Thematic areas "***Physico-chemical nanomaterials science***"

A local gradient continuum theory for thermoelastic nonferromagnetic dielectrics: Accounting for electrics and mass quadrupole moments

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A complete set of equations of local gradient electro-thermo-mechanics of non-ferromagnetic dielectrics is obtained within the framework of the continuum-thermodynamic approach that accounts for mass and electric charge fluxes of a non-convective and non-diffusive nature (local mass displacement [1] and an electric polarization current). We assume that the above mass and electric fluxes are caused by the change of not only the dipole moments but also the quadrupoles of the mass and electric charge. We find that compared to the classical theory of dielectrics, the space of thermodynamic constitutive variables additionally includes the following four pairs of conjugate parameters: (i) the density of induced mass and the modified chemical potential, (ii) the mass dipole moment and the gradient of the modified chemical potential, (iii) the mass quadrupole moment and the second gradient of the modified chemical potential, (iv) the electric quadrupole moment and the gradient of the electric field. We analyze the connection between the obtained set of equations and the equations of several gradient-type theories that have been previously proposed in the literature [2, 3]. The mass forces that appear in the equation of motion as a result of accounting for the local mass displacement are investi-

gated. The key set of equations is obtained for a linearized approximation, along with the corresponding boundary-value conditions. We demonstrate the ability of the proposed gradient-type theory to describe the near-surface and size effects.

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