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Technology Models for Solid Oxide Fuel Cell Systems Materials for Fuel Cells Mini-Micro Fuel Cells Advances in Solid Oxide Fuel Cells VIII Solid Oxide Fuel Cells VIII Advances in Solid Oxide Fuel Cells IX Mesoporous Platinum Electrodes for Solid Oxide Fuel Cells Advances in Solid Oxide Fuel Cells II Dynamic Modeling and Predictive Control in Solid Oxide Fuel Cells Intermediate-Temperature Solid Oxide Fuel Cells Advances in Solid Oxide Fuel Cells Fuel Cell Technologies: State And Perspectives

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The high temperature solid oxide fuel cell (SOFC) is identified as one of the leading fuel cell technology contenders to capture the energy market in years to come. However, in order to operate as an efficient energy generating system, the SOFC requires an appropriate

control system which in turn requires a detailed modelling of process dynamics. Introducting state-of-the-art dynamic modelling, estimation, and control of SOFC systems, this book presents original modelling methods and brand new results as developed by the authors. With comprehensive coverage and bringing together many aspects of SOFC technology, it considers dynamic modelling through first-principles and data-based approaches, and considers all aspects of control, including modelling, system identification, state estimation, conventional and advanced control. Key features: Discusses both planar and tubular SOFC, and detailed and simplified dynamic modelling for SOFC Systematically describes single model and distributed models from cell level to system level Provides parameters for all models developed for easy reference and reproducing of the results All theories are illustrated through vivid fuel cell application examples, such as state-of-the-art unscented Kalman filter, model predictive control, and system identification techniques to SOFC systems The tutorial approach makes it perfect for learning the fundamentals of chemical engineering, system identification, state estimation and process control. It is suitable for graduate students in chemical, mechanical, power, and electrical engineering, especially those in process control, process systems engineering, control systems, or fuel cells. It will also aid researchers who need a reminder of the basics as well as an overview of current techniques in the dynamic modelling and control of SOFC. This book presents methodologies suitable for the optimal

design of control and diagnosis strategies for Solid Oxide Fuel Cell (SOFC) systems. One key feature of the methodologies presented is the use of modeling tools with an ideal balance between accuracy and computational burden. Particular emphasis is given to the useful combination of models within a hierarchical framework to reduce the experimental efforts required for characterization and testing. Such tools are proven to be highly effective for SOFC systems destined for both residential and transportation applications. Throughout the book, optimization is always conceived in such a way so as to allow the SOFC systems to work efficiently while guaranteeing safe thermal operation, as well as an extended lifetime. This book is aimed at scientists and engineers involved in the design of marketable SOFC systems. It gathers the knowledge and experience derived from other research and industry practice for which control and diagnosis have proven to be the main keys to success and market penetration. Developing materials for SOFC applications is one of the key topics in energy research. The book focuses on manganite structured materials, such as doped lanthanum chromites and lanthanum manganites, which have interesting properties: thermal and chemical stability, mixed ionic and electrical conductivity, electrocatalytic activity, magnetocaloric property and colossal magnetoresistance (CMR). These materials have applications in solid oxide fuel cells, high temperature NOx sensors, hard disk read heads, magnetic sensors and magnetoresistive random access memories.

For the first time, the charge density distributions have been studied in these materials as synthesized by high temperature solid state reaction. Charge density analysis is helpful in understanding the physical and chemical properties of materials and in developing optimized structures. The morphological, elemental, optical and magnetic properties of the materials have also been studied. Solid Oxide Fuel Cells, SOFC, Manganite Structured Materials, Lanthanum Chromites, Lanthanum Manganites, Electrocatalytic Activity, Magnetocaloric Property, Colossal Magnetoresistance, High Temperature NOx Sensors, Hard Disk Read Heads, Magnetic Sensors, Magnetoresistive Random Access Memories, Charge Density Distribution Fuel Cells have become a potentially highly efficient sustainable source of energy and electricity for an ever-demanding power hungry world. The two main types of fuel cells ripe for commercialisation are the high temperature solid oxide fuel cell (SOFC) and the low temperature polymer electrolyte membrane fuel cell (PEM). The commercial uses of which include, but are not limited to, military, stand-by power, commercial and industrial, and remoter power. However, all aspects of the electricity market are being considered. This book has brought together a team of world-renowned experts in all aspects of fuel cell development for both SOFC and PEM in a workshop environment. The workshop held between June 6–10, 2004 was held in the capital city of the Ukraine, Kiev. The reason for the venue was that Ukraine is the third largest resource of zircon sands, a major source of

