Advanced Methods of Solid Oxide Fuel Cell Modeling
Interactive Temperature Solid Oxide Fuel Cells
Solid Oxide Fuel Cell Lifetime and Reliability
High-temperature Solid Oxide Fuel Cells
Multi-scale Modeling and Predictive Control in Solid Oxide Fuel Cells
Mathematical Modeling of Solid Oxide Fuel Cells
Hybrid Systems
Support Modeling and Control of Fuel Cells
Computer Modeling of Solid Oxide Fuel Cells
Analytical Modeling of Fuel Cells
High-temperature Solid Oxide Fuel Cells
Multi-level Mathematical Modeling of Solid Oxide Fuel Cells
Solid Oxide Fuel Cell Modeling in Solid Oxide Fuel Cells
Dynamic Modeling and Predictive Control in Solid Oxide Fuel Cells
Fundamentals of Heat and Fluid Flow in High Temperature Fuel Cells
Modeling, Design, Construction, and Operation of Power Generators with Solid Oxide Fuel Cells
Solid Oxide Fuel Cells for the 21st Century
Modeling and Simulation for Solid Oxide Fuel Cell Power System
Dynamic Modeling and Predictive Control in Solid Oxide Fuel Cells
Multi-level Mathematical Modeling of Solid Oxide Fuel Cells
Solid Oxide Fuel Cells
Intermediate Temperature Solid Oxide Fuel Cells
"The emerging fuel cell (FC) technology is growing rapidly in its applications from small-scale portable electronics to large-scale power generation. This book gives students, engineers, and scientists a solid understanding of the FC dynamic modeling and controller design to adapt FCs to particular applications in distributed power generation."--BOOK JACKET.
Solid Oxide Fuel Cell Lifetime and Reliability
"A timely treatment of the modeling and advanced control of the most promising fuel cell technology - SOFC (solid oxide fuel cells) - from cell to system level Dynamic Modeling and Predictive Control in Solid Oxide Fuel Cells: Delivers comprehensive coverage of SOFC dynamic models and modeling approach from first principles, bringing together many aspects of SOFC technology in one book for the first time Provides parameters for all models developed for easy reference and reproducing of the results Discusses lumped model and distributed model from cell level to system level Applications to the state-of-the-art unscented Kalman filter, model predictive control, and monitoring techniques to SOFC systems (uses NMPC, which is well understood by both industry and academia Essential reading for Graduate students and researchers in the area of fuel cells, process systems engineering, control systems engineering, process control and electrochemical engineering"--
High-temperature Solid Oxide Fuel Cells: Fundamentals, Design and Applications
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
Solid Oxide Fuel Cells: Facts and Figures

Solid Oxide Fuel Cells (SOFCs) are promising electrochemical power generation devices that can convert chemical energy of a fuel into electricity in an efficient, environmentally-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 power applications, such as hybrid power plants, 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 power applications.
Read Book Modeling Of Solid Oxide Fuel Cell System Multi Scale Modeling And Simulation Of Thermal Fluid And Electrochemical Transport In A Solid Oxide Fuel Cell

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.

Mechanical Characterization and Modeling of Solid Oxide Fuel Cell Electrolytes with Honeycomb Support

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.

Modeling and Control of Fuel Cells

This book presents a comprehensive overview of the modeling and control of fuel cells. It covers fundamental concepts, mathematical modeling, simulation techniques, and practical control strategies. The book is designed for researchers, engineers, and graduate students interested in fuel cell technology.

Computer Modeling of Solid Oxide Fuel Cells

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.

Analytical Modelling of Fuel Cells

High-temperature Solid Oxide Fuel Cells for the 21st Century

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.

Modeling and Simulation for Solid Oxide Fuel Cell Power System

Dynamic Modeling and Predictive Control in Solid Oxide Fuel Cells

Multi-Level Mathematical Modeling of Solid Oxide Fuel Cells

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.

Solid Oxide Fuel Cells
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 electrolyte, 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

Computer Modeling of Solid Oxide Fuel Cells

Fuel cells are attractive electrochemical energy converters featuring potentially very high thermodynamic efficiency factors. The focus of this volume of Advances in Chemical Engineering is on quantitative approaches, particularly based on chemical engineering principles, to analyze, control and optimize the steady state and dynamic behavior of low and high temperature fuel cells (PEMFC, DMFC, SOFC) to be applied in mobile and stationary systems. Updates and informs the reader on the latest research findings using original reviews Written by leading industry experts and scholars Reviews and analyzes developments in the field

Finite Element Modeling of Solid Oxide Fuel Cells

Fuel Cell Engineering

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. ~Addresses 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.

Modeling of Solid Oxide Fuel Cells

Although, the basic concept of a fuel cell is quite simple, creating new designs and optimizing their performance takes serious work and a mastery of several technical areas. PEM Fuel Cell Modeling and Simulation Using Matlab provides design engineers and researchers with a valuable tool for understanding and overcoming barriers to designing and building the next generation of PEM Fuel Cells. With this book, engineers can test components and verify designs in the development phase, saving both time and money. Easy to read and understand, this book provides design and modelling tips for fuel cell components such as: modelling proton exchange structure, catalyst layers, gas diffusion, fuel distribution structures, fuel cell stacks and fuel cell plant. This book includes design advice and MATLAB and FEMLAB codes for Fuel Cell types such as: polymer electrolyte, direct methanol and solid oxide fuel cells. This book also includes types for one, two and three dimensional modeling and two-phase flow phenomena and microfluidics. *Modeling and design validation techniques *Covers most types of Fuel Cell including SOFC *MATLAB and FEMLAB modelling codes *Translates basic phenomena into mathematical equations

Mini-Micro Fuel Cells
The model simulations were in good agreement with experimental data from studies in the literature and demonstrate the essential role of the exchange current density and the volume-specific effective anode surface area, whose values are often not reported in the literature.

