
Handbook of Nanoelectrochemistry

Mahmood Aliofkhazraei
Abdel Salam Hamdy Makhlouf
Editors

Handbook of Nanoelectrochemistry

Electrochemical Synthesis Methods,
Properties, and Characterization
Techniques

With 753 Figures and 131 Tables

 Springer Reference

Editors

Mahmood Aliofkhazraei
Department of Materials Engineering
Tarbiat Modares University
Tehran, Iran

Abdel Salam Hamdy Makhlouf
Manufacturing Engineering Department
College of Engineering and Computer
Science
University of Texas Pan-American
Edinburg, TX, USA

ISBN 978-3-319-15265-3 ISBN 978-3-319-15266-0 (eBook)

ISBN 978-3-319-15267-7 (print and electronic bundle)

DOI 10.1007/978-3-319-15266-0

Library of Congress Control Number: 2015949631

Springer Cham Heidelberg New York Dordrecht London

© Springer International Publishing Switzerland 2016

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Printed on acid-free paper

Springer International Publishing AG Switzerland is part of Springer Science+Business Media
(www.springer.com)

Preface

Nowadays, human cannot still expand the frontiers of knowledge by having an unchanged usual view to the natural, chemical and biological processes. In order to develop and grow the human knowledge, it is necessary to see from different views and in various aspects. Looking from the large and broad scales such as the mapping of cities and countries with satellite, etc., give us the information which are unachievable by the normal vision. However, looking to the nature, from the perspective of micron and nanometer (at atomic scales) provides the information which can more easily discover the mystery of that phenomenon. What is now known as nanotechnology is becoming familiar and controlling many phenomena at the atomic and angstrom dimensions which is a difficult way with promising future and very amazing results. For instance, the recent progress in fabrication of carbon nanotubes, microelectronic chips, bimolecular engines, and nanomachines, nanosensors, microfilters and other cases have resulted in changes and developments in computers, electronics, aerospace, biochemistry, ecology, chemistry and other sciences. Electrochemistry beside the presence of powerful microscopic methods and electrodes with nanometer dimensions helped us for microstructural investigation and identification of nanostructured surfaces.

Nanotechnology has also contributed in developing and progressing of analytical electrochemistry which is very widespread scientific field. Any non-uniformity in the surfaces causes to the lack of repeatability in the obtaining of expected results. For example, information surrounding the surfaces, interfaces, corrosion, failure or abrasion of the surfaces, non-uniformity of the surfaces, recognition of the existed components in the surfaces and the degree of their oxidation are much more necessitated to study the processes. This vital information can be obtained by nanotechnology, and different microscopic techniques have been improved and developed in order to analyze the surfaces at atomic scales.

Electrochemical deposition of the metals is an ancient art which is one of the primary processes in the protection using nanosized materials. Electrochemical deposition, electroless deposition and substitution reaction which are used for the deposition of metallic alloys and metallic composite materials, taking advantage of the electrochemical reactions. Multilayered thin film, nanowires, nanowires with

nanometer layers, nanotubes, nanoparticles located in the metallic matrix and nanoparticles containing membranes can be fabricated by nanoelectrochemistry. The topics covered in this field of science are very broad. The progress in nanoelectrochemistry increased sharply during the recent years. As a result, this handbook aims to gather different aspects of nanoelectrochemistry beside its advances.

The editors of this handbook would like to appreciate all of contributors to this handbook and thank them for their hard work, patience during preparation of this handbook and also their high quality chapters. We wish publishing of this handbook will help all researchers to benefit from this collection and further progress of nanoelectrochemistry.

Summer 2015

Mahmood Aliofkhazraei
Abdel Salam Hamdy Makhoulouf

Contents

Volume 1

Part I Synthesis and Fabrication of Nanostructured Materials.....	1
1 Electrochemical Fabrication of Graphene-Based Nanomaterials	3
Alina Pruna, Daniele Pullini, and David Mataix Busquets	
2 Electrochemical Fabrication of Nanostructures	23
R. Abdel-Karim	
3 Electrochemical Preparation of Nanoresonators	47
Andrzej Kudelski	
4 Electrochemically Fabricated Nanostructures in Energy Storage and Conversion Applications	71
Kafil M. Razeeb, Maksudul Hasan, Mamun Jamal, and Alan Mathewson	
5 Electrochemical Synthesis of Metal Chalcogenide Nanorods, Nanotubes, Segmented Nanorods, and Coaxial Nanorods	101
Néstor L. Chévere-Trinidad, Serkan Gurbuz, Jessica Kramer, and Dhandapani Venkataraman	
6 Nanomaterials Produced by Electrocrystallization Method	135
Maria Trzaska and Zdzislaw Trzaska	
7 Formation and Characterization of Bimetallic Nanoparticles in Electrochemistry	169
Chun-Jern Pan, Loka Subramanyam Sarma, and Bing-Joe Hwang	

