



Energy Technology 2013

Carbon Dioxide Management and Other Technologies

Edited by:

Soobhankar Pati • Jaroslaw Drellich
Animesh Jha • Neale Neelameggham
Leon Prentice • Cong Wang

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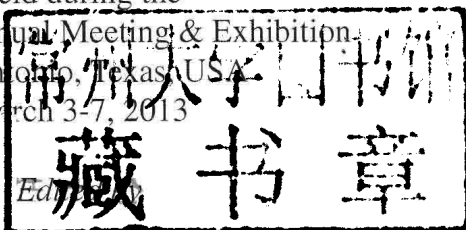
TMS

Energy Technology 2013

Carbon Dioxide Management and Other Technologies

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Preface

This volume contains selected papers presented at the Energy Technology and CO₂ Management symposium organized in conjunction with the TMS 2013 Annual Meeting & Exhibition in San Antonio, Texas, USA, and organized by the TMS Energy Committee. As the title of symposium “Energy Technology and CO₂ Management” suggests it intends to address the issues, intricacies and challenges relating to energy and environmental science.

This is the sixth year of the Energy Technology and CO₂ Management symposium, which was initiated in 2007–2008. During the first two years, emphasis was given to topics on CO₂ minimization by chemical reduction of oxides or physical minimization by other methods. It was called CO₂ Reduction Metallurgy. Starting in 2010, the proceedings has been renamed as Energy Technology with articles from the symposium on Carbon Dioxide & Other Greenhouse Gas Reduction Metallurgy, Energy Efficiency and Waste Heat Recovery in Metallurgical Processes. In 2012 it was decided to encompass all these topics in a symposium titled "Energy Technologies and Carbon Dioxide Management". This is the second year of including all the above technologies along with articles from other symposiums like magnetic materials for energy applications and materials for clean power systems.

Since energy is an emerging issue in any branch of the industry, the symposium intends to address the needs for sustainable technologies with reduced energy consumption and pollutants. Given the spread of topics in energy among numerous journals, making the work less accessible to many researchers, we decided to compile information on research activities in the area of energy and this book is the result. The availability of focused scientific information into a few accessible resources should be attractive and gratifying to many researchers. The authors have contributed to this book, and they provide a summary of current research on energy technology and CO₂ management. This volume also contains some articles from the Magnetic Materials for Energy Applications – III and Materials in Clean Power Systems VIII: Durability of Materials symposiums.

The symposium was open to participants from both industry and academia and focused on energy efficient technologies include innovative ore beneficiation, smelting technologies, recycling and waste heat recovery. This volume also covers various technological aspects of sustainable energy ecosystems, processes that improve energy efficiency, reduce CO₂ and other greenhouse emissions. It also includes contributions from all areas of non-nuclear and non-traditional energy sources.

This year the Energy Committee introduced a special session on Energy Education, which is unique among all technical symposiums organized at TMS. This volume includes the manuscripts from selected talks on Energy Education. The session on Energy Education was arranged by Dr. Arthur E. Morris.

We hope this book will serve as a reference for both new and current materials scientists and metallurgists, particularly those who are actively engaged in exploring innovative technologies and routes that lead to more efficiency and sustainability.

This book could not materialize without contributions from the authors of included papers, time and effort of the reviewers dedicated to the manuscripts during the review process, and help received from the publisher. We thank them all! We wish to acknowledge the efforts of Energy Committee Chair Jaroslaw Drelich and past Chair Cindy Belt for enhancing the proceedings of *Energy Technology 2013*. We thank Dr. Arthur E. Morris for putting his efforts in organizing the Energy Education session. We also acknowledge the organizers of the rest of the symposiums, from which articles were added to *Energy Technology 2013*.

Magnetic Materials for Energy Applications – III

Sivaraman Guruswamy, University of Utah

Thomas G. Woodcock, IFW Dresden

Yongmei Jin, Michigan Technological University

Raju V. Ramanujan, Nanyang Technological University

Frank Johnson, GE Global Research

Oliver Gutfleisch, Technische Universität Darmstadt

Materials in Clean Power Systems VIII: Durability of Materials

Sebastien Dryepondt, ORNL

Kinga Unocic, ORNL

Jeffrey W. Fergus, Auburn University

Xingbo Liu, West Virginia University

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Soobhankar Pati

Jaroslaw Drelich

Animesh Jha

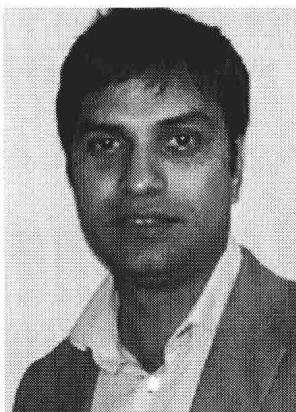
Neale Neelameggham

Leon Prentice

Cong Wang

Editors

Soobhankar Pati is an Assistant Professor at IIT Bhubaneswar, India. His research interest includes clean energy, advance manufacturing process and green metallurgy. Prior to joining IIT, he was with Metal Oxygen Separation Technology Inc. (MOxST), Natick, MA, where he was instrumental in developing a revolutionary process for electrolytic production of metals directly from their oxides. His innovations led to making gas handling in the process much simpler and more robust, and facilitated scale-up of the process from a few grams to kilogram scale. In addition, Soobhankar was a Visiting Scientist at Boston University in the Department of Materials Science and Engineering, where he received a Ph.D. in 2010. At Boston University, his contributions led to breakthroughs which reduced the cost of pure oxygen production in this direct oxide electrolysis process. As part of his graduate research he developed a new technology for using the energy in industrial and municipal waste to directly make hydrogen gas at high efficiency. His research work at Boston University won various clean energy awards. He is currently a member of TMS and actively takes part regularly in Energy Committee and Magnesium Committee activities.

