

Contents

I

Part One

1	Introduction	3
1.1	Why this book	3
1.1.1	Deformation-recrystallization and their microstructure	3
1.1.2	Examples of industrial applications	4
1.2	Relationship between this course and other major courses	6
1.3	Contents in this book	6
1.4	How to learn	6
1.5	Exercises	7
2	Deformation of materials	8
2.1	Learning objectives	8
2.2	Introduction	8
2.3	Plastic deformation in a single crystal	9
2.3.1	Slip systems	9
2.3.2	Slip lines and slip bands	13
2.3.3	Schmid's law	14
2.3.4	Cross slip	19
2.3.5	Multiple-slip	20
2.3.6	Determine the slip system	21
2.3.7	Rotation of crystals during tension and compression	24
2.3.8	Stress-strain curve of single crystals	26

2.3.9	Upper-lower yielding effects	28
2.3.10	Work hardening	31
2.3.11	Mechanical twinning	33
2.3.12	Slip vs twinning	42
2.3.13	Stress-strain curve during twinning	42
2.4	Plastic deformation in polycrystalline materials	43
2.4.1	Features of poly-crystalline deformation and role of grain boundary	43
2.4.2	Deformation of bi-crystals	44
2.4.3	Macro-accommodation: five independent slip systems	44
2.4.4	Deformed microstructure	47
2.4.5	Hall-Petch relationship	52
2.5	Deformation texture	54
2.5.1	Description of crystal orientation	54
2.5.2	Orientation distribution	55
2.5.3	Classification of deformation textures	56
2.6	Deformation of polymers	59
2.6.1	Amorphous thermoplastics	60
2.6.2	Semi-crystalline thermoplastics	63
2.7	Summary	64
2.8	Exercises	64

II

Part Two

3	Recrystallization of materials	69
3.1	Learning objectives	69
3.2	Introduction	69
3.3	Thermodynamics consideration	70
3.4	Recovery of deformed metals	72
3.4.1	Basic features	72
3.4.2	Recoveries of physical and mechanical properties	73
3.4.3	Kinetics of recovery	73
3.4.4	Microstructure evolution during recovery	75
3.5	Recrystallization of materials	78
3.5.1	Introduction	78
3.5.2	Basic laws of recrystallization	80
3.5.3	Recrystallization kinetics	83
3.5.4	Factors affecting the kinetics of recrystallization	86
3.5.5	Nucleation and growth during recrystallization	89
3.5.6	Effects of secondary particles	93

3.6	Grain growth after recrystallization	96
3.6.1	Introduction	96
3.6.2	Normal grain growth and annealing twins	97
3.6.3	Abnormal grain growth or secondary recrystallization	98
3.7	Recrystallization textures and their control	101
3.7.1	Typical recrystallization textures in metals and alloys	101
3.7.2	Texture evolution during grain growth	101
3.7.3	Theories of recrystallization texture	102
3.7.4	Applications	102
3.8	Summary	104
3.9	Exercises	105
4	Hot deformation of materials	107
4.1	Learning objectives	107
4.2	Introduction	107
4.3	Dynamic recovery	108
4.3.1	Stress-strain curve in dynamic recovery	108
4.3.2	Mechanism of microstructure evolution during recovery	109
4.4	Dynamic recrystallization	110
4.4.1	Stress-strain curve in dynamic recrystallization	110
4.4.2	Dynamically recrystallized microstructure	112
4.4.3	Z-parameter and its relation with hot-deformed microstructure	114
4.4.4	Characteristics of dynamic recrystallization	115
4.4.5	Recrystallization in non-metallic inorganic materials	116
4.4.6	Texture formation during hot deformation	118
4.5	Creep	118
4.5.1	Introduction	118
4.5.2	The creep curve	118
4.5.3	Creep mechanisms	120
4.6	Deformation mechanism maps	123
4.7	Superplasticity	124
4.8	Summary	127
4.9	Exercises	127

III

Part Three

5	Analytical techniques	131
5.1	Learning objectives	131
5.2	Introduction	131

5.3	Description of orientation	132
5.3.1	Coordinate systems	132
5.3.2	Rotation (orientation) matrix	134
5.3.3	Crystallographically-related solutions	137
5.4	Stereographic projection and pole figure	140
5.4.1	Stereographic projection	140
5.4.2	Inverse pole figure	144
5.5	Techniques to determine crystallographic textures	144
5.6	Representations of texture by EBSD	149
5.6.1	Pole figure from EBSD	150
5.6.2	Inverse pole figure from EBSD	150
5.6.3	ODF from EBSD	152
5.7	Summary	154
5.8	Exercises	154
6	Software and worked examples	156
6.1	Learning objectives	156
6.2	Introduction	156
6.3	MTEX	157
6.3.1	Introduction	157
6.3.2	Basic crystallography	159
6.4	Worked examples by using MTEX	161
6.4.1	Pole figure and standard stereographic projection	161
6.4.2	Inverse pole figure	164
6.4.3	Schmid factor and Taylor factor	165
6.4.4	Texture from X-ray diffraction	170
6.4.5	Texture by EBSD	172
6.4.6	Simulation of texture distribution	175
6.4.7	Simulation of texture evolution	180
6.5	TexTools	183
6.6	Summary	188
6.7	Exercises	188
	Bibliography	190
	Index	191