Chemical Solution Deposition Of Semiconductor Films Gary Hodes

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Transparent Conductive Materials Woodhead Publishing
Nanomaterials contain some unique properties due to their nanometric size and surface functionalization. Nanomaterial functionalization also affects their compatibility to biocompatibility and toxicity behaviors. environment and living organism. This makes functionalized nanomaterials a material with huge scope and few challenges. This book provides detailed information about the nanomaterial functionalization and their application. Recent advancements, challenges and opportunities in the preparation and applications of functionalized nanomaterials are also highlighted. This book can serve as a reference book for scientific investigators, doctoral and post-doctoral scholars; undergrad and grad. This book is very useful for multidisciplinary researchers, industry personnel's, journalists, and policy makers. Features: Covers all aspects of Nanomaterial functionalization and its applications Describes and methods of functionalized nanomaterials synthesis for different applications Discusses the challenges, recent findings, and cutting-edge global research trends on functionalization of nanomaterials and its applications It discusses the regulatory frameworks for the safe use of functionalized nanomaterials. It contains contributions from international experts from multiple disciplines.

Cadmium based II-VI Semiconducting Nanomaterials Elsevier
This is the first text to cover all aspects of solution processed functional oxide thin-films. Chemical Solution Deposition (CSD) comprises all solution based thin- film deposition techniques, which involve chemical reactions of precursors during the formation of the oxide films, i. e. sol-gel type routes, metallo-organic decomposition routes, hybrid routes, etc. While the development of sol-gel type processes for optical coatings on glass by silicon dioxide and titanium dioxide dates from the mid-20th century, the first CSD derived electronic oxide thin films, such as lead zirconate titanate, were prepared in the 1980's. Since then CSD has emerged as a highly flexible and cost-effective technique for the fabrication of a very wide variety of functional oxide thin films. Application areas include, for example, integrated dielectric capacitors, ferroelectric random access memories, pyroelectric infrared detectors, piezoelectric micro-electromechanical systems, antireflective coatings, optical filters, conducting-, transparent conducting-, and superconducting layers, luminescent coatings, gas sensors, thin film solid-oxide fuel cells, and photoelectrocatalytic solar cells. In the appendix detailed "cooking recipes" for selected material systems are offered.

Design and Engineering of Microreactor and Smart-Scaled Flow Processes Elsevier
The critical contribution of this dissertation is to provide a better understanding of the fundamental Chemical Bath Deposition (CBD) growth kinetic and mechanism for the well known II-VI semiconductor CdS using the newly developed continuous flow microreactor. This continuous flow microreactor provides the temporal resolution to control the homogeneous reaction of the chemical solution before it impinges on the substrate surface. This capability was used to decouple the homogeneous particle formation and deposition from the molecular level heterogeneous surface reaction to overcome the drawbacks associated with a conventional batch process. Transmission electron microscopy (TEM) analysis indicated an impinging flux without the formation of nanoparticles which could be obtained from this reactor in a short residence time. In addition, the reactor could be operated in a homogeneous particle formation regime. Size increasing CdS nanoparticles grown by homogeneous reaction were clearly observed from TEM and SEM micrographs by increasing the residence time from 1 to 280 sec using pre-heated precursor solutions. The formation of CdS nanorod and arrayed nanorod bundle structures using the CBD recipe were also observed in some areas and reported here for the first time. The growth kinetics were studied using a particle-free flux. The deposition results suggest that HS- ions formed through the thiourea hydrolysis reaction are the dominant sulfide ion source responsible for the CdS deposition rather than thioura itself that had been widely discussed in almost all of the previous literature. This finding could not be observed previously by a conventional CBD batch setup because all the reactant solutions were sequentially pulled into the reaction beaker and mixed all at once. An impinging flux without the formation of nanoparticles enables us to deposit extremely smooth and highly oriented nanocrystalline CdS semiconductor thin films at low temperature (80°C). Enhancement-mode functional thin film transistors with an effective mobility of mueff =1.46 cm2/V s, drain current on-to-off ratio of approximately 105 and turn-on voltage at 0 V were fabricated from the as-deposited films without any post annealing process. This microreactor could be adapted for the deposition of other compound semiconductor thin films such as highly transparent amorphous Indium Oxide (In2O3) thin films at low temperature (70°C) using chemical solution deposition and opens a low-cost avenue to fabricate thin film flexible electronics on polymeric substrates.