8	Synthesis, Modification, and Characterization of Nanocarbon Electrodes for Determination of Nucleic Acids.....	241
	David Hynek, Katerina Tmejova, Jiri Kudr, Ondrej Zitka, Lukas Nejd, Pavel Kopel, Branislav Ruttkay-Nedecky, Jindrich Kynicky, Jaromir Hubalek, Rene Kizek, and Vojtech Adam	
9	Porous Indium Phosphide: Preparation and Properties	283
	Suchikova Yana	
Part II	Synthesis and Fabrication of Nanostructured Coatings and Thin Films	307
10	Recent Approaches for Designing Nanomaterials-Based Coatings for Corrosion Protection	309
	Nedal Abu-Thabit and Abdel Salam Hamdy Makhlouf	
11	Electrodeposited Zn-Nanoparticles Composite Coatings for Corrosion Protection of Steel	333
	Liana Maria Muresan	
12	Electrochemical Fabrication of Multi-Nanolayers.....	355
	Paul McCloskey, Terence O'Donnell, Brice Jamieson, Donald Gardner, Michael A. Morris, and Saibal Roy	
13	Electroless Nanocomposite Coatings: Synthesis, Characteristics, and Applications.....	389
	Sankara Narayanan T.S.N., Seshadri S.K., Il Song Park, and Min Ho Lee	
14	Self-Assembled Monolayers on Nanostructured Composites for Electrochemical Sensing Applications.....	417
	Nada F. Atta, Ekram H. El-Ads, and Ahmed Galal	
15	Nanostructured Hybrid Graphene-Conducting Polymers for Electrochemical Supercapacitor Electrodes	479
	Punya A. Basnayaka, Manoj K. Ram, Elias K. Stefanakos, and Ashok Kumar	
16	The Electrochemistry of Peptide Self-Assembled Monolayers	503
	Emanuela Gatto, M. Caruso, and M. Venanzi	
17	Electrophoretic Deposition (EPD): Fundamentals and Applications from Nano- to Microscale Structures	561
	Pouya Amrollahi, Jerzy S. Krasinski, Ranji Vaidyanathan, Lobat Tayebi, and Daryoosh Vashaee	

18 Nanoporous Anodic Aluminum Oxide: Fabrication, Characterization, and Applications.....	593
Wojciech J. Stepniowski and Zbigniew Bojar	
19 Electrodeposition of ZnO Nanostructures: Growth, Doping, and Physical Properties	647
M. Allan Thomas and Jingbiao Cui	
20 Nanostructured Transition Metal Oxides Produced by Electrodeposition for Application as Redox Electrodes for Supercapacitors.....	681
M. Fátima Montemor, S. Eugénio, N. Tuyen, R.P. Silva, T.M. Silva, and M.J. Carmezim	
21 Nanoscale Electrodeposition of Metals and Semiconductors from Ionic Liquids Probed by Scanning Tunneling Microscopy	715
Hong-Dan Peng, Yu Zhao, and Ge-Bo Pan	
Volume 2	
Part III Electrochemical Properties and Characterization of Nanostructured Materials.....	739
22 Characterization of Nanomaterials in Electrochemistry	741
Giorgia Greco	
23 Electrochemical Control of the Core-Shell Cobalt-Platinum Nanoparticles.....	769
S. Grau, E. Gómez, J.M. Feliu, and E. Vallés	
24 Metal Oxide Nanoparticle Engineering for Printed Electrochemical Applications.....	783
Pawel Jerzy Wojcik, Luis Pereira, Rodrigo Martins, and Elvira Fortunato	
25 Microstructural Aspects of Ionic Conductivity in Nanocrystalline Zirconia.....	819
Mirosław M. Bućko	
26 Wet Chemical Approaches for Chemical Functionalization of Silicon and Titanium Nanomaterials	849
Kerrilee A. Stewart and Harinder Pal Singh Missan	

