
Solid Oxide Fuel Cells 16 (SOFC-XVI)

Editors:

K. Eguchi

S. C. Singhal

Sponsoring Division:



High-Temperature Energy, Materials, & Processes



Published by

The Electrochemical Society

65 South Main Street, Building D
Pennington, NJ 08534-2839, USA

tel 609 737 1902

fax 609 737 2743

www.electrochem.org

ecstransactions™

Vol. 91, No. 1

Copyright 2019 by The Electrochemical Society.
All rights reserved.

This book has been registered with Copyright Clearance Center.
For further information, please contact the Copyright Clearance Center,
Salem, Massachusetts.

Published by:

The Electrochemical Society
65 South Main Street
Pennington, New Jersey 08534-2839, USA

Telephone 609.737.1902
Fax 609.737.2743
e-mail: ecs@electrochem.org
Web: www.electrochem.org

ISSN 1938-6737 (online)
ISSN 1938-5862 (print)
ISSN 2151-2051 (cd-rom)

ISBN 978-1-60768-874-7 (PDF)
ISBN 978-1-62332-575-6 (CD/USB)

Printed in the United States of America.

ECS Transactions, Volume 91, Issue 1
Solid Oxide Fuel Cells 16 (SOFC-XVI)

Table of Contents

Preface *iii*

Chapter 1
Plenary Lectures — R&D Overview

Toward a Hydrogen Society — Introduction of Representative Projects in Japan 3
D. Hara

The Status of SOFC and SOEC R&D in the European Fuel Cell and Hydrogen Joint 9
Undertaking Programme
*N. Lympieropoulos, D. Tsimis, A. Aguilo-Rullan, M. Atanasiu, E. Zafeiratou,
D. Dirmiki*

Overview of U.S. Department of Energy Office of Fossil Energy's Solid Oxide Fuel 27
Cell Program for FY2019
S. D. Vora, G. Jesionowski, M. C. Williams

Chapter 2
Cells, Stacks, and Systems

Progress of SOFC Residential CHP System: Over 50,000 Units Market Experience of 43
Osaka Gas
T. Nakao, S. Inoue, S. Uenoyama, Y. Takuwa, M. Suzuki

Latest Results and Commercialization of the Ceres Power SteelCell® Technology 51
Platform
*R. T. Leah, A. Bone, A. Selcuk, M. Rahman, A. Clare, M. Lankin, F. Felix,
S. Mukerjee, M. Selby*

Progress in HEXIS' SOFC Development 63
*A. Mai, J. G. Grolig, M. Dold, F. Vandercruysse, R. Denzler, B. Schindler,
A. Schuler*

Basic Study of Two-Stage Solid Oxide Fuel Cell Stacks with Fuel Regenerator <i>K. Nakamura, T. Ide, Y. Kawabata, T. Nakajima, T. Dohkoh, M. Shirai, S. Akabane, T. Hatae</i>	71
Research of SOFC Combined Heat and Power Systems with Natural Gas <i>H. Meng, M. Han, Z. Sun</i>	81
Elcogen – Next Generation Solid Oxide Cell and Stack Technology <i>M. Noponen, P. Torri, J. Göös, J. Puranen, H. Kaar, S. Pylypko, M. Roostar, E. Öunpuu</i>	91
Study on Coal Syngas Applicability to SOFC Module <i>S. Sakuno, S. Suzuki, T. Suto, N. Ogawa, M. Okura, H. Hayakawa</i>	99
Results from Industrial Size Biogas-Fed SOFC Plant (DEMOSOFC Project) <i>M. Santarelli, M. Gandiglio, M. Acri, T. Hakala, M. Rautanen, A. Hawkes</i>	107
Development of the 5kW _e SteelCell® Technology Platform for Stationary Power and Transport Applications <i>A. Ballard, T. Domanski, L. Rees, C. Nobbs, N. Lawrence, K. Heffer, J. Harman, C. Evans, P. Barnard, S. Mukerjee, M. Selby</i>	117
Stack Development and Industrial Scale-Up <i>C. Geipel, K. Hauptmeier, K. Herbrig, F. Mittmann, M. Münch, M. Pötschke, L. Reichel, T. Strohbach, T. Seidel, A. Surrey, C. Walter</i>	123
Development of a Versatile, High-Performance Solid Oxide Fuel Cell Stack Technology <i>N. Minh, Y. H. Lee, T. Q. Tran, H. Ren, E. Fullerton, E. Wu, Y. S. Meng</i>	133
Manufacturing and Electrochemical Evaluation of SOFCRoll with the $\text{La}_{0.43}\text{Ca}_{0.37}\text{Ni}_{0.06}\text{Ti}_{0.94}\text{O}_{3-\gamma}$ - $\text{Zr}_{0.92}\text{Y}_{0.08}\text{O}_{2-\gamma}$ anode <i>K. M. Nowicki, H. Zeng, J. T. S. Irvine</i>	139
Demonstration of SOFC Power Sources for Drones (UAVs; Unmanned Aerial Vehicles) <i>H. Sumi, S. Nakabayashi, T. Kawada, Y. Uchiyama, N. Uchiyama, K. Ichihara</i>	149
Experimental Analysis of a 25 kW _e Solid Oxide Fuel Cell Module for Co-Generation of Hydrogen and Power <i>S. Santhanam, D. Ullmer, Z. Wuillemin, E. Varkaraki, C. Beetschen, Y. Antonetti, A. Ansar</i>	159

Integration of Solid Oxide Fuel Cell with Liquid Desiccant Cooling for Generation of Combined Cooling and Power for a Server <i>M. Asghari, A. Lavernia, A. Saeedmanesh, S. James, J. Brouwer</i>	167
SOFC's Bumpy Road and Hopeful Future – a Case Study <i>Y. Du, P. Cheekatamarla</i>	179
Design and Experimental Realization of a Steam-Driven Micro Recirculation Fan for Solid Oxide Fuel Cell Systems <i>P. H. Wagner, Z. Wuillemin, S. Diethelm, J. Van herle, J. Schiffmann</i>	187
Operation of an SOFC CHP System with Wood Gas from a Fixed-Bed Updraft Gasifier <i>S. Weissensteiner, M. Hauth, M. Seidl, N. Soukup, C. Sallai, I. Obernberger, T. Brunner, C. Ramerstorfer, S. Megel, J. Schnetter</i>	195
Parametric Analysis of Solid Oxide Co-Electrolysis Cell Systems: Relationship between System Performance, External Heat and Parasitic Power <i>G. Min, Y. J. Park, J. Hong</i>	207
Progress in SOEC Development Activities at Haldor Topsøe <i>R. Küngas, P. Blennow, T. Heiredal-Clausen, T. Holt Nørby, J. Rass-Hansen, J. B. Hansen, P. G. Moses</i>	215
Development of Highly Efficient SOFC Using Two-Stage Stacks System and Fuel Regeneration in Tokyo Gas <i>T. Dohkoh, S. Akabane, M. Shirai, T. Nakajima, Y. Kawabata, T. Ide, K. Nakamura, T. Hatae</i>	225
Solid Oxide Development Status at DTU Energy <i>A. Hagen, H. L. Frandsen</i>	235
An Improvement of Efficiency and Toughness of Solid Oxide Fuel Cells by Industry-Academia Collaboration <i>T. Horita</i>	247
Thermo-Fluid Analysis of a Planar Solid Oxide Fuel Cell with an Improved Flow Field by Manifold and Flow Channel Design <i>J. Y. Kim, D. H. Kim, W. Lee, S. Lee, Y. Bae, J. Hong</i>	255

Through Interface Optimization to New Generation of Robust Electrolyte Supported Cell with High Power Density <i>N. Trofimenko, M. Kusnezoff, S. Mosch, A. Michaelis</i>	263
Additive Manufacturing of Advanced Solid Oxide Fuel Cells – a Review <i>Y. Du, O. S. Fatoba</i>	277
The Characteristics of Cermet-Supported Tubular Solid Oxide Fuel Cells Manufactured by Thermal Spraying <i>C. J. Li, X. Chen, S. L. Zhang, C. X. Li, G. J. Yang</i>	285
Shaping of Ceria-Based SOFC Cells: Development of a Combined Tape-Casting and Infiltration Route <i>L. Guesnet Jr., P. M. Geffroy Sr., A. Flura III, C. Nicollet II, J. C. Grenier Sr., J. Vulliet IV, T. Chartier Sr., J. M. Bassat Sr.</i>	291
Electrochemical Performances of SOFC as Function of the Sputtered Parameters of the YSZ Electrolyte <i>P. Briois, J. H. Park, A. Billard, J. W. Son</i>	301
Material Development Strategy of Lightweight Solid Oxide Fuel Cells for Airplane System Electrification <i>S. Hashimoto, T. Hirota, K. Suzuki, T. Namioka, H. Ito, R. Miyata, K. Kobayashi, K. Yashiro, H. Takamura, T. Kawada, K. Yoshimi, N. Kijima, T. Manabe, T. Tsuchiya, T. Kojima, K. Okai</i>	311
Multi-Gas Sensors for Enhanced Reliability of SOFC Operation <i>R. A. Potyrailo, J. Brewer, B. Scherer, V. Srivastava, M. Nayeri, C. Henderson, C. Collazo-Davila, M. A. Carpenter, N. Houlihan, V. Vulcano Rossi, A. Shapiro</i>	319
Tubular Solid Oxide Fuel Cells Fabricated by Tape-Casting and Dip-Coating Methods <i>N. Hedayat, Y. Du</i>	329
A High-Energy Module Containing a Micro-Tubular Solid Oxide Fuel Cell Coupled with Catalytic Partial Oxidation of n-Butane <i>J. Shi, S. Gong, H. Zeng, T. Cao, Y. Shi, N. Cai</i>	339
Testing of 5x5 cm ² Solid Oxide Fuel Cell in Direct Methane <i>P. K. Tiwari, S. Basu</i>	349

