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The theoretical ultimate magnetoelectric coefficients of magnetoelectric composites by optimization design

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We investigate what is the largest magnetoelectric (ME) coefficient of ME composites, and how to realize it. From the standpoint of energy conservation, a theoretical analysis is carried out on an imaginary lever structure consisting of a magnetostrictive phase, a piezoelectric phase, and a rigid lever. This structure is a generalization of various composite layouts for optimization on ME effect. The predicted theoretical ultimate ME coefficient plays a similar role as the efficiency of ideal heat engine in thermodynamics, and is used to evaluate the existing typical ME layouts, such as the parallel sandwiched layout and the serial layout. These two typical layouts exhibit ME coefficient much lower than the theoretical largest values, because in the general analysis the stress amplification ratio and the volume ratio can be optimized independently and freely, but in typical layouts they are dependent or fixed. To overcome this shortcoming and achieve the theoretical largest ME coefficient, a new design is presented. In addition, it is found that the most commonly used electric field ME coefficient can be designed to be infinitely large. We doubt the validity of this coefficient as a reasonable ME effect index and consider three more ME coefficients, namely the electric charge ME coefficient, the voltage ME coefficient, and the static electric energy ME coefficient. We note that the theoretical ultimate value of the static electric energy ME coefficient is finite and might be a more proper measure of ME effect.

Keywords: magnetoelectric composite; magnetoelectric coefficient; optimization