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Modelling of thermo-electro-magneto-mechanical properties of layered magnetostrictive-piezoelectric laminate composites

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Abstract:

In this study, the effective magneto-electro-thermo-mechanical properties of multiferroic tri-layer composite are calculated, which are based on equivalent layered approach where all the three phases are considered for homogenization. Also, the influence of epoxy are evaluated because it may have great impact on the composite. According to this analytical model, the homogenization is achieved in two steps. In the first step, homogenization of the piezoelectric layer and the epoxy matrix is done (Homogenization I). In the second step, the magnetostrictive layer is homogenized with Homogenization I. This model is developed based on a set of simple approximations such as iso-strain and iso-stress equilibrium conditions, "rule of mixtures" and that the matrix has perfect bonding (no slip between fiber and matrix interface). This analytical model does not consider the geometric properties such as shape, dimension of fiber and matrix as well as interface effects. Furthermore, the study is focused on the thermal properties if the magneto-electro-elastic (MEE) composites by varying the volume fractions of the piezomagnetic, piezoelectric and epoxy phases. For $BaTiO_3$-epoxy-$CoFe_2O_4$ multilayer composite, it is clear that the epoxy have significant effect on the composite, and it cannot be ignored. What's more, the volume fraction of constituting layers on the magnetoelectric coefficients are investigated. The magneto-electric effect cannot be found in any individual phase, but it can be observed in the composite and the value of it depends on the percentages of the three phases. Last but not least, the present model can be used for optimizing parameters in the layout/material design of these multilayers for a maximized product property, such as magnetoelectric property. Influence of temperature gradients is considered on the mechanical, electrical and magnetic properties MEE composites is also studied. Numerical comparisons are made with different exiting models in the literature to show the effectiveness of the developed analytical model.