material for the solid oxide fuel cell. Ukraine is looking at undertaking a very large effort in the solid oxide fuel cell arena, and hopes, one day, to be an international player in this market, and this book is an outcome from the workshop. The book focuses on the issues related to fuel cells, particularly the state-of-the-art internationally, the issues that were of particular interest for getting fuel cells fully commercialized, and advances in fuel cell materials and technology. The focus was on all types of fuel cells, but the emphasis was particularly on solid oxide fuel cells (SOFC), due to their importance to the host country. The book is an essential reference to researchers, academics and industrialists interested in up-to-date information on SOFC and PEM development. Solid Oxide Fuel Cells: From Fundamental Principles to Complete Systems is as a valuable resource for beginners, experienced researchers, and developers of solid oxide fuel cells. It provides a fundamental understanding of SOFCs by covering the present state-of-the-art as well as ongoing research and future challenges to be solved. It discusses current and future materials and provides an overview of development activities with a more general system approach toward fuel cell plant technology, including plant design and economics, industrial data and advances in technology. Provides an understanding of the operating principles of SOFCs Discusses state-of-the-art materials, technologies and processes Includes a review of current industry and lessons learned Offers a more general system approach toward fuel cell plant technology, including plant design

and economics of SOFC manufacture Covers significant technical challenges that remain to be solved Presents the status of government activities, industry and market This book is aimed at electrochemists, batteries and fuel cell engineers, alternative energy scientists, and professionals in materials science. Ceramic fuel cells, commonly known as solid oxide fuel cells (SOFCs), have been under development for a broad range of electric power generation applications. The most attractive feature of the SOFC is its clean and efficient production of electricity from a variety of fuels. The SOFC has the potential to be manufactured and operated cost-effectively. The widening interest in this technology, thus, arises from the continuing need to develop cleaner and more efficient means of converting energy sources into useful forms. This topical book provides a comprehensive treatise on solid oxide fuel cells and succeeds successfully in filling the gap in the market for a reference book in this field. Directed towards scientists, engineers, and technical managers working with SOFCs as well as ceramic devices based on conducting materials, and in related fields, the book will also be invaluable as a textbook for science and engineering courses. A fuel cell is an electrochemical device that converts the chemical energy of a reaction (between fuel and oxidant) directly into electricity. Given their efficiency and low emissions, fuel cells provide an important alternative to power produced from fossil fuels. A major challenge in their use is the need for better materials to make fuel cells cost-effective and more durable. This

important book reviews developments in materials to fulfil the potential of fuel cells as a major power source. After introductory chapters on the key issues in fuel cell materials research, the book reviews the major types of fuel cell. These include alkaline fuel cells, polymer electrolyte fuel cells, direct methanol fuel cells, phosphoric acid fuel cells, molten carbonate fuel cells, solid oxide fuel cells and regenerative fuel cells. The book concludes with reviews of novel fuel cell materials, ways of analysing performance and issues affecting recyclability and life cycle assessment. With its distinguished editor and international team of contributors, Materials for fuel cells is a valuable reference for all those researching, manufacturing and using fuel cells in such areas as automotive engineering. Examines the key issues in fuel cell materials research Reviews the major types of fuel cells such as direct methanol and regenerative fuel cells Further chapters explore ways of analysing performance and issues affecting recyclability and life cycle assessment This book discusses recent advances in intermediate-temperature solid oxide fuel cells (IT-SOFCs), focusing on material development and design, mechanism study, reaction kinetics and practical applications. It consists of five chapters presenting different types of reactions and materials employed in electrolytes, cathodes, anodes, interconnects and sealants for IT-SOFCs. It also includes two chapters highlighting new aspects of these solid oxide fuel cells and exploring their practical applications. This insightful and useful book appeals to a wide readership in

various fields, including solid oxide fuel cells, electrochemistry, membranes and ceramics. Zongping Shao is a Professor at the State Key Laboratory of Materials-Oriented Chemical Engineering and the College of Energy, Nanjing University of Technology, China. Moses O. Tade is a Professor at the Department of Chemical Engineering, Curtin University, Australia. The Ninth International Symposium on Solid Oxide Fuel Cells: Materials, Science, and Technology was held in January 2012 as part of the 36th International Conference on Advanced Ceramics and Composites (ICACC). This symposium provided an international forum for scientists, engineers, and technologists from around the world to present and discuss the latest advances in solid oxide fuel cells. This issue features fourteen papers selected from the symposium, offering readers a broad panorama of the current status of solid oxide fuel cells technology, as well as emerging issues and future directions in the field. Presents innovative approaches towards affordable, highly efficient, and reliable sustainable energy systems Written by leading experts on the subject, this book provides not only a basic introduction and understanding of conventional fuel cell principle, but also an updated view of the most recent developments in this field. It focuses on the new energy conversion technologies based on both electrolyte and electrolyte-free fuel cells?from advanced novel ceria-based composite electrolyte low temperature solid oxide fuel cells to non-electrolyte fuel cells as advanced fuel-to-electricity conversion technology. Solid

