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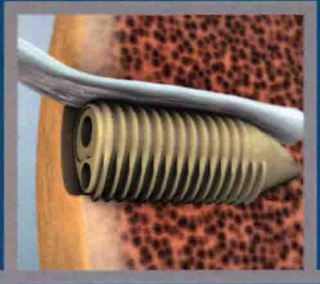
Shape-Memory Polymer Device Design



David L. Safranski
Jack C. Griffis

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A Volume in the Plastics Design Library Series

Shape-Memory Polymer Device Design

David L. Safranski and Jack C. Griffis

Shape-Memory Polymer Device Design introduces the properties of shape-memory polymers and provides engineering principles for designing and manufacturing with them. This book provides a guide to the R&D engineer/scientist and design engineer to add the shape-memory effect of polymers into the design toolbox. This work is the first book to focus on applying the basic science knowledge to design practical devices.

This book introduces the concept of shape-memory polymers, the history of their use, and the range of current applications. It details the specific design principles for working with shape-memory polymers, which do not often apply to mechanically inactive materials and products. Material selection is thoroughly discussed, because chemical structure and thermomechanical properties are intrinsically linked to shape-memory performance. Further chapters discuss programming the temporary shape and recovery through a variety of activation methods with real-world examples. Finally, current devices across a variety of markets are highlighted to show the breadth of possible applications.

ABOUT THE AUTHORS

David L. Safranski , PhD, is a Director of Basic Research at MedShape, Inc.

Jack C. Griffis is the Senior Vice President of Research & Development at MedShape, Inc.

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ISBN 978-0-323-37797-3

9 780323 377973

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SHAPE-MEMORY POLYMER DEVICE DESIGN

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William Andrew is an imprint of Elsevier
The Boulevard, Langford Lane, Kidlington, Oxford, OX5 1GB, United Kingdom
50 Hampshire Street, 5th Floor, Cambridge, MA 02139, United States

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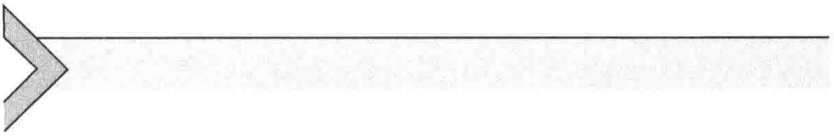
British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data
A catalog record for this book is available from the Library of Congress

ISBN: 978-0-323-37797-3

Publisher: Matthew Deans
Acquisition Editor: David Jackson
Editorial Project Manager: Anna Valutkevich
Production Project Manager: Susan Li
Cover Designer: Mark Rogers



SHAPE-MEMORY POLYMER DEVICE DESIGN

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To Kathryn and Caroline.

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David L. Safranski, PhD, is the Director of Basic Research at MedShape, Inc., an Atlanta-based orthopedic device company. His current research focuses on both the basic science and translational aspects of designing shape-memory polymers and textiles for medical applications. He has authored numerous peer-reviewed articles and book chapters on shape-memory polymers and functional biomaterials, and holds several patents around shape-memory polymers and devices. Dr. Safranski received his PhD from the School of Materials Science and Engineering at the Georgia Institute of Technology, where he also serves as an adjunct faculty member.

Jack C. Griffis III, MS, is the Senior Vice President of Advanced Research and Technology at MedShape, Inc., an Atlanta-based orthopedic device company. He is the recipient of five national design excellence awards in medical device engineering and has cleared more than 50 different medical technologies with the FDA. In 2013, he was inducted into the National Academy of Inventors, and has been awarded 41 US patents in biomedical technologies. Mr. Griffis received his MS in mechanical engineering from the Georgia Institute of Technology.

PREFACE

David Safranski and Jack Griffis started their work with shape-memory polymers in 2005 and 2007, respectively. Each of them began in collaboration with Ken Gall, who currently serves as chair of Mechanical Engineering and Materials Science at Duke University. The Gall group moved from the University of Colorado Boulder to Georgia Tech in the summer of 2005, and David joined as an undergraduate assistant. Owing to the jovial, high energy, start-up atmosphere, he continued his graduate research with the Gall group. As MedShape grew out of the Gall group, Jack joined MedShape as full-time employee number 2 and was responsible for the US FDA clearance of shape-memory polymer devices WedgeLoc, Morphix, ExoShape and Eclipse in 2008, 2009, 2011, and 2013 respectively. Following completion of his PhD in Materials Science and Engineering, David joined MedShape in 2011. Together, David and Jack have worked on numerous product development efforts, federally funded research grants, and private contract research projects, all focused on shape-memory and functional polymer technologies.

First and foremost, this book is meant to help you design a shape-memory polymer device. We've organized this book in a rational manner to help you accomplish this goal. In Chapter 1, Introduction to Shape-Memory Polymers, we cover the basics of shape-memory polymers, including thermomechanical properties, how to classify them, fundamental mechanism, some limitations, and terminology. While terminology may often be overlooked, it is critical to understand the literature, especially when various authors have used different terms over the past 20 years. We hope that Chapter 1, Introduction to Shape-Memory Polymers, in particular, provides some consistency and clarity when beginning to navigate design utilizing these functional materials. In Chapter 2, Design, the design cycle involving shape-memory polymers is described in detail. In addition, practical methods of manufacturing, programming, and activation are covered along with environmental considerations commonly overlooked in design, but that are critical to these specialty materials. Chapter 3, Material Selection, serves as a foundation for material selection by providing material selection case studies of shape-memory polymer applications and tabulated properties of a variety of shape-memory polymers. Chapter 4, Programming of

Shape-Memory Polymers: The Temperature Memory Effect and Triple/Multiple-Shape Memory Effect in Polymers and Chapter 5, Activation Mechanisms of Shape-Memory Polymers, explore in depth the programming and activation aspects of the shape-memory cycle, respectively. While many applications of shape-memory polymers exist, we limited ourselves in Chapter 6, Applications of Shape-Memory Polymers, to providing an overview of those applications that have been commercialized or have high commercial potential. These examples come from a wide range of fields, but focus was primarily on biomedical applications because of their recent commercial success. Previous texts have focused on all the different possible chemistries for shape-memory polymers and their potential applications. From the combination of device design, material selection, and shape-memory polymer fundamentals, we hope that this work serves as a practical guide to assist in your endeavors in designing a shape-memory polymer device.

ACKNOWLEDGMENTS

We would like to thank all the contributors for their work and for their assistance in reviewing sections of this book: Stephen Laffoon, Dalton Sycks, Ken Gall, Rui Xiao, Cheng Zhang, Wei Min Huang, Drew Hanzon, Kai Yu, and Christopher Yakacki. For their motivation and support of this project, we would like to thank Anna Valutkevich, Heather Cain, and Matthew Deans from Elsevier. We would like to recognize all the members of the shape-memory polymer field for publishing their work, which makes this book possible. We thank the following companies that provided illustrations and figures of their products: Composite Technology Development, Inc., EndoShape, Inc., HRL Laboratories, LLC., MedShape, Inc., and Spintech, LLC. We are especially grateful to our wives Kathryn Safranski and Caroline Griffis for their endless support, patience, and encouragement.