Wafer Bonding Elsevier
Ferroelectricity in Doped Hafnium Oxide: Materials, Properties and Devices covers all aspects relating to the structural and electrical properties of HfO2 and its implementation into semiconductor devices, including a comparison to standard ferroelectric materials. The ferroelectric and field-induced ferroelectric properties of HfO2-based films are considered promising for various applications, including non-volatile memories, negative capacitance field-effect-transistors, energy storage, harvesting, and solid-state cooling. Fundamentals of ferroelectric and piezoelectric properties, HfO2 processes, and the impact of dopants on ferroelectric properties are also extensively discussed in the book, along with phase transition, switching kinetics, epitaxial growth, thickness scaling, and more. Additional chapters consider the modeling of ferroelectric phase transformation, structural characterization, and the differences and similarities between HFO2 and standard ferroelectric materials. Finally, HfO2 based devices are summarized. Explores all aspects of the structural and electrical properties of HfO2, including processes, modelling and implementation into semiconductor devices Considers potential applications including FeCaps, FeFETs, NCFETs, FTJs and more Provides comparison of an emerging ferroelectric material to conventional ferroelectric materials with insights to the problems of downscaling that conventional ferroelectrics face

Solution Deposition of Semiconductor Thin Films for Photovoltaics Springer Science & Business Media
Solution Processed Metal Oxide Thin Films for Electronic Applications discusses the fundamentals of solution processing materials chemistry techniques as they are applied to metal oxide materials systems for key device applications. The book introduces basic information (materials properties, materials synthesis, barriers), discusses ink formulation and solution processing methods, including sol-gel processing, surface functionalization aspects, and presents a comprehensive accounting on the electronic applications of solution processed metal oxide films, including thin film transistors, photovoltaic cells and other electronics devices and circuits. This is an important reference for those interested in oxide electronics, printed electronics, flexible electronics and large-area electronics. Provides in-depth information on solution processing fundamentals, techniques, considerations and barriers combined with key device applications Reviews important device applications, including transistors, light-emitting diodes, and photovoltaic cells Includes an overview of metal oxide materials systems (semiconductors, nanomaterials and thin films), addressing materials synthesis, properties, limitations and surface aspects

Chemical Solution Synthesis for Materials Design and Thin Film Device Applications John Wiley & Sons
Principles of Chemical Vapor Deposition provides a simple introduction to heat and mass transfer, surface and gas phase chemistry, and plasma discharge characteristics. In addition, the book includes discussions of practical films and reactors to help in the development of better processes and equipment. This book will assist workers new to chemical vapor deposition (CVD) to understand CVD reactors and processes and to comprehend and exploit the literature in the field. The book reviews several disparate fields with which many researchers may have only a passing acquaintance, such as heat and mass transfer, discharge physics, and surface chemistry, focusing on key issues relevant to CVD. The book also examines examples of realistic industrial reactors and processes with simplified analysis to demonstrate how to apply the principles to practical situations. The book does not attempt to exhaustively survey the literature or to intimidate the reader with irrelevant mathematical apparatus. This book is as simple as possible while still retaining the essential physics and chemistry. The book is generously illustrated to assist the reader in forming the mental images which are the basis of understanding.