Part IV Electrochemical Properties and Characterization of Nanostructured Coatings and Thin Films	867
27 Electron Transfer and Charge Storage in Thin Films of Nanoparticles	869
Krzysztof Winkler and Emilia Grądzka	
28 Electroforming and Electrodeposition on Complex 3D Geometries: Special Requirements and New Methods	941
Anne Jung, Martin Weinmann, and Harald Natter	
29 Modeling of Metal Electrodeposition at the Nanoscale	971
O.A. Oviedo and E.P.M. Leiva	
Part V New Properties	1011
30 Plasmonic Nanostructured Supports for Spectro-Electrochemistry of Enzymes on Electrodes	1013
Inez M. Weidinger	
31 Self-Organized Nano- and Microstructure of Electrochemical Materials by Design of Fabrication Approaches	1033
Zhenyu Chu, Lei Shi, and Wanqin Jin	
32 Application of Two-Dimensional Heisenberg Model to Electrochemical Nucleation Theory	1057
Sergei A. Baranov	
Part VI Applications	1071
33 Scanning Electrochemical Microscopy: A Multiplexing Tool for Electrochemical DNA Biosensing	1073
Mohtashim Hassan Shamsi and Heinz-Bernhard Kraatz	
34 Implementation of Nanostructured Catalysts in the Electrochemical Promotion of Catalysis	1095
Holly A.E. Dole and Elena A. Baranova	
35 Self-Assembled Peptide Nanostructures for the Development of Electrochemical Biosensors	1125
Jaime Castillo-León, Kinga Zór, and Winnie E. Svendsen	
36 Electrochemical Sensors Based on Nanostructured Materials	1143
Iuliana Moldoveanu, Raluca-Ioana Stefan-van Staden, and Jacobus Frederick van Staden	

37 Biocomposite Nanomaterials for Electrochemical Biosensors.....	1161
Stelian Lupu, Paul Cătălin Balaure, Cecilia Lete, and Constantin Mihailciuc	
38 Development of Nanostructures by Electrochemical Method for Chemical Sensors.....	1195
Surajit Kumar Hazra and Sukumar Basu	
39 Nanomaterials in Solar Cells.....	1251
Razika Tala-Ighil	
40 Characterization of Metallic Micro(Nano)cluster-Based Contacts for High-Effective Photovoltaic Devices.....	1271
Viktor Laptev and Halyna Khlyap	
41 Anodically Grown TiO₂ Nanotube Membranes: Synthesis, Characterization, and Application in Dye-Sensitized Solar Cells.....	1299
Adriano Sacco, Andrea Lamberti, Stefano Bianco, and Elena Tresso	
Part VII Future Prospects of Nanostructured Materials and Coatings.....	1327
42 Frontiers of Nanoelectrochemistry and Application of Nanotechnology: A Vision for the Future.....	1329
Sukanchan Palit	
43 New Insights in Nanoelectrodeposition: An Electrochemical Aggregative Growth Mechanism.....	1349
Jon Ustarroz, Annick Hubin, and Herman Terryn	
44 Recent Advances in Synthesis, Modification, and Applications of TiO₂ Nanotube Arrays by Electrochemical Anodization.....	1379
Jianying Huang, Keqin Zhang, and Yuekun Lai	
45 New Approaches to the Study of Spinel Ferrite Nanoparticles for Biomedical Applications.....	1417
Noppakun Sanpo, Christopher C. Berndt, Cuie Wen, and James Wang	
Index.....	1443

About the Editors



Mahmood Aliofkhaezrai Department of Materials Engineering, Tarbiat Modares University, Tehran, Iran

Dr. Mahmood Aliofkhaezrai is assistant professor in materials engineering department at Tarbiat Modares University. Dr. Aliofkhaezrai's research interests include nanotechnology and its use in surface and corrosion science. One of his main interests is plasma electrolysis, an area in which he published more than 40 papers and a book. In total, he has published more than 12 books and 90 journal papers. He has given

invited talks including several keynotes in several countries. Dr. Aliofkhaezrai has received several awards including the Khwarizmi award, IMES medal, INIC award, best thesis award (multiple times), best book award (multiple times), and the best young nanotechnologist award of Iran (twice). He is on the advisory editorial board of several materials science and nanotechnology journals. He is a member of the national association of surface sciences, Iranian corrosion association, and national elite foundation of Iran.



