces in complex oxide nanostructures nano ionics and resistance switching in oxides assembly and processing of oxide nanostructures zinc oxide titanium dioxide other oxide semiconductors and their applications **Nanostructured Metal Oxides and Devices** M. K. Jayaraj, 2020-04-16 This book

primarily covers the fundamental science synthesis characterization optoelectronic properties and applications of metal oxide nanomaterials It discusses the basic aspects of synthetic procedures and fabrication technologies explains the related experimental techniques and also elaborates on the current status of nanostructured oxide materials and related devices Two major aspects of metal oxide nanostructures their optical and electrical properties are described in detail The first five chapters focus on the optical characteristics of semiconducting materials especially metal oxides at the nanoscale The following five chapters discuss the electrical properties observed in metal oxide based semiconductors and the status quo of device level developments in a variety of applications such as sensors transistors dilute magnetic semiconductors and dielectric materials The basic science and mechanism behind the optoelectronic phenomena are explained in detail to aid readers interested in the structure property symbiosis in semiconducting nanomaterials In short the book offers a valuable reference guide for researchers and academics in the areas of material science and semiconductor technology especially nanophotonics and electronics

**Metal Oxide Nanostructures** Daniela Nunes, Ana Pimentel, Lidia Santos, Pedro Barquinha, Luis Pereira, Elvira Fortunato, Rodrigo Martins, 2018-11-01 Metal Oxide Nanostructures Synthesis Properties and Applications covers the theoretical and experimental aspects related to design synthesis fabrication processing structural morphological optical and electronic properties on the topic In addition it reviews surface functionalization and hybrid materials focusing on the advantages of these oxide nanostructures The book concludes with the current and future prospective applications of these materials Users will find a complete overview of all the important topics related to oxide nanostructures from the physics of the materials to its application Delves into hybrid structured metal oxides and their promising use in the next generation of electronic devices Includes fundamental chapters on synthesis design and the properties of metal oxide nanostructures Provides an in depth overview of novel applications including chromogenics electronics and energy

**Synthesis, Properties, and Applications of Oxide Nanomaterials** José A. Rodriguez, Marcos Fernández-García, 2007-03-09 Current oxide nanomaterials knowledge to draw from and build on Synthesis Properties and Applications of Oxide Nanomaterials summarizes the existing knowledge in oxide based materials research It gives researchers one comprehensive resource that consolidates general theoretical knowledge alongside practical applications Organized by topic for easy access this reference Covers the fundamental science synthesis characterization physicochemical properties and applications of oxide nanomaterials Explains the fundamental aspects quantum mechanical and thermodynamic that determine the behavior and growth mode of nanostructured oxides Examines synthetic procedures using top down and bottom up fabrication technologies involving liquid solid or gas solid transformations Discusses the sophisticated experimental techniques and state of the art theory used to characterize the structural and electronic properties of nanostructured oxides Describes applications such as sorbents sensors ceramic materials electrochemical and photochemical devices and catalysts for reducing environmental pollution transforming hydrocarbons and producing

hydrogen With its combination of theory and real world applications plus extensive bibliographic references *Synthesis Properties and Applications of Oxide Nanomaterials* consolidates a wealth of current complex information in one volume for practicing chemists physicists and materials scientists and for engineers and researchers in government industry and academia It is also an outstanding reference for graduate students in chemistry chemical engineering physics and materials science

**Nanostructured Anodic Metal Oxides** Grzegorz D. Sulka, 2020-03-30 *Nanostructured Anodic Metal Oxides Synthesis and Applications* reviews the current status of fabrication strategies that have been successfully developed to generate nanoporous nanotubular and nanofibrous anodic oxides on a range of metals The most recent achievements and innovative strategies for the synthesis of nanoporous aluminum oxide and nanotubular titanium oxide are discussed However a special emphasis is placed on the possibility of fabrication of nanostructured oxide layers with different morphologies on other metals including aluminum titanium tantalum tin zinc zirconium and copper In addition emerging biomedical applications of synthesized materials are discussed in detail During the past decade great progress has been made both in the preparation and characterization of various nanomaterials and their functional applications The anodization of metals has proven to be reliable for the synthesis of nanoporous nanotubular and nanofibrous metal oxides to produce a desired diameter density aspect ratio length to diameter of pores tubes and internal pore tube structure

**Metal Oxide Nanostructures and Their Applications: Growth and properties, pt. 1** Ahmad Umar, Yoon-Bong Hahn, 2010 Volume 1 *Growth and Properties Part 1 Nanostructured Metal Oxides* Enrico Traversa, 2006 The use of metal oxides in nanostructured form made possible by recent advances in their synthesis allow the exploitation of unique physical and chemical properties of materials This issue presents the latest advances in the controlled synthesis and processing of nanostructured oxides and the design fabrication and performance of devices that utilize them The emphasis will be on the beneficial effects of using nanostructured materials in environmentally friendly applications

**Solution Methods for Metal Oxide Nanostructures** Rajaram S. Mane, Vijaykumar Jadhav, Abdullah M. Al-Enizi, 2023-06-27 *Solution Methods for Metal Oxide Nanostructures* reviews solution processes that are used for synthesizing 1D 2D and 3D metal oxide nanostructures in either thin film or in powder form for various applications Wet chemical synthesis methods deal with chemical reactions in the solution phase using precursors at proper experimental conditions Wet chemical synthesis routes offer a high degree of controllability and reproducibility for 2D nanomaterial fabrication Solvothermal synthesis template synthesis self assembly oriented attachment hot injection and interface mediated synthesis are the main wet chemical synthesis routes for 2D nanomaterials *Solution Methods for Metal Oxide Nanostructures* also addresses the thin film deposition metal oxides nanostructures which plays a very important role in many areas of chemistry physics and materials science Each chapter includes information on a key solution method and their application in the design of metal oxide nanostructured materials with optimized properties for important applications The pros and cons of the solution method and their significance and

future scope is also discussed in each chapter Readers are provided with the fundamental understanding of the key concepts of solution synthesis methods for fabricating materials and the information needed to help them select the appropriate method for the desired application Reviews the most relevant wet chemical solution methods for metal oxide nanostructures including sol gel solvothermal hydrothermal co precipitation methods and more Addresses thin film deposition techniques for metal oxide nanostructures such as spray pyrolysis electrodeposition spin coating and self assembly Discusses the pros and cons of each solution method and its significance and future opportunities