Oxide Fuel Cells: From Electrolyte-Based to Electrolyte-Free Devices is divided into three parts. Part I covers the latest developments of anode, electrolyte, and cathode materials as well as the SOFC technologies. Part II discusses the non-electrolyte or semiconductor-based membrane fuel cells. Part III focuses on engineering efforts on materials, technology, devices and stack developments, and looks at various applications and new opportunities of SOFC using both the electrolyte and non-electrolyte principles, including integrated fuel cell systems with electrolysis, solar energy, and more. -Offers knowledge on how to realize highly efficient fuel cells with novel device structures -Shows the opportunity to transform the future fuel cell markets and the possibility to commercialize fuel cells in an extended range of applications -Presents a unique collection of contributions on the development of solid oxide fuel cells from electrolyte based to non-electrolyte-based technology -Provides a more comprehensive understanding of the advances in fuel cells and bridges the knowledge from traditional SOFC to the new concept -Allows readers to track the development from the conventional SOFC to the non-electrolyte or single-component fuel cell Solid Oxide Fuel Cells: From Electrolyte-Based to Electrolyte-Free Devices will serve as an important reference work to students, scientists, engineers, researchers, and technology developers in the fuel cell field. This book examines the various interfacial reactions that take place when glass seals come into contact with components of SOFCs in reducing and oxidizing conditions.

In developing an understanding of the structure and function of SOFCs, interfacial compatibility is an imperative criterion. This book addresses the technical challenges of developing sealants to avoid leakage losses at high operating temperatures, which are profoundly impactful to the efficiency of the fuel cell. This resource is important for anyone working with or studying fuel cell design and development, and is a pivotal source of cutting-edge information for research groups actively engaged in developing hermetic and stable seals which show minimum interfacial chemical reaction with interconnect and electrolyte. Solid Oxide Fuel Cells (SOFCs) operate at high temperatures allowing more fuel flexibility and also useful heat output and so increase total efficiency, but does give some interesting engineering challenges. Solid Oxide Fuels Cells: Facts and Figures provides clear and accurate data for a selection of SOFC topics from the specific details of Ni cermet anodes, chemical expansion in materials, and the measuring and modelling of mechanical stresses, to the broader scope of the history and present design of cells, to SOFC systems and the future of SOFC. Celebrating Ulf Bossel ' s work on Solid Oxide Fuel Cells, and especially his running of the European Fuel Cell Forum, Solid Oxide Fuels Cells: Facts and Figures covers important topics on the way including intermediate temperature fuel cells, metal supported fuel cells and both new materials and engineering solutions to some of the challenges of getting SOFC to market. The chapters are based on the special plenary talks given by some of the most respected and

talented people in the field at the 2010 European SOFC Forum in Luzern and the title for this book comes from the report produced by Ulf for the IEA " Final Report on SOFC Data, Facts and Figures ", Swiss Federal Office of Energy, Berne, 1992. The comprehensive nature of Solid Oxide Fuels Cells: Facts and Figures makes it a key resource of SOFC topics for students, lecturers, researchers and industry practitioners alike. This volume contains an archival record of the NATO Advanced Institute on Mini – Micro Fuel Cells – Fundamental and Applications held in Çesme – Izmir, Turkey, July 22–August 3, 2007. The ASIs are intended to be a high-level teaching activity in scientific and technical areas of current concern. In this volume, the reader may find interesting chapters on Mini-Micro Fuel Cells with fundamentals and applications. In recent years, fu- cell development, modeling and performance analysis has received much attention due to their potential for distributed power which is a critical issue for energy security and the environmental protection. Small fuel cells for portable applications are important for the security. The portable devices (many electronic and wireless) operated by fuel cells for providing all-day power, are very valuable for the security, for defense and in the war against terrorism. Many companies in NATO and non-NATO countries have concentrated to promote the fuel cell industry. Many universities with industrial partners committed to the idea of working together to develop fuel cells. As tech- logy advanced in the 1980s and beyond, many government organizations joined in spending money

