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TWO-SCALE COMPUTATIONAL HOMOGENIZATION OF ELECTROACTIVE POLYMER COMPOSITES AT FINITE STRAINS

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The development of numerical strategies for the simulation of electroelastic materials undergoing large strains could be useful for the design and optimization of advanced technical applications in the area of large-strain electromechanical actuation. Potential applications include, for example, artificial muscles or robotics [1]. From a practical viewpoint, materials capable of delivering very large or "giant" deformations under applied electric fields are particularly attractive. Thus, the enhancement of effective actuation is important for the development of technically relevant electroactive elastomers. The effective coupling of dielectric elastomers can drastically be enhanced by the addition of high-electric-permittivity particles [2]. This phenomenon can be explained by the following two effects: firstly, the overall electric permittivity is increased. Secondly, the high contrast of the individual phases on the microlevel induces pronounced electric-field fluctuations [3]. Both contributions lead to an increase in electrostatic stress and thus electroactivity. The resulting *electroactive polymer composites* have been investigated on a theoretical basis by using, for example, finite element simulations [4] and homogenization techniques based on sequential laminates [5].

The present contribution aims at providing a *two-scale computational homogenization framework* for electroelastic materials at finite strains. This framework can be applied to the simulation, characterization and optimization of electroelastic solids undergoing large deformations. In detail we derive a coupled FE^2-method, which solves a macroscopic boundary-value problem in consideration of the response of attached microscopic representative volume elements. This computational method is well established in the

context of purely mechanical problems [6, 7] and has been extended to the homogenization of physically coupled phenomena like, for example, thermo-, electro-, and magneto-mechanics [8, 9, 10].
We will apply the method to the simulation of *dielectric polymer-ceramic composites* and analyze the influence of the choice of inclusion material and shape on the overall actuation performance of electroelastic actuators. Finally, we show the applicability of the method to the fully coupled two-scale simulation of electroelastic boundary value problems at finite strains.

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