Abdel Salam Hamdy Makhoulf Manufacturing Engineering Department, College of Engineering and Computer Science, University of Texas Pan-American, Edinburg, TX, USA

Prof. Dr. Abdel Salam Hamdy Makhoulf, Ph.D., P.ENG., is RGV STAR Professor in the Department of Manufacturing Engineering, University of Texas-Pan American, in Edinburg, Texas, USA. He is the founder

of Surface Engineering Laboratory and a leading faculty of the Rapid Response Manufacturing Center. His research interests include preparation and characterization of advanced coatings, corrosion, nano/biomaterials, renewable energy, and advanced materials and polymers. Prof. Makhoulf was able to make breakthroughs in several highly important areas of materials science and corrosion engineering.

Prof. Makhlof is a multiple-award winner for his academic excellence: He received several prestigious awards in **Germany** (Humboldt Research Award for Experienced Scientists at Max Planck Institute); **USA** (Fulbright Visiting Scholar, NSF Fellow, and Department of Energy Fellow); **Belgium** (Belgian Federal Science Research Fellowship); **Arab League** (Arab Youth Excellence Award in Innovation 2013); **Jordan** (Abdul Hameed Shoman Award in Engineering Science 2012); **Egypt** (National Prize of Egypt in Advanced Science and Technology 2006; Egyptian Prize of Excellence in Surface Technology and Corrosion 2006; and Egyptian Prize of Excellence and Innovation in Materials Science and their Applications 2009); and **Palestine** (An-Najah Prize for Research 2014). Prof. Makhlof's biography was selected to be included in *Who's Who in the World*® 2015, 2007, and 2006.

Prof. Makhlof is a persistent journal reviewer, advisor, and judge of the work of his peers. He is a referee for over 30 international journals of a high caliber, and a continued board member of over 20 journals. He is also an experienced editor with board titles at journals published by Springer and Elsevier, an expert evaluator for the EU's FP7, with an estimated budget of over €50.521 billion, DAAD and German Aerospace Center, the US Fulbright Commission, the Qatar National Research Fund, the Kuwait Foundation for the Advancement of Sciences, and a consultant at Innosquared GmbH, Germany. He is a reviewer/panelist for the NSF programs: Manufacturing Machines and Equipment, Materials Engineering and Processing, and CREST; with an estimated budget of over \$7.6 billion. He is a member of the advisory committee of Australia – EU initiative “Corrosion Matters” through the EU program H2020.

Prof. Makhlof has organized and served as a head speaker at highly prestigious international symposiums and conferences over 30 times. His publication list (+170) includes studies and review papers authored in journals from top publishers. He is the editor of 12 books, 17 book chapters, and has 2 US patents. He supervised 11 Ph.D. and master's students, and 5 postdoctoral fellows.

Contributors

R. Abdel-Karim Department of Metallurgy, Faculty of Engineering-Cairo University, Giza, Egypt

Nedal Abu-Thabit Department of Chemical and Process Engineering Technology, Jubail Industrial College, Jubail, Saudi Arabia

Vojtech Adam Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Brno, Czech Republic, European Union

Central European Institute of Technology, Brno University of Technology, Brno, Czech Republic, European Union

Pouya Amrollahi Helmerich Advanced Technology Research Center, School of Material Science and Engineering, Oklahoma State University, Tulsa, OK, USA

Nada F. Atta Chemistry Department, Faculty of Science, Cairo University, Giza, Egypt

Paul Cătălin Balaure Department of Organic Chemistry, Faculty of Applied Chemistry and Materials Science, University Politehnica of Bucharest, Bucharest, Romania

Elena A. Baranova Department of Chemical and Biological Engineering, and Centre for Catalysis Research and Innovation, University of Ottawa, Ottawa, ON, Canada

Serghei A. Baranov Institute of Applied Physics AS RM, Chisinau, Moldova
Dnester University, Tiraspol, Moldova

Punya A. Basnayaka Department of Mechanical Engineering and Clean Energy Research Center, University of South Florida, Tampa, FL, USA

Department of Engineering and Engineering Technology, Cuyahoga Community College, Cleveland, OH, USA

Sukumar Basu IC Design and Fabrication Centre, Department of Electronics and Telecommunication Engineering, Jadavpur University, Kolkata, WB, India

Christopher C. Berndt Faculty of Engineering and Industrial Sciences, Swinburne University of Technology, Hawthorn, VIC, Australia

