Polymers and Polymeric Composites: A Reference Series

Series Editor
Sanjay Palsule
Indian Institute of Technology-Roorkee
Saharanpur, India
This series provides a comprehensive collection of reference handbooks on all aspects around polymers and polymeric composites. Polymeric materials of all sorts have been emerging as key materials for many applications and for meeting the challenges of the 21st century. From commodity applications to engineering and high tech applications, even including aerospace subsystems, these materials have an important role to play. The study of polymeric and polymeric composite materials is one of the most important and of the most vibrant focus areas in chemical and material scientific research. “Polymers and Polymeric Composites: A Reference Series” compiles the most comprehensive reference handbooks on these materials under one roof. Readers will find all they need to know in well-organized and thoroughly structured reference works covering various topics, such as the structures and properties of polymers, polymeric materials and composites (e.g. structures of amorphous and of crystalline polymers, viscoelastic properties, mechanical and thermal properties, and many more); methods and methodology (including polymer characterization, polymerization reaction engineering, polymer processing, and many more); or different compound classes (from polymer additives, polymer blends, and fiber reinforced composites, to liquid crystalline polymers, nano-polymers and nano-polymeric composites, and even bio-polymeric materials). While each volume is dedicated to a selected topic, concisely structured and thoroughly edited by experts, with contributions written by leading scientists, the complete collection provides the most comprehensive and most complete overview over the entire field of polymers and polymeric composites. Volumes in this series serve as reference compilation for every scientist working with or on polymers, polymeric materials and composites, whether at universities or in industry, from graduate student level to practitioners and lead scientists alike.

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Electromechanically active polymers (EAPs) consist of “intelligent” or “smart” soft materials that are inherently able to change dimensions and/or shape in response to electrical stimuli. As such, they transduce electrical energy into mechanical work, serving as actuators. They can also operate in reverse mode, transducing mechanical work into electrical energy, enabling their use as mechanoelectrical sensors or mechanical energy harvesters to generate electricity. These functionalities come with unique properties, such as electrically-controllable strains and stresses, high mechanical flexibility, and often stretchability, low mass density, structural simplicity, ease of processing, scalability, no acoustic noise and, in most cases, low costs. Owing to the unique combination of these functional and structural properties, EAP transducers are often referred to also as “artificial muscles.” They are studied for applications in a diversity of fields, including haptics, optics, acoustics, fluidics, automotive, robotics, orthotics, medical tools, artificial organs, and energy harvesting.

A few years ago, the rapid expansion of the EAP technologies stimulated in Europe the creation of the “European Scientific Network for Artificial Muscles” (ESNAM), gathering the most active research institutes, industrial developers, and end users in the EAP field. That initiative had in Europe its ideal environment. Indeed, over the past four decades the Old Continent has been concentrating a growing number of research institutes with recognized expertise in key areas of what was progressively emerging as a new field of science and technology. Aimed at addressing the widely perceived need for cooperation in that expanding field, from the year 2007 a small group of qualified and motivated partners informally established ESNAM, which then steadily grew up until the year 2010, when it was awarded with a European COST (Cooperation in Science and Technology) grant (COST Action MP1003), until 2014. By that time, ESNAM had become the first example of a structured network in the EAP field, gathering 74 member organizations from 26 European countries, able to strengthen the impact of the EAP science and technology. In 2014, the network has evolved into a nonprofit international association called EuroEAP Society (European Society for Electromechanically Active Polymer Transducers and Artificial Muscles). The society is at present actively pursuing its mission to promote and contribute to the scientific and technological advancement of EAPs.
This book represents one of the scientific legacies of ESNAM. It is not just another book on EAPs. It is meant to serve as a concise reference for the entire EAP field, filling a critical gap within the related scientific literature: the lack of a comprehensive and organized introduction at a tutorial level. Indeed, the purpose of this book is not to describe the latest findings and innovations, but, rather, present basic concepts and established knowledge in a simple form, especially conceived for those who are entering the field for the first time. Nevertheless, while the book is primarily designed for new comers, especially students, it also aims at serving as a unique reference, useful even to researchers and practitioners.

