
Contents

Introduction	ix
Part 1. Crystal Elasticity: Dimensionless and Multiscale Representation	1
Chapter 1. Macroscopic Elasticity: Conventional Writing	3
1.1. Generalized Hooke's law	3
1.1.1. Cubic symmetry	4
1.1.2. Hexagonal symmetry	8
1.2. Theory and experimental precautions	10
Chapter 2. Macroscopic Elasticity: Dimensionless Representation and Simplification	13
2.1. Cubic symmetry: cc and fcc metals	14
2.2. Hexagonal symmetry	19
2.3. Other symmetries	27
2.4. Problem posed by cubic sub-symmetries	27
Chapter 3. Crystal Elasticity: From Monocrystal to Lattice	31
3.1. Discrete representation	31
3.2. Continuous representation for cubic symmetry	34
3.3. Continuous representation for the hexagonal symmetry	37

Chapter 4. Macroscopic Elasticity: From Monocrystal to Polycrystal	43
4.1. Homogenization: several historical approaches and a simplified approach	43
4.2. Choice of “ideal” data sets and comparison of various approaches	47
4.3. Two-phase materials, inverse problem and textured polycrystals	51
4.3.1. Two-phase materials	51
4.3.2. Reverse problem	52
4.3.3. Textured materials	54
Chapter 5. Experimental Macroscopic Elasticity: Relation with Structural Aspects and Physical Properties	57
5.1. A high-performance experimental method	57
5.2. Elasticity of nickel-based superalloys	60
5.2.1. Single-grained superalloy	61
5.2.2. Passage from cubic symmetry to transverse isotropic symmetry	62
5.2.3. Rafting	65
5.2.4. Precipitation in Inconel 718	66
5.3. Elasticity and physical properties	69
5.3.1. Phase transformations	69
5.3.2. Magneto-elasticity	72
5.3.3. Ferroelectricity and phase transformation	74
5.4. Influence of porosity and damage on elasticity	75
5.4.1. Isotropic porosity	75
5.4.2. Anisotropic porosity	77
5.4.3. Micro-cracks and extreme porosity	78
5.5. The mystery of the diamond structure	79
5.6. What about amorphous materials?	81
5.7. Inelasticity and fine structure of crystals	84
5.7.1. Relaxation of substitutional defects	85
5.7.2. Relaxation of interstitial defects	87
Part 2. Lagrangian Theory of Vibrations: Application to the Characterization of Elasticity	91
Introduction to Part 2	93
Chapter 6. Tension–Compression in a Cylindrical Rod	95
6.1. Tension–compression without transverse deformation	95
6.2. Tension–compression with transverse deformation	97
6.3. Determination of E and ν of isotropic and anisotropic materials	98

Chapter 7. Beam Bending	101
7.1. Homogeneous beam bending without shear.	101
7.2. Homogeneous beam bending with shear.	103
7.2.1. Homogeneous beam bending with shear (rotation)	103
7.2.2. Homogeneous beam bending with shear (deformation)	107
7.2.3. Homogeneous beam bending with shear (comparison).	112
7.3. Application to the characterization of the elasticity of bulk materials	113
7.4. Composite beam bending (substrate + coating).	114
7.5. Composite beam bending (substrate + “sandwich” coating)	117
7.6. Application to the characterization of single coatings	117
7.7. Three-layer beam bending	120
7.8. Multi-layered and with gradient in elastic properties of materials.	123
Chapter 8. Plate Torsion	127
8.1 Torsion of homogeneous cylinder	127
8.2. Torsion of homogeneous plate	128
8.3. Determination of the shear modulus and Poisson’s ratio for bulk materials	131
8.4. Torsion of composite plate.	134
Chapter 9. Thin Plate Bending	137
9.1. Bending vibrations of a homogeneous thin plate.	137
9.2. Application to the characterization of thin plate elasticity	139
Chapter 10. Vibration Measurements and Macroscopic Internal Stresses	145
10.1. Experimental evidence of the relaxation of the internal stresses of bulk materials	145
10.2. Internal stresses and homogeneous beam vibration.	148
10.3. Analysis of the profile of internal stresses of coated materials (static case).	150
10.3.1. Analysis of the profile of symmetric double coating stresses	150
10.3.2. Analysis of the profile of single coating stresses.	151
10.4. Influence of internal stresses on the vibrations of coated materials	154
10.4.1. Influence of internal stresses on the vibrations of coated materials in sandwich configuration.	154

10.4.2. Influence of internal stresses on the vibrations of coated materials in single coating configuration	155
10.5. Application to the determination of internal stresses of coated materials	157
Conclusion	163
References	165
Index	171