Development of a Novel High Efficiency, Low Cost Hybrid SOFC/Internal Combustion Engine Power Generator <i>R. J. Braun, E. Reznicek, C. Cadigan, N. P. Sullivan, R. Danforth, T. M. Bandhauer, S. Garland, D. Olsen, B. Windom, B. Schaffer</i>	355
The Sputtering of Heusler Alloy Catalyst onto the Porous Anode of the Intermediate Temperature Solid Oxide Fuel Cells for Ammonia Disassociation <i>H. Chao, T. C. K. Yang, S. F. Wang, S. Q. Lu</i>	361
Power Generation Characteristics of Solid Oxide Fuel Cell Fueled by Nitrogenous Compound <i>R. Morikawa, T. Sasaki, S. Ohyagi, T. Wakabayashi</i>	367
High Performing and Durable Anode-Supported Solid Oxide Fuel Cell by Using Tape Casting, Lamination and Co-Firing Method <i>A. Hussain, M. Z. Khan, R. H. Song, J. E. Hong, S. B. Lee, T. H. Lim</i>	373
Effectiveness Investigation of Using SOFC Power Modules for Landfill Gas Utilization in Russia <i>Y. V. Volkova, A. A. Volkova, N. Plotnikov, P. A. Trubaev, O. V. Verevkin</i>	381
Electrochemical Characteristics of Solid Oxide Fuel Cell Using Gas from Biomass Gasification <i>S. Yamaguchi, T. Ozaki, T. Suyama, H. Muroyama, T. Matsui, K. Eguchi</i>	391
Aerosol Deposition as a Promising Technique to Fabricating a Thin-Film Solid Electrolyte of Solid Oxide Fuel Cells <i>S. I. Bredikhin, D. A. Agarkov, E. Agarkova, I. Burmistrov, A. Cherkasov, V. Pukha, D. Yalovenko, N. Lyskov</i>	403
Two-Dimensional Temperature Distribution Estimation for a Cross-Flow Planar Solid Oxide Fuel Cell Stack <i>X. Wu, J. Jiang, W. Zhao</i>	415

Chapter 3 **Characterization and Testing**

Current Distribution of Operating the Large Scale Planar SOFC <i>N. Yanagibashi, T. Sato, M. Egawa</i>	427
---	-----

Active Near-Infrared Imaging for Spatio-Temporal Monitoring of a Solid Oxide Cell in Operation <i>G. Jeanmonod, S. Diethelm, J. Van herle</i>	437
Fabrication and Characterization of a Small Tubular Solid Oxide Fuel Cell with the $\text{La}_{0.43}\text{Ca}_{0.37}\text{Ni}_{0.06}\text{Ti}_{0.94}\text{O}_{3-\gamma}$ Anode <i>H. Zeng, K. M. Nowicki, J. T. S. Irvine, Y. Shi, N. Cai</i>	447
Raman Spectra Studies of Inner “Anode Electrolyte” Interface on ESC and ASC SOFCs <i>G. Eliseeva, D. A. Agarkov, I. Burmistrov, A. Gamova, I. Ionov, S. Rabotkin, V. Semenov, A. Solovyev, I. Tartakovskii, S. I. Bredikhin</i>	457
Preliminary Long-Term Experimental Characterization of a Solid Oxide Fuel Cell Operated in DIR-SOFC Mode <i>J. Kupecki, M. Wierzbicki, S. Jagielski, R. Kluczowski, K. Motylinski, M. Skrzypkiewicz</i>	471
Mechanistic Insight into Porous Electrode Impedance: An Example of Ni+YSZ Cermet Anodes <i>A. Nanning, M. Gerstl, M. Bram, A. K. Opitz</i>	479
Development of Testing Technology and Analysis of Behavior of SOFC Planar Single Cell under High Gas Utilization <i>T. Sato, N. Yanagibashi, M. Egawa</i>	491
Microstructure and Performance Analysis of Solid Oxide Fuel Cells Co-Sintered on Inert Substrates <i>F. Wankmüller, N. Russner, A. Weber, M. Meffert, J. Schmieg, H. Störmer, J. C. Njodzefon, P. Lupetin, D. Gerthsen, E. Ivers-Tiffée</i>	501
New Methodology of Studying H_2S Poisoning Effects on SOFC’s Fueled by Carbon Containing Fuels like Biogas <i>H. Langnickel, A. Hagen</i>	511
Investigation of Tin Liquid Anode on Hybrid Direct Carbon Fuel Cells <i>S. Li, C. Jiang, J. T. S. Irvine</i>	523
Internal Current Collection in Microtubular SOFCs: Minimisation of Contact Resistance via Brazing and Plating <i>O. Hodjati-Pugh, A. Dhir, R. Steinberger-Wilckens</i>	533

Influence of Carbon Deposition on the Current Distribution in an Anode-Supported Planar Solid Oxide Fuel Cell In-Situ Assessed by Segmented Electrodes <i>K. Sasaki, H. Nakajima, T. Kitahara</i>	549
<i>Operando NAP-HT-XPS and Impedance Spectroscopy Study of Pulsed Laser Deposited Ni-Ce_{0.9}Gd_{0.1}O_{2-δ} Solid Oxide Fuel Cell Electrode</i> <i>G. Nurk, K. Kooser, O. Korjus, R. Kanarbik, S. Urpelainen, T. Käämbre, U. Joost, M. Kook, M. Kodu, P. Möller, I. Kivi, M. Vestli, J. J. Gallet, F. Bournel, E. Kukk, E. Lust</i>	555
Developing Accelerated Stress Test Protocols for Solid Oxide Fuel Cells and Electrolysers: The European Project AD ASTRA <i>S. J. McPhail, D. Pumiglia, J. Laurencin, A. Hagen, A. Leon, J. Van herle, D. Vladikova, D. Montinaro, P. Piccardo, P. Polverino, K. Herbrig</i>	563
Ceria/Lanthanum Silicate Bi-Layer Electrolytes for SOFC Operating at Intermediate Temperatures <i>S. Takahashi, H. Sumi, Y. Fujishiro</i>	571
Evaluation Method of Current Distribution in SOFC in Operation <i>T. Tsuchikura, T. Sakamoto, T. Zukawa, H. Sumi, K. Sato, K. Yashiro, T. Hashida, T. Kawada</i>	579
In-Depth Analysis of Electrochemical Impedance Spectra from SOC <i>I. C. Vinke, L. G. J. de Haart, R. A. Eichel</i>	589
Characterizing with Shannon 1948 Entropy Leading to a Modeling and Testing Method for SOFC and SOEC High Temperature Heat Exchangers <i>J. P. Janssens Sr., M. Dubuisson</i>	599

Chapter 4 **Durability and Reliability**

Comprehensive Hypotheses for Degradation Mechanisms in Ni-Stabilized Zirconia Electrodes <i>M. B. Mogensen, M. Chen, H. L. Frandsen, C. Graves, A. Hauch, T. Jacobsen, S. H. Jensen, T. L. Skafte, X. Sun</i>	613
Lifetime Prediction of Anode-Supported Solid Oxide Fuel Cell on the Basis of Individual Components Degradation <i>M. Z. Khan, R. H. Song, S. B. Lee, T. H. Lim</i>	621