on fuel-cell research. In recent years, interest in using fuel cells to power portable electronic devices and other small equipment (cell phones, mobile phones, lab-tops, they are used as micro power source in biological applications) has increased partly due to the promise of fuel cells having higher energy density. High-temperature Solid Oxide Fuel Cells, Second Edition, explores the growing interest in fuel cells as a sustainable source of energy. The text brings the topic of green energy front and center, illustrating the need for new books that provide comprehensive and practical information on specific types of fuel cells and their applications. This landmark volume on solid oxide fuel cells contains contributions from experts of international repute, and provides a single source of the latest knowledge on this topic. A single source for all the latest information on solid oxide fuel cells and their applications Illustrates the need for new, more comprehensive books and study on the topic Explores the growing interest in fuel cells as viable, sustainable sources of energy The world's ever-growing demand for power has created an urgent need for new efficient and sustainable sources of energy and electricity. Today's consumers of portable electronics also demand devices that not only deliver more power but are also environmentally friendly. Fuel cells are an important alternative energy source, with promise in military, commercial and industrial applications, for example power vehicles and portable devices. A fuel cell is an electrochemical device that directly converts the chemical energy of a fuel into electrical energy. Fuel cells represent

the most efficient energy conversion technologies to-date and are an integral part in the new and renewable energy chain (e.g., solar, wind and hydropower). Fuel cells can be classified as either high-temperature or lowtemperature, depending on their operating temperature, and have different materials requirements. This book is dedicated to the study of high temperature fuel cells. In hightemperature fuel cells, the electrolyte materials are ceramic or molten carbonate, while the electrode materials are ceramic or metal (but not precious metal). High operation temperature fuel cells allow internal reforming, promote rapid kinetics with non-precious materials and offer high flexibilities in fuel choice, and are potential and viable candidate to moderate the fast increase in power requirements and to minimize the impact of the increased power consumption on the environment. 'Materials for High Temperature Fuel Cells' is part of the series on Materials for Sustainable Energy and Development edited by Prof. Max Q. Lu. The series covers advances in materials science and innovation for renewable energy, clean use of fossil energy, and greenhouse gas mitigation and associated environmental technologies. Due to its many potential benefits, including high electrical efficiency and low environmental emissions, solid oxide fuel cell (SOFC) technology is the subject of extensive research and development efforts by national laboratories, universities, and private industries. In these proceedings, international scientists and engineers present recent technical progress on materials-related aspects of fuel cells including SOFC

component materials, materials processing, and cell/stack design, performance, and stability. Emerging trends in electrochemical materials, electrodics, interface engineering, long-term chemical interactions, and more are included. This book is compiled of papers presented at the Proceedings of the 30th International Conference on Advanced Ceramics and Composites, January 22-27, 2006, Cocoa Beach, Florida. Organized and sponsored by The American Ceramic Society and The American Ceramic Society's Engineering Ceramics Division in conjunction with the Nuclear and Environmental Technology Division. Intermediate Temperature Solid Oxide Fuel Cells: Electrolytes, Electrodes and Interconnects introduces the fundamental principles of intermediate solid oxide fuel cells technology. It provides the reader with a broad understanding and practical knowledge of the electrodes, pyrochlore/perovskite/oxide electrolytes and interconnects which form the backbone of the Solid Oxide Fuel Cell (SOFC) unit. Opening with an introduction to the thermodynamics, physiochemical and electrochemical behavior of Solid Oxide Fuel Cells (SOFC), the book also discusses specific materials, including low temperature brownmillerites and aurivillius electrolytes, as well as pyrochlore interconnects. This book analyzes the basic concepts, providing cutting-edge information for both researchers and students. It is a complete reference for Intermediate Solid Oxide Fuel Cells technology that will be a vital resource for those working in materials science, fuel cells and solid state chemistry. Provides a single source of

information on glass, electrolytes, interconnects, vanadates, pyrochlores and perovskite SOFC Includes illustrations that provide a clear visual explanation of concepts being discussed Progresses from a discussion of basic concepts that will enable readers to easily comprehend the subject matter Fuel Cells have become a potentially highly efficient sustainable source of energy and electricity for an ever-demanding power hungry world. The two main types of fuel cells ripe for commercialisation are the high temperature solid oxide fuel cell (SOFC) and the low temperature polymer electrolyte membrane fuel cell (PEM). The commercial uses of which include, but are not limited to, military, stand-by power, commercial and industrial, and remoter power. However, all aspects of the electricity market are being considered. This book has brought together a team of world-renowned experts in all aspects of fuel cell development for both SOFC and PEM in a workshop environment. The workshop held between June 6–10, 2004 was held in the capital city of the Ukraine, Kiev. The reason for the venue was that Ukraine is the third largest resource of zircon sands, a major source of material for the solid oxide fuel cell. Ukraine is looking at undertaking a very large effort in the solid oxide fuel cell arena, and hopes, one day, to be an international player in this market, and this book is an outcome from the workshop. The book focuses on the issues related to fuel cells, particularly the state-of-the-art internationally, the issues that were of particular interest for getting fuel cells fully commercialized, and advances in fuel cell materials