Stefano Bianco Center for Space Human Robotics@PoliTO, Istituto Italiano di Tecnologia, Torino, Italy

Applied Science and Technology Department, Politecnico di Torino, Torino, Italy

Zbigniew Bojar Department of Advanced Materials and Technologies, Faculty of Advanced Technologies and Chemistry, Military University of Technology, Warszawa, Poland

Mirosław M. Bućko Faculty of Materials Science and Ceramics, University of Science and Technology, Krakow, Poland

David Mataix Busquets Universidad Politécnica de Valencia, Valencia, Spain

M.J. Carmezim Centro de Química Estrutural, Instituto Superior Técnico, Universidade de Lisboa, Avenida Rovisco Pais, Lisbon, Portugal

ESTSetúbal, Instituto Politécnico de Setúbal, Setúbal, Portugal

M. Caruso Department of Chemical Sciences and Technologies, University of Rome “Tor Vergata”, Rome, Italy

Jaime Castillo-León Sol Voltaics AB, Lund, Sweden

Néstor L. Chévere-Trinidad Department of Chemistry, University of Massachusetts Amherst, Amherst, MA, USA

Zhenyu Chu State Key Laboratory of Materials-Oriented Chemical Engineering, Nanjing Tech University, Nanjing, People’s Republic of China

Jingbiao Cui Department of Physics, University of Memphis, Memphis, TN, USA

Holly A.E. Dole Department of Chemical and Biological Engineering, and Centre for Catalysis Research and Innovation, University of Ottawa, Ottawa, ON, Canada

Ekram H. El-Ads Chemistry Department, Faculty of Science, Cairo University, Giza, Egypt

S. Eugénio Centro de Química Estrutural, Instituto Superior Técnico, Universidade de Lisboa, Avenida Rovisco Pais, Lisbon, Portugal

J.M. Feliu Departamento de Química Física, Instituto de Electroquímica, Universidad de Alicante, Alicante, Spain

Elvira Fortunato CENIMAT/I3N, Departamento de Ciência dos Materiais, Faculdade de Ciências e Tecnologia, FCT, Universidade Nova de Lisboa (UNL), Caparica, Portugal

Ahmed Galal Chemistry Department, Faculty of Science, Cairo University, Giza, Egypt

Donald Gardner Intel Corporation, Santa Clara, USA

Emanuela Gatto Department of Chemical Sciences and Technologies, University of Rome “Tor Vergata”, Rome, Italy

E. Gómez Ge-CPN, Departament de Química Física, Institut de Nanociència i Nanotecnologia (IN2UB), Universitat de Barcelona, Barcelona, Spain

Emilia Grażdzka Institute of Chemistry, University of Białystok, Białystok, Poland

S. Grau Ge-CPN, Departament de Química Física, Institut de Nanociència i Nanotecnologia (IN2UB), Universitat de Barcelona, Barcelona, Spain

Giorgia Greco Department of Science, University of Roma Tre, Rome, Italy

Serkan Gurbuz Department of Chemistry, University of Massachusetts Amherst, Amherst, MA, USA

Maksudul Hasan Tyndall National Institute, University College Cork, Cork, Ireland

Surajit Kumar Hazra Department of Physics and Materials Science, Jaypee University of Information Technology, Wazirpur, Solan, HP, India

Jianying Huang National Engineering Laboratory for Modern Silk, College of Textile and Clothing Engineering, Soochow University, Suzhou, People’s Republic of China

Jaromir Hubalek Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Brno, Czech Republic, European Union
Central European Institute of Technology, Brno University of Technology, Brno, Czech Republic, European Union

Annick Hubin Department Materials and Chemistry, Research Group Electrochemical and Surface Engineering (SURF), Vrije Universiteit Brussel (VUB), Brussels, Belgium

Bing-Joe Hwang Nanoelectrochemistry Laboratory, Department of Chemical Engineering, National Taiwan University of Science and Technology, Taipei, Taiwan

National Synchrotron Radiation Research Center, Hsinchu, Taiwan

David Hynek Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Brno, Czech Republic, European Union
Central European Institute of Technology, Brno University of Technology, Brno, Czech Republic, European Union

Mamun Jamal Tyndall National Institute, University College Cork, Cork, Ireland

Brice Jamieson ELIX Wireless Charging Systems, Vancouver, Canada

Wanqin Jin State Key Laboratory of Materials-Oriented Chemical Engineering, Nanjing Tech University, Nanjing, People's Republic of China

