

Contents

1	Solid Solution	1
1.1	Solubility	1
1.2	Lattice Location	5
1.3	Partial Molar Volume and Strain Field	6
1.4	Atomistic Calculations of the Heat of Solution	7
	References	9
2	Hydrogen Trapping and Its Detection	11
2.1	Manifestations and Analyses of Hydrogen Trapping	11
2.1.1	Solid Solubility at Low Temperatures	11
2.1.2	Hydrogen Thermal Desorption Analysis	15
2.2	Partition of Hydrogen Among Different Traps	26
2.2.1	Equilibrium Distribution	26
2.2.2	Kinetics of Hydrogen Trapping	28
2.3	Visualization of Hydrogen Distribution	29
	References	32
3	Interactions of Hydrogen with Lattice Defects	35
3.1	Dislocations	35
3.1.1	Experimental Results	35
3.1.2	Theoretical Estimation of Hydrogen-Dislocation Interactions	40
3.2	Vacancies	43
3.2.1	Density	43
3.2.2	Vacancy Clusters and Migration	45
3.2.3	Interaction of Hydrogen with Vacancies	48
3.3	Precipitates	56
3.4	Grain Boundaries	59
3.5	Voids and Surfaces	60
	References	61

4	Diffusion and Transport of Hydrogen	65
4.1	Determination of Diffusion Coefficient	65
4.2	Diffusion Process	68
4.3	Hydrogen Transport by Dislocations	72
4.3.1	Release of Internal Hydrogen	73
4.3.2	Electrochemical Permeation	74
	References	76
5	Deformation Behaviors	79
5.1	Elastic Moduli	79
5.2	Flow Stress	80
5.3	Stress Relaxation and Creep	87
5.3.1	Stress Relaxation	87
5.3.2	Creep	90
5.3.3	Implications of Surface Effects	92
5.4	Direct Observation of Dislocation Activity	94
5.5	Elastic and Atomistic Calculations	95
5.5.1	Elastic Shielding of Stress Centers	95
5.5.2	Mobility of Screw Dislocations – Atomistic Calculations	98
	References	100
6	Manifestations of Hydrogen Embrittlement	103
6.1	Tensile Tests	103
6.2	Fracture Mechanics Tests	108
6.2.1	Crack Initiation	109
6.2.2	Crack Growth	114
6.3	Fatigue	117
6.4	Delayed Fracture	124
6.4.1	Factors Affecting Delayed Fracture	124
6.4.2	Incubation Period	126
6.4.3	Effects of Environmental Variations	130
	References	133
7	Characteristic Features of Deformation and Fracture in Hydrogen Embrittlement	137
7.1	Fractographic Features	137
7.2	Strain Localization and Plastic Instability	151
7.2.1	Strain Localization	151
7.2.2	Plastic Instability	156
7.3	Precursory Damage to Crack Initiation	157
7.3.1	Generation of Damage During Mechanical Tests	157
7.3.2	Effects of Stress History	161
	References	164

8	Effects of Microstructural Factors on Hydrogen Embrittlement . . .	167
8.1	Dislocation and Slip Configurations	168
8.2	Impurities and Alloying Elements	178
8.3	Heterogeneous Phases	181
8.4	Phase Stability and Deformation Microstructures of Austenitic Stainless Steels	185
8.4.1	Hydrides and Phase Changes	185
8.4.2	Compositional Effects on Hydrogen Embrittlement . . .	188
8.4.3	Fractographic Features	192
8.4.4	Deformation Microstructures	193
	References	195
9	Mechanistic Aspects of Fracture I ~ Brittle Fracture Models	197
9.1	Internal Pressure Theory	198
9.2	Surface Adsorption Theory	201
9.3	Lattice Decohesion Theory	202
9.3.1	Cohesive Strength	202
9.3.2	Local Stress Intensity Approach	203
9.4	Theories of Intergranular Fracture	205
9.4.1	Interface Decohesion	205
9.4.2	Formation of Incipient Crack – Meaning of Surface Energy in Fracture Criteria	209
9.5	Summary of Brittle Fracture Models	213
	References	214
10	Mechanistic Aspects of Fracture II ~ Plasticity-Dominated Fracture Models	217
10.1	Outline of Elemental Concepts of Ductile Fracture	217
10.1.1	Void Nucleation	217
10.1.2	Void Growth and Coalescence	218
10.1.3	Plastic Instability	221
10.2	Hydrogen-Enhanced Localized Plasticity Theory	225
10.3	Adsorption-Induced Dislocation Emission Theory	228
10.4	Autocatalytic Void-Formation and Shear-Localization Theory . . .	229
10.5	Hydrogen-Enhanced Strain-Induced Vacancy Theory	230
10.5.1	Brief Summary of Findings	231
10.5.2	Crack Growth Resistance and its Microscopic Origin . . .	233
10.5.3	Simulation of <i>R</i> -Curve and Strain Localization Near the Crack-Tip	235
10.6	Summary of Ductile Fracture Models	236
	References	238



<http://www.springer.com/978-981-10-0160-4>

Fundamentals of Hydrogen Embrittlement

Nagumo, M.

2016, IX, 239 p. 140 illus., 131 illus. in color., Hardcover

ISBN: 978-981-10-0160-4