**PEM Fuel Cell Modeling and Simulation Using Matlab**

Abstract: Planar solid oxide fuel cells (SOFCs) are made up of repeating sequences of electrolytes, electrodes, seals, interconnects, and current collectors. For electro-chemical reasons it is best to keep the electrolyte as thin as possible. However, for electrolyte-supported cells, the thin electrolytes are susceptible to damage during production, assembly, and operation. To produce cells with sufficient mechanical robustness, electrolytes can be made with a co-sintered honeycomb structure that supports the thin, electro-chemically efficient electrolyte membranes.

**Modeling of Solid Oxide Fuel Cell Functionally Graded Electrodes and a Feasibility Study of Fabrication Techniques for Functionally Graded Electrodes**

A comprehensive membrane-electrode assembly (MEA) model of Solid Oxide Fuel Cell (SOFC) is developed to investigate the effect of various design and operating conditions on the cell performance and to examine the underlying mechanisms that govern their performance. We review and compare the current modeling methodologies, and develop an one-dimensional MEA model based on a comprehensive approach that include the dusty-gas model (DGM) for gas transport in the porous electrodes, the detailed heterogeneous elementary reaction kinetics for the thermo-chemistry in the anode, and the detailed electrode kinetics for the electrochemistry at the triple-phase boundary. With regard to the DGM, we corrected the Knudsen diffusion coefficient in the previous model developed by Multidisciplinary University Research Initiative. Further, we formulate the conservation equations in the unsteady form, allowing for analyzing the response of the MEA to imposed dynamics. As for the electrochemistry model, we additionally analyzed all the possibilities of the rate-limiting reaction and proposed rate-limiting switched mechanism. Our model prediction agrees with experimental results significantly better than previous models, especially at high current density.

**Modeling Solid Oxide Fuel Cells**

**Advanced Methods of Solid Oxide Fuel Cell Modeling**

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.

**Modeling of Solid Oxide Fuel Cell/gas Turbine Hybrid Systems**

Multi-Level Mathematical Modeling of Solid Oxide Fuel Cells.

**Mathematical Modeling of Solid Oxide Fuel Cells**

In fuel cell research, the gap between fundamental electrochemical processes and the engineering of fuel cell systems is bridged by the physical modelling of fuel cells. This relatively new discipline aims to understand the basic transport and kinetic phenomena in a real cell and stack environment, paving the way for improved design and performance. The author brings his unique approach to the analytical modeling of fuel cells to this essential reference for energy technologists. Covers recent advances and analytical solutions to a range of problems faced by energy technologists, from catalyst layer performance to thermal stability Provides detailed graphs, charts and other tools (glossary, index) to maximize R&D output while minimizing costs and time spent on dead-end research. Presents Kulikovsky's signature approach (and the data to support it)—which uses "simplified" models based on idealized systems, basic geometries, and minimal assumptions—enabling qualitative understanding of the causes and effects of phenomena.

**Dynamic Modeling and Predictive Control in Solid Oxide Fuel Cells**
Fundamentals of Heat and Fluid Flow in High Temperature Fuel Cells

Solid Oxide Fuel Cells

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.

Porous Electrodes Modeling of Solid Oxide Fuel Cells and Advanced Lead Acid Batteries

Solid Oxide Fuel Cell Components

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. Introducing 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 in the SOFC system. 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.

Three Dimensional Computational Fluid Dynamics Modeling of Solid Oxide Fuel Cell Using Different Fuels

Fundamentals of Heat and Fluid Flow in High Temperature Fuel Cells introduces key-concepts relating to heat, fluid and mass transfer as applied to high temperature fuel cells. The book briefly covers different type of fuel cells and discusses solid oxide fuel cells in detail, presenting related mass, momentum, energy and species equation. It then examines real case studies of hydrogen- and methane-fed SOFC, as well as combined heat and power and hybrid energy systems. This comprehensive reference is a useful resource for those working in high temperature fuel cells, power engineering and development, including energy researchers, engineers and graduate students.
Read Book Modeling Of Solid Oxide Fuel Cell System Multi Scale Modeling And Simulation Of Thermal Fluid And Electrochemical Transport In A Solid Oxide Fuel Cell

Provides broad coverage of key concepts relating to heat transfer and fluid flow in high temperature fuel cells. Presents in-depth knowledge of solid oxide fuel cells and their application in different kinds of heat and power systems. Examines real-life case studies, covering different types of fuels and combined systems, including CHP.

**Models for Solid Oxide Fuel Cell Systems**

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.

**Design and Operation of Solid Oxide Fuel Cells**

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 Fuel 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.

**Advances in Medium and High Temperature Solid Oxide Fuel Cell Technology**

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 Fuel 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.

**Modeling of Solid Oxide Fuel Cells**

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.