Interfacial stresses in bimaterial composites with nanosized interface relief

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ABSTRACT

At the macrolevel, the effect of surface/interface energy for a stressed solid is ignored as it is small compared to the bulk energy. However, the surface/interface effects become significant for nanoscale materials and structures due to the high surface-to-volume ratio. In particular, the surface/interface stresses are directly related to the size effect, that means the material properties of a specimen depend on its size. The continuum surface/interface stress model assumes that solid consists of bulk and surface phases which coherent bonded and have different elastic properties. The consideration of this model helps to understand the unusual elastic properties of nanomaterials.

In this work, we compare analytical and numerical solutions for 2-D solid mechanics problems of elastic bimaterial composites with a nanometer interface relief that arises on a boundary between two different bulk phases (the first problem) and on an interface of a nearly circular inclusion (the second problem). It is supposed that the uniform stress state takes place at infinity. Contact between two domains satisfies to the ideal conditions of cohesion. The conditions at the interface are formulated according to the generalized Laplace – Young law [1], and the simplified Gurtin – Murdoch's surface/interface elasticity model [2] which is applied to take into account the interfacial stress effect. The problems are solved in terms of Goursat – Kolosov complex potentials [3]. Following the work [4], we use first-order boundary perturbation method that leads to the successive solutions of the singular integro-differential equation in unknown interfacial stress. To solve the described problems numerically, we use finite-element method.

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