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Abstract:

Thermoelastic analysis at micro and nano-scale is becoming important along with the miniaturization of the device and wide application of ultrafast lasers, even the novel laser burst technology, where size effect on heat conduction and elastic deformation increase and classical theory of thermoelastic coupling does not hold any more. In this work, a size-dependent thermoelastic model is established for higher order simple material by adopting both the size effect of heat conduction and elasticity with the aids of extended irreversible thermodynamics and generalized free energy. It is proven that the present model is in essence identical to the coupling of nonlocal heat conductive law (GK model) and nonlocal elastic (stress gradient) model. Also, higher order boundary conditions for stress tensor and heat flux are presented and discussed. For numerical evaluation, a bi-layered structure is considered with interfacial thermal contact resistance and elastic wave impendence incorporated. From numerical results, the effects of size-dependent characteristic lengths and material constants of each layer on the transient responses are discussed, systematically. This study is expected to be helpful for theoretical modeling of thermoelasticity at nano-scale, and may be beneficial to design of nano-sized and multi-layered devices.

Key words: Size effect; Extended irreversible thermodynamics; High order simple material