Anne Jung Applied Mechanics, Saarland University, Saarbruecken, Germany

Halyna Khlyap University of Stuttgart, Kaiserslautern, Germany

Rene Kizek Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Brno, Czech Republic, European Union

Central European Institute of Technology, Brno University of Technology, Brno, Czech Republic, European Union

Pavel Kopel Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Brno, Czech Republic, European Union

Central European Institute of Technology, Brno University of Technology, Brno, Czech Republic, European Union

Heinz-Bernhard Kraatz Department of Physical and Environmental Sciences, University of Toronto Scarborough, Toronto, ON, Canada

Department of Chemistry, University of Toronto, Toronto, ON, Canada

Jessica Kramer Department of Chemistry, University of Massachusetts Amherst, Amherst, MA, USA

Jerzy S. Krasinski Helmerich Advanced Technology Research Center, School of Electrical and Computer Engineering, Oklahoma State University, Tulsa, OK, USA

Andrzej Kudelski Faculty of Chemistry, University of Warsaw, Warsaw, Poland

Jiri Kudr Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Brno, Czech Republic, European Union

Central European Institute of Technology, Brno University of Technology, Brno, Czech Republic, European Union

Ashok Kumar Department of Mechanical Engineering, University of South Florida, Tampa, FL, USA

Clean Energy Research Center, University of South Florida, Tampa, FL, USA

Jindrich Kynicky Central European Institute of Technology, Brno University of Technology, Brno, Czech Republic, European Union

Yuekun Lai National Engineering Laboratory for Modern Silk, College of Textile and Clothing Engineering, Soochow University, Suzhou, People's Republic of China
Physikalisches Institute and Center for Nanotechnology (CeNTech), Westfälische Wilhelms-Universität Münster, Münster, Germany

Andrea Lamberti Applied Science and Technology Department, Politecnico di Torino, Torino, Italy

Viktor Laptev New Russian University, Moscow, Russia

Min Ho Lee Department of Dental Biomaterials and Institute of Biodegradable Materials, Institute of Oral Bioscience and BK21 Plus Program, School of Dentistry, Chonbuk National University, Jeonju, Republic of Korea

E.P.M. Leiva Instituto de Investigaciones en Físico-Química de Córdoba (INFIQC-CONICET), Departamento de Matemática y Física, Facultad de Ciencias Químicas, Universidad Nacional de Córdoba, Córdoba, Argentina

Cecilia Lete Laboratory of Electrochemistry, Institute of Physical Chemistry “Ilie Murgulescu” of the Romanian Academy, Bucharest, Romania

Stelian Lupu Department of Analytical Chemistry and Environmental Engineering, Faculty of Applied Chemistry and Materials Science, University Politehnica of Bucharest, Bucharest, Romania

Abdel Salam Hamdy Makhlof Manufacturing Engineering Department, College of Engineering and Computer Science, University of Texas Pan-America, Edinburg, TX, USA

Rodrigo Martins CENIMAT/I3N, Departamento de Ciência dos Materiais, Faculdade de Ciências e Tecnologia, FCT, Universidade Nova de Lisboa (UNL), Caparica, Portugal

Alan Mathewson Tyndall National Institute, University College Cork, Cork, Ireland

Paul McCloskey Tyndall National Institute, University College Cork, Cork, Ireland

Constantin Mihailciuc Department of Physical Chemistry, Faculty of Chemistry, University of Bucharest, Bucharest, Romania

Harinder Pal Singh Missan Fuel Cell Materials Research Lab, Department of Physics, University of the West Indies, Trinidad and Tobago, West Indies

Iuliana Moldoveanu Laboratory of Electrochemistry and PATLAB Bucharest, National Institute of Research for Electrochemistry and Condensed Matter, Bucharest, Romania

Faculty of Applied Chemistry and Materials Science, Politehnica University of Bucharest, Bucharest, Romania

M. Fátima Montemor Centro de Química Estrutural, Instituto Superior Técnico, Universidade de Lisboa, Avenida Rovisco Pais, Lisbon, Portugal

Michael A. Morris University College, Cork, Ireland

Liana Maria Muresan Department of Chemical Engineering, Babes–Bolyai University, Cluj–Napoca, Romania

