

Contents

Introduction	9
1 Basic model relations for the heterogeneous thermoelastic solid with surface geometric inhomogeneity	13
1.1 The base of the model description	13
1.2 Constitutive relations	15
1.3 Conclusions	23
2 Heterogeneous elastic bodies	25
2.1 Boundary value problems for steady-state	25
2.1.1 Key equation systems	26
2.1.2 Boundary conditions	28
2.2 Steady-state of layer	30
2.2.1 Force-free layer	30
2.2.2 Estimation of model parameters	40
2.2.3 Steady-state of the stretched layer	44
2.2.4 Size effect of layer strength	47
2.2.5 Asymmetric mass sources	51
2.2.6 Boundary conditions and effects associated with near-surface non-homogeneity	58
2.3 Bodies of cylindrical geometry	62
2.3.1 Solid cylinder	62
2.3.2 Cylinder strength. Size effect of strength	67
2.3.3 Medium with cylindrical circular cavity	68
2.4 Bodies of spherical geometry	71
2.4.1 Solid sphere	71
2.4.2 Medium with spherical cavity	72
2.5 The mass density-dependent moduli of elasticity	76
2.5.1 Near-surface non-homogeneity in the half-space	78
2.5.2 Steady-state of the layer	81

2.5.3	Young's modulus and Poisson's ratio	86
2.5.4	Layer strength.....	91
2.6	Wave processes in heterogeneous solids.....	94
2.6.1	System of equations	94
2.6.2	Influence of structural heterogeneity of material and inhomogeneity real body surface on natural frequencies of layer oscillations.....	96
2.7	Contribution of interface factor into acoustic emission in solids.....	103
2.7.1	Half-space dynamic behavior caused by instantaneous change of mass density at the surface.....	103
2.7.2	Dynamic behavior of medium with spherical cavity	107
2.8	Conclusions	110
3	Solid solutions	113
3.1	Basic relations of the binary solid solution model	113
3.1.1	Solving system of equations.....	117
3.1.2	Steady state. Key system of equations.....	118
3.2	Long range interaction and skeleton material heterogeneity	119
3.3	Steady state of a two-component layer	120
3.3.1	Force free layer	122
3.3.2	Layer strength.....	127
3.4	Steady state of a two-component cylinder.....	128
3.4.1	Force free cylinder	130
3.4.2	Effect of admixture on the solid cylinder strength	136
3.5	Mass density dependent moduli of elasticity.....	138
3.5.1	Near-surface non-homogeneity in the layer	139
3.5.2	Size effects	140
3.5.3	The strength of the layer	145
3.6	Near-surface diffusion acceleration.....	147
3.7	Conclusions	150
4	Heterogeneous electrically conductive solids	151
4.1	Balance equations and constitutive relations.....	151
4.1.1	Solving system of equations.....	156
4.2	Bodies with flat boundaries	161
4.2.1	Near-surface non-homogeneity in half-space	161

4.2.2 Layer steady state	167
4.2.3 Electron subsystem and size effect of layer strength	177
4.3 Bodies of cylindrical geometry	179
4.3.1 Solid cylinder	179
4.3.2 Cylinder strength	195
4.3.3 Infinite medium with cylindrical cavity	197
4.4 Bodies of spherical geometry	205
4.4.1 Solid sphere	205
4.4.2 Infinite medium with spherical cavity	210
4.5 Near-surface non-homogeneity: size effects of strength and elasticity moduli	213
4.5.1 Near-surface non-homogeneity in half-space	214
4.5.2 Electron subsystem and size effect of elastic moduli	217
4.5.3 Layer strength and dependence of elastic moduli on mass density	220
4.6 Conclusions	224
References	227

objects feature is the proportionality of contributions of surface and bulk factors in internal energy, and the heterogeneity of physical and mechanical fields causes the existence of thermodynamic forces along with the simultaneous absence of thermodynamic flows at equilibrium. In engineering practice, there is generally known the dependence of strength, corrosion resistance, etc. on the roughness (geometric inhomogeneity) of the body surface. Surface and structural non-homogeneities are associated with various size effects, including strength limits, moduli of elasticity, and so on. Modeling of such non-homogeneities usually takes into account long-range interaction, i.e. the dependence of the state at the body point under consideration on the state of other points.

Without reviewing the extensive literature on long range interaction we note that various nonlocal and gradient theories [5, 11, 27, 28, 32, 63, 71, 93, 95, 96, 98, 118] and models constructed using homogenization methods [9, 31, 35, 37, 59, 120] consider such phenomena.

This book presents an original approach to the construction of nonlocal models of solid mechanics. The approach is based on the basic principles of thermodynamics of nonequilibrium processes and the functional dependence between thermodynamic flows and forces. Among the influence functions in functional kinetic equations are those