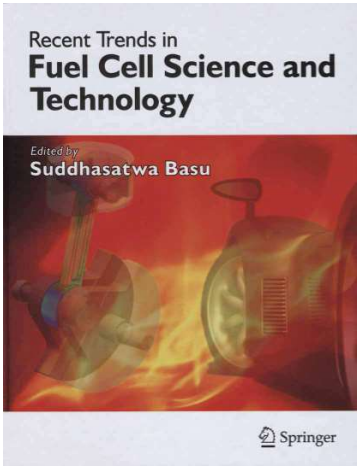
Recent Trends in
Fuel Cell Science and Technology
Edited by
Suddhasatwa Basu
Springer

Fue

Fuel Cell Science

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

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 loving memory of n
Professors N.M. Bose a
who nurtured and ins

Preface

Fuel cell science and technology is evolving fast for the past t
way of transforming chemical energy of hydrogen rich compo
of direct conversion of chemical energy to electrical energy w
in 1839 using a fuel cell, it was only in the middle of the twen
led to the use of fuel cell in space missions. The interest in cc
has caught up with government organizations and private cor
fluctuating oil prices and environmental concerns. It is well kr
is a primary source of gasoline, is not going to last more than a
demand in the developed and developing countries. Although t
may last another two to three hundred years with the curren
efficient and pollution-free. Thus, scientists all over the worl
in their quest of solution to the energy crises looming largely o
the present status of the rapidly developing field of fuel cell s
science and technology is multidisciplinary in nature, contri
areas of fuel cell technology are brought under one umbrella.
work on different principles on the basis of different electro-rea
and fuels. Thus, instead of a single authored book, it is more a
various experts in the abovementioned areas. The reader shoul
towards commercialization and it is not possible to provide
However, this book provides sufficient information on FC tech

of solid oxide fuel cells (SOFC). SOFCs, operated in the r
60-80%, have a tremendous potential in the future as statio
to megawatt range. Since it is operated at high temperature, n
in Chapter 12. Chapter 13 covers the power conditioner sy
and challenges of fuel cell science and technology are preser

Acknowledgen

In writing this book, I was inspired by memories of working w
Electrochemical Engineering and Fuel Cells. Generous funding
of Technology (IIT) Delhi and Ministry of Non-conventional
drawn me into the research and development of fuel cell techn
technology during teaching of electrokinetic transport course
course of discussion with my research students, I was moti
mentioned in the Preface why I have chosen to bring out an ed
experts in different areas of fuel cell technology are sought.
sharing valuable state-of-the-art knowledge and experience o
topics. Reviewing chapters was not an easy task as they dealt
technologies. The objective of the book is fulfilled through
further revision carried out by the respective authors. Several
Dr. T.K. Roy, CMDC Ltd. and Dr. V.V. Krishnan, IIT Delhi we
directions of fuel cell science and technology. Encouraging
Verma, Amit K. Jha, Krishna V. Singh and Hiralal Pramanil
potential of fuel cell technology.

Finally, without the support of my wife and son, from wh
book would not have been published in its present form.

Contents

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Edited by S. Basu
Anamaya Publishers, New Delhi, India

1. Introduction to F

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1. Introduction

A fuel cell is an electrochemical device (a galvanic cell) whicl into electrical energy (electricity); byproducts are heat and wate in some fuel cell types, the additional byproducts may be c hydrocarbons depending on the fossil fuels used. There is no c are generated. Sulfur is poison to all fuel cells so it must be re fuel cell type; hence, no SO_x are generated. A fuel cell produce as the fuel and oxidant are supplied. For reference, primary cel producing device (one-way chemical reaction producing elec battery is discharged. A rechargeable or secondary battery is having reversible chemical reaction producing or using electr

The components of a fuel cell are anode, anodic catalys cathode, bipolar plates/interconnects and sometimes gaskets for anode and cathode. The stack of such fuel cells (a repeated

series/parallel connections to yield the desired voltage and
porous gas diffusion layers, usually made of highly electron co
conductivity theoretically) such as porous graphite thin lay
platinum for low temperature fuel cells and nickel for high
depending on the fuel cell type. The electrolyte is made of
conductivity and *theoretically* zero electron conductivity. T
cathode or vice versa) are different depending on the type of
Table 1. The bipolar plates (or interconnects) collect the electri
reactive gases in the fuel cell stack.

The anode reaction in fuel cells is either direct oxidation of
via a reforming step for hydrocarbon fuels. The cathode reacti
cells. For hydrogen/oxygen (air) fuel cells, the overall reactio

$$H_2 + \tfrac{1}{2} O_2 \rightarrow H_2O \quad \text{with} \quad \Delta G$$

where ΔG is the change in Gibbs free energy of formation. Th
at cathode or anode depending on the type of the fuel cell. The t

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[†]Formerly at Department of Mechanical Engineering, Rochester Insti