Sankara Narayanan T.S.N. Department of Dental Biomaterials and Institute of Biodegradable Materials, Institute of Oral Bioscience and BK21 Plus Program, School of Dentistry, Chonbuk National University, Jeonju, Republic of Korea

Harald Natter Physical Chemistry, Saarland University, Saarbruecken, Germany

Lukas Nejd Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Brno, Czech Republic, European Union

Terence O'Donnell University College Dublin, Dublin, Ireland

O.A. Oviedo Instituto de Investigaciones en Físico-Química de Córdoba (INFIQC-CONICET), Departamento de Matemática y Física, Facultad de Ciencias Químicas, Universidad Nacional de Córdoba, Córdoba, Argentina

Sukanchan Palit Department of Chemical Engineering, University of Petroleum and Energy Studies, Dehradun, India

Haridevpur, Kolkata, India

Chun-Jern Pan Nanoelectrochemistry Laboratory, Department of Chemical Engineering, National Taiwan University of Science and Technology, Taipei, Taiwan

Ge-Bo Pan Division of Interdisciplinary Research, Suzhou Institute of Nano-tech and Nano-bionics (sinano), Chinese Academy of Sciences, Suzhou, China

Il Song Park Division of Advanced Materials Engineering and Institute of Biodegradable Materials, Chonbuk National University, Jeonju, Republic of Korea

Hong-Dan Peng Division of Interdisciplinary Research, Suzhou Institute of Nano-tech and Nano-bionics (sinano), Chinese Academy of Sciences, Suzhou, China

Luis Pereira CENIMAT/I3N, Departamento de Ciência dos Materiais, Faculdade de Ciências e Tecnologia, FCT, Universidade Nova de Lisboa (UNL), Caparica, Portugal

Alina Pruna University of Bucharest, Magurele, Bucharest, Romania

Universidad Politécnica de Valencia, Valencia, Spain

Daniele Pullini Centro Ricerche Fiat, Torino, Orbassano, Italy

Manoj K. Ram Clean Energy Research Center, University of South Florida, Tampa, FL, USA

Nanotechnology Research and Education Center, University of South Florida, Tampa, FL, USA

Kafil M. Razeeb Tyndall National Institute, University College Cork, Cork, Ireland

Saibal Roy Tyndall National Institute, Cork, Ireland

Branislav Ruttkay-Nedecky Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Brno, Czech Republic, European Union
Central European Institute of Technology, Brno University of Technology, Brno, Czech Republic, European Union

Seshadri S.K. Department of Metallurgical and Materials Engineering, Indian Institute of Technology Madras, Chennai, India

Adriano Sacco Center for Space Human Robotics@PoliTO, Istituto Italiano di Tecnologia, Torino, Italy

Noppakun Sanpo Faculty of Engineering and Industrial Sciences, Swinburne University of Technology, Hawthorn, VIC, Australia

Loka Subramanyam Sarma Department of Chemistry, Yogi Vemana University, Kadapa, Andhra Pradesh, India

Mohtashim Hassan Shamsi Department of Physical and Environmental Sciences, University of Toronto Scarborough, Toronto, ON, Canada

Department of Chemistry, University of Toronto, Toronto, ON, Canada

Lei Shi State Key Laboratory of Materials-Oriented Chemical Engineering, Nanjing Tech University, Nanjing, People's Republic of China

R.P. Silva Centro de Química Estrutural, Instituto Superior Técnico, Universidade de Lisboa, Avenida Rovisco Pais, Lisbon, Portugal

T.M. Silva Centro de Química Estrutural, Instituto Superior Técnico, Universidade de Lisboa, Avenida Rovisco Pais, Lisbon, Portugal

Department of Mechanical Engineering, GI-MOSM, Instituto Superior de Engenharia de Lisboa (ISEL), Lisbon, Portugal

Elias K. Stefanakos Clean Energy Research Center, University of South Florida, Tampa, FL, USA

Wojciech J. Stepniowski Department of Advanced Materials and Technologies, Faculty of Advanced Technologies and Chemistry, Military University of Technology, Warszawa, Poland

Raluca-Ioana Stefan-van Staden Laboratory of Electrochemistry and PATLAB Bucharest, National Institute of Research for Electrochemistry and Condensed Matter, Bucharest, Romania

Faculty of Applied Chemistry and Materials Science, Politehnica University of Bucharest, Bucharest, Romania

