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POWER OPTIMIZATION FOR PIEZOELECTRIC VIBRATIONS ENERGY HARVESTERS WITH MATERIAL TAILORING

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Summary: This work tailors piezoelectric materials properties using the homogenization method to achieve higher electrical power output for the unimorph piezoelectric harvester configuration. Two piezoelectric materials are considered for this purpose: BaTiO3 and PZN-4.5%PT single crystals. Each piezoelectric material is tailored as a single crystal, polycrystalline or as a piezocomposite with polymer PVDF-TrFE. The tailored or homogenized properties are calculated based in the method of asymptotic homogenization which is implemented using the finite element method. A computational model is developed to optimize the harvester power output for various loadings. The different harvesters are tuned for ambient vibrations and modelled using the finite element method. As design variables one considers, for the single crystal its orientation, for the polycrystalline material the microstructural orientation distribution of the grains and for the piezocomposite the piezoelectric grains orientations, unit cell piezoelectric material volume fraction and polymer orientation. To do the optimization a simulated annealing algorithm is used. Several examples are presented and discussed considering harvester excitation near and far away resonance frequency. A sensitivity study for the electric circuit resistance is performed.