<i>Operando</i> Studies of Carbon Removal and Partial Oxidation in Solid Oxide Fuel Cells <i>W. A. Maza, S. Tsoi, D. A. Steinhurst, B. C. Eigenbrodt, R. A. Walker, J. C. Owrutsky</i>	629
Effects of Polarization on the Microstructural Changes at the YSZ/Ni-YSZ Interface <i>G. Rinaldi, A. Nakajo, P. Caliandro, L. Navratilova, J. Van herle</i>	641
Impact of Microstructure and Polarization on the Degradation of Ni-YSZ Electrode: An Experimental and Modeling Approach <i>F. Monaco, M. Hubert, J. Vulliet IV, D. Montinaro, J. P. Ouweltjes, P. Cloetens, P. Piccardo, F. Lefebvre-Joud, J. Laurencin</i>	653
Effect of H ₂ O and CO ₂ on LSCF-GDC Composite Cathodes <i>C. Pellegrinelli, Y. L. Huang, E. D. Wachsman</i>	665
Degradation Mechanism of Oxygen Electrode Under Fuel-Cell and Electrolysis Mode Operations <i>J. H. Lee, H. I. Ji, S. Lee, J. S. Kim, S. M. Choi, S. Yang, H. Kim, K. J. Yoon, J. W. Son</i>	681
Electrochemical Performance and Degradation Analysis of an SOFC Short Stack for Operation of More than 100,000 Hours <i>Q. Fang, L. Blum, D. Stolten</i>	687
Effects of Naphthalene on the Performance of Ni/YSZ Anode-Supported SOFCs <i>M. Hauser, S. Herrmann, M. Hauck, S. Fendt, H. Jeong, C. Lenser, N. H. Menzler, H. Spliethoff</i>	697
Long-Term Operation and Post Analysis of a Stack with Methane Fuel <i>Y. Wang, W. Shi, H. Li, M. Han, Z. Sun</i>	707
SOC Degradation: Long-Term and Small-Scale Effects <i>N. H. Menzler, D. Sebold, S. Zischke</i>	719
Monitoring and Diagnostics of SOFC Stacks and Systems <i>J. Mougín, B. Morel, A. Ploner, P. Caliandro, J. Van Herle, P. Boškoski, B. Dolenc, M. Gallo, P. Polverino, A. Pohjoranta, A. Nieminen, S. Pofahl, J. P. Ouweltjes, S. Diethelm, A. Leonardi, F. Galiano, C. Tanzi</i>	731
Pressurized Ammonia and Syngas Planar Anode-Supported Solid Oxide Fuel Cells and Their Performance Stability Test <i>S. S. Shy, Y. T. Hung, Z. H. Chou, Z. L. Bong, J. J. Zhao</i>	745

Fast Fuel Variation and Identification of SOFC System Changes Using Online Health Monitoring Tools and Fault Diagnosis	753
<i>V. Subotic, P. Harter, B. Stoeckl, M. Preininger, M. Kusnezoff, V. Lawlor, S. Pofahl, T. W. Napporn, S. Megel, H. Schroettner, C. Hochenauer</i>	
Evaluation of Creep Properties in Anode Materials for Solid Oxide Fuel Cells by Using Small Punch Testing Method	761
<i>Y. Huang, K. Sato, K. Kumada, T. Hashida</i>	
Degradation Analysis of SOFC Performance (2) — Severe Operation with an Instantaneous Load Fluctuation	771
<i>K. Asano, A. Ido, H. Morita, T. Yamamoto, Y. Mugikura</i>	
High-Efficiency Biomass Gasifier SOFC Systems with Direct Internal Tar Reforming	781
<i>A. Cavalli, P. V. Aravind</i>	
Distribution of Relaxation Time Analysis of the Initial Performance Degradation on Ni-YSZ Anode Support Cells	791
<i>W. Shi, Z. Lyu, M. Han</i>	
Degradation Analysis of SOFC Performance (1) — Severe Operation with High Fuel Utilization	801
<i>A. Ido, K. Asano, H. Morita, T. Yamamoto, Y. Mugikura</i>	
Calculation of Ohmic Resistance Increase Induced by Phase Transformation of Zirconia Electrolyte in SOFC Cell by Raman Spectroscopy	809
<i>T. Ishiyama, H. Kishimoto, K. Yamaji, T. Horita, H. Yokokawa</i>	
Experiments with Button-Type Solid Oxide Fuel Cells Using Electrochemical Impedance Spectroscopy to Detect Carbon Formation	815
<i>J. N. Stam, P. V. Aravind</i>	
Proposal of a Modified Four-Point Bending Method for Determining Interfacial Fracture Energy at Electrode/Electrolyte Interfaces in SOFCs	825
<i>K. Kumada, K. Sato, Y. Asoh, T. Hashida</i>	
Variation of Mechanical Properties of YSZ upon Cubic to Tetragonal Phase Transformation Promoted by Impurity Ni	837
<i>H. Umemura, C. Sekizawa, S. Watanabe, K. Yashiro, T. Kawada</i>	
Influence of Current Load on the Growth of SrZrO ₃ at the GDC/YSZ Interface	847
<i>Y. Inoue, J. T. Chou, T. Kawabata, J. Matsuda, S. Taniguchi, K. Sasaki</i>	

Chapter 5 Metal Supported Cells

Fabrication and Characterization of Metal-Supported Solid Oxide Fuel Cell Fabricated by Atmospheric Plasma Spraying <i>C. L. Chang, C. H. Tsai, C. Y. Fu, C. S. Yang, S. F. Yang, R. Y. Lee</i>	855
Internal Reforming on Metal Supported SOFCs <i>A. Hagen, X. Sun, B. R. Sudireddy, A. H. Persson</i>	867
Progress in Metal-Supported Solid Oxide Fuel Cells and Electrolyzers with Symmetric Metal Supports and Infiltrated Electrodes <i>E. Dogdibegovic, F. Shen, R. Wang, I. Robinson, G. Y. Lau, M. C. Tucker</i>	877
Optimized Cell Processing as the Key of High Electrochemical Performance of Metal-Supported Solid Oxide Fuel Cells <i>F. Thaler, A. Nenning, C. Bischof, D. Udomsilp, L. G. J. de Haart, A. K. Opitz, M. Bram</i>	887
Characterization of Self-Sealed Metal Supported SOFCs with the Very Low Pressure Plasma Sprayed ScSZ Electrolyte <i>Y. P. Wang, J. T. Gao, S. Y. Kang, C. X. Li, S. L. Zhang, G. J. Yang, C. J. Li</i>	901
Development of Metal-Supported Planar SOFCs Fabricated by All Wet Process on Metallurgical Porous Substrates <i>Y. Yamaguchi, H. Sumi, H. Takahashi, R. Mori, H. Shimizu</i>	909
Origins of High Power Outputs in Hydrogen Permeable Metal-Support Fuel Cells <i>Y. Aoki, S. Jeong, C. Zhu, H. Habazaki</i>	917
Shrinkage Dynamics of Stainless Steel 430-L and Yttrium Stabilized Zirconia and Its Application in Co-Sintering for MS-SOFCs <i>S. Y. Toor, A. F. Alharbi, E. Croiset</i>	921
Development of Thin-Film Solid Oxide Fuel Cells Supported on Anode/Metal Substrates <i>S. Kang, J. Lee, S. W. Cha, J. Bae</i>	931
Fabrication of Metal-Supported Proton-Conducting Electrolysers with Thin Film Sr- and Ce-Doped BZY Electrolyte <i>M. Stange, A. M. Dayaghi, C. Denonville, Y. Larring, P. M. Rørvik, R. Haugsrud, T. Norby</i>	941

Development and Evaluation of Thin Flexible Metal-Supported Solid Oxide Fuel Cells <i>C. H. Tsai, C. L. Chang, C. Y. Fu, C. S. Yang, S. H. Wu, M. F. Han</i>	951
Performance and Thermal Properties of Ni/Mo Metal-Supported Solid Oxide Fuel Cell <i>S. F. Yang, C. H. Tsai, C. L. Chang, C. Y. Fu, C. S. Yang, L. W. Huang, R. Y. Lee</i>	963

Chapter 6 Proton Conducting Cells

Electrochemical Performance of a Novel Proton Conducting Electrolyte-Based IT-SOFC <i>N. Radenahmad, A. Afif, J. I. Lee, M. Saqib, J. Y. Park, J. Zaini, A. K. Azad</i>	971
High Performance Dense Proton Ceramic Electrolyte Material Obtained by Cold Sintering Process <i>K. Thabet, A. Le Gal La Salle, E. Quarez, O. Joubert</i>	983
Development of kW-Scale Protonic Ceramic Fuel Cells and Systems <i>R. J. Braun, A. Dubois, K. Ferguson, C. Duan, C. Karakaya, R. J. Kee, H. Zhu, N. P. Sullivan, E. Tang, M. Pastula, A. Wood, T. Joia, R. O'Hayre</i>	997
Leakage Current and Chemical Potential Profile in Proton-Conducting Bi-Layered Solid Oxide Electrolyte with BZY and Hole-Blocking Layers <i>Y. Matsuzaki, Y. Tachikawa, Y. Baba, K. Sato, H. Iinuma, G. Kojo, H. Matsuo, J. Otomo, H. Matsumoto, S. Taniguchi, K. Sasaki</i>	1009
Performance of Anode-Supported Proton-Conducting Solid Oxide Fuel Cells with Lanthanum-Based Thin Bilayer Electrolyte <i>H. Matsuo, G. Kojo, K. Sakata, Y. Matsuzaki, J. Otomo</i>	1019
Advancement of Proton-Conducting Solid Oxide Fuel Cells and Solid Oxide Electrolysis Cells at Idaho National Laboratory (INL) <i>H. Ding, W. Wu, D. Ding</i>	1029
Development of Metal Supported Cells Using BaZrO ₃ -Based Proton Conducting Ceramics <i>F. Han, X. Zhou, A. M. Dayaghi, T. Norby, M. Stange, N. Sata, R. Costa</i>	1035
Synthesis and Characterization of a New Electrolyte Composition for Protonic SOFC <i>R. D. F. Cuer, D. Zanetti de Florio</i>	1047

