

CONTEMPORARY METALLIC MATERIALS

Md Abdul Maleque
Iskandar Idris Yaacob
Zahurin Halim



IIUM PRESS

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

CONTEMPORARY METALLIC MATERIALS

Edited by:

Md Abdul Maleque

Iskandar Idris Yaacob

Zahurin Halim



IIUM Press

Published by:
IIUM Press
International Islamic University Malaysia

First Edition, 2011
©IIUM Press, IIUM

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without any prior written permission of the publisher.

Perpustakaan Negara Malaysia

Cataloguing-in-Publication Data

ISBN: 978-967-418-164-2

Member of Majlis Penerbitan Ilmiah Malaysia – MAPIM
(Malaysian Scholarly Publishing Council)

Printed by :

IIUM PRINTING SDN. BHD.

No. 1, Jalan Industri Batu Caves 1/3

Taman Perindustrian Batu Caves

Batu Caves Centre Point

68100 Batu Caves

Selangor Darul Ehsan

Table of Content

Chapter 1 Upgrading of Laterite Ore by Reduction and Leaching <i>Hadi Purwanto and Pramusanto</i>	1
Chapter 2 Upgrading of Iron Sand by Magnetic Concentration and Reduction <i>Muta'alim, Hadi Purwanto, Nuryadi Saleh and Pramusanto</i>	7
Chapter 3 Microstructure and Mechanical Properties of Neutron Transmutation Doped of Silicon under Cf-252 Neutron Bombardment <i>Agus Geter Edy Sutjipto, Roslan Yahya</i>	16
Chapter 4 Effect of Stabilizer Addition on Crystal Formation of Zirconia Synthesize From Zircon Sand <i>Yuhelda Dahlan Hadi Purwanto, Nuryadi Saleh and Pramusanto</i>	20
Chapter 5 Upgrading of Iron-rich Laterite Ore Using Reverse Flotation <i>Hadi Purwanto, Mutaalim, Yuhelda Dahlan, Nuryadi Saleh and Pramusanto</i>	27
Chapter 6 Influences of Additives on Copper Film Quality and Gap Filling Capability of Plating Process <i>Shahjahan Mridha and Law Shao Beng</i>	34
Chapter 7 Grain Refining in AISI 430 Ferritic Stainless Steel Welds by Addition of Metal Powder <i>Shahjahan Mridha and Muhammed Olawale Hakeem Amuda</i>	41
Chapter 8 Grain Refinement Practices in Ferritic Stainless Steel Welds <i>Muhammed Olawale Hakeem Amuda and Shahjahan Mridha</i>	48
Chapter 9 Alloy Coating on Steel Surfaces by Melt Synthesis of Elemental Metal Powders <i>Shahjahan Mridha</i>	53

Chapter 10	59
Synthesis And Characterization of Lithium Manganese Copper Oxides for use in Lithium Rechargeable Cells	
<i>I.I. Yaacob, N. Kamarulzaman, and W.J. Basirun^f</i>	
Chapter 11	65
Influence of Grain Size on Magnetic Properties of Electroplated NiFe	
<i>Yusrini Marita and Iskandar Idris Yaacob</i>	
Chapter 12	70
Composite Coating on Titanium Alloy Using High Power Laser	
<i>Shahjahan Mridha</i>	
Chapter 13	75
The Tribological Behaviour of Al-Si Automotive Piston Material	
<i>Arifutzzaman and Md Abdul Maleque</i>	
Chapter 14	81
Conceptual Design of Folding Bicycle Frame with Light Weight Materials	
<i>Md Abdul Maleque and Mohd Nizam</i>	
Chapter 15	86
Reverse Engineering of Automotive Piston	
<i>Md Abdul Maleque and A. Arifutzzaman</i>	
Chapter 16	92
Recent Trend in Application of High Temperature Ferritic Fe-Cr Alloys in Power Plant	
<i>Mohd Hanafi Bin Ani and Raihan Othman</i>	
Chapter 17	98
Measurement of Oxygen Permeability in Bulk Alloys by Internal Oxidation of Dilute Constituent	
<i>Mohd Hanafi Bin Ani and Raihan Othman</i>	
Chapter 18	104
Recent Trend on Application of High Temperature Ferritic Fe-Cr Alloys in Solid Oxide Fuel Cells	
<i>Mohd Hanafi Bin Ani and Raihan Othman</i>	
Chapter 19	110
Principle of Solid Electrolyte Oxygen Sensor	
<i>Mohd Hanafi Bin Ani and Raihan Othman</i>	
Chapter 20	116
Surface Oxygen Potential on the Oxide Scale during High Temperature Oxidation of Fe-Cr Alloys at 1073 K	
<i>Mohd Hanafi Bin Ani and Raihan Othman</i>	

