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Abstract

## **Homogénéisation des structures multiferroïques multicouches avec propriétés couplées magnétoélectriques**

### **Homogeneization of multiferroic structures with coupled magnetoelectric properties**

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This work deals with the determination of the effective response of a multilayered or laminated heterostructure composed of materials with an arbitrary coupled anisotropic behavior. In particular, we elaborate a fully algebraic technique for obtaining the homogenized parameters of a magneto-electro-elastic system (artificial multiferroic). To do this, we load the system with an arbitrary electromagnetic/mechanical generalized action and we calculate the coupled physical fields within each layer. Then, we determine the average values of these fields, eventually obtaining the effective tensor response of the whole structure. The theory has been developed for an arbitrary lamination direction, taken into account by means of an ad hoc lamination tensor  $P$  whose components are obtained in closed form. Its implementation is based on simple matrix algebra and does not require any extensive computation. Moreover, the formalism has been generalised to graded structures and to multiple-rank laminated materials. We also propose an explicit procedure for the homogenization of laminated magneto-electro-elastic nonlinear materials. It means that we determine the effective response of a multilayered structure composed of materials with an arbitrarily nonlinear and anisotropic coupled behavior.