Chapters on fundamentals, materials, device configurations, models, applications, as well as operative guidelines on how to start experimenting cover all the EAP categories, which are divided in seven sections. The first four sections deal with ionic EAPs, i.e., those materials that are activated by an electrically-induced transport of ions and/or molecules: gels, ionic polymer-metal composites, conducting polymers, and electroresponsive carbon based materials. The last three sections deal with electronic EAPs, i.e., those materials that are activated by electrostatic forces: piezoelectric and electrostrictive polymers, polymer electrets and ferroelectrets, and dielectric elastomers. Within each EAP family (ionic and electronic), the sequential order of presentation of the materials belonging to the family roughly corresponds to the chronological order of their discovery/invention. This is aimed at providing the reader with an idea about the development that the EAP field has undergone on the global scale substantially from the 1950s onwards.

The creation of this book has been made possible by a combined effort at different levels and from different actors: the section Editors, who have greatly helped in conceiving the focus of the chapters, selecting the authors, and revising the contributions; the authors, who have offered outstanding competence and significant dedication to prepare highly valuable content; and the European COST programme, which has financially supported the ESNAM network and the publication of this book. I have full faith that the combination of all these efforts has made this book a useful reference for a diversity of readers interested in the exciting EAP field.

*Federico Carpi*
Queen Mary University of London, UK
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COST is a pan-European intergovernmental framework. Its mission is to enable breakthrough scientific and technological developments leading to new concepts and products and thereby contribute to strengthening Europe’s research and innovation capacities.

It allows researchers, engineers, and scholars to jointly develop their own ideas and take new initiatives across all fields of science and technology, while promoting multi- and interdisciplinary approaches. COST aims at fostering a better integration of less research intensive countries to the knowledge hubs of the European Research Area. The COST Association, an International not-for-profit Association under Belgian Law, integrates all management, governing, and administrative functions necessary for the operation of the framework. The COST Association has currently 36 Member Countries. www.cost.eu

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Section Editors

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Yoshihito Osada  Riken Advanced Science Institute, Wako, Saitama, Japan
Andreas Richter  Technical University of Dresden, Dresden, Germany

Section II: Ionic Polymer-Metal Composites

Kinji Asaka  National Institute of Advanced Industrial Science and Technology, Tokyo, Japan
Kwang Kim  University of Nevada, Las Vegas, USA
Keisuke Oguro  National Institute of Advanced Industrial Science and Technology, Tokyo, Japan

Section III: Conducting Polymers

Edwin Jager  Linköping University, Linköping, Sweden
John Madden  University of British Columbia, Vancouver, BC, Canada
Toribio Otero  University of Cartagena, Cartagena, Spain
Frédéric Vidal  University of Cergy-Pontoise, Cergy-Pontoise, France

Section IV: Electroresponsive Carbon-Based Materials

Alvo Aabloo  University of Tartu, Cergy-Pontoise, Estonia
Ray H. Baughman  University of Texas, Dallas, USA
Geoffrey Spinks  University of Wollongong, Wollongong, NSW, Australia

Section V: Piezoelectric and Electrostrictive Polymers

Siegfried Bauer  Johannes Kepler University, Linz, Austria
Zhongyang Cheng  Auburn University, Zhongyang, AL, USA
Eiichi Fukada  Kobayasi Institute of Physical Research, Tokyo, Japan
Qiming Zhang  Pennsylvania State University, State College, PA, USA

Section VI: Polymer Electrets and Ferroelectrets
Reimund Gerhard  University of Potsdam, Reimund, Germany
Gerhard Sessler  Darmstadt University of Technology, Darmstadt, Germany