	<i>Mohd Hanafi Bin Ani and Raihan Othman</i>	
Chapter 21		121
Reverse Engineering for Automotive Fuel Tank		
	<i>Md Abdul Maleque and Atiqah Afdzaluddin</i>	
Chapter 22		127
The possibility of utilizing scanning electron microscope for materials characterization		
	<i>Agus Geter Edy Sutjipto</i>	
Chapter 23		135
Piezoelectricity of Zinc Oxide Thin film as Source of Energy for Sensor Applications		
	<i>Agus Geter Edy Sutjipto, Liyana Abdul Gafar and Nor Azyati Syazwina Roselan</i>	
Chapter 24		141
Study on Zinc Oxide Crystal Growth		
	<i>Agus Geter Edy Sutjipto, Liyana Abdul Gafar and Nor Azyati Syazwina Roselan</i>	
Chapter 25		147
Green Nanotechnology using SEM and AFM		
	<i>A.G.E. Sutjipto and R. Muhida</i>	
Chapter 26		155
The effect of Cobalt addition on structural and magnetic properties of electrodeposited Iron-Platinum nanocrystalline thin films		
	<i>Seoh Hian Teh¹, Iskandar Idris Yaacob</i>	
Chapter 27		163
Mechanochemical Synthesis of CeO ₂ Nanopowder using Planetary Ball Milling		
	<i>Iskandar I. Yaacob</i>	
Chapter 28		170
A Study on Double Junction Zinc Based/Polymer Thin Film Solar Cell		
	<i>S. A. Mohamad and A. K. Arof</i>	
Chapter 29		176
A Voltammetric Study of Zinc Telluride Thin Films Prepared for Photovoltaic Applications		
	<i>S. A. Mohamad and A. K. Arof</i>	
Chapter 30		181
Electrodeposition Technique for ZnO Semiconductor Thin Films Fabrication		
	<i>S. A. Mohamad</i>	
Chapter 31		186
Electroless Nickel Based Coatings From Solution Containing Sodium Hypophosphite		
	<i>Suryanto</i>	

Chapter 32 Aluminum Spray Coating for Corrosion Resistance of Steel	192
	<i>Suryanto</i>
Chapter 33 Electrodeposition of Alloys	198
	<i>Suryanto</i>
Chapter 34 Corrosion Behavior of Duplex Stainless Steel in Sea Water	204
	<i>Suryanto</i>
Chapter 35 Cathodic Protection of Underground Pipes	210
	<i>Suryanto</i>

Principle of Solid Electrolyte Oxygen Sensor

Mohd Hanafi Bin Ani and Raihan Othman
 Faculty of Engineering – International Islamic University Malaysia
 ✉ : mhanafi@iium.edu.my

Keywords: Oxygen sensor, Solid electrolyte, Electrochemical concentration cell, Fe-Cr alloys.

Abstract: The principle of solid electrolyte oxygen sensor has been discussed. An example of its' application in the high temperature oxidation of Fe-Cr alloys was given. In Ar-21%O₂ mixed gas, the oxygen chemical potential of the oxide formed on Fe-10~17Cr alloys is slightly smaller than the atmosphere. Electrochemical concentration cell using solid electrolyte provides an accurate measurement of surface oxygen potential, thus widely apply in oxygen sensing.

Introduction

In the industry and practical application, evaluation of gas concentration is important to continuously monitor the reaction environment. Solid electrolyte gas sensor is based on electrochemical concentration cell, which will generates electromotive force (emf) if there is concentration gradient of gas between the cells. Recently, many gas sensing materials have been developed. Stabilized zirconia oxygen sensor is one of important material that has been developed and successfully utilized in automotive, combustion, steel industries etc. In this paper, the principle of solid electrolyte oxygen sensor will be discussed with some example of application in high temperature oxidation of Fe-Cr alloys.

Measurement Principle

Calcia stabilized zirconia (CSZ) is well known as an ionic conductor widely uses as solid electrolyte in oxygen sensor / pump at high temperature. Fig. 1 shows a schematic diagram of an oxygen sensor using CSZ as electrolyte. If one side of oxygen partial pressure, $P_{O_2}^I$ is known value, the oxygen partial pressure in the closed system, $P_{O_2}^{II}$ can be measured. The electromotive force (emf) of this cell is expressed as Nernst equation below.

$$E = \frac{\mu_{O_2}^I - \mu_{O_2}^{II}}{4F} = \frac{RT}{4F} \ln \frac{P_{O_2}^I}{P_{O_2}^{II}} \quad (19.1)$$

where R , T and F denote gas constant, temperature and Faraday constant, respectively.