Fabrication of SOFC Using BaZr _{0.8} Y _{0.2} O _{3-δ} Nano-Slurry Electrolyte <i>M. Nakamura, T. Sakai, T. Kato, S. Koura, A. Oohira</i>	1053
Inkjet Printing of Solid Oxide Fuel Cells and Proton Ceramic Fuel Cells <i>E. H. Kang, G. D. Han, H. J. Choi, K. Bae, H. Jeong, D. Y. Jang, J. H. Shim</i>	1059
Elastic Properties of Yttrium Doped Barium Zirconate <i>K. Hinata, F. Iguchi</i>	1065
Electrochemical Performance of Anode-Supported Protonic Ceramic Fuel Cells with Various Composite Cathodes <i>H. Shimada, T. Yamaguchi, Y. Yamaguchi, Y. Fujishiro, Y. Mizutani</i>	1075
Ni-YSZ a New Support for Proton Conducting Fuel Cells <i>S. Vafaenezhad, N. K. Sandhu, A. R. Hanifi, T. H. Etsell, P. Sarkar</i>	1085

Chapter 7 Electrolyte Materials, Fabrication and Performance

Effect of Microstructure Control of Thin Film Ytria Stabilized Zirconia Electrolyte for Solid Oxide Fuel Cells by Adjusting Oblique Angle and Target Substrate Distance of Sputtering Process <i>S. Lee, W. Yu, G. Y. Cho, S. W. Cha</i>	1097
Effect of Temperature on Deuteron Solubilities in Fluorite-Type Oxide Ion Conducting Electrolytes <i>T. Yamaguchi, T. Ishiyama, H. Kishimoto, K. Develos-Bagarinao, K. Yamaji</i>	1105
Fluorite Materials for SOFC Electrolyte Applications <i>S. Zhang, C. Savaniu, J. T. S. Irvine</i>	1111
Strain Effects in YSZ Thin Films by Elastic Waves <i>Y. Miyoshi, F. Iguchi</i>	1121
Electrical Properties of Oxyapatite-Type Solid Electrolyte and Its Application to Solid Oxide Fuel Cell <i>A. Mineshige, M. Momai, A. Matsumaru, S. Yagi, T. Yazawa</i>	1129

Fabrication and Characterization of YSZ/GDC Bilayer Electrolyte Thin Films by Spray-Coating and Co-Sintering <i>C. Ding, H. Iwai, M. Kishimoto</i>	1139
In Situ Densification of Gadolinium-Doped Ceria Interlayer by Infiltration Process in SOFC <i>G. Wang, C. Jia, Z. Sun, M. Chen, M. Han</i>	1149
Thin-Film Gd-Doped Ceria Sr-Barrier Layers for Electrolyte Supported SOFCs <i>F. Han, N. Sata, M. Riegraf, F. M. Fuchs, R. Semerad, C. Geipel, C. Walter, R. Costa</i>	1157
Evaluation of Praseodymium and Gadolinium Doped Ceria as a Possible Barrier Layer Material for Solid Oxide Cells <i>B. J. Kamecki, J. Karczewski, P. Jasinski, S. Molin</i>	1165
Comparison of Structural and Transport Properties of Zirconia Single-Crystals Stabilized by Yttria and Gadolinia <i>D. A. Agarkov, E. Agarkova, M. Borik, S. I. Bredikhin, A. Kulebyakin, I. Kuritsyna, E. Lomonova, F. Milovich, V. Myzina, P. Ryabochkina, N. Tabachkova, T. Volkova</i>	1173
Conductivity of ScSZ Ceramics in Vicinity of Polymorphic Phase Transitions <i>V. I. Barbashov, E. V. Chaika</i>	1185
Lowering the Sintering Temperature of a SOFC by Morphology Control of the Electrolyte Powder <i>M. Machado, L. P. R. Moraes, L. N. Rodrigues, T. S. Rodrigues, F. C. Fonseca</i>	1193
Enhancing the Sinterability of Gadolinium-Doped Ceria by Wet Chemical Processing <i>S. U. Rehman, A. Shaur, R. H. Song, S. J. Park, T. H. Lim, J. E. Hong, S. B. Lee</i>	1201
Evaluation of Fe-Doped CGO Electrolyte for Application in IT-SOFCs <i>M. Machado, L. P. R. Moraes, L. N. Rodrigues, M. Tabanez, M. Ferrazoli, F. C. Fonseca</i>	1209
Study of CaTiO ₃ Based Ionic Conductors for Lightweight SOFCs <i>K. Suzuki, Y. Kouchi, T. Hirota, H. Kato, T. Namioka, H. Ito, H. J. Hong, K. Yashiro, T. Kawada, K. Okai, S. Hashimoto</i>	1217
Effects of Na ⁺ , K ⁺ and B ³⁺ Substitutions on the Electrical Properties of La ₁₀ Si ₆ O ₂₇ Ceramics <i>S. F. Wang, Y. F. Hsu, Y. L. Liao, T. T. Yang, P. Jasinski</i>	1223

Chapter 8
SOFC Cathode Materials, Fabrication and Performance

- Correlation between Electrode Reaction and Chromium Deposition in SOFC Cathodes 1231
S. Kageyama, Y. Shindo, Y. Fujimaki, K. Mizuno, Y. Kimura, T. Nakamura, F. Iguchi, K. Yashiro, H. Yugami, T. Kawada, K. Amezawa
- Performance and Durability Evaluation for Anode-Supported Solid Oxide Fuel Cell with $\text{Ce}_{0.8}\text{Sm}_{0.2}\text{O}_{2-\delta}$ - $\text{SmBa}_{0.5}\text{Sr}_{0.5}\text{Co}_2\text{O}_{5-\delta}$ Composite Cathodes 1239
T. N. Lin, H. Y. Kuo, C. Y. Yeh, W. X. Kao, Y. N. Cheng, R. Y. Lee
- Degradation Analysis of Solid Oxide Fuel Cells with $(\text{La},\text{Sr})(\text{Co},\text{Fe})\text{O}_{3-\delta}$ Cathode/ Gd_2O_3 - CeO_2 Interlayer/ Y_2O_3 - ZrO_2 Electrolyte System: The Influences of Microstructural Change and Solid Solution Formation 1247
T. Matsui, S. Li, Y. Inoue, N. Yoshida, H. Muroyama, K. Eguchi
- Microscopic Studies on the Secondary Phases in LSCF after Cr Poisoning 1257
S. S. Liu, K. D. Bagarinao, R. A. Budiman, T. Ishiyama, H. Kishimoto, K. Yamaji, T. Horita, H. Yokokawa
- Surface Modifications of Nano-Structured Cathodes to Enhance Durability of Intermediate Temperature Solid Oxide Fuel Cells 1263
Y. Wen, T. Yang, D. Lee, H. N. Lee, E. J. Crumlin, K. Huang
- Dependence of $\text{La}_{0.57}\text{Sr}_{0.38}\text{Co}_{0.2}\text{Fe}_{0.8}\text{O}_{3-\delta}$ Cathode Degradation Rate on Electrode Thickness 1273
T. Shimura, Y. Komatsu, A. Sciazko, A. He, N. Shikazono
- Synthesis and Characterization of Praseodymium Cuprates Compounds as Innovative and Efficient Oxygen Electrode for IT-SOFCs 1279
G. Cordaro, A. Flura III, A. Donazzi, R. Pelosato, F. Mauvy, C. Cristiani, G. Dotelli, J. C. Grenier
- Fabrication and Performance of La, Co-Substituted SrTiO_3 as Cathode Materials of Solid Oxide Fuel Cell 1291
C. Jia, Q. Ma, M. Han, W. Wang, N. H. Menzler, O. Guillon
- The Influence of Iron Doping on Performance of $\text{SrTi}_{1-x}\text{Fe}_x\text{O}_{3-\delta}$ Perovskite Oxygen Electrode for SOFC 1299
A. Mroziński, S. Molin, J. Karczewski, B. J. Kamecki, P. Jasinski

