Preface

Professor Hisaaki Tobushi is one of the leading Japanese researchers in intelligent materials and structures and has a worldwide reputation because of his great impact on various research topics. This book has been published in commemoration of his retirement from Aichi Institute of Technology, and to express sincere respect and gratitude for his significant achievements and longtime contributions to the research on shape memory alloys, polymers, and composites. Many active researchers in his field have contributed to this memorial book, some of them are close to Prof. Tobushi, and have also contributed to his published studies. The contents of this book are not limited to one field, metallurgical, chemical, mechanical, engineering, experimental and theoretical, and applications.

Professor Tobushi was born in 1946 at Taketa, Oita in Kyushu, Japan and spent his early years there. After graduating from high school, he entered the Department of Mechanical Engineering in Kyushu Institute of Technology in 1965. He then majored in solid mechanics at the graduate school in Nagoya University from 1969, and received his Ph.D. from Nagoya University in 1976. He began his career as Assistant Professor at Aichi Institute of Technology in 1975 and worked as Associate Professor there since 1979. He spent 3 months at University of Manitoba, Canada in 1983 as a visiting scholar, and collaborated with Prof. John Cahoon on the shape memory alloy heat engine. After returning to Aichi Institute of Technology, he started to work on shape memory alloys. He has been a full Professor there since 1991.

In his academic career, Prof. Tobushi has worked as the member of the Japan Society of Mechanical Engineers, the American Society of Mechanical Engineers, the Society for Experimental Mechanics, the Japan Society for Experimental Mechanics, the Japan Institute of Metals and Materials, the Society of Materials Science, Japan and the Japanese Society for Engineering Education. He has been conferred the Honorary Member of the Polish Society of Theoretical and Applied Mechanics since 2013.

We will take this opportunity to summarize his main achievements, although we cannot cover all of his research because of space limitations. The summary below will briefly describe his extensive research and will help the readers to understand the meaning and message of the publication of this book. His papers mentioned in this summary are listed in the chapter of the review paper on the research by Prof. H. Tobushi.

1. **Characteristics of shape memory alloy heat engine**
   Hisaaki Tobushi investigated the mechanical analysis of a solar-powered solid state engine with Prof. J.R. Cahoon during his stay at University of Manitoba. After returning to Japan, he continued to study the output power characteristics of the shape memory alloy heat engines: the twin crank type engine, the disk offset crank type engine and other solutions. These studies have been evaluated as one of the pioneering works on the shape memory alloy heat engines.
2. **Thermomechanical properties of shape memory alloy**
   Tobushi investigated the thermomechanical properties of shape memory alloy with Prof. K. Tanaka on the thermomechanical modeling due to the martensitic transformation and the R-phase transformation. They and Prof. C. Lexcellent, Dr. A. Ziolkowski and coworkers also studied the cyclic deformation properties, the properties of strain energy and dissipated work, the behavior of recovery stress and the deformation properties due to both the stress-induced martensitic and R-phase transformations. These studies are required to design shape memory alloy elements in applications. The results obtained have been highly evaluated and cited in many papers and books.
3. **Influence of stress- and strain-controlled subloop loadings on deformation properties**
   The functional properties of the shape memory alloy appear due to the martensitic transformation. The martensitic transformation depends on stress and temperature. The deformation behavior depends therefore on the hysteresis of the stress and temperature. Tobushi, Prof. W.K. Nowacki, Prof. E.A. Pieczyska, Dr. K. Takeda, and their coworkers clarified the influence of the stress- and strain-controlled loading conditions on the subloop deformation behavior. In the case of the stress-controlled subloop, strain increases due to the martensitic transformation during unloading, and decreases due to the reverse transformation during reloading. The transformation-induced creep and creep recovery appear under constant stress in the stress-controlled subloop, and the transformation-induced stress relaxation and stress recovery appear under constant strain. These studies have been also cited many times.
4. **Bending fatigue properties and enhancement of fatigue life of shape memory alloy**
   Tobushi, Prof. P.H. Lin, Dr. Matsui and coworkers developed the rotating-bending, pulsating-bending and alternating-bending fatigue machines. The fatigue properties are one of the most important problems in applications of

shape memory alloys subjected to cyclic motions, such as actuators, robots, and heat engines. The reports on the fatigue properties are, however, still limited. They investigated the bending fatigue properties of the shape memory alloy thin wire, thin tape, thin tube and highelastic thin wire in the rotating-bending and plane bending fatigue tests. Tobushi, Dr. S. Kucharski and coworkers also reported the enhancement of fatigue life of shape memory alloy by nitrogen ion implantation and ultrasonic shot peening. These studies have been highly evaluated and cited in many papers.

