Aspects of the Multiscale Modeling of Electromechanically Coupled Materials

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The contribution covers the multiscale modeling of electromechanically coupled materials. It will discuss homogenization procedures for piezoelectric materials as well as the efficient determination of overall material parameters.
The continuum mechanical description of piezoelectric material behaviour in general follows a phenomenological law that represents the main characteristics of the polycrystalline material. However, when it is desired to capture a wider range of microscopic effects, the phenomenological approach on the macroscale is often not sufficient. To this end two homogenization approaches are formulated, which are both reflecting the heterogeneous crystal setup of the piezoelectric material up to certain accuracy. The thermodynamically consistent formulations are able to generate the macroscopic material response without using an explicit macroscopic material law. For the individual domains on the mesoscale we use a transversely isotropic model, see [1], [2].
The first approach uses orientation distribution functions for the domain orientations, which are attached to every material point of the macroscopic model [3]. In this context a thermodynamically consistent formulation for the description of the polycrystalline behaviour of the piezoelectric material will be derived and several applications will show the efficiency of the proposed formulation.
The second approach is based on an FE^2-formulation and accounts for a discrete representation of the mesoscopic scale [4]. The mesoscopic scale is represented by representative volume elements and connected to the macroscale by use of boundary integrals. Based on this approach, efficient algorithms for the determination of overall material properties are derived. Therewith the macroscopic moduli of micro-heterogeneous electromechanically coupled materials can be accurately computed.

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