Variational bounds for the effective electroelastic moduli of piezoelectric composites with electromechanical coupling spring-type interfaces

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The present work focuses on variational bounds for the effective electroelastic moduli of multiphase piezoelectric composites with electromechanical coupling spring-type interfaces. Both the inhomogeneities and the matrix are assumed to be piezoelectric and transversely isotropic. The inhomogeneities are assumed to be spheroidal. The effective properties of the piezoelectric composite with interfacial imperfection are defined and the principles of minimum internal energy and enthalpy are derived. These principles are applied to obtain the upper and lower bounds for the effective electroelastic moduli. An example of a two-phase composite is given for detailed discussion, where dependence of the electroelastic moduli and their bounds on the inhomogeneity shapes and orientations as well as the interface properties is provided and discussed. To qualitatively account for the dependence, analysis based on two possible mechanisms, i.e., the simple mixture rule of composite and the weakening effect by imperfect interface, are also provided.

Keywords: Piezoelectric composite, Spring-type interface, Electromechanical coupling, Variational bounds, Effective electroelastic moduli