Shape Memory Materials

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Foreword

This book introduces a wide range of shape memory materials, such as alloys, ceramics, gels, polymers, and composites, but focuses mainly on polymer materials. Readers can study physical properties related to shape recovery, the mechanism of shape memory effect, typical materials, the history of material development for each shape memory material, and differences among shape memory materials. This book is suitable for beginners who start to learn about shape memory materials and for experts to re-realize and come up with new concepts for designing new materials.

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Preface

Additive manufacturing or 3D printing is one of the latest trends in material science and is even evolving into multidimensional printing beyond three dimensions through everyday innovations and research. When 3D-printed materials change shape with time in response to specific stimuli, this is known as *4D printing*. Universities and research organizations across the world have heavily invested their intellectual resources into this evolving trend in material science. Multidimensional printing can be realized with the use of shape-morphing and shape memory materials in place of conventional 3D-printed raw materials. Shape-morphing and shape memory materials thus form the basis of such innovations. The origins of shape memory materials can be traced back to the 1940s, when Ti-Ni alloys were explored for their memorizing abilities. Research on Ti-Ni-based materials reigned in the arena of shape memory smart materials until gels, ceramics, and polymers evolved as alternative options. The advantages of newer technologies over old existing techniques become the impetus for all innovations. Thus, studies on shape memory polymers over alloys have taken the lead.

Many peer-reviewed articles on shape memory materials have been published, covering studies on the memorizing behavior of alloys and polymers. This work adopts a unique narrative style by defining smart materials and taking the reader on a journey through the various shape memory materials and their corresponding activation techniques, characterizations, response stimuli, syntheses, and applications. Shape memory materials suit the demands of aerospace applications, and industry-specific studies have been initiated on the remote activation of these materials by indirect thermal or electrical actuation. Electroactivity demands studies on conductivity; these have been reviewed and reported chronologically in this work. The prospects of shape memory materials are discussed, befitting smart actuations for aerospace and other applications.

Graduate students working in materials science and interested faculties, industries, and innovators can make use of this book to understand the recent advances in the field of shape memory materials. This book comprehensively reviews the evolution of smart materials through the lessons learned from nature to the current scenario.

The first chapter gives an overview of the topic, with illustrations from nature that inspired researchers to develop newer materials with improved properties. Chapters 2 through 6 deal with various shape memory materials and their advantages and disadvantages, illustrating their various applications in the fields of science and engineering. Chapter 7 explains the processing of composite material from shape memory polymers to cater for newer applications. Chapter 8 is dedicated to the high-temperature applications of

shape memory materials, as aerospace applications and modern manufacturing techniques demand thermally stable materials for extreme synthesis and operating environments. Chapter 9 discusses methods of electrical actuation, one of the most modern and demanding actuation techniques. The future prospects of shape memory materials are discussed in Chapter 10, and the book leaves the reader with a fresh overview of the latest technological innovations.

The authors would like to acknowledge Dr. Sreejalakshmi G, associate professor of the Department of Chemistry at the Indian Institute of Space Science and Technology, who was instrumental in providing constructive criticism and has been motivational since the initial stages of the work. The authors are grateful to Dr. Ashok and Shri. Angappan of Air Frame Division, Aeronautical Development Agency, for the valuable input in shaping this work. The reviews and comments of Dr. Usha KM and Dr. Sasikumar P, scientists at the Vikram Sarabhai Space Centre, India, and the comments and input of the reviewers from CRC Press have also been valuable in shaping this book. We express our gratitude to the Vikram Sarabhai Space Centre, Department of Space, India, for helping us to make this publication a reality.

All the references cited are the major sources of data for this book, and hence, all the scientists/researchers behind the cited/referred works are hereby sincerely thanked. A word of acknowledgment is appropriate for our families and all those who offered honest positive criticism and support throughout the publication of this book.

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