

Recent Trends in Fuel Cell Science and Technology

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Edited by

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Springer



Anamaya

A C.I.P. catalogue record for the book is available from the Library of Congress

ISBN 0-387-35537-5 (HB)

Copublished by Springer
233 Spring Street, New York 10013, USA
with Anamaya Publishers, New Delhi, India

Sold and distributed in North, Central and South America by Springer,
233 Spring Street, New York, USA

In all other countries, except India, sold and distributed by Springer,
P.O. Box 322, 3300 AH Dordrecht, The Netherlands

In India, sold and distributed by Anamaya Publishers
F-154/2, Lado Sarai, New Delhi-110 030, India

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Printed in India.

In loving memory of my parents
Professors N.M. Bose and N. Bose
who nurtured and inspired me

Preface

Fuel cell science and technology is evolving fast for the past two decades as it is thought to be an efficient way of transforming chemical energy of hydrogen rich compounds to electrical energy. Although this idea of direct conversion of chemical energy to electrical energy was first demonstrated by Sir William Grove in 1839 using a fuel cell, it was only in the middle of the twentieth century when Bacon's pioneering work led to the use of fuel cell in space missions. The interest in commercialization of fuel cell for civilian use has caught up with government organizations and private corporations for the past decade on account of fluctuating oil prices and environmental concerns. It is well known that the conventional fossil fuel, which is a primary source of gasoline, is not going to last more than a hundred years in the face of ever-increasing demand in the developed and developing countries. Although the reserves of natural gas, coal and tar sands may last another two to three hundred years with the current rate of production, their conversion is not efficient and pollution-free. Thus, scientists all over the world have taken up fuel cell development work in their quest of solution to the energy crises looming largely on global population. This book aims to script the present status of the rapidly developing field of fuel cell science and technology. Since fuel cell (FC) science and technology is multidisciplinary in nature, contributions from the world experts in different areas of fuel cell technology are brought under one umbrella. There are different types of fuel cells, which work on different principles on the basis of different electro-reactions, temperatures, electrodes, electrolytes and fuels. Thus, instead of a single authored book, it is more appropriate to present the work carried out by various experts in the abovementioned areas. The reader should note that FC technology is fast developing towards commercialization and it is not possible to provide crucial details of the patented technology. However, this book provides sufficient information on FC technology so that new researchers from similar areas and those readers who are working in FC technology would be able to take up problems in the area of industry needs.

Introduction to fuel cells and the common topics related to fuel cells, e.g. electro-analytical techniques and power conditioning, are included in the beginning and end of the book in their logical sequence. In-between, chapters describe the state-of-the-art of different types of fuel cell systems. Chapter 1 describes introduction to fuel cell technology and different types of fuel cells. Chapter 2 on electro-analytical techniques in fuel cell research and development deals with evaluation of kinetics of electro-catalytic reaction in half-cell, electro-analytical tools for single cell and stack design. Polymer electrolyte membrane fuel cell (PEMFC) has a promise of providing higher efficiency of the drive system and is regarded as the future motive power source for the transport sector. Thus, special emphasis is given on PEMFC. Chapters 3 to 5 discuss, elaborately, the latest developments in PEMFC, gas diffusion layer and water management in PEMFC. There are certain disadvantages associated with hydrogen such as large-scale and economical production of hydrogen from fossil fuel or other renewal route, emission of polluting gases as by-products during production of hydrogen from fossil fuel, dispensing and storage problems of hydrogen and safety issues. On the other hand, alcohols are produced from renewal sources, easy to handle, store and dispense. Use of alcohols directly into the fuel cell as fuel has been investigated for the past ten years. In Chapters 6 and 7, micro fuel cells, which are based on direct alcohol PEM fuel cell and direct alcohol alkaline fuel cell are presented. High temperature fuel cells are covered in Chapters 8 to 11 in the order of operating temperature. Phosphoric acid, molten carbonate fuel cells and direct conversion of coal in fuel cell are elaborately discussed in Chapters 8 to 10. Chapter 11 describes the principles, designs and state-of-the-art

of solid oxide fuel cells (SOFC). SOFCs, operated in the range of 700-1000°C with an efficiency of 60-80%, have a tremendous potential in the future as stationary power source in the order of kilowatt to megawatt range. Since it is operated at high temperature, material issues related to SOFC are discussed in Chapter 12. Chapter 13 covers the power conditioner system for fuel cell. Finally, future directions and challenges of fuel cell science and technology are presented in Chapter 14.

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Acknowledgements

In writing this book, I was inspired by memories of working with my teachers in the area of Interfacial and Electrochemical Engineering and Fuel Cells. Generous funding and the platform provided by Indian Institute of Technology (IIT) Delhi and Ministry of Non-conventional Energy Sources, Government of India, has drawn me into the research and development of fuel cell technology. While covering the subject of fuel cell technology during teaching of electrokinetic transport course to the graduate students of IIT Delhi and in course of discussion with my research students, I was motivated to write a book on fuel cells. I have mentioned in the Preface why I have chosen to bring out an edited book whereby contributions from world experts in different areas of fuel cell technology are sought. I owe my thanks to all the contributors for sharing valuable state-of-the-art knowledge and experience on different types of fuel cells and associated topics. Reviewing chapters was not an easy task as they dealt with interdisciplinary fields of sciences and technologies. The objective of the book is fulfilled through patient and careful reading by myself and further revision carried out by the respective authors. Several occasions and informal discussions held with Dr. T.K. Roy, CMD C Ltd. and Dr. V.V. Krishnan, IIT Delhi were helpful in writing the last chapter on future directions of fuel cell science and technology. Encouraging discussions with my research students, Anil Verma, Amit K. Jha, Krishna V. Singh and Hiralal Pramanik brought confidence in believing in future potential of fuel cell technology.

Finally, without the support of my wife and son, from whom I took away important family time, this book would not have been published in its present form.

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