Chemical Solution Deposition Of Semiconductor Films William Andrew
Discover the materials set to revolutionize the electronics industry The search for electronic materials that can be cheaply solution-processed into films, while simultaneously providing quality device characteristics, represents a major challenge for materials scientists. Continuous semiconducting thin films with large carrier mobilities are particularly desirable for high-speed microelectronic applications, potentially providing new opportunities for the development of low-cost, large-area, flexible computing devices, displays, sensors, and solar cells. To date, the majority of solution-processing research has focused on molecular and polymeric organic films. In contrast, this book reviews recent achievements in the search for solution-processed inorganic semiconductors and other critical electronic components. These components offer the potential for better performance and more robust thermal and mechanical stability than comparable organic-based systems. Solution Processing of Inorganic Materials covers everything from the more traditional fields of sol-gel processing and chemical bath deposition to the cutting-edge use of nanomaterials in thin-film deposition. In particular, the book focuses on materials and techniques that are compatible with high-throughput, low-cost, and low-temperature deposition processes such as spin coating, dip coating, printing, and stamping. Throughout the text, illustrations and examples of applications are provided to help the reader fully appreciate the concepts and opportunities involved in this exciting field. In addition to presenting the state-of-the-art research, the book offers extensive background material. As a result, any researcher involved or interested in electronic device fabrication can turn to this book to become fully versed in the solution-processed inorganic materials that are set to revolutionize the electronics industry.

Proceedings of the IV Advanced Ceramics and Applications Conference Springer Science & Business Media
Chemical Solution Deposition Of Semiconductor FilmsCRC Press

Springer Handbook of Inorganic Photochemistry Newnes
The aim of this new compendium is to provide a solid understanding of the recent developments in advanced polymeric materials from macro- to nano-length scales. Composites are becoming more important because they can help to improve our quality of life, such as being put into service in flight vehicles, automobiles, boats, pipelines, buildings, roads, bridges, and dozens of other products, including medical products. The chapters cover a multitude of important advances, including explanations of the significance of the new fillers, like graphene and carbon nanotubes, in different matrix systems. Coverage of the application of these materials in biological and others fields also makes this book unique. Topics include advances on the processing, properties, recyclability, and reparability, and applications for polymer matrix composites, ceramic matrix composites, carbon matrix composites, wood-based composites, biocomposites, ecocomposites, nanocomposites, and more.

Epitaxial Growth of Complex Metal Oxides CRC Press
The atomic arrangement and subsequent properties of a material are determined by the type and conditions of growth leading to epitaxy, making control of these conditions key to the fabrication of higher quality materials. Epitaxial Growth of Complex Metal Oxides reviews the techniques involved in such processes and highlights recent developments in fabrication quality which are facilitating advances in applications for electronic, magnetic and optical purposes. Part One reviews the key techniques involved in the epitaxial growth of complex metal oxides, including growth studies using reflection high-energy electron diffraction, pulsed laser

deposition, hybrid molecular beam epitaxy, sputtering processes and chemical solution deposition techniques for the growth of oxide thin films. Part Two goes on to explore the effects of strain and stoichiometry on crystal structure and related properties, in thin film oxides. Finally, the book concludes by discussing selected examples of important applications of complex metal oxide thin films in Part Three. Provides valuable information on the improvements in epitaxial growth processes that have resulted in higher quality films of complex metal oxides and further advances in applications for electronic and optical purposes Examines the techniques used in epitaxial thin film growth Describes the epitaxial growth and functional properties of complex metal oxides and explores the effects of strain and defects

Ferroelectricity in Doped Hafnium Oxide Springer Science & Business Media

Discussing specific depositions of a wide range of semiconductors and properties of the resulting films, Chemical Solution Deposition of Semiconductor Films examines the processes involved and explains the effect of various process parameters on final film and film deposition outcomes through the use of detailed examples. Supplying experimental res