and technology. The focus was on all types of fuel cells, but the emphasis was particularly on solid oxide fuel cells (SOFC), due to their importance to the host country. The book is an essential reference to researchers, academics and industrialists interested in up-to-date information on SOFC and PEM development. This issue of ECS Transactions contains papers from the Twelfth International Symposium on Solid Oxide Fuel Cells (SOFC-XII),a continuing biennial series of symposia. The papers deal with materials for cell components and fabrication methods for components and complete cells. Also contained are papers on cell electrochemical performance and its modelling, stacks and systems, and prototype testing of SOFC demonstration units for different applications. Solid oxide fuel cells (SOFCs) have long offered promise of renewable and highly efficient direct chemical to electrical energy conversion, though their high cost and operating temperatures have limited commercial adoption and applications. Recently, research efforts have focused on reducing the operating temperature by thinning the fuel cell membrane, thereby eliminating the requirement of high-temperature (800 C to 1000 C) compatible ceramic electrodes, and allowing the use of more traditional metallic catalysts that were previously limited to lower temperature fuel cell types due to materials compatibility constraints. However, because these operating temperatures (400 C to 600 C) remain much higher than those found in low temperature fuel cells, the morphological stability of these metallic catalytic

electrodes at these intermediate temperatures is a critical factor impacting fuel cell performance. Our first study investigates the morphological stability of mesoporous platinum thin films deposited via nanosphere lithography on yttria-stabilized zirconia (YSZ). Carboxylate-modified polystyrene nanospheres were spin-coated onto YSZ substrates, diameter-reduced via reactive ion etching, and used as a shadow mask for e-beam platinum deposition. The spheres were then removed by sonication, leaving behind a hexagonal close-packed array of holes in the Pt film. Hole diameters were measured pre- and post-annealing in 5% forming gas and pure oxygen environments, mimicking the anode and cathode environments, respectively, of a fuel cell. Annealing temperatures and times were varied, and the hole evolution model by Srolovitz and Safran was used to extract an activation energy for platinum surface diffusion under each annealing environment. Calculated activation energies were 1.16 eV and 1.22 eV for forming gas and oxygen environments, respectively, with a slightly smaller diffusion prefactor for the latter environment. Our second study evaluates the performance of these mesoporous platinum films as SOFC electrodes. We compare the mesoporous platinum films to standard nanoporous platinum electrodes, using simple SOFC devices with 100 μm thick polycrystalline YSZ as the electrolytes. Four electrode configurations were investigated (noted as cathode-anode): nano-nano, meso-nano, nano-meso, and meso-meso. SEM images of the electrodes before and after

testing are compared. We also evaluated the electrical performance of the electrodes by measuring current output as a function of time at constant voltage, current as a function of voltage, and impedance spectra pre- and post-constant voltage testing. The data suggest that, for these devices and operating conditions, oxygen reduction kinetics and cathode triple phase boundary lengths are the main factors limiting performance. Devices with nanoporous cathodes exhibited higher absolute current density compared to devices with mesoporous cathodes. The nanoporous cathode devices also exhibited decreasing current at constant voltage over time, whereas the mesoporous cathode devices reached a stable current after approximately 5 h. SEM images show that the nanoporous electrodes underwent significant morphological change during testing, as compared to the mesoporous electrodes and impedance spectra quantitatively show that the nanoporous cathode devices exhibit greater resistance increase after testing than the mesoporous cathode devices. The book summarizes the current state of the solid oxide fuel cell (SOFC) technology in power generation applications. It describes the single cells, SOFC stacks, micro-combined heat and power systems, large-scale stationary power generators and polygeneration units. The principles of modeling, simulation and controls of power systems with solid oxide fuel cells are presented and discussed. Authors provide theoretical background of the technology followed by the essential insights into the integrated power systems. Selected aspects of the design,