Section VII: Dielectric Elastomers
Roy Kornbluh  SRI International, Menlo Park, CA, USA
Anne Ladegaard Skov  Technical University of Denmark, Lyngby, Denmark
Qibing Pei  University of California, Los Angeles, USA
Ron Pelrine  SRI International, Menlo Park, CA, USA
Contributors

Alvo Aabloo  Intelligent Materials and Systems Lab, Institute of Technology, University of Tartu, Tartu, Estonia

Garima Agrawal  DWI-Leibniz Institute for Interactive Materials, Institute of Technical and Macromolecular Chemistry, RWTH Aachen University, Aachen, Germany

Gursel Alici  School of Mechanical, Materials, and Mechatronic Engineering, ARC Centre of Excellence for Electromaterials Science, University of Wollongong, Wollongong, NSW, Australia

Ruy Alberto Pisani Altafin  Departamento de Sistemas de Computação, Federal University of Paraíba, João Pessoa, PB, Brazil

Kinji Asaka  Inorganic Functional Material Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), Ikeda, Osaka, Japan

Siegfried Bauer  Soft Matter Physics, Johannes Kepler University Linz, Linz, Austria

Simona Bauer-Gogonea  Soft Matter Physics, Johannes Kepler University Linz, Linz, Austria

Ray H. Baughman  The Alan G. MacDiarmid NanoTech Institute, University of Texas at Dallas, Richardson, TX, USA

Richard Baumgartner  Soft Matter Physics, Johannes Kepler University Linz, Linz, Austria

Mohammed Y. Benslimane  Danfoss PolyPower A/S, Nordborg, Denmark

Silmon James Biggs  Parker Hannifin Inc., Sunnyvale, CA, USA

Eliana Bortot  Faculty of Mechanical Engineering, Technion - Israel Institute of Technology, Haifa, Israel

Federico Carpi  School of Engineering and Materials Science, Queen Mary University of London, London, UK
Youngsu Cha  Center for Robotics Research, Korea Institute of Science and Technology, Seoul, Republic of Korea

Zheng Chen  Department of Electrical Engineering and Computer Science, Wichita State University, Wichita, KS, USA

Martin Elstner  TU Dresden, Center for Advancing Electronics Dresden (cfaed), Dresden, Germany

Meisam Farajollahi  Mechanical Engineering, Advanced Materials and Process Engineering Lab, University of British Columbia, Vancouver, BC, Canada

Bernhard Ferse  Faculty of Electrical and Computer Engineering, Institute of Semiconductors and Microsystems, Technische Universität Dresden, Dresden, Germany

Javad Foroughi  ARC Centre of Excellence for Electromaterials Science, Intelligent Polymer Research Institute, University of Wollongong, North Wollongong, NSW, Australia

Giuseppe Gallone  Department of Civil and Industrial Engineering, University of Pisa, Pisa, Italy

Massimiliano Gei  School of Engineering, Cardiff University, Cardiff, UK

Reimund Gerhard  Applied Condensed-Matter Physics, Institute of Physics and Astronomy, Faculty of Science, University of Potsdam, Potsdam-Golm, Germany

Ingrid Graz  Soft Matter Physics, Johannes Kepler University Linz, Linz, Austria

Henry Haus  Institute of Electromechanical Design, Technische Universität Darmstadt, Darmstadt, Germany

Wei Hu  Henry Samueli School of Engineering and Applied Science, University of California – Los Angeles, Los Angeles, CA, USA

Edwin W. H. Jager  Department of Physics, Chemistry and Biology (IFM), Linköping University, Linköping, Sweden

Biosensors and Bioelectronics, Linköping University, Linköping, Sweden

Jin-Han Jeon  School of Mechanical, Aerospace and Systems Engineering, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Republic of Korea

Norihiro Kamamichi  Department of Robotics and Mechatronics, Tokyo Denki University, Tokyo, Japan

Keiichi Kaneto  Kyushu Institute of Technology, Eamex Co. Ltd, Chuoku, Fukuoka, Japan