**Multifunctional Nanostructured Metal Oxides for Energy Harvesting and Storage Devices** Vijay B. Pawade, Paresh H. Salame, Bharat Apparao

Bhanvase, 2020-05-21 Metal oxide nanoparticles exhibit potential applications in energy and environmental fields such as solar cells fuel cells hydrogen energy and energy storage devices This book covers all points from synthesis properties and applications of transition metal oxide nanoparticle materials in energy storage and conversion devices Aimed at graduate level students and researchers associated with the energy and environment sector this book addresses the application of nontoxic and environmentally friendly metal oxide materials for a clean environment and deals with synthesis properties and application metal oxides materials for energy conversion energy storage and hydrogen generation

**Metal Oxide Nanostructures and Their Applications** Yoon-Bong Hahn, 2010 **Metal Oxide Nanoparticles in Organic Solvents**

Markus Niederberger, Nicola Pinna, 2009-09-17 Metal Oxide Nanoparticles in Organic Solvents discusses recent advances in the chemistry involved for the controlled synthesis and assembly of metal oxide nanoparticles the characterizations required by such nanoobjects and their size and shape depending properties In the last few years a valuable alternative to the well known aqueous sol gel processes was developed in the form of nonaqueous solution routes Metal Oxide Nanoparticles in Organic Solvents reviews and compares surfactant and solvent controlled routes as well as providing an overview of techniques for the characterization of metal oxide nanoparticles crystallization pathways the physical properties of metal oxide nanoparticles their applications in diverse fields of technology and their assembly into larger nano and mesostructures Researchers and postgraduates in the fields of nanomaterials and sol gel chemistry will appreciate this book's informative approach to chemical formation mechanisms in relation to metal oxides

**Metal Oxide Nanostructures**, 2009

**1-dimensional Metal Oxide Nanostructures** Zainovia Lockman, 2018 This book covers recent developments in synthesis and growth process of 1 D metal oxide nanostructures with a focus on semi templated method of oxidation origin

**Versatile Applications of Nanostructured Metal Oxides** Li Li, 2014 **Metal Oxides for Biomedical and**

**Biosensor Applications** Kunal Mondal, 2021-12-04 Metal Oxides for Biomedical and Biosensor Applications gives an in depth overview of the emerging research in the biomedical and biosensing applications of metal oxides including optimization of their surface and bulk properties Sections cover biomedical applications of metal oxides for use in cell cultures antibacterial and antimicrobial treatments dental applications drug delivery cancer therapy immunotherapy

photothermal therapy tissue engineering and metal oxide based biosensor development As advanced and biofunctionalized nano micro structured metal oxides are finding applications in microfluidics optical sensors electrochemical sensors DNA based biosensing imaging diagnosis and analysis this book provides a comprehensive update on the topic Additional sections cover research challenges technology limitations and future trends in metal oxides and their composites regarding their usage in biomedical applications Includes an overview of the important applications of metal oxides for biomedical and biosensing technologies Addresses the relationship between material properties such as structure morphology composition and performance Reviews the design and fabrication strategies of metal oxides for use in medical and biosensing applications

**Functional Metal Oxide Nanostructures** Junqiao Wu, Jinbo Cao, Wei-Qiang Han, Anderson Janotti, Ho-Cheol

Kim, 2014-09-17 Metal oxides and particularly their nanostructures have emerged as an important class of materials with a rich spectrum of properties and great potential for device applications In this book contributions from leading experts emphasize basic physical properties synthesis and processing and the latest applications in such areas as energy catalysis and data storage Functional Metal Oxide Nanostructures is an essential reference for any materials scientist or engineer with an interest in metal oxides and particularly in recent progress in defect physics strain effects solution based synthesis ionic conduction and their applications

Oxide Nanostructures Avanish Kumar Srivastava, 2014-04-09 Nanomaterials their synthesis and property studies have been an obsession with modern current physicists chemist and materials scientists for their vast array of technological implications and the remarkable way their properties are modified or enhanced when the size dimensions are reduced to the realm of nanometers Although nanomaterials for a lot of practical purposes have been in existence since the remotest past of civilization it is only in the last few decades that the field has been gaining the attention that it deserves from the scientific and industrial fraternity A lot of this has to do with the immense improvement we made in tools to study and characterize these materials Metal oxides have been one of the well documented and hottest branches of nanomaterials revolution with oxides such as  $\text{TiO}_2$   $\text{ZnO}$   $\text{CuO}$   $\text{Fe}_3\text{O}_4$   $\text{Cr}_2\text{O}_3$   $\text{Co}_3\text{O}_4$   $\text{MnO}_2$  and many more being an integral part to a variety of technological advancements and industrial applications From green power issues like photovoltaic cells to rechargeable batteries from drug delivery agents to antimicrobial and cosmetic products from superconductor materials to semiconductors and insulators metal oxides have been omnipresent in terms of both commercial prerogatives and research highlights This book is solely devoted towards this special section of nanomaterials with an aim to partially access the science pertaining to the oxides of metals

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