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Book review

Christian Lexcellent, *Shape-Memory Alloys Handbook*, Wiley-ISTE, ISBN 978-1-84821-434-7, March 2013, 380 pages.

The book is divided into 10 chapters.

Chapter 1, "Some General Points about SMAs", provides a comprehensive and concise presentation of shape memory alloys (SMAs) to familiarize the reader with the concept of shape memory martensitic transformation—basics of the shape memory mechanism—before giving a synopsis of the whole book.

Chapter 2, "The world of shape memory alloys", prepared in cooperation with Michel Morin, INSA Lyon, develops the metallurgy of shape memory alloys, such as heat treatments that confer the properties of shape memory alloys to the copper-based and NiTi-based alloys.

Chapter 3, "Martensitic Transformation", studies this solid-state phase transformation, which is the crystallographic mechanism of shape memory. The author states having written this chapter as a synthesis of the book of Kaushik Bhattacharya on the microstructure of martensite, which is a reference book on this topic.

Chapter 4, "Thermodynamic Framework for the Modeling of Solid Materials", gives the thermodynamic basis for thermomechanical modeling of thermal and magnetic shape memory alloys, modeling that will be discussed later in the book.

Chapter 5, "Use of the "CTM" to Model SMAs", where the abbreviation CTM stands for "crystallographic theory of martensite", studies the process of reorientation of martensite variants and pseudo-elastic behavior in the case of a monocrystal. In addition, the transformation surfaces in the stress space are calculated for the single crystal and for polycrystals. In the case of polycrystals, the study is rigorous. Indeed the crystallographic orientation of the grains in the polycrystalline aggregate is parameterized by the Euler angles. It is actually a micro–macro transition or homogenization that takes into account the crystallographic texture.

Chapter 6, "Phenomenological and Statistical Approaches for SMAs", studies the thermomechanical coupling (magnetic if applicable) using phenomenological models such as the model of Preisach, or models based on the thermodynamics of irreversible processes, see Chapter 4 on models.

Chapter 7, "Macroscopic Models with Internal Variables", summarizes many models, most of which are based on the thermodynamics of irreversible processes. The author and his graduate students as well as the entire French school of mechanics of materials have made a significant contribution to these models.

Chapter 8, "Design of SMA Elements: Case Studies", offers simplified calculations of structure size based on mechanics of materials or on the finite element method.

Chapter 9, "Behavior of Magnetic SMAs", describes a class of SMAS for which the shape change does not result from the application of a thermal field, but from that of a magnetic field. The main advantage of these newer materials is that their response time is as short as that of magnetostrictive materials, in the range of milliseconds. The scientific literature on the ferromagnetic shape memory materials is currently experiencing a significant increase. Their study is exciting because, in addition to the thermomechanical approach, it includes the physics of magnetism that is rich and subtle.

Chapter 10, "Fracture Mechanics of SMAs", reminds us that these materials are primarily intended to make actuators and sensors. Although the author does not directly study the fatigue behavior of the SMAs, he devotes an extensive study on the fracture mechanics. Under the assumption of a linear elastic behavior, stress analysis at the crack tip is made by an analytical approach of complex potential type.

Finally, Chapter 11, "General Conclusion", offers a list of issues that have been resolved and a—even longer—list of unresolved issues. The author also gives clues to the future avenues of inquiry that can be a helpful guide to researchers and doctoral students who want to work on this exciting research topic.

In a relatively compact and practical size (380 pages)—you can easily carry it in your briefcase—, the work of Christian Lexcellent is actually a real handbook or a concise encyclopedia on the SMAS. Indeed, it covers both the thermal and the magnetic actuated SMAS, the more theoretical issues such as martensitic transformation, thermodynamics of irreversible processes, theories of homogenization and the more practical problems of SMAS design. In addition, two readings of the book are possible, pencil in hand following the calculations—the reader is well guided—or accepting the formal development and focusing on the physical significance of the results of the calculations. Even in the latter case, the accompanying text emphasizes enough the physical meaning underlying the calculations for the reader to understand. The author has made an important pedagogic effort to make sometimes abstract theories accessible to a large audience of readers. For example, the

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calculation of the martensitic structure in which the thickness of two variants is parameterized by x, respectively $(1-x)$, makes use of positive definite matrices and polar decomposition, which probably led C. Licht (reference [LIC 98] of the book) to the enigmatic title "$x(1-x)$ I rather like it" in his contribution to the Proceedings of the MECAMAT—Aussois meeting, 1998. But with the pedagogic presentation of Christian Lexcellent, the detailed description of the calculation steps, the illustration by calculations on practical examples, the reader will really like it. The author also provides the reader with concise summaries of theories published in long and arduous scientific articles. For example, the magnetic actuation models for SMAS based on O'Handley and Murray's work are synthesized on half a page, as well as the models of Ullakko and Likhachev. A researcher entering to work on SMAS magnetic actuation can thus benefit from this review of the basic models and save valuable time in the study of the basic literature review.

Although this is a first edition, there are only very few small misprints that do absolutely not hinder the understanding of the scientific developments.

In conclusion, the reviewer had a real pleasure to study, often in detail, this book useful to any researcher—confirmed or beginner—interested in SMAS. He would strongly recommend the acquisition and reading of this handbook.

About the author.

Christian Lexcellent is Distinguished Professor at the "École nationale supérieure de mécanique et des microtechniques de Besançon" and a researcher in the Department of Applied Mechanics at FEMTO-ST in France. He is a specialist in the mechanics of materials and phase transition and has taught in the subjects of mechanics of continuum media and shape memory alloys. He is also a member of the International Committee of ESOMAT.

The book is also published in a French version by Éditions Hermes—Lavoisier, Cachan, France.

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