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Piezoelectric Material Tailoring for Vibrations Energy Harvesters Power Optimization