5. **Torsional deformation properties of shape memory alloy thin tape and their application**
The torsional deformation was obtained by simply grasping both ends of shape memory alloy thin tapes and by twisting them. If the torsional deformation of shape memory alloy thin tapes was used, the reciprocating two-way shape memory alloy actuators with a simple structure can be developed. Tobushi and coworkers developed the torsional testing device and performed the torsional tests. The torsional deformation and fatigue properties of shape memory alloy thin tapes and application models were clarified. These pioneering works have been also highly evaluated.
6. **Thermomechanical properties of shape memory polymer**
Tobushi at first investigated the thermomechanical properties of shape polymer with Dr. S. Hayashi who developed the polyurethane shape memory polymer. In order to evaluate the properties of shape fixity and shape recovery, they also proposed at first the shape fixity rate to define as a ratio of fixed strain to maximum strain and the shape recovery rate to define as a ratio of recovered strain to applied strain. These proposed rates have been used by many researchers to investigate the deformation properties of shape memory polymers. They and Prof. E.A. Pieczyska, Prof. A. Bhattacharyya and coworkers also proposed the constitutive models to express the thermomechanical properties of shape fixity, shape recovery and recovery stress in shape memory polymer. These studies are required to design shape memory polymer elements in applications. The results obtained have been highly evaluated and most frequently cited in many papers.
7. **Thermomechanical properties of shape memory polymer foam and secondary shape forming**
In the shape memory polymer foam, the volume change is quite high. In applications in space engineering, the deployable properties of the structure is requested. The shape memory polymer foam has the high function applicable to these applications. In these applications, the fixed shape is held in the long term and the shape recovery after the long-term fixed shape is required. Tobushi and coworkers investigated the long-term shape fixity and shape recovery. In the experiment of long-term shape fixity, they confirmed that the shape recovery rate is low when the fixed shape is held at high temperature. If this irrecoverable property is applied to obtain the different shape from the original shape, it is useful in applications for the shape forming. This property can be therefore applied in the secondary shape forming. These findings have been also highly evaluated.

8. **Shape memory composite and functionally graded shape memory polymer**
   The shape recovery appears during heating in both shape memory alloy and shape memory polymer. The rigidity and yield stress are, however, high at high temperature and low at low temperature in shape memory alloy, but on the contrary, the rigidity and yield stress are high at low temperature and low at high temperature in shape memory polymer. The dependence of deformation properties on temperature is therefore quite opposite between the shape memory alloy and shape memory polymer. If the shape memory composites are developed by combining the shape memory alloy and shape memory polymer, the new functional properties which cannot be obtained by themselves may be achieved. Tobushi and coworkers developed the shape memory composite by combining the shape memory alloys with various phase transformation temperatures and the shape memory polymer with different glass transition temperatures. The reciprocating three-way bending motion was observed during heating and cooling. They also developed the functionally graded shape memory polymers laminated by various sheet and foam having various glass transition temperatures. They will be applied in medical nursing care robots and devices.

Professor Hisaaki Tobushi significantly has contributed to the educational activities through writing books related to shape memory materials: (1) Mechanical Properties of Shape Memory Alloys with K. Tanaka and S. Miyazaki published in 1993 by Yokendo Pub., (2) Strength of Materials—Application to Strength Design with S. Kitaoka, Y. Sugano, K. Tanaka, A. Kato, and S. Nagaki published in 1996 by Yokendo Pub., (3) Basic Exercises on Strength of Materials with S. Kitaoka, Y. Sugano, K. Tanaka, A. Kato, and S. Nagaki published in 1999 by Yokendo Pub., (4) Shape Memory Materials and their Applications with K. Tanaka, H. Horikawa, and M. Matsumoto published in 2004 by Corona Pub., (5) Mechanical Properties of Shape Memory Materials with R. Matsui, K. Takeda, and E.A. Pieczyska published in 2013 by Nova Science Pub., and (6) Strength of Materials—Fundamentals of Mechanical Design with T. Inaba, T. Ikeda, Y. Takeich, Y. Ono, and R. Matsui published in 2014 by Corona Pub. He also has written many book chapters and review papers in various journals on the mechanical properties of shape memory alloy and shape memory polymer.

We are grateful to Prof. Hisaaki Tobushi for his seminal and longtime contribution to the development of shape memory alloys, polymers, and their composites.

Finally, we gratefully acknowledge Mrs. Nathalie Jacobs at Springer Publisher for support of the book project.

Kowloon, Hong Kong — Qingping Sun
Toyota, Japan — Ryosuke Matsui
Toyota, Japan — Kohei Takeda
Warsaw, Poland — Elżbieta A. Pieczyska

http://www.springer.com/978-3-319-53305-6

Advances in Shape Memory Materials
In Commemoration of the Retirement of Professor
Hisaaki Tobushi
Sun, Q.-P.; Matsui, R.; Takeda, K.; Pieczyska, E.A. (Eds.)
2017, X, 241 p., Hardcover
ISBN: 978-3-319-53305-6