

Contents

1 Bulk Amorphous Alloys	
A. Inoue	1
1.1 History of Bulk Amorphous Alloys	1
1.2 Dominant Factors for High Glass-Forming Ability	3
1.3 Crystal Nucleation and Growth Behavior of Alloys with High GFA	8
1.4 Continuous Cooling Transformation of Alloys with High GFA	10
1.5 Preparative Methods and Maximum Thickness of Bulk Amorphous Alloys	11
1.6 Structural Relaxation and Glass Transition	15
1.7 Physical Properties	20
1.7.1 Density	20
1.7.2 Electrical Resistivity	20
1.7.3 Thermal Expansion Coefficient	23
1.8 Mechanical Properties	24
1.9 Viscoelasticity	29
1.10 Soft Magnetic Properties	34
1.10.1 Formation and Soft Magnetic Properties of Bulk Amorphous Alloys	34
1.10.2 Glass-Forming Ability of Fe-(Al,Ga)-Metalloid, Fe-TM-B, and Co-TM-B Alloys	38
1.11 Viscous Flow and Microformability of Supercooled Liquids	39
1.11.1 Phase Transition of Bulk Amorphous Alloys	39
1.11.2 Deformation Behavior of Supercooled Liquids	40
1.11.3 Microforming of Supercooled Liquids	41
1.12 Bulk Amorphous Alloys Produced by Powder Consolidation	43
1.12.1 Consolidation Conditions	43
1.12.2 Density and Properties of Consolidated Bulk Amorphous Alloys	44
1.13 Applications and Future Prospects	47
References	48

2 Stress Relaxation and Diffusion in Zr-Based Metallic Glasses Having Wide Supercooled Liquid Regions	
Y. Kawamura, T. Shibata, A. Inoue, T. Masumoto, K. Nonaka, H. Nakajima, and T. Zhang	52
2.1 Introduction	52
2.2 Experiments	53
2.3 Results and Discussion	54
2.3.1 Stress Relaxation in $Zr_{65}Al_{10}Ni_{10}Cu_{15}$ Metallic Glass	54
2.3.2 Diffusion in $Zr_{55}Al_{10}Ni_{10}Cu_{25}$ Metallic Glass	61
2.4 Conclusions	67
References	67
3 The Anomalous Behavior of Electrical Resistance for Some Metallic Glasses Examined in Several Gas Atmospheres or in a Vacuum	
O. Haruyama, H. Kimura, N. Nishiyama, T. Aoki, and A. Inoue	69
3.1 Introduction	69
3.2 Experimental Procedure	71
3.3 Results and Discussion	71
3.3.1 Pd-Si Based Glasses	71
3.3.2 $Pd_{40}Ni_{10}Cu_{30}P_{20}$ Glass	77
3.3.3 $Zr_{60}Al_{15}Ni_{25}$ Glass	79
3.3.4 Change in Electrical Resistivity Associated with Glass Transition	80
3.4 Concluding Remarks	84
References	85
4 Methods for Production of Amorphous and Nanocrystalline Materials and Their Unique Properties	
T. Aihara, E. Akiyama, K. Aoki, M. Sherif El-Eskandarany, H. Habazaki, K. Hashimoto, A. Kawashima, M. Naka, Y. Ogino, K. Shimiyama, K. Suzuki, and T. Yamasaki	87
4.1 Introduction	87
4.2 Crystalline-Amorphous Cyclic Transformation of Ball Milled $Co_{75}Ti_{25}$ Alloy Powder	88
4.2.1 Use of Mechanical Alloying Technique for Amorphization ..	88
4.2.2 Ball Milling Procedure and Analyzing Technique	88
4.2.3 Structural Changes vs. Milling Time	89
4.2.4 TEM Observations	90
4.2.5 Magnetization	92
4.2.6 Thermal Stability	93
4.2.7 Possible Reasons for the Cyclic Crystalline-Amorphous Transformations	95

4.3	Formation of Amorphous and Nanocrystalline Ni-W Alloys by Electrodeposition and Their Mechanical Properties	96
4.3.1	Electrodeposition – A Method for the Production of the Amorphous Materials	96
4.3.2	Preparation of Ni-W Alloys and Technique Used for Studies	97
4.3.3	Brittleness of the As-electrodeposited Ni-W Alloys	104
4.3.4	Hardness of the Nanocrystalline Ni-W Alloys	105
4.4	Formation of Ti-Based Amorphous Alloys by Sputtering and Their Physical Properties	109
4.4.1	Sputtering Technique	109
4.4.2	Samples Preparation and Description of the Analytical Equipment Used	109
4.4.3	Structure and Mechanical Properties of Sputtered Alloys . .	110
4.4.4	Amorphous to Crystalline Phase Transition	114
4.5	Hydrogen Evolution Characteristics of Ni-Mo Alloy Electrodes Prepared by Mechanical Milling and Sputter Deposition	115
4.5.1	CO ₂ Recycling Problem	115
4.5.2	Experimental Procedure	116
4.5.3	Mechanically Alloyed Ni-Mo Electrodes	118
4.5.4	Sputter-deposited Ni-Mo Electrode	122
4.6	Concluding Remarks	128
	References	130
5 Amorphous and Partially Crystalline Alloys Produced by Rapid Solidification of The Melt in Multicomponent (Si,Ge)-Al-Transition Metals Systems		
	D. V. Louzguine and A. Inoue	133
5.1	Introduction	133
5.2	Multicomponent Fully Amorphous Si and Ge-based Alloys	135
5.2.1	Influence of Composition and Cooling Rate on the Structure of (Si,Ge)-Al-TM Alloys	135
5.2.2	Reasons for the Elevated Glass-forming Ability	139
5.2.3	Properties	140
5.2.4	Thermal Stability and Crystallization of the Amorphous Phase	142
5.2.5	Production of Bulk Amorphous Samples by Hot Pressing. Densification Behaviour.	146
5.3	Precipitation of Nanocrystalline c-Ge Particles in Mixed Si-Ge-Al-TM and Ge-Si-Al-TM Alloys	150
5.3.1	Microstructure and Phase Composition of Rapidly Solidified Si-Ge-Al-TM Alloys	150

5.3.2	Crystallization Process in the Rapidly Solidified Si-Ge-Al-TM Alloys	157
5.3.3	The Effect of Si Addition to Melt Spun Ge-Al-TM Alloys .	160
	References	164
6	Global CO₂ Recycling – Novel Materials, Reduction of CO₂ Emissions, and Prospects	
	K. Hashimoto, K. Izumiya, K. Fujimura, M. Yamasaki, E. Akiyama, H. Habazaki, A. Kawashima, K. Asmi, K. Shimamura, and N. Kumagai	166
6.1	Introduction	166
6.2	Global CO ₂ Recycling	167
6.3	Key Materials for Global CO ₂ Recycling	169
6.3.1	Cathode Materials	169
6.3.2	Anode Materials	174
6.3.3	Catalysts for CO ₂ Methanation	179
6.4	A Global CO ₂ Recycling Plant for Substantiation of the Idea	182
6.5	Energy Balance and Amounts of Reduction of CO ₂ Emissions	183
6.6	Economy of the Global CO ₂ Reduction	184
6.7	Concluding Remarks	185
	References	185
7	Formation of Nano-sized Martensite and its Application to Fatigue Strengthening	
	M. Shimojo and Y. Higo	186
7.1	Introduction	186
7.2	Formation of Micro-sized Martensite	186
7.3	Formation of Nano-sized Martensite	191
7.4	Application of Micro and Nano-sized Martensite to Materials Strengthening	196
7.5	Conclusions and Future Work	204
	References	204
	Index	205