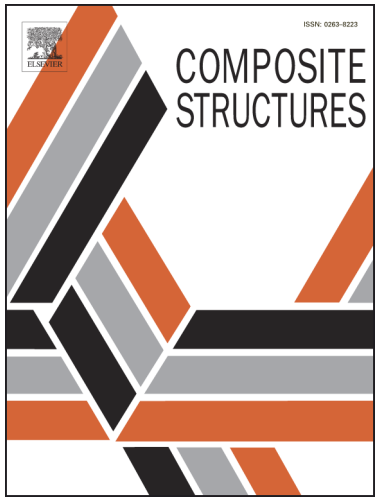

Static nonlinear model of both ends clamped magnetoelectric heterostructures with fully magneto-mechanical coupling

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Static nonlinear model of both ends clamped magnetoelectric heterostructures with fully magneto-mechanical coupling

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Abstract

A static fully magneto-mechanical coupling nonlinear model of magnetoelectric (ME) effect in both ends clamped magnetostrictive/piezoelectric heterostructures is established. The magnetoelectric effect, which arose from piezoelectric effect driven by magnetostrictive force, is studied. As the both ends of the heterostructures are fixed, the piezoelectric material can be equivalent to the linear spring load of magnetostrictive actuator. The nonlinear theoretical model is built based on a nonlinear magnetostrictive constitutive relation and a linear piezoelectric model. The hysteresis and fully coupled magneto-mechanical effects, including stress-dependent magnetization, stress-dependent magnetostriction and ΔE effect of magnetostrictive material are considered in this model. Using the model, the influence of the pre-stress, magnetic field and the length fraction of the magnetostrictive material on the magnetoelectric response is qualitatively predicted. Furthermore, the model can explain the "self-biased" response caused by the hysteretic characteristics of the ME composites. A ME heterostructures prototype is designed and manufactured based on Terfenol-D/PZT heterostructures. The model is validated by comparing the simulated ME response with experiment at the quasi-static condition. The nonlinear ME model provides a theoretical basis for the optimization design of high-performance ME devices.

Keywords: Magnetoelectric effect, Static nonlinear magnetoelectric model, Fully magneto-mechanical coupling, Magnetoelectric hysteresis

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