Homogenization based modelling of electroactive porous metamaterials with nonlinear effects

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Abstract

We consider electroactive porous metamaterials which can serve for fluid transport, or shape morphing due to the pore inflation effect. The conference paper is devoted to the homogenization based modelling of periodic structures accounting for nonlinearities arising with moderate deformations which require to respect equilibria satisfied in deformed configurations. The micromodel describes the fluid-structure interaction in periodic porous structures with electroactive elements, such as the piezoelectric, or flexoelectric segments controlable by external electric circuits. Such microstructures can induce the fluid flow due to the peristaltic deformation which is generated by the piezoelectric, or flexoelectric actuators. The cell problems (at the micro-level) provide characteristic responses of the microstructures with respect to macroscopic strains, fluid pressure and electric potentials. The homogenized model is derived under the small deformation assumption. However, the nonlinearity associated with deforming configuration is respected by deformation-dependent homogenized coefficients of the hypoelastic constitutive law and all other effective (homogenized) material parameters evaluated using the characteristic responses of the microstructure. To reduce the computational efficiency, the sensitivity analysis of the homogenized coefficients with respect to deformation induced by the macroscopic quantities is employed (1). This enables to avoid the two-scale tight coupling of the macro- and microproblems otherwise needed in nonlinear problems using the "FEˆ2" method. The paper summarizes our recent theoretical results: piezoelectric effective properties generated by weakly flexoelectric microstructures, controlable weakly piezoelectric microstructures, and inflatable microstructures equipped with automatic, or controlled valves, and the unilateral selfcontact in deforming porosities (2). All the effective material models are derived using the asymptotic homogenization applied to incremental formulations. The models are implemented in the SfePy finite element code (sfepy.org)

(1) E. Rohan, V. Lukeš, Homogenized model of peristaltic deformation driven flows in piezoelectric porous media, Computers & Structures, Volume 302, 2024, 107470, ISSN 0045-7949,

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