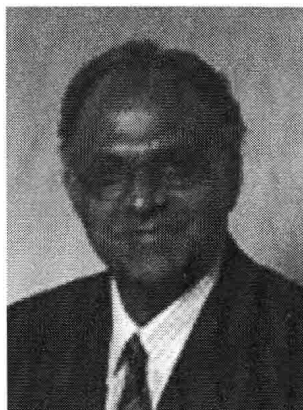


Jaroslav W. Drelich came to Michigan Technological University (Michigan Tech) in 1997 and currently is a professor of materials science and engineering. His main research interests are in applied surface chemistry and interfacial engineering for ore dressing and materials processing, nanotechnology, materials recycling, characterization of materials' surfaces, engineering, modification and testing of biomaterials, and formulation of antimicrobial materials. Aside from teaching several courses on characterization and processing of materials at Michigan Tech, Dr. Drelich has edited five books, published over 150 technical papers, holds nine patents and has more than 50 conference presentations, including several keynote addresses, to his credit. He was appointed in 2011 as Adjunct Professor to the Department of Chemical and Material Engineering at the University of Alberta, Canada. Dr. Drelich is the Editor of a new journal *Surface Innovation*. He also serves on the External Advisory Board for the *Journal of Adhesion Science and Technology*, *International Journal of Advanced Materials Manufacturing & Characterization* and *Journal of Nanomaterials &*

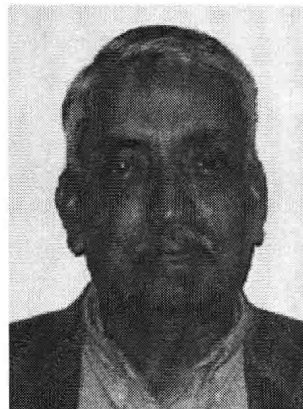


Molecular Nanotechnology. Dr. Drelich is the active member of The Minerals, Metals & Materials Society (TMS), Society for Mining, Metallurgy and Exploration (SME), and American Chemical Society (ACS), and has served on a number of different committees; currently, he serves as Chair for the TMS Energy Committee.

Animesh Jha obtained his Bachelor (from the University of Roorkee, India) and Master of Engineering (Indian Institute of Science, Bangalore) degrees in India in 1979 and 1981, respectively. He obtained his Ph.D. and Diploma of Imperial College in October 1984 from the University of London. Prof. Jha has over 30 years of research experience in the field of materials processing, chemical thermodynamics, kinetics, glass science and photonic optical materials. His current research areas are on critical materials for energy sector, light-matter interaction, and integrated photonic devices for energy efficient light sources, chemical and biological sensing. He brings unique expertise to the TMS as a member which he has been since 1992. Prof. Jha is also a member of the Institute of Physics, Optical Society of America, and IEEE. He is a Fellow of the Institute of Physics.



Neale R. Neelameggham is 'Guru' at IND LLC, involved in technology marketing and consulting in the field of light metals and associated chemicals [boron, magnesium, titanium, lithium and alkali metals], rare earth elements, battery and energy technologies, etc. He has over 38 years of expertise in magnesium production technology from the Great Salt Lake brine in Utah, involved in Process Development of its startup company NL magnesium through the presently known US Magnesium LLC, and was its Technical Development Scientist from where he retired. Dr. Neelameggham's expertise includes an in-depth and detailed knowledge of all competing technologies of magnesium production, both electrolytic and thermal processes worldwide, as well as alloy development. Dr. Neelameggham holds 13 patents and a pending patent on boron production, and has several technical papers to his credit. As a member of TMS, AIChE, and a former member of American Ceramics Society he is well versed in energy engineering, bio-fuels, rare-earth minerals and metal processing and related processes. Dr. Neelameggham has served in the Magnesium Committee



of LMD since its inception in 2000, chaired it in 2005, and in 2007 he was made a permanent co-organizer for the Magnesium Symposium. He has been a member of the Reactive Metals Committee, Recycling Committee, Titanium Committee, and Programming Committee Representative of LMD and LMD council. In 2008, LMD and EPD created the Energy Committee following the symposium on CO₂ Reduction Metallurgy Symposium initiated by him. Dr. Neelameggham was the inaugural Chair for the Energy Committee. He has been a co-editor of the Energy Technology proceedings since 2008. He received the LMD Distinguished Service Award in 2010. Dr. Neelameggham holds a doctorate in extractive metallurgy from the University of Utah.

Leon Prentice is a Senior Research Engineer with the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia's national research agency. He is a chemical engineer with a particular interest in technology development through process development and scale-up, especially in developing more energy efficient and environmentally responsible production processes.



Cong Wang is Senior Research Engineer of Saint-Gobain Innovative Materials R&D. Prior to joining Saint-Gobain, he worked at the Alcoa Technical Center. He obtained his Ph.D. from Carnegie Mellon University, M.S. from the Institute of Metal Research, Chinese Academy of Sciences, and B.S. from Northeastern University with distinctions, respectively. His specialties are in materials processing, microstructure characterization, mechanical testing, and electrochemistry.



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Carbon Dioxide Management and Other Technologies

Alternative Green Processes

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