construction and operation of power units in range from single kilowatts to hundreds of kilowatts are presented. Finally, the book reports the selected studies on prototype systems which have been constructed in Europe. The book discusses the theoretical and practical aspects of operation of power generators with solid oxide fuel cells including fabrication of cells, design of stacks, system modeling, simulation of stationary and non-stationary operation of systems, fuel preparation and controls. High Temperature Solid Oxide Fuel Cells: Fundamentals, Design and Applications provides a comprehensive discussion of solid oxide fuel cells (SOFCs). SOFCs are the most efficient devices for the electrochemical conversion of chemical energy of hydrocarbon fuels into electricity, and have been gaining increasing attention for clean and efficient distributed power generation. The book explains the operating principle, cell component materials, cell and stack designs and fabrication processes, cell and stack performance, and applications of SOFCs. Individual chapters are written by internationally renowned authors in their respective fields, and the text is supplemented by a large number of references for further information. The book is primarily intended for use by researchers, engineers, and other technical people working in the field of SOFCs. Even though the technology is advancing at a very rapid pace, the information contained in most of the chapters is fundamental enough for the book to be useful even as a text for SOFC technology at the graduate level. This book fills the need for a practical reference for all

scientists and graduate students who are seeking to define a mathematical model for Solid Oxide Fuel Cell (SOFC) simulation. Structured in two parts, part one presents the basic theory, and the general equations describing SOFC operation phenomena. Part two deals with the application of the theory to practical examples, where different SOFC geometries, configurations, and different phenomena are analyzed in detail. Fuel cells are widely regarded as the future of the power and transportation industries. Intensive research in this area now requires new methods of fuel cell operation modeling and cell design. Typical mathematical models are based on the physical process description of fuel cells and require a detailed knowledge of the microscopic properties that govern both chemical and electrochemical reactions. Advanced Methods of Solid Oxide Fuel Cell Modeling proposes the alternative methodology of generalized artificial neural networks (ANN) solid oxide fuel cell (SOFC) modeling. Advanced Methods of Solid Oxide Fuel Cell Modeling provides a comprehensive description of modern fuel cell theory and a guide to the mathematical modeling of SOFCs, with particular emphasis on the use of ANNs. Up to now, most of the equations involved in SOFC models have required the addition of numerous factors that are difficult to determine. The artificial neural network (ANN) can be applied to simulate an object ' s behavior without an algorithmic solution, merely by utilizing available experimental data. The ANN methodology discussed in Advanced Methods of Solid Oxide Fuel Cell Modeling can

be used by both researchers and professionals to optimize SOFC design. Readers will have access to detailed material on universal fuel cell modeling and design process optimization, and will also be able to discover comprehensive information on fuel cells and artificial intelligence theory. Design and Operation of Solid Oxide Fuel Cells: The Systems Engineering Vision for Industrial Application presents a comprehensive, critical and accessible review of the latest research in the field of solid oxide fuel cells (SOFCs). As well as discussing the theoretical aspects of the field, the book explores a diverse range of power applications, such as hybrid power plants, polygeneration, distributed electricity generation, energy storage and waste management—all with a focus on modeling and computational skills. Dr. Sharifzadeh presents the associated risks and limitations throughout the discussion, providing a very complete and thorough analysis of SOFCs and their control and operation in power plants. The first of its kind, this book will be of particular interest to energy engineers, industry experts and academic researchers in the energy, power and transportation industries, as well as those working and researching in the chemical, environmental and material sectors. Closes the gap between various power engineering disciples by considering a diverse variety of applications and sectors Presents and reviews a variety of modeling techniques and considers regulations throughout Includes CFD modeling examples and process simulation and optimization programming guidance Ceramic Engineering

and Science Proceedings Volume 34, Issue 4 - Advances in Solid Oxide Fuel Cells IX A collection of 13 papers from The American Ceramic Society ' s 37th International Conference on Advanced Ceramics and Composites, held in Daytona Beach, Florida, January 27-February 1, 2013. This issue includes papers presented in Symposium 3 - 10th International Symposium on Solid Oxide Fuel Cells: Materials, Science, and Technology. The First Book Centered on Materials Issues of SOFCs Although the high operating temperature of solid oxide fuel cells (SOFCs) creates opportunities for using a variety of fuels, including low-grade hydrogen and those derived from biomass, it also produces difficulties in materials performance and often leads to materials degradation during operation. These obstacles have proven to be challenges in the path to greater commercialization. Focusing on materials-related issues, Solid Oxide Fuel Cells: Materials Properties and Performance provides state-of-the-art information for the selection and development of materials for improved SOFC performance. The Materials behind the Development of SOFCs Summarizing progress in the field thus far, the book describes current materials, future advances in materials, and significant technical problems that remain unresolved. The first three chapters explore materials for the electrochemical cell: electrolytes, anodes, and cathodes. The next two chapters discuss interconnects and sealants, which are two supporting components of the fuel cell stack. The final chapter addresses the various issues involved in materials processing for SOFC applications,