Nanoscale Ferroelectrics and Multiferroics CRC Press

Field-coupled nanocomputing (FCN) paradigms offer fundamentally new approaches to digital information processing that do not utilize transistors or require charge transport. Information transfer and computation are achieved in FCN via local field interactions between nanoscale building blocks that are organized in patterned arrays. Several FCN paradigms are currently under active investigation, including quantum-dot cellular automata (QCA), molecular quantum cellular automata (MQCA), nanomagnetic logic (NML), and atomic quantum cellular automata (AQCA). Each of these paradigms has a number of unique features that make it attractive as a candidate for post-CMOS nanocomputing, and each faces critical challenges to realization. This State-of-the-Art-Survey provides a snapshot of the current developments and novel research directions in the area of FCN. The book is divided into five sections. The first part, Field-Coupled Nanocomputing Paradigms, provides valuable background information and perspectives on the QDCA, MQCA, NML, and AQCA paradigms and their evolution. The second section, Circuits and Architectures, addresses a wide variety of current research on FCN clocking strategies, logic synthesis, circuit design and test, logic-in-memory, hardware security, and architecture. The third section, Modeling and Simulation, considers the theoretical modeling and computer simulation of large FCN circuits, as well as the use of simulations for gleaning physical insight into elementary FCN building blocks. The fourth section, Irreversibility and Dissipation, considers the dissipative consequences of irreversible information loss in FCN circuits, their quantification, and their connection to circuit structure. The fifth section, The Road Ahead: Opportunities and Challenges, includes an edited transcript of the panel discussion that concluded the FCN 13 workshop.

Solution Processed Metal Oxide Thin Films for Electronic Applications CRC Press

The handbook comprehensively covers the field of inorganic photochemistry from the fundamentals to the main applications. The first section of the book describes the historical development of inorganic photochemistry, along with the fundamentals related to this multidisciplinary scientific field. The main experimental techniques employed in state-of-art studies are described in detail in the second section followed by a third section including theoretical investigations in the field. In the next three sections, the photophysical and photochemical properties of coordination compounds, supramolecular systems and inorganic semiconductors are summarized by experts on these materials. Finally, the application of photoactive inorganic compounds in key sectors of our society is highlighted. The sections cover applications in bioimaging and sensing, drug delivery and cancer therapy, solar energy conversion to electricity and fuels, organic synthesis, environmental remediation and optoelectronics among others. The chapters provide a concise overview of the main achievements in the recent years and highlight the challenges for future research. This handbook offers a unique compilation for practitioners of inorganic photochemistry in both industry and academia.

Ceramic Materials for Electronics, Third Edition John Wiley & Sons

Material synthesis by the transformation of organometallic compounds (precursors) by vapor deposition techniques such as chemical vapor deposition (CVD) and atomic layer deposition (ALD) has been in the forefront of modern day research and development of new materials. There exists a need for new routes for designing and synthesizing new precursors as well as the application of established molecular precursors to derive tuneable materials for technological demands. With regard to the precursor chemistry, a most detailed understanding of the mechanistic complexity of materials formation from molecular precursors is very important for further development of new processes and advanced materials. To emphasize and stimulate research in these areas, this volume comprises a selection of case studies covering various key-aspects of the interplay of precursor chemistry with the process conditions of materials formation, particularly looking at the similarities and differences of CVD, ALD and nanoparticle synthesis, e.g. colloid chemistry, involving tailored molecular precursors.

Comprehensive Semiconductor Science and Technology Springer

Zinc Oxysulfide (ZnOS) has demonstrated potential in the last decade to replace CdS as a buffer layer material since it is a wide-band-gap semiconductor with performance advantages over CdS (Eg = 2.4 eV) in the near UV-range for solar energy conversion. However, questions remain on the growth mechanisms of chemical bath deposited ZnOS. In this study, a detailed model is employed to calculate solubility diagrams that describe simple conditions for complex speciation control using only ammonium hydroxide without additional base. For these conditions, ZnOS is deposited via aqueous solution deposition on a quartz crystal microbalance in a continuous flow cell. Data is used to analyze the growth rate dependence on temperature and also to elucidate the effects of dimethylsulfoxide (DMSO) when used as a co-solvent. Activation energies (EA) of ZnOS are calculated for different flow rates and solution compositions. As a result, the measured EA relationships are affected by changes in the primary growth mechanism when DMSO is included.

