Physico-chemical nanomaterials science

A gradient-type continuum theory for thermoelastic dielectrics: Accounting for mass and charge transfer due to structural changes

V. F. Kondrat[1], O. R. Hrytsyna[2]

[1] *Hetman Petro Sahaydachnyi National Army Academy, Heroiv Majdanu str. 32, Lviv, 79000, Ukraine.*

[2] *Center of Mathematical Modeling of Pidstryhach Institute for Applied Problems of Mechanics and Mathematics, National Acad. of Sci. of Ukraine. Dudajev str. 15, Lviv, 79005, Ukraine.*

E-mail: gryt045@gmail.com

It is well known that classical theories of piezoelectrics cannot describe a number of the available experimental results [1, 2]. To correct this shortcoming, gradient or nonlocal-type theories of dielectrics have been developed. There are a few approaches to formulation of such theories [1, 2]. In a recent work [3], a novel continuous thermodynamic approach was introduced that accounts for non-convective and non-diffusive mass fluxes. Here, we relate these fluxes to the local mass displacements caused by the changes in the material structure. We also analyze the relation of this approach to other nonlocal theories [1, 2]. In addition, we show how the gradient-type theory of dielectrics can be formulated by taking into account the polarization fluxes only, whereby the higher-order electric moments are taken into account (for example, the quadrupole moment). We consider also the case of local mass displacements.

The equations governing the motion of a dielectric within the framework of our theory are written down. We propose a method to account for the inertia and irreversibility of local mass displacements and polarizations. We also show how to transform the gradient-type constitutive equations to non-local constitutive equations of integral-type. The possibility to use the proposed approach to describe near-surface phenomena and structure with local sources is discussed.

1. *Yang J. S.* Review of a few topics in piezoelectricity // Appl. Mech. Rev. – 2006. – **59**. – P. 335-345.
2. *Kondrat V., Hrytsyna O.* The linear theories of electro-magneto-mechanics of dielectrics // Phys. & Math. Modeling and Inform. Technology. – 2009. – Issue 9. – P. 7-46. (In Ukrainian)
3. *Burak Ya., Kondrat V., Hrytsyna O.* Fundamentals of the local gradient theory of dielectrics. – 2011, Uzhgorod: Lira. – 208 p. (In Ukrainian)