such as the microstructure of the component layers and the processing methods used to fabricate the microstructure. An Important Enabling Technology for Future Sustainable Energy Systems This volume shows how the performance of SOFCs can be improved through novel materials and methods, thereby, bringing them closer to commercialization. Fuel cells are a very promising technology for the clean and efficient production of power. Fuel Cell Technology is an up-to-date survey of the development of this technology and will be bought by researchers and graduate students in materials control and chemical engineering working at universities and institutions and researchers and technical managers in commercial companies working in fuel cell technology. In this book well-known experts highlight cutting-edge research priorities and discuss the state of the art in the field of solid oxide fuel cells giving an update on specific subjects such as protonic conductors, interconnects, electrocatalytic and catalytic processes and modelling approaches.Fundamentals and advances in this field are illustrated to help young researchers address issues in the characterization of materials and in the analysis of processes, not often tackled in scholarly books. Fuel cells are, according to some, the answer to the future problems of energy resources. Rather than solve those problems alone, they will doubtless form part of a growing group of alternative energy sources such as wind, tidal, photovoltaic and nuclear sources which will reduce our dependence on oil. Stationary fuel cells are the kind used mainly for home,

office and large-scale power plants. For those seeking a current overview of stationary fuel cells, their status and applications, market developments, market players, economics and future potential, this is where to look. Not a purely engineering textbook, it is designed to provide potential adopters of fuel cells with the information needed to make sensible decisions, and as such it is unique. *Expert summary of current and future status *Decision-making aid for non-engineers *Increasingly important fuel source Solid oxide fuel cells (SOFCs) are promising electrochemical power generation devices that can convert chemical energy of a fuel into electricity in an efficient, environmental-friendly, and quiet manner. Due to their high operating temperature, SOFCs feature fuel flexibility as internal reforming of hydrocarbon fuels and ammonia thermal cracking can be realized in SOFC anode. This book presents an overview of the SOFC technology with a focus on the recent developments in new technologies and new ideas for addressing the key issues of SOFC development. This book first introduces the fundamental principles of SOFCs and compares SOFC technology with conventional heat engines as well as low temperature fuel cells. Then the latest developments in SOFC R&D are reviewed and future directions are discussed. Key issues related to SOFC performance improvement, long-term stability, mathematical modelling, as well as system integration/control are addressed, including material development, infiltration technique for nano-structured electrode fabrication, focused ion beam – scanning

electron microscopy (FIB-SEM) technique for microstructure reconstruction, the Lattice Boltzmann Method (LBM) simulation at pore scale, multi-scale modelling, SOFC integration with buildings and other cycles for stationary applications. Due to its many potential benefits, including high electrical efficiency and low environmental emissions, solid oxide fuel cell (SOFC) technology is the subject of extensive research and development efforts by national laboratories, universities, and private industries. This collection of papers provides valuable insights on materials-related aspects of fuel cells such as SOFC component materials, materials processing, and cell/stack design, performance, and stability. Emerging trends in electrochemical materials, electrodics, interface engineering, long-term chemical interactions are also covered. A comprehensive guide to the modelling and design of solid oxide fuel cell hybrid power plants This book explores all technical aspects of solid oxide fuel cell (SOFC) hybrid systems and proposes solutions to a range of technical problems that can arise from component integration. Following a general introduction to the state-of-the-art in SOFC hybrid systems, the authors focus on fuel cell technology, including the components required to operate with standard fuels. Micro-gas turbine (mGT) technology for hybrid systems is discussed, with special attention given to issues related to the coupling of SOFCs with mGTs. Throughout the book emphasis is placed on dynamic issues, including control systems used to avoid risk conditions. With an eye to mitigating the high costs

and risks incurred with the building and use of prototype hybrid systems, the authors demonstrate a proven, economically feasible approach to obtaining important experimental results using simplified plants that simulate both generic and detailed system-level behaviour using emulators. Computational models and experimental plants are developed to support the analysis of SOFC hybrid systems, including models appropriate for design, development and performance analysis at both component and system levels. Presents models for a range of size units, technology variations, unit coupling dynamics and start-up and shutdown behaviours Focuses on SOFCs integration with mGTs in light of key constraints and risk avoidance issues under steady-state conditions and during transient operations Identifies interaction and coupling problems within the GT/SOFC environment, including exergy analysis and optimization Demonstrates an economical approach to obtaining important experimental results while avoiding high-cost components and risk conditions Presents analytical/computational and experimental tools for the efficient design and development of hardware and software systems Hybrid Systems Based on Solid Oxide Fuel Cells: Modelling and Design is a valuable resource for researchers and practicing engineers involved in fuel cell fundamentals, design and development. It is also an excellent reference for academic researchers and advanced-level students exploring fuel cell technology. Fuel cell technology is quite promising for conversion of chemical energy of

hydrocarbon fuels into electricity without forming air pollutants. There are several types of fuel cells: polymer electrolyte fuel cell (PEFC), phosphoric acid fuel cell (PAFC), molten carbonate fuel cell (MCFC), solid oxide fuel cell (SOFC), and alkaline fuel cell (AFC). Among these, SOFCs are the most efficient and have various advantages such as flexibility in fuel, high reliability, simple balance of plant (BOP), and a long history. Therefore, SOFC technology is attracting much attention as a power plant and is now close to marketing as a combined heat and power generation system. From the beginning of SOFC development, many perovskite oxides have been used for SOFC components; for example, LaMnO -based oxide for the cathode and 3 LaCrO for the interconnect are the most well known materials for SOFCs. The 3 current SOFCs operate at temperatures higher than 1073 K. However, lowering the operating temperature of SOFCs is an important goal for further SOFC development. Reliability, durability, and stability of the SOFCs could be greatly improved by decreasing their operating temperature. In addition, a lower operating temperature is also beneficial for shortening the startup time and decreasing energy loss from heat radiation. For this purpose, faster oxide ion conductors are required to replace the conventional Y O -stabilized ZrO 2 3 2 electrolyte. A new class of electrolytes such as LaGaO is considered to be 3 highly useful for intermediate-temperature SOFCs. High temperature solid oxide fuel cell (SOFC) technology is a promising power generation option that features high electrical efficiency

and low emissions of environmentally polluting gases such as CO2, NOox and SOx. It is ideal for distributed stationary power generation applications where both high-efficiency electricity and high-quality heat are in strong demand. For the past few decades, SOFC technology has attracted intense worldwide R&D effort and, along with polymer electrolyte membrane fuel cell (PEMFC) technology, has undergone extensive commercialization development. This book presents a systematic and in-depth narrative of the technology from the perspective of fundamentals, providing comprehensive theoretical analysis and innovative characterization techniques for SOFC technology. The book initially deals with the basics and development of SOFC technology from cell materials to fundamental thermodynamics, electronic properties of solids and charged particle transport. This coverage is extended with a thorough analysis of such operational features as current flow and energy balance, and on to voltage losses and electrical efficiency. Furthermore, the book also covers the important issues of fuel cell stability and durability with chapters on performance characterization, fuel processing, and electrode poisoning. Finally, the book provides a comprehensive review for SOFC materials and fabrication techniques. A series of useful scientific appendices rounds off the book. Solid oxide fuel cell technology is a standard reference for all those researching this important field as well as those working in the power industry. Provides a comprehensive review of solid oxide fuel cells from history and design to

chemistry and materials development Presents analysis of operational features including current flow, energy balance, voltage losses and electrical efficiency Explores fuel cell stability and durability with specific chapters examining performance characterization, fuel processing and electrode poisoning Solid Oxide Fuel Cell Lifetime and Reliability: Critical Challenges in Fuel Cells presents in one volume the most recent research that aims at solving key issues for the deployment of SOFC at a commercial scale and for a wider range of applications. To achieve that, authors from different regions and backgrounds address topics such as electrolytes, contaminants, redox cycling, gas-tight seals, and electrode microstructure. Lifetime issues for particular elements of the fuel cells, like cathodes, interconnects, and fuel processors, are covered as well as new materials. They also examine the balance of SOFC plants, correlations between structure and electrochemical performance, methods for analysis of performance and degradation assessment, and computational and statistical approaches to quantify degradation. For its holistic approach, this book can be used both as an introduction to these issues and a reference resource for all involved in research and application of solid oxide fuel cells, especially those developing understanding in industrial applications of the lifetime issues. This includes researchers in academia and industrial R&D, graduate students and professionals in energy engineering, electrochemistry, and materials sciences for energy applications. It might also be of

particular interest to analysts who are looking into integrating SOFCs into energy systems. Brings together in a single volume leading research and expert thinking around the broad topic of SOFC lifetime and durability Explores issues that affect solid oxide fuel cells elements, materials, and systems with a holistic approach Provides a practical reference for overcoming some of the common failure mechanisms of SOFCs Features coverage of integrating SOFCs into energy systems