

SHAPE MEMORY MATERIALS

Edited by

K. OTSUKA

Institute of Materials Science, University of Tsukuba

and

C. M. WAYMAN

*Department of Materials Science and Engineering
University of Illinois*



**CAMBRIDGE
UNIVERSITY PRESS**

Contents

List of contributors	pAge	xi
Preface		xiii
1 Introduction		1
<i>K. Otsuku and C. M. Wayman</i>		
1.1 Invitation to shape memory effect and the notion of martensitic transformation		1
1.2 Martensitic transformations: crystallography		5
1.3 Martensitic transformations: thermodynamic aspects		21
2 Mechanism of shape memory effect and superelasticity		27
<i>K. Otsuku and C. M. Wayman</i>		
2.1 Stress-induced martensitic transformation and superelasticity		27
2.2 Shape memory effect		36
2.3 Rubber-like behavior		44
3 Ti-Ni shape memory alloys		49
<i>T. Saburi</i>		
3.1 Structure and transformations		49
3.2 Mechanical behavior of Ti-Ni alloys		58
3.3 Ternary alloying		73
3.4 Self-accommodation in martensites		79
3.5 All-round shape memory (Two-way shape memory)		84
3.6 Effects of irradiation on the shape memory behavior		87
3.7 Sputter-deposited films of Ti-Ni alloys		87
3.8 Melt-spun ribbons of Ti-Ni alloys		93
4 Cu-based shape memory alloys		97
<i>T. Tadaki</i>		
4.1 Phase diagrams of typical Cu-based shape memory alloys		97
4.2 Mechanical behavior		100

- 4.3 Aging effects of shape memory alloys
- 4.4 Thermal cycling effects
- 4.5 Improvements of shape memory alloys
- 5 Ferrous shape memory alloys**
 - T. Maki***
 - 5.1 Morphology and substructure of ferrous martensite
 - 5.2 Ferrous alloys exhibiting shape memory effect
 - 5.3 Shape memory effect associated with a' thin plate martensite
 - 5.4 Shape memory effect associated with ϵ martensite in Fe-Mn-Si alloys
- 6 Fabrication of shape memory alloys**
 - Y. Suzuki***
 - 6.1 Fabrication of Ti-Ni based alloys
 - 6.2 Fabrication of Cu-Al-Zn based alloys
 - 6.3 Powder metallurgy and miscellaneous methods
- 7 Characteristics of shape memory alloys**
 - J. Van Humbeeck and R. Stalmans***
 - 7.1 Summary of the functional properties
 - 7.2 A generalized thermodynamic description of shape memory behaviour
 - 7.3 Two-way memory behaviour
 - 7.4 Constrained recovery - generation of recovery stresses
 - 7.5 The high damping capacity of shape memory alloys
 - 7.6 Cycling effects, fatigue and degradation of shape memory alloys
 - 7.7 Property values
- 8 Shape memory ceramics**
 - K. Uchino***
 - 8.1 Development trends of new principle actuators
 - 8.2 Shape memory ceramics
 - 8.3 Sample preparation and experiments
 - 8.4 Fundamental properties of the electric field-induced phase transition
 - 8.5 Comparison with shape memory alloys
 - 8.6 Applications of shape memory ceramics
 - 8.7 Conclusions
- 9 Shape memory polymers**
 - M. Irie***
 - 9.1 Shape memory effect of polymer materials

9.2	Thermal-responsive shape memory effect	206
9.3	Photo-responsive shape memory effect	212
9.4	Chemo-responsive shape memory effect	218
10	General applications of SMA's and smart materials	220
	<i>K. N. Melton</i>	
10.1	Introduction	220
10.2	History of applications of SMA	221
10.3	SMA couplings	222
10.4	Electrical connectors	226
10.5	Fastener type applications	230
10.6	History of applications of superelasticity	232
10.7	Selection criteria for SMA applications	234
10.8	Smart materials	237
11	The design of shape memory alloy actuators and their applications	240
	<i>I. Ohkata and Y. Suzuki</i>	
11.1	Characteristics of shape memory alloy actuators	240
11.2	The design of shape memory alloy springs	242
11.3	The design of two-way actuators	247
11.4	Shape memory alloy actuator applications	254
12	Medical and dental applications of shape memory alloys	267
	<i>S. Miyazaki</i>	
12.1	Introduction	267
12.2	Application examples	267
12.3	Corrosion resistance	276
12.4	Elution test	278
12.5	Biocompatibility	279
	<i>Index</i>	282