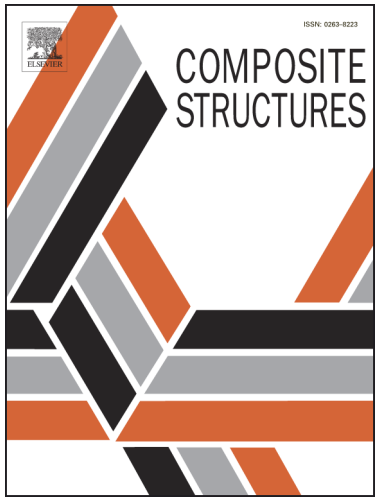

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Theoretical prediction of Resonant and off-resonant Magnetoelectric Coupling in Layered Composites with Anisotropic Piezoelectric Properties

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ABSTRACT

In order to explain unique magnetoelectric (ME) coupling behaviors found in a trilayer ME laminate having a piezoelectric crystal particularly with anisotropic planar piezoelectric properties, a theoretical model based on the average field method is developed. New analytical expressions could be derived to predict the transverse ME voltage coefficients at off- and in-resonance frequencies respectively. It is predicted that transverse ME voltage coefficients should be anisotropic under in-plane magnetic fields at both off- and in-resonance frequencies. Furthermore, numerical simulations based on material parameters of a representative 2-2 trilayer, composed of Metglas/[011] $Pb(Mg_{1/3}Nb_{2/3})O_3$–$PbTiO_3$ crystal/Metglas, prove the emergence of multiple resonance frequencies and characteristic phase difference in the complex ME voltages at each resonant frequency. All these theoretical predictions are in good agreement with the experimental results both at off- and in-resonant frequencies. The theoretical expressions developed here could be broadly applicable to the various types of layered ME laminates with a piezoelectric material with or without anisotropic piezoelectric coefficients.