Osaka Institute of Technology, Eamex Co. Ltd., Osaka, Japan
Alexandre Khaldi Department of Physics, Chemistry and Biology (IFM), Linköping University, Linköping, Sweden

Kwang Kim Department of Mechanical Engineering, University of Nevada, Las Vegas, NV, USA

Seon Jeong Kim Center for Self-Powered Actuation and Department of Biomedical Engineering, Hanyang University, Seoul, South Korea

Mihkel Koel Department of Chemistry, Tallinn University of Technology, Tallinn, Estonia

Alexander Kogler Soft Matter Physics, Johannes Kepler University Linz, Linz, Austria

Soo Jin Adrian Koh Department of Mechanical Engineering, National University of Singapore, Singapore, Singapore

Roy Kornbluh SRI International, Menlo Park, CA, USA

Markus Krause Soft Matter Physics, Johannes Kepler University Linz, Linz, Austria

Karl Kruusamäe Department of Mechanical Engineering, University of Texas at Austin, Austin, USA

Kam K. Leang Department of Mechanical Engineering, University of Utah, Salt Lake City, UT, USA

Peter Leichsenring Institut für Festkörpermechanik, TU Dresden, Dresden, Germany

Holger Mößinger Institute of Electromechanical Design, Technische Universität Darmstadt, Darmstadt, Germany

John D. W. Madden Electrical and Computer Engineering, Advanced Materials and Process Engineering Lab, University of British Columbia, Vancouver, BC, Canada

José G. Martinez Center for Electrochemistry and Intelligent Materials (CEMI), Universidad Politécnica de Cartagena, Cartagena, Spain

Ali Maziz Department of Physics, Chemistry and Biology (IFM), Linköping University, Linköping, Sweden

David McCoul Henry Samueli School of Engineering and Applied Science, University of California – Los Angeles, Los Angeles, CA, USA

Daniel Melling Institute for Medical Science and Technology, University of Dundee, Dundee, UK

Axel Mellinger Department of Physics, Central Michigan University, Mount Pleasant, MI, USA
**Contributors**

**Indrek Must**  IMS lab, Institute of Technology, University of Tartu, Tartu, Estonia

**Rahim Mutlu**  School of Mechanical, Materials, and Mechatronic Engineering, ARC Centre of Excellence for Electromaterials Science, University of Wollongong, Wollongong, NSW, Australia

**Keisuke Oguro**  National Institute of Advanced Industrial Science and Technology (AIST), Ikeda, Osaka, Japan

**Il-Kwon Oh**  School of Mechanical, Aerospace and Systems Engineering, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Republic of Korea

**Hidenori Okuzaki**  Interdisciplinary Graduate School of Medicine and Engineering, University of Yamanashi, Kofu, Yamanashi, Japan

**Dorina Opris**  Functional Polymers Laboratory, EMPA, Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland

**Toribio F. Otero**  Electrochemistry, Intelligent Materials and Devices, Universidad Politécnica de Cartagena, Cartagena, Spain

**Viljar Palmre**  Department of Mechanical Engineering, University of Nevada, Las Vegas, NV, USA

**Luis Pedrero**  Faculty of Electrical and Computer Engineering, Institute of Semiconductors and Microsystems, Technische Universität Dresden, Dresden, Germany

**Qibing Pei**  Henry Samueli School of Engineering and Applied Science, University of California – Los Angeles, Los Angeles, CA, USA

**Anna-Liisa Peikolainen**  Intelligent Materials and Systems Lab, Institute of Technology, University of Tartu, Tartu, Estonia

**Ron Pelrine**  SRI International, Menlo Park, CA, USA

**Andrij Pich**  DWI-Leibniz Institute for Interactive Materials, Institute of Technical and Macromolecular Chemistry, RWTH Aachen University, Aachen, Germany

