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Ceremony for the inauguration of the MIRAI fuel cell vehicle on March 25, 2015, in front of the hydrogen station at Kyushu University



Ceremony marking the start of operation of a 250 kW-class solid oxide fuel cell power generation system coupled with micro gas turbine at Kyushu University, on March 13, 2015

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Editors

# Hydrogen Energy Engineering

A Japanese Perspective

 Springer

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# Preface

The purpose of this book is to give an overview of hydrogen energy engineering, especially from a Japanese perspective. After decades of research, development, and demonstration, the era of practical fuel cells and related hydrogen technologies has just begun. Commercial products are now available for daily life in various applications such as residential stationary fuel cells for powering houses and small businesses, and in fuel cell vehicles. There is a steady acceleration in research activities directed towards the wider application of these technologies.

Besides such technological efforts, academics have a responsibility to establish scientific disciplines within this engineering field. Because hydrogen gas is a secondary-energy carrier (like electricity), a comprehensive understanding of hydrogen-related technologies is essential. This should cover the whole process including hydrogen production, storage, and utilization. Relevant scientific disciplines such as electrochemistry and materials science are regarded as important fundamental areas for research, and special emphasis should be placed on the interaction of materials with hydrogen. As we have learned from the Fukushima disaster in Japan, safety is an essential aspect of hydrogen energy technologies, as with other energy engineering fields. In particular, we have to manage high-pressure hydrogen gas. Therefore, fundamental understanding of this issue should be researched, published, and compiled to establish safe design principles.

Considerable efforts have been made globally in these fields; however, Japan can take a leadership role by sharing recent experience in hydrogen-related technologies. Such technology sharing could increase the feasibility of hydrogen use all over the world. We are especially happy to share our experience with young students and researchers, because it is exciting to work in an environment where many new challenges are fully supported by society as a whole.

Compiling the very broad aspects of hydrogen energy into a single volume is a very difficult task. A decade ago, the International Research Center for Hydrogen Energy in Kyushu University's Ito Campus was founded in order to establish hydrogen energy engineering as a core subject in Japan. Such efforts have resulted

in the establishment of a highly collaborative and interdisciplinary team in Kyushu University focusing on hydrogen energy research.

We would like to acknowledge many organizations and individuals who have kindly supported our efforts. In particular, continuous support for the International Research Center for Hydrogen Energy from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) is gratefully acknowledged. The Next-Generation Fuel Cell Research Center (NEXT-FC) was established through the funding from the Ministry of Economy, Trade and Industry (METI). Special support for various technological and demonstration projects on the Ito Campus in the “Smart Fuel Cell Demonstration Project” is gratefully acknowledged, from the Cabinet Secretariat and the Cabinet Office, approved by the Ministry of Finance (MOF), for the Fukuoka International Strategic Zone. Many original findings have been made by various research projects via the New Energy and Industrial Technology Development Organization (NEDO), the Japan Science and Technology Organization (JST), and the Japan Society for the Promotion of Science (JSPS) including a Grant-in-Aid for Scientific Research, the World Premier International Research Center Initiative (WPI), and the Center of Innovation (COI) program. Close collaboration with the local government of Fukuoka Prefecture is a unique feature of the Hydrogen Projects of Kyushu University, with the significant and enthusiastic support from current Governor Hiroshi Ogawa and former Governor Wataru Aso. Continuous support and encouragement from the president of Kyushu University, Dr. Chiharu Kubo, and former presidents, Dr. Setsuo Arikawa and Dr. Chisato Kajiyama, are gratefully recognized. We also thank our industry partners for their continuous collaborations through NEXT-FC and other centers. Finally, we wish to thank many senior collaborators: Prof. Emer. Dr. Yukitaka Murakami, who initiated this hydrogen project; many professors in the Department of Mechanical Engineering; and many visiting professors including Prof. Dr. Harry L. Tuller (MIT), Prof. Dr. Ludwig J. Gauckler (ETH), Prof. Dr. John Kilner (Imperial College London), Prof. Dr. Kenichiro Ota (Yokohama National University), and Prof. Dr. Masahiro Watanabe (University of Yamanashi), whose encouragement has made this comprehensive book into a reality. We also wish to thank our colleagues who have helped so much in the finalization of this manuscript: Ms. Ayumi Zaito, Dr. Haruumi Hasuo, and Ms. Miki Fujita for editorial support and project management, as well as Dr. Nicola H. Perry, Dr. George F. Harrington, and Dr. Benjamin V. Cunnings for helping to edit the manuscript.

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