High Performance $\text{La}_{0.5}(\text{Ba}_{0.2}\text{Sr}_{0.2}\text{Ca}_{0.1})\text{Co}_{0.8}\text{Fe}_{0.2}\text{O}_{3-\delta}$ - $\text{BaZr}_{0.1}\text{Ce}_{0.7}\text{Y}_{0.1}\text{Yb}_{0.1}\text{O}_{3-\delta}$ Composite Cathode for Proton-Conducting Solid Oxide Fuel Cells <i>L. Jia, Y. Pei, J. Chen, B. Chi, J. Pu, J. Li</i>	1309
Electrode Properties and High Temperature Stability of $\text{PrNi}_{1-x}\text{Fe}_x\text{O}_3$ Cathode <i>R. Chiba, T. Ishibashi, Y. Saito, S. Onodera</i>	1317
Cobalt Substituted Lanthanide Nickelates ($\text{Ln}_2\text{Ni}_{1-x}\text{Co}_x\text{O}_{4+\delta}$, Ln = La, Pr; $x=0, 0.1, 0.2$) as High Performance Oxygen Electrodes for Solid Oxide Cells <i>V. Vibhu, I. C. Vinke, R. A. Eichel, J. M. Bassat Sr., L. G. J. de Haart</i>	1327
Temperature Programmed Oxygen Desorption and Sorption Processes on $\text{Pr}_{2-x}\text{La}_x\text{NiO}_{4+\delta}$ Nickelates <i>A. Usenka Sr., V. Pankov, V. Vibhu, A. Flura III, J. C. Grenier Sr., J. M. Bassat Sr.</i>	1341
Double Columnar Interlayer for Increased Cathodic Activity of Intermediate Temperature Solid Oxide Fuel Cells <i>T. Ishihara, B. Kang, A. Takagaki</i>	1355
Measurement of Polarization Resistance of LSM + YSZ Electrodes on YSZ Using AC and DC Methods <i>A. Szendrei, T. D. Sparks, A. V. Virkar</i>	1363
Characterization of Active Sites in Solid Oxide Fuel Cell Composite Cathode through Oxygen Isotope Labeling Combined with Three-Dimensional Microstructural Analysis by Focused Ion Beam – Scanning Electron Microscopy <i>T. Nagasawa, T. Shimura, N. Shikazono, K. Hanamura</i>	1371
Effect of Interfacial Properties on the Electrochemical Performance of Solid Oxide Fuel Cells <i>K. Develos-Bagarinao, J. Szász, J. C. De Vero, H. Kishimoto, T. Ishiyama, K. Yamaji, E. Ivers-Tiffée, H. Yokokawa</i>	1377
Dynamic X-ray Spectroscopy of $\text{La}_{0.6}\text{Sr}_{0.4}\text{CoO}_{3-\delta}$ Thin Film Electrodes <i>B. S. Gerwe, K. Mizuno, O. Sekizawa, K. Nitta, K. Amezawa, S. B. Adler</i>	1387
Screening of Cathode Materials for Inert-Substrate-Supported Solid Oxide Fuel Cells <i>F. Grimm, N. H. Menzler, P. Lupetin, O. Guillon</i>	1397
Improving Oxygen Electrodes by Infiltration and Surface Decoration <i>P. V. Hendriksen, M. Khoshkalam, X. Tong, Đ. Tripković, M. A. Faghihi-Sani, M. Chen</i>	1413

Effect of Si-Doping on the Structure and Conductivity of $(\text{Sr}/\text{Ca})_2\text{MnFeO}_{6-\delta}$ Systems <i>A. D. Smith, M. S. James, P. R. Slater</i>	1425
Study of a Promising Co-Doped Double Perovskite Cathode Material for IT-SOFCs <i>D. Babindamana, C. Jia, M. Han</i>	1437
Dependence of Crystal Structure, Morphology and Electrical Conductivity of $\text{Pr}_2\text{Ni}_{1-x}\text{Cu}_x\text{O}_{4+\delta}$ and $\text{PrLaNi}_{1-x}\text{Cu}_x\text{O}_{4+\delta}$ Ceramics on Cu Content <i>T. Hashimoto, T. Yugi, M. Sasaki, C. Wang, M. Sakai, H. Soga, T. Okiba</i>	1445
Influence of Humidity and Carbon Dioxide on the $(\text{La}_{0.6}\text{Sr}_{0.4})_{0.99}\text{Co}_{1-x}\text{M}_x\text{O}_{3-\delta}$ ($\text{M} = \text{Nb}, \text{Ti}$) Oxygen Electrode Characteristics <i>A. Heinsaar, I. Kivi, G. Nurk, J. Aruväli, E. Lust</i>	1453
Development of $\text{LaNiO}_3\text{-Ce}_{0.9}\text{Gd}_{0.1}\text{O}_{1.95}$ Composite Cathode for Lowering the Operating Temperature of SOFCs <i>T. Hirota, T. Namioka, Y. Mori, T. Miyata, D. Tanaka, H. Itoh, S. Hashimoto</i>	1461
Introduction of Sulfate to Stabilize the $n = 3$ Ruddlesden-Popper System $\text{Sr}_4\text{Fe}_3\text{O}_{10-\delta}$, as a Potential SOFC Cathode <i>A. Jarvis, F. J. Berry, J. F. Marco, P. R. Slater</i>	1467
Infrared Study of the O–H Stretching Vibration in Sr-Doped LaMO_3 ($\text{M} = \text{Co}, \text{Yb}, \text{Gd}$) Cathode Materials <i>H. Yan, Y. Lee</i>	1477
Effect of Microstructure on Electrochemical Performance of Nano-Structured $\text{La}_{0.8}\text{Sr}_{0.2}\text{Co}_{0.2}\text{Fe}_{0.8}\text{O}_{3-\delta}\text{-Gd}_{0.2}\text{Ce}_{0.8}\text{O}_{1.9}$ Composite Cathodes <i>D. Li, C. Liu, D. Su, C. Dai, Y. Xiong</i>	1483
Influence of Water Vapor on Performance Degradation and Microstructural Change of $(\text{La},\text{Sr})(\text{Co},\text{Fe})\text{O}_{3-\delta}$ Cathode <i>H. Muroyama, M. Kim, T. Matsui, K. Eguchi</i>	1491
$\text{BaCo}_{0.4}\text{Fe}_{0.4}\text{Zr}_{0.2}\text{O}_{3-\delta}$ Cathode Materials for Protonic Ceramic Fuel Cells <i>M. Saqib, J. I. Lee, J. Y. Park</i>	1503
Preparation of Sm^{3+} and Nd^{3+} Co-Doped Ceria Diffusion Barriers for IT-SOFCs through a Step-Wise Sintering Method <i>J. Wang, X. Chang, B. Cao, J. Yang, W. Guan Sr.</i>	1509

A Robust $\text{YCo}_{0.5}\text{Fe}_{0.5}\text{O}_3$ Nanofiber Cathode Synthesized by Electrospinning for Intermediate-Temperature Solid Oxide Fuel Cells <i>J. Yang, J. Zhou, J. Wang, Z. Zong, K. Wu</i>	1517
Promotion of SOFC Cathode Performance and Durability by the Addition of Mixed Conducting Praseodymium Oxides <i>Y. Wang, T. Su, A. D. Brocato, X. D. Zhou</i>	1527
Synthesis and Electrochemical Performance of Ni Substituted $\text{SrTi}_{0.3}\text{Fe}_{0.7}\text{O}_{3-\delta}$ Cathode: Effect of A-Site Deficiency <i>W. Ni, W. Ma, Q. Zhong, T. Zhu, M. Han</i>	1535
Structural and Thermal Properties of Ni-Doped SrZrO_3 for Solid Oxide Fuel Cells <i>P. Kaur, K. Singh</i>	1543
Extrinsic Fe^{3+} Stabilized $\text{La}_{1-x}\text{Sr}_x\text{CoO}_{3-\delta}$ Thin Film Cathode for Enhanced Electrochemical Performance <i>Y. Li, W. Zhang, B. Yu</i>	1551

Chapter 9 Fuel Compatibility and Alternative Fuels

A Study on Multi-Fuel Power Generation by Using Flat-Tube Solid Oxide Fuel Cells with Double-Sided Cathodes <i>J. Yang, Y. Wang, H. Zhang, W. Liu, Y. Ru, J. Wang, W. Guan Sr., B. Chi, L. Jia</i>	1561
Quick Degradation Detection on Biogas-Fuelled SOFCs <i>A. Baldinelli, V. Subotic, F. Mondì, A. Di Michele, L. Barelli, G. Bidini</i>	1571
'Waste-to-Energy' Fuel Cell Systems <i>A. Fuente Cuesta, C. Savaniu, K. D. Pointon, J. T. S. Irvine</i>	1581
Optimization of Anode Off-Gas Recycle Ratio for a Natural Gas-Fueled 1 kW SOFC CHP System <i>Z. Lyu, M. Han</i>	1591
Ammonia as Promising Fuel for Solid Oxide Fuel Cells: Experimental Analysis and Performance Evaluation <i>B. Stoeckl, M. Preininger, V. Subotić, H. Schroettner, P. Sommersacher, M. Seidl, S. Megel, C. Hochenauer</i>	1601

Low Temperature Ammonia Decomposition Catalyst and Its Application for Direct Ammonia-Fueled Solid Oxide Fuel Cells <i>Y. Wang, J. Yang, J. Wang, W. Guan Sr., B. Chi, L. Jia, H. Ying, Y. Xia, J. Chen</i>	1611
Syngas Fuelled High Performance Solid Oxide Fuel Cell <i>N. Radenahmad, J. Taweekun, A. Afif, J. Y. Park, J. Zaini, A. K. Azad</i>	1621
Indirect Internal Reforming SOFC Accommodating Graded-Catalytic Domain Fabricated by Paper-Structured Catalyst <i>Ö. Aydin, G. Matsumoto, A. Kubota, D. L. Tran, M. Sakamoto, Y. Shiratori</i>	1631
A Multifuel Processor for SOFC Power Plants Created to Operate in the Arctic Region <i>A. V. Samoilov, D. A. Agarkov, S. I. Bredikhin</i>	1641
Fuel Impurity Poisoning of Ru/ γ -Al ₂ O ₃ Catalyst Packed in the Reformer for Biogas-Fueled SOFC System <i>H. Setiawan, T. G. Yu, T. G. H. Nguyen, M. Sakamoto, T. Uchida, Y. Shiratori</i>	1651
Performance Enhancement of Ni-Loaded Paper-Structured Catalyst for Dry Reforming of Methane by the Dispersion of Ceria-Based Oxides <i>P. H. Tu, T. G. H. Nguyen, M. Sakamoto, T. Uchida, T. C. D. Doan, M. C. Dang, Y. Shiratori</i>	1661