**Cedric Plesse**  Université de Cergy-Pontoise, Cergy-Pontoise cedex, France

**Maurizio Porfiri**  Department of Mechanical and Aerospace Engineering, Tandon School of Engineering, New York University, Brooklyn, NY, USA

**David Pugal**  University of Nevada, Reno, NV, USA

**Tristan Putzeys**  Department of Physics and Astronomy, Soft Matter and Biophysics Section, KU Leuven, Leuven, Belgium

**Xunlin Qiu**  Department of Physics and Astronomy, University of Potsdam, Potsdam-Golm, Germany
Andreas Richter Institute of Semiconductors and Microsystems, Faculty of Electrical and Computer Engineering, Dresden University of Technology and Center for Advancing Electronics Dresden, Dresden, Germany

Dmitry Rychkov Institute of Physics and Astronomy, University of Potsdam, Potsdam, Germany

Mirza Saqib Sarwar Electrical and Computer Engineering, Advanced Materials and Process Engineering Lab, University of British Columbia, Vancouver, BC, Canada

Helmut F. Schlaak Institute of Electromechanical Design, Technische Universität Darmstadt, Darmstadt, Germany

Reinhard Schwödiauer Soft Matter Physics, Johannes Kepler University Linz, Linz, Austria

Mohsen Shahinpoor Biomedical Engineering/Advanced Robotics (BEAR) Laboratories, Department of Mechanical Engineering, Graduate School of Biomedical Science and Engineering, University of Maine, Orono, ME, USA

Herbert Shea LMTS: Microsystems For Space Technologies Lab, EPFL, Neuchatel, Switzerland

Jun Shintake LIS: Laboratory of Intelligent Systems, EPFL, Lausanne, Switzerland

Anne L. Skov Technical University of Denmark (DTU), Lyngby, Denmark

Geoffrey M. Spinks ARC Centre of Excellence for Electromaterials Science, Intelligent Polymer Research Institute, University of Wollongong, North Wollongong, NSW, Australia

Richard J. Spontak Department of Chemical and Biomolecular Engineering, North Carolina State University, Raleigh, NC, USA

David Stadler Optotune AG, Dietikon, Switzerland

Tyler Stalbaum Department of Mechanical Engineering, University of Nevada, Las Vegas, NV, USA

Ji Su Advanced Materials and Processing Branch, NASA Langley Research Center, Hampton, VA, USA

Yuji Suzuki The University of Tokyo, Tokyo, Japan

Yoshihiro Tajitsu Faculty of Engineering Science, Kansai University, Osaka, Japan

Kentaro Takagi Department of Mechanical Science and Engineering, Nagoya University, Nagoya, Japan

Xiaobo Tan Department of Electrical and Computer Engineering; Department of Mechanical Engineering, Michigan State University, East Lansing, MI, USA
Contributors

Marcus Tietze Faculty of Electrical and Computer Engineering, Institute of Semiconductors and Microsystems, Technische Universität Dresden, Dresden, Germany

Janno Torop Intelligent Materials and Systems Lab, Institute of Technology, University of Tartu, Tartu, Estonia

Frederic Vidal Université de Cergy-Pontoise, Cergy-Pontoise cedex, France

Andreas Voigt Institute of Semiconductors and Microsystems, Faculty of Electrical and Computer Engineering, Dresden University of Technology and Center for Advancing Electronics Dresden, Dresden, Germany

Michael Wübchenhorst Department of Physics and Astronomy, Soft Matter and Biophysics Section, KU Leuven, Leuven, Belgium

Thomas Wallmersperger Institut für Festkörpermechanik, TU Dresden, Dresden, Germany

Masaki Yamakita Department of Mechanical and Control Engineering, Tokyo Institute of Technology, Tokyo, Japan

Yoshinobu Yasuno Kobayashi Institute of Physical Research, Tokyo, Japan

Xiaoqing Zhang School of Physics Science and Engineering, Tongji University, Shanghai, China

Wen Zheng School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai, China