Photoelectrochemical Materials and Energy Conversion Processes Springer

The author provides a unified account of the electrochemical material science of metal chalcogenide (MCh) compounds and alloys with regard to their synthesis, processing and applications. Starting with the chemical fundamentals of the chalcogens and their major compounds, the initial part of the book includes a systematic description of the MCh solids on the basis of the Periodic Table in terms of their structures and key properties. This is followed by a general discussion on the electrochemistry of chalcogen species, and the principles underlying the electrochemical formation of inorganic compounds/alloys. The core of the book offers an insight into available experimental results and inferences regarding the electrochemical preparation and microstructural control of conventional and novel MCh structures. It also aims to survey their photoelectrochemistry, both from a material-oriented point of view and as connected to specific processes such as photocatalysis and solar energy conversion. Finally, the book illustrates the relevance of MCh materials to various applications of electrochemical interest such as (electro)catalysis in fuel cells, energy storage with intercalation electrodes, and ion sensing.

Precursor Chemistry of Advanced Materials CRC Press

Metal oxide systems are well known for their high dielectric constants, which are important for advanced microelectronics applications. The microelectronics industry currently employs vacuum-based techniques, such as chemical vapor deposition (CVD), to deposit metal oxide films. These vapor-phase deposition techniques suffer due to their slow deposition rates and their use of expensive equipment. Additionally, these processes sometimes require the use of harmful source gases and/or generate corrosive by-products. On the other hand, solution-processed thin films fabricated by spin-coating are advantageous because the process is simple, low cost, and scalable. Aqueous solution deposition is particularly attractive because it offers a green alternative to vapor-phase deposition and has been shown to produce uniform thin films by spin coating on hydrophilic silicon surfaces. However, it has been shown that silicon's native oxide can degrade device performance due to its electronic interfacial states. In addition, aqueousderived thin films suffer from poor electrical performance due to mobile water and hydroxyl protons, often requiring very high temperature anneals to mitigate. Such anneals compromise the interface between the film and the silicon substrate, hence the electrical performance. One effective method to control the interface, and thus improve device performance, is to functionalize the semiconductor surface using wet chemistry. Here, we address the concerns of aqueous thin film deposition and present a method for alleviating the issues associated with current silicon-silicon oxide devices. We use wet chemical functionalization to graft selfassembled monolayers (SAMs) onto oxide-free silicon, then spin-coat an aqueous thin film on top of the SAM layer. The chemical stability of the SAM and the changes that occur at the interfaces between the Si/SAM/film stack during film deposition and dehydration are monitored by in situ Fourier transform infrared spectroscopy (FTIR) and ex situ X-ray photoelectron spectroscopy (XPS). The modification of the Si/SAM interface is studied as a function of annealing temperature, with electrical measurements used as a metric to quantify the effectiveness of the SAM layer to alleviate issues of interfacial defects observed for films on silicon oxide. The results are presented in three parts: (1) a dehydration study of aqueous-derived thin films deposited on silicon oxide, (2) the synthesis of a novel SAM interfacial layer tailored to accommodate aqueous, Al-based precursors and (3) a study to quantify the effectiveness, if any, on the SAM interfacial layer through electrical characterization methods. In the first part, we investigate the mechanism for dehydration of aqueous thin films and present a method to enhance the removal of water from the films. Using in situ FTIR, we find that the addition of a protective capping layer can enhance the dehydration of the thin film and prevent water reabsorption for a period of up to 14 days. In the second part, we present hydrosilylation methods to graft SAMs onto oxide-free silicon surfaces. The results show that it is possible to covalently attach the SAMs to silicon, evidenced by the formation of Si-C (detected by XPS) at the interface between the Si and the SAM. Four phosphonic acid-terminated SAMs are prepared and contact angle measurements are used as a metric for evaluating which can best accommodate aqueous spin-coater solutions. To conclude, we investigate the interface between the SAM layer and an aluminum-based thin film derived from aqueous precursor solutions. Current-voltage and capacitance-voltage measurements are used to quantify the effectiveness of the SAM layer.