Chapter 10

SOFC Anode Materials, Fabrication and Performance

Nickel-Free SOFC Anode for Ethanol Electrocatalysis <i>B. J. M. Sarruf, A. Coralli, J. E. Hong, R. Steinberger-Wilckens, P. E. V. de Miranda</i>	1673
Electrochemical- and Crystallographic <i>Operando</i> Characterization of La _{0.75} Sr _{0.25} Cr _{0.5} Mn _{0.3} Ni _{0.2} O _{3-δ} Anode Infiltrated into Sc _{0.2} Ce _{0.01} Zr _{0.79} O _{2-δ} Electrolyte Scaffold <i>O. Korjus, G. Nurk, J. Aruväli, I. Kivi, M. Maide, E. Lust</i>	1683
Performance Evolution of Niobium Doped Lanthanum Strontium Ferrate Perovskite Anode for Solid Oxide Fuel Cells <i>J. Li, Z. Lü, J. T. S. Irvine</i>	1693

Reversible <i>In-Situ</i> Exsolution of Fe Catalyst in La _{0.5} Sr _{1.5} Fe _{1.5} Mo _{0.5} O _{6-δ} Anode for SOFCs	1701
<i>H. Qi, T. Yang, W. Li, L. Ma, S. Hu, W. Shi, E. M. Sabolsky, J. W. Zondlo, R. Hart, G. A. Hackett, X. Liu</i>	
Evaluation of Strontium Doped Lanthanum Chromium Manganite (LSCM) and Gadolinium Doped Ceria (GDC) Anode with Different Compositions	1711
<i>A. Sciazko, R. Yokoi, Y. Komatsu, T. Shimura, N. Shikazono</i>	
Design of Fibre Ni/CGO Anode and Model Interpretation	1721
<i>M. Ouyang, A. Bertei, S. J. Cooper, Y. Wu, X. Liu, P. Boldrin, M. Kishimoto, B. Wu, N. P. Brandon</i>	
Recent Advances in Rh/CGO Co-Impregnated La _{0.20} Sr _{0.25} Ca _{0.45} TiO ₃ Anodes for Solid Oxide Fuel Cells: Evaluation of Upscaling and Durability	1741
<i>R. Price, U. Weissen, M. Verbraeken, J. G. Grolig, A. Mai, J. T. S. Irvine</i>	
Synthesis and Evaluation of the A-Site Deficient Perovskite La _{0.65} Sr _{0.3} Cr _{0.85} Ni _{0.15} O _{3-δ} as Fuel Electrode for High Temperature Co-Electrolysis Enhanced by <i>In Situ</i> Exsolution of Ni Nanoparticles	1751
<i>D. M. Amaya Dueñas, G. Chen, A. Weidenkaff, N. Sata, F. Han, G. Schiller, R. Costa, A. K. Friedrich</i>	
Liquid-Based Synthesis of Nickel- and Lanthanum- Co-Doped Strontium Titanates for Use as Anodes in All-Ceramic Solid Oxide Fuel Cell Anodes	1761
<i>G. R. Stevenson, P. Boldrin, N. P. Brandon</i>	
Treading in the Limited Stability Regime of Lanthanum Strontium Ferrite — Reduction, Phase Change and Exsolution	1771
<i>T. Götsch, N. Köpfle, L. Schlicker, E. A. Carbonio, M. Hävecker, A. Knop-Gericke, R. Schloegl, M. F. Bekheet, A. Gurlo, A. Doran, J. Bernardi, B. Klötzer, S. Penner</i>	
Development of Epitaxial Thin Film Model Electrodes for the Systematic Investigation of Metal Exsolution from MIEC Perovskite Oxides	1783
<i>M. L. Weber, Q. Ma, P. Meuffels, F. V. E. Hensling, C. Lenser, F. Gunkel, N. H. Menzler, R. Dittmann, R. Waser, O. Guillon</i>	
Effect of Infiltration on Performance of Ni-YSZ Fuel Electrodes	1791
<i>S. A. Barnett, B. K. Park, R. Scipioni</i>	

Fabrication and Characterisation of Nanoscale Ni-CGO Electrode from Nano-Composite Powders <i>J. Chen, M. Ouyang, P. Boldrin, X. Liu, J. Darr, A. Atkinson, N. P. Brandon</i>	1799
Infiltration of Rare Earth Oxide into NiO-YSZ Anode Substrate for the High Performance Micro-Tubular SOFC Using LSGM Electrolyte Film <i>Z. Tan, A. Takagaki, T. Ishihara</i>	1807
Assessing Sulfur-Induced Degradation Mechanisms in SOFCs with Chronocoulometry and Operando Optical Imaging <i>E. D. Pomeroy, W. A. Maza, D. A. Steinhurst, J. C. Owrutsky, R. A. Walker</i>	1815
From Microstructure to Performance: A Detailed Multi-Level Study of SOFC Anodes <i>A. Weber, S. Dierickx</i>	1827
Hydrogen Oxidation Activity of SOFC Anodes with Metal Oxide Addition <i>N. Fujiwara, T. Kayamori, T. Mishina, S. Tada, Y. Kobayashi, R. Kikuchi</i>	1837
Commercial SOFC Fed with Dry Ethanol: Challenge or Realty? <i>M. Lo Faro Sr., S. C. Zignani, A. S. Aricò</i>	1845
<i>In Operando</i> Study on Nickel Morphological Change at Three-Phase-Boundary in Solid Oxide Fuel Cell Using Patterned Nickel-Film Electrode <i>Z. Jiao, N. Shikazono</i>	1853
Dual-Resolution Microstructural Analysis of Anisotropic Pore Structure in SOFC Anode Fabricated by Phase-Inversion Tape Casting <i>M. Kishimoto, A. Masuyama, H. Iwai, H. Yoshida</i>	1861
Performance and Optimization of Ni/3 Mol% Y ₂ O ₃ -ZrO ₂ Anode Supported SOFC <i>Y. Zhang, T. Zhu, Z. Sun, M. Han</i>	1871
Novel SOFC Anodes Using Pyrochlore-Type Mixed Conducting Materials <i>R. Kikuchi, T. Sasouzaki, S. Tada</i>	1881
Alternative Ni-Alloy Cermet Anode Materials for SOFCs <i>Y. Ishibashi, S. Futamura, Y. Tachikawa, J. Matsuda, Y. Shiratori, S. Taniguchi, K. Sasaki</i>	1889

Critical S/C Ratio of the Carbon Deposition in the SOFC Anode Using CH ₄ : In-Situ Analysis of the Anode Surface <i>H. Watanabe, R. Okino, K. Hanamura</i>	1897
SOFC Anodes Impregnated with Noble Metal Catalyst Nanoparticles for High Fuel Utilization <i>S. Futamura, A. Muramoto, Y. Tachikawa, J. Matsuda, S. M. Lyth, Y. Shiratori, S. Taniguchi, K. Sasaki</i>	1905
Exsolution of Nano Metal Particle on Anode for Increased Performance at Low Temperature Operation <i>B. Kang, A. Takagaki, T. Ishihara</i>	1915
Study of Microextrusion Printing for Enlarging Electrode–Electrolyte Interfacial Area in Anode-Supported SOFCs <i>H. Seo, T. Nishi, M. Kishimoto, C. Ding, H. Iwai, M. Saito, H. Yoshida</i>	1923
Performance Characteristics of La _{0.3} Sr _{0.5} Ni _{0.04} Ti _{0.96} O _{3-δ} Anodes for Solid Oxide Fuel Cell <i>M. Shahid, S. Basu</i>	1933
Characteristics of LaCo _{1-x} Ni _x O _{3-δ} Coated on Ni/YSZ Anode Using CH ₄ Fuel in Solid Oxide Fuel Cells <i>J. H. Kim, G. Y. Jang, J. W. Yun</i>	1941
Pd-Doped Lanthanum Strontium Ferrite as Promising Reversible Electrode <i>E. Di Bartolomeo, F. Zurlo, A. Marucci, S. Licoccia</i>	1949
Combining Transition Metals – An Approach towards High-Performing Coking Tolerant Solid Oxide Fuel Cell Anodes <i>D. B. Drasbæk, M. L. Traulsen, B. R. Sudireddy, P. Holtappels</i>	1953
Inhibition of Ni Grain Growth in Ni-BCY Anode Substrate for Solid Oxide Fuel Cell <i>Y. Itagaki, J. Cui, Y. Tani, H. Aono, H. Yahiro</i>	1963
Dependence of the Electrochemical Performance of Ni/YSZ Anode on Water Vapor Partial Pressure <i>R. A. Budiman, T. Ishiyama, S. S. Liu, K. D. Bagarinao, H. Kishimoto, K. Yamaji, T. Horita</i>	1973
Contraction of Porous Nickel during Low Temperature Oxidation <i>Y. Morishita, F. Zhao, S. Watanabe, K. Yashiro, T. Kawada</i>	1979

Electrochemical Impedance Analysis of Ni/CGO10-Based Electrolyte-Supported Cells <i>M. Riegraf, S. Dierickx, A. Weber, R. Costa, G. Schiller, K. A. Friedrich</i>	1985
Study on Ni-(Ce,Zr,M)O _{2-δ} Anode for Direct Internal Reforming SOFC Fueled by Biogas <i>S. Takata, M. Sakamoto, T. Yamamoto, F. Tamazaki, Y. Shiratori</i>	1993
Sulfur-Resistant Liquid Antimony Anode for Direct Carbon Fuel Cells <i>Y. Jiang, T. Cao, Y. Shi, N. Cai</i>	2001

Chapter 11 Cell, Stack, and System Modeling and Simulation

Numerical Model of Direct Internal Reforming SOFC: A Comparison between Anode-Support and Metal-Support <i>Y. Wang, J. Ren, Y. Shi, X. Li</i>	2013
Impact of Carbon Deposition on Diffusion Parameters in Porous Anodes of Solid Oxide Fuel Cells Using the Lattice Boltzmann Method <i>M. Espinoza-Andaluz, M. Realpe, T. Li, M. Andersson</i>	2023
Stochastic Geometrical and Microstructural Modeling for Solid Oxide Cell Electrodes <i>H. Moussaoui, J. Laurencin, M. Hubert, R. Sharma, P. Cloetens, G. Delette, Y. Gavet, J. Debayle</i>	2031
Numerical Optimization of the Solid Oxide Fuel Cell Electrode-Electrolyte Interface Structure with Adjoint Method <i>A. He, J. Onishi, N. Shikazono</i>	2045
In-Silico Design of Functionally Graded Electrodes for Solid Oxide Fuel Cells <i>Z. Yan, A. He, S. Hara, N. Shikazono</i>	2055
Modelling of a Reversible SOC in Ansys Fluent <i>S. Herrmann, Z. Z. Ong, M. Hauck, M. Hauser, F. Fischer, J. Weinrich, M. Gaderer, H. Spliethoff</i>	2065
SOC-Stack FEM-Modelling on Different Length Scales <i>N. Russner, H. Geisler, S. Dierickx, A. Weber</i>	2075

Transient Modelling of Solid Oxide Cell Modules and 50 kW Experimental Validation <i>M. Tomberg, S. Santhanam, M. P. Heddrich, A. Ansar, K. A. Friedrich</i>	2089
Thermodynamic Optimization of a SOFC-CHP System with Exhaust Gas Recirculation Employing an In-House Numerical Simulator <i>Y. J. Park, G. Min, J. Hong</i>	2097
Performance Analysis of SOFC with Electrode-Electrolyte Interface Tailored by Laser Micro-Machining <i>T. Nakagawa, M. Kishimoto, H. Iwai, M. Saito, H. Yoshida, R. Lahoz, M. A. Laguna-Bercero, A. Larrea</i>	2105
Numerical Model of Sulfur Poisoning on LSCF Cathode and Its Application to a 2-D Single Cell Simulation <i>H. Iwai, K. Maejima, M. Kishimoto, M. Saito, H. Yoshida, H. Kishimoto, K. Yamaji, H. Yokokawa</i>	2115
Topology Optimization of Electrolyte-Anode Interfaces in Solid Oxide Fuel Cells <i>J. Onishi, N. Shikazono</i>	2127
Numerical Simulation of Planar SOFC Single Cell Fueled by Hydrogen, Nitrogen and Water Vapor Considering Fuel Gas Leakage from Cell Side <i>T. Tanaka, Y. Inui, G. Pongratz, V. Subotic, C. Hochenauer</i>	2137
Performance Modeling of Solid Oxide Fuel Cell Energy Conversion Networks (ECN) <i>M. C. Williams, S. D. Vora, R. S. Gemmen</i>	2149
Modeling Analysis of Gas Reverse Strategy between Symmetric Solid Oxide Fuel Cell Electrodes <i>Z. Zong, J. Wang, Z. Zhang, Q. Chen, J. Zhou, K. Wu, Y. Cheng</i>	2169

Chapter 12 Interconnect, Contact and Sealing Materials

Chromium Oxidation and Evaporation on Interconnects from a Stack and CHP-Systems Perspective <i>J. G. Grolig, G. Longo, A. Mai</i>	2181
Electrical Conductivity Behaviour of Ferritic Steel Interconnect in Function of Spinel Composition, Electrode Material and Thermal Cycles <i>P. Coquoz, N. Coton, F. Morand, S. Frund, R. Ihringer</i>	2189

Enhancing the Robustness of Brittle Solid Oxide Cell Stack Components <i>H. L. Frandsen, I. Ritucci, P. Khajavi, B. Talic, R. Kiebach, P. V. Hendriksen</i>	2201
Interconnect Material Optimization for Low-Temperature Operation in FCH JU Project qSOFC <i>C. Bernuy-Lopez, L. Rioja-Monllor, J. Mikkola, M. Rautanen, S. Hailler, M. Noponen, M. Stenström, R. Berger, J. Westlinder</i>	2213
Improved Robustness and Low Area Specific Resistance with Novel Contact Layers for the Solid Oxide Cell Air Electrode <i>B. Talic, I. Ritucci, R. Kiebach, P. V. Hendriksen, H. L. Frandsen</i>	2225
FEM Model-Based Design Optimization of a Planar SOFC Interconnector Flowfield <i>A. Weber, H. Geisler</i>	2233
Evaluation of SUS430 with Mn-Co Coating as SOFC Interconnect in Reducing Atmosphere <i>C. Jia, M. Chen, M. Han, J. Wu</i>	2241
The Effect of Pre-Heat Treatment of AluChrom 318 on the Corrosion Behaviour and Cr Evaporation in SOFC Cathode Air Pre-Heater <i>K. Zhang, A. El-kharouf, R. Steinberger-Wilckens</i>	2253
The Influence of Different Factors on the Dual Atmosphere Effect Observed for AISI 441 Interconnects Used in Solid Oxide Fuel Cells <i>C. Goebel, C. Bo, J. E. Svensson, J. Froitzheim</i>	2261
Performance and In-Situ Densification of Mn-Co Spinel Coating on SUS430/441 Interconnect by Spraying Method <i>H. Chen, C. Jia, M. Han</i>	2267
Evaluation of Titanium Based Alloys as Interconnects for the Light Weight SOFC System <i>K. Kobayashi, R. Miyata, K. Yashiro, H. Takamura, K. Yoshimi, T. Kawada, S. Hashimoto, K. Okai</i>	2279
Cu-Based Coatings for IT-SOFC Applications <i>M. Tomas, C. Goebel, J. E. Svensson, J. Froitzheim</i>	2291
Semiconductive α -Al ₂ O ₃ /Sr ₃ Al ₂ O ₆ Oxide Layer Formed on Fe-Cr-Al Alloy <i>H. C. Pham, S. Taniguchi, Y. Inoue, J. T. Chou, K. Sasaki</i>	2299

Development of Oxide Dispersed Ferritic Steel as a Solid Oxide Fuel Cell Interconnect <i>T. H. Kim, M. Z. Khan, R. H. Song, S. B. Lee, T. H. Lim, J. E. Hong</i>	2307
A Novel Silver-Based Braze Sealant for Metal-Supported Solid Oxide Fuel Cells Applications <i>L. W. Huang, C. K. Liu, Y. N. Cheng, R. Y. Lee</i>	2313
Thermo-Mechanical Fatigue of SOFC Glass-Ceramic Sealant/Steel Interconnect Joint in a Reducing Atmosphere <i>K. Y. Chen, C. K. Lin, S. H. Wu, C. K. Liu, R. Y. Lee</i>	2323

Chapter 13 Solid Oxide Electrolysis and Reversible Cells and Systems

Co-Electrolysis of Biohythane Using Solid Oxide Fuel Cell Technology <i>K. Panagi, C. J. Laycock, J. P. Reed, A. J. Guwry</i>	2333
A Simple Approach to Enhance the Direct Production of Methane through Co-Electrolysis of CO ₂ and H ₂ O <i>M. Lo Faro Sr., S. C. Zignani, S. Trocino, A. S. Aricò</i>	2343
Preparation and Performance of Sr-Co Free Perovskite-Type Oxide La _{0.6} Ca _{0.4} Fe _{0.8} Ni _{0.2} O _{3-δ} as an Oxygen Electrode for Reversible Solid Oxide Electrochemical Cell <i>Y. Tian, Y. Liu, W. Wang, L. Jia, B. Chi, J. Pu, J. Li</i>	2351
Transition Metal Elements as Ni/GDC Dopants for the H ₂ O Electrolysis Process in SOECs: Fe-Ni vs Au-Mo-Ni Interaction <i>C. Neofytidis, E. Ioannidou, S. G. Neophytides, D. K. Niakolas</i>	2359
Influence of A-Site Deficiency, Porous Electrolyte Scaffold and Loading of MIEC Material on the Performance of La _{0.8} Sr _{0.2} Cr _{0.5} Mn _{0.5} O _{3-δ} Based R-SOC Fuel Electrode <i>M. Maide, P. Möller, G. Nurk, E. Lust</i>	2369
Further Improvement of Performances and Durability of Oxygen and Hydrogen Electrodes for Reversible Solid Oxide Cells <i>H. Uchida, H. Nishino, K. Kakinuma, M. E. Brito</i>	2379

Oxygen-Deficient Nd _{0.8} Sr _{1.2} Ni _{0.8} M _{0.2} O _{4-δ} (M = Ni, Co, Fe) Nickelates as Oxygen Electrode Materials for SOFC/SOEC	2387
<i>B. I. Arias-Serrano, E. Kravchenko, K. Zakharchuk, J. Grins, G. Svensson, V. Pankov, A. Yaremchenko</i>	
Perovskite-like LaNiO _{3-δ} as Oxygen Electrode Material for Solid Oxide Electrolysis Cells	2399
<i>A. Yaremchenko, B. I. Arias-Serrano, K. Zakharchuk, J. R. Frade</i>	
Development of Advanced Nickelate-Based Oxygen Electrodes for Solid Oxide Cells	2409
<i>M. A. Laguna-Bercero, A. Orera, M. Morales-Zapata, A. Larrea</i>	
Effect of SrTi _{0.3} Fe _{0.6} Co _{0.1} O ₃ Infiltration on the Performance of LSM-YSZ Cathode Supported Solid Oxide Fuel Cells with Sr(Ti,Fe)O ₃ Anodes	2417
<i>S. L. Zhang, H. Wang, C. X. Li, C. J. Li, S. A. Barnett</i>	
Electrochemical Performance, Microstructure and Chemical Compositions of Cu-Based Nanoparticles Driven by Exsolution of CuFe ₂ O ₄ in CO ₂ /H ₂ O and H ₂ O Electrolysis	2425
<i>K. T. Wu, J. Matsuda, A. Takagaki, T. Ishihara</i>	
Development of Solid Oxide Electrolysis Cells for Hydrogen Production at High Current Densities	2433
<i>X. Tong, P. V. Hendriksen, A. Hauch, M. Chen</i>	
Forschungszentrum Jülich – Progress in SOC Development	2443
<i>L. Blum, Q. Fang, L. G. J. de Haart, J. Malzbender, N. Margaritis, N. H. Menzler, R. Peters</i>	
The SOC4NH ₃ Project. Production and Use of Ammonia by Solid Oxide Cells	2455
<i>J. B. Hansen, P. V. Hendriksen</i>	
White Syngas by Co-Electrolysis for Industrial Chemistry	2467
<i>S. R. Foit, L. Dittrich, T. Theuer, S. Morgenthaler, R. A. Eichel, L. G. J. de Haart</i>	
Scenario Based Optimization of SOE and Reversible-SOC Systems	2475
<i>F. Koberg, D. Reichholf, R. Schaperl</i>	
Test and Evaluation of an Hybrid Storage Solution for Buildings, Based on a Reversible High-Temperature Electrolyzer	2485
<i>A. Nechache, S. Hody</i>	

Development and Testing of a 5kW-Class Reversible Solid Oxide Cell System <i>R. Peters, M. Frank, W. Tiedemann, I. Hoven, R. Deja, V. N. Nguyen, L. Blum, D. Stolten</i>	2495
Development of Alternative Fuel Electrodes for Upgrading Biogas through CO ₂ <i>N. Zhang, Y. Tian, X. Yue, L. Sammes, J. T. S. Irvine</i>	2507
Optimization of Solid Oxide Cells and Stacks for Reversible Operation <i>A. Ploner, A. Hauch, S. Pylypko, S. Di Iorio, G. Cubizolles, J. Mougin</i>	2517
Solid Oxide Cells for Power-to-X: Application & Challenges <i>R. Costa, D. M. Amaya Dueñas, G. Futter, T. Jahnke, M. Riegraf, G. Schiller, A. Surrey</i>	2527
System Development and Demonstration of Large-Scale High-Temperature Electrolysis <i>O. Posdziech, T. Geißler, K. Schwarze, R. Blumentritt</i>	2537
Reversible Solid Oxide Cell Systems for Grid Energy Management <i>E. Reznicek, R. J. Braun</i>	2547
Solid Oxide Steam Electrolysis with Integration of Solar Heat <i>G. Schiller, M. Lang, N. Monnerie, P. Sundarraj, P. Szabo</i>	2553
Enhanced CO ₂ Electrolysis at Redox Engineered Interfaces <i>J. T. S. Irvine, K. Xie</i>	2565
Transient Operation Strategies for MW-Scale SOC Systems <i>S. Santhanam, A. Padinjarethil, M. Tomberg, M. P. Heddrich, A. Ansar</i>	2571
Co-Electrolysis CFY-Stack Operation and Integration for Carbon Capture and Utilization <i>M. Kusnezoff, S. Megel, C. Rix, P. Adam, E. Reichelt, G. Herz, M. Jahn, N. Trofimenko, A. Michaelis</i>	2579
Electrochemical Characterization and Performance Assessment of SOC Stacks in Electrolysis Mode <i>M. Preininger, B. Stoeckl, V. Subotic, R. Schauperl, C. Hochenauer</i>	2589

Lifetime Capacity – An Important Performance Metric for SOEC Stacks <i>R. Küngas, P. Blennow, T. Heiredal-Clausen, T. Holt Nørby, J. Rass-Hansen, P. G. Moses</i>	2601
First-Principles Investigation of Promoting Effect in CO ₂ Methanation with an Electric Field in SOEC <i>K. Wakamatsu, T. Ogura</i>	2613
Improving the Efficiency of High-Temperature Electrolysis of Carbon Dioxide in a Solid Oxide Cell <i>A. V. Call, T. D. Holmes, K. Yanallah, P. D. Desai, W. B. Zimmerman, R. H. Rothman</i>	2623
Optimization and Durability of Reversible Solid Oxide Cells <i>X. Sun, B. R. Sudireddy, X. Tong, M. Chen, K. Brodersen, A. Hauch</i>	2631
Methane Production and Electricity Generation in a Proton Conducting Tubular Reversible Solid Oxide Cell <i>Y. Chen, M. Liu, Y. Shi, N. Cai</i>	2641
Hydrogen Production Combining Steam Reform and Electrolysis by Electrochemical Cell Using Proton Conducting Oxide <i>Y. Okuyama, S. Nagatomo, A. Niisaka, N. Matsunaga, G. Sakai, Y. Sasamata, Y. Ogura, Y. Mizutani</i>	2653
Numerical and Experimental Study on Operation of Reversible Solid Oxide Fuel Cells <i>V. Subotic, T. Thaller, M. Preininger, G. Pongratz, B. Stoeckl, H. Schroettner, C. Hoehenauer</i>	2661
Intermediate Temperature H ⁺ -SOEC with Proton Conducting BaZr _{0.6} Ce _{0.2} Y _{0.2} O _{3-δ} Electrolyte <i>H. Toriumi, C. Zhu, H. Habazaki, Y. Aoki</i>	2669
Theoretical Investigation of CO ₂ Reduction at Ni/SDC and La(Sr)FeO _{3-δ} Cathodes in Solid Oxide Electrolysis Cells <i>B. Ren, L. Ricardez-Sandoval, E. Croiset</i>	2673
Electrolysis of Carbon Dioxide in an Anode-Supported Large-Scale Solid Oxide Electrolysis Cell Based on Double-Sided Air Electrodes <i>W. B. Guan Sr., L. M. Lu, J. Yang, J. X. Wang</i>	2683

Distinguishing the CO ₂ Electro-Catalytic Reduction Pathway on Modified Ni/GDC Electrodes for the SOEC H ₂ O/CO ₂ Co-Electrolysis Process <i>E. Ioannidou, S. G. Neophytides, D. K. Niakolas</i>	2687
Oxidative Coupling of Methane in Solid Oxide Electrolysis Cell <i>S. Kodama, R. Kikuchi, N. Fujiwara, S. Tada, Y. Kobayashi, S. T. Oyama</i>	2697
Fuel Production with a Cathode-Supported Honeycomb Solid Oxide Electrolysis Cell <i>Y. Iwanaga, H. Nakajima, K. Ito</i>	2707
Long Term Behavior of Solid Oxide Electrolyser (SOEC) Stacks <i>M. Lang, S. Raab, M. S. Lemcke, C. Bohn, M. Pysik</i>	2713
Long-Term Degradation and Poisoning Effects of Ni-YSZ YSZ GDC PSC in Electrolysis Mode <i>P. Möller, G. Nurk, F. Kukk, R. Kanarbik, E. Lust</i>	2727
Reverse Current Treatment of Short Stacks – Experimental Results and System Considerations <i>M. Hauck, S. Herrmann, M. Hauser, A. Geiger, F. Fischer, J. Weinrich, M. Gaderer, H. Spliethoff</i>	2737
Assessment of a Solid Oxide Electrolysis Cell Performance Applying a Prediction Tool with Correlation Equations <i>M. Nishi, H. Morita, K. Yasumoto, T. Okawa, Y. Mugikura</i>	2749
Deuterium Isotope Analysis of Electrochemical Promotion in Ammonia Synthesis on Iron-Based Catalyst <i>C. I. Li, H. Matsuo, J. Otomo</i>	2761
Development of a Novel Energy System Based on Reversible Solid Oxide Cells and Power to Gas Technology for the Urban Energy Conversion and Storage <i>Z. Zhang, Z. Zong, J. Zhou, K. Wu</i>	2771

Author Index