Kerrilee A. Stewart Fuel Cell Materials Research Lab, Department of Physics, University of the West Indies, Trinidad and Tobago, West Indies

Winnie E. Svendsen DTU Nanotech, Technical University of Denmark, Kgs. Lyngby, Denmark

Razika Tala-Ighil Unité de recherche matériaux, procédés pour l'environnement, URMPE Institute of Electrical and Electronic Engineering, University M'Hamed Bougara, Umbb, Boumerdes, Algeria

Lobat Tayebi Helmerich Advanced Technology Research Center, School of Material Science and Engineering, Oklahoma State University, Tulsa, OK, USA

Department of Developmental Sciences, Marquette University School of Dentistry, Milwaukee, WI, USA

Herman Terry Department Materials and Chemistry, Research Group Electrochemical and Surface Engineering (SURF), Vrije Universiteit Brussel (VUB), Brussels, Belgium

M. Allan Thomas Department of Physics and Astronomy, University of Arkansas at Little Rock, Little Rock, AR, USA

Katerina Tmejova Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Brno, Czech Republic, European Union
Central European Institute of Technology, Brno University of Technology, Brno, Czech Republic, European Union

Elena Tresso Center for Space Human Robotics@PoliTO, Istituto Italiano di Tecnologia, Torino, Italy

Applied Science and Technology Department, Politecnico di Torino, Torino, Italy

Maria Trzaska Institute of Precision Mechanics, Warsaw, Poland

Zdzislaw Trzaska University of Ecology and Management, Warsaw, Poland

N. Tuyen Centro de Química Estrutural, Instituto Superior Técnico, Universidade de Lisboa, Avenida Rovisco Pais, Lisbon, Portugal

Jon Ustarroz Department Materials and Chemistry, Research Group Electrochemical and Surface Engineering (SURF), Vrije Universiteit Brussel (VUB), Brussels, Belgium

Ranji Vaidyanathan Helmerich Advanced Technology Research Center, School of Material Science and Engineering, Oklahoma State University, Tulsa, OK, USA

E. Vallés Ge-CPN, Departament de Química Física, Institut de Nanociència i Nanotecnologia (IN2UB), Universitat de Barcelona, Barcelona, Spain

Jacobus Frederick van Staden Laboratory of Electrochemistry and PATLAB Bucharest, National Institute of Research for Electrochemistry and Condensed Matter, Bucharest, Romania

Daryoosh Vashaee Helmerich Advanced Technology Research Center, School of Electrical and Computer Engineering, Oklahoma State University, Tulsa, OK, USA
Electrical and Computer Engineering Department, North Carolina State University, Raleigh, NC, USA

M. Venanzi Department of Chemical Sciences and Technologies, University of Rome “Tor Vergata”, Rome, Italy

Dhandapani Venkataraman Department of Chemistry, University of Massachusetts Amherst, Amherst, MA, USA

James Wang Faculty of Engineering and Industrial Sciences, Swinburne University of Technology, Hawthorn, VIC, Australia

Inez M. Weidinger Institut für Chemie, PC 14, Technische Universität Berlin, Berlin, Germany

Martin Weinmann Physical Chemistry, Saarland University, Saarbruecken, Germany

Cuie Wen Faculty of Engineering and Industrial Sciences, Swinburne University of Technology, Hawthorn, VIC, Australia

Krzysztof Winkler Institute of Chemistry, University of Bialystok, Bialystok, Poland

Pawel Jerzy Wojcik CENIMAT/I3N, Departamento de Ciência dos Materiais, Faculdade de Ciências e Tecnologia, FCT, Universidade Nova de Lisboa (UNL), Caparica, Portugal

Suchikova Yana Berdyansk State Pedagogical University, Berdyansk, Zaporizhia Oblast, Ukraine

Keqin Zhang National Engineering Laboratory for Modern Silk, College of Textile and Clothing Engineering, Soochow University, Suzhou, People’s Republic of China

Yu Zhao Division of Interdisciplinary Research, Suzhou Institute of Nano-tech and Nano-bionics (sinano), Chinese Academy of Sciences, Suzhou, China

Ondrej Zitka Department of Chemistry and Biochemistry, Faculty of Agronomy, Mendel University in Brno, Brno, Czech Republic, European Union

Central European Institute of Technology, Brno University of Technology, Brno, Czech Republic, European Union

Kinga Zór DTU Nanotech, Technical University of Denmark, Kgs. Lyngby, Denmark