Chemical Solution Deposition of Functional Oxide Thin Films John Wiley & Sons

An international group of leading scientists from the field has contributed to the 12th volume in this series, covering a range of different types of solar cells and including a critical comparison of the different techniques available for manufacturing the semiconductors needed. The result is an expert insight the central questions surrounding photovoltaic materials and systems, reflecting the latest developments in this hot and timely green topic.

Advanced Nano Deposition Methods Springer

Thin film photovoltaics are among the most promising clean, renewable energy technologies and have the potential to meet future world energy demand by covering only a small fraction of the earth's surface. To meet this challenge, annual production of photovoltaic modules, despite recent escalation, must still increase several orders of magnitude, and the development of inexpensive and scalable thin film deposition methods is of crucial importance to this effort. The cost and scalability limitations of the standard high-vacuum thin film deposition methods may be overcome by using solution-based methods. Furthermore, the transition from photovoltaic materials containing cadmium, indium, and tellurium to materials comprised of earth-abundant, non-toxic elements is expected to accelerate their large-scale deployment. Here, I present several strategies for the improvement of inorganic thin films synthesized by solution deposition. In this work, two low-cost, solution-based methods (chemical bath deposition and nanocrystal inks) were applied to the deposition of thin films of ZnS, SnS, and Cu2ZnSnS4 (CZTS), all potential earth-abundant non-toxic materials for photovoltaics. First, through the chemical bath deposition of SnS, I show how film quality is a function of deposition kinetics and can be manipulated through control of bath compositions and post-annealing parameters to improve film properties In the same SnS system, using nanocrystal inks, I show that control over nanocrystal morphology can be used as a strategy for improving thin film quality. A selective synthesis was developed for the production of high-aspect ratio sheet-like nanocrystals. Nanocrystal inks formulated from these crystals were capable of producing extremely highly-oriented thin films through the lamellar stacking of SnS sheets, which yielded favorable optical and electronic properties. The second major study in nanocrystal inks examined the efficacy of inorganic ligand exchanges and the resulting effect on film formation. Ammonium polysulfides were demonstrated as a novel species for ligand exchange on cubic ZnS nanocrystals, where they were shown to remove native ligands with high efficacy and improve film quality. Finally, this ligand exchange was applied to CZTS nanocrystal inks with promising implications for the deposition solar absorber layers. The use of these ligands has the

potential to improve efficiency and lower costs in the production of CZTS photovoltaics and other chalcogenide thin films.

Atomic Layer Deposition for Semiconductors Chemical Solution Deposition Of Semiconductor Films

This two volume set reviews the key issues in processing and characterization of nanoscale ferroelectrics and multiferroics, and provides a comprehensive description of their properties, with an emphasis in differentiating size effects of extrinsic ones like boundary or interface effects. Recently described nanoscale novel phenomena are also addressed. Organized into three parts it addresses key issues in processing (nanostructuring), characterization (of the nanostructured materials) and nanoscale effects. Taking full advantage of the synergies between nanoscale ferroelectrics and multiferroics, the text covers materials nanostructured at all levels, from ceramic technologies like ferroelectric nanopowders, bulk nanostructured ceramics and thick films, and magnetoelectric nanocomposites, to thin films, either polycrystalline layer heterostructures or epitaxial systems, and to nanoscale free standing objects with specific geometries, such as nanowires and tubes at different levels of development. This set is developed from the high level European scientific knowledge platform built within the COST (European Cooperation in Science and Technology) Action on Single and multiphase ferroics and multiferroics with restricted geometries (SIMUFER, ref. MP0904). Chapter contributors have been carefully selected, and have all made major contributions to knowledge of the respective topics, and overall, they are among most respected scientists in the field.