

Numerical computation of the effective properties of smart composite materials

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ABSTRACT

The design of composite materials requires microstructurally based computational approaches to optimize the shape and the spatial arrangement of the constituents with respect to a sought-after effective property. This topic remains widely opened especially in the case of heterogeneous media which exhibit multifield couplings in their constitutive relations. Up to now, the numerical homogenization schemes widely used in this framework rely on the use of the finite-element method. We present results obtained with an alternative scheme based on fast Fourier transforms which has become popular for the study of the mechanical properties (elasticity, viscoplasticity, among others) of polycrystals and composite materials. It allows to consider unit-cell problems presenting complex microstructure with fine-scale information within reasonable computing times. Besides, it does not require a specific meshing of the microstructure. In this discussion, attention is paid to the linear properties of smart composite materials, used as sensors or actuators, with piezoelectric and magnetoelastic constituents. The numerical scheme proposed consists in the iterative resolution of periodic coupled Lippmann–Schwinger equations using the uncoupled Green operators (relative to elasticity, permittivity, and permeability) of a reference medium. The numerical results, on the effective response and the local fields, for various multifield couplings and microstructural cases, are compared with analytical solutions and finite element results.