Solid Oxide Fuel Cell Technology Principles

Solid Oxide Fuel Cell TechnologyHigh-temperature Solid Oxide Fuel Cells: Fundamentals, Design and ApplicationsSolid Oxide Fuel Cells IXModeling Solid Oxide Fuel CellsSolid Oxide Fuel CellsProceedings of the Fourth International Symposium on Solid Oxide Fuel Cells (SOFC-IV)Solid Oxide Fuels Cells: Facts and FiguresSolid Oxide Fuel CellsSolid Oxide Fuel Cells 12 (SOFC-XII)High-Temperature Solid Oxide Fuel Cells for the 21st CenturySolid Oxide Fuel CellsFuel Cell Technologies: State And PerspectivesSolid Oxide Fuel CellsSolid Oxide Fuel Cell Lifetime and ReliabilityPerovskite Oxide for Solid Oxide Fuel CellsSolid Oxide Fuel CellsSolid Oxide Fuels Cells: Facts and FiguresProceedings of the Fifth International Symposium on Solid Oxide Fuel Cells (SOFC-V)Solid Oxide Fuel Cells (SOFC IX).Advances in Medium and High Temperature Solid Oxide Fuel Cell Technology K Huang S.C. Singhal S. C. Singhal Roberto Bove Bin Zhu M. Dokiya John T.S. Irvine Radenka Maric S. C. Singhal Kevin Kendall S. C. Singhal Nigel Sammes Jeffrey Fergus Nigel Brandon Tatsumi Ishihara Radenka Maric John T.S. Irvine U. Stimming S. C. Singhal Marta Boaro
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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

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

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

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

solid oxide fuel cells from fundamental principles to complete systems is a valuable resource for beginners experienced researchers and developers of solid oxide fuel cells sofcs 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 the 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

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

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

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

the first book centered on materials issues of sofcsalthough 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 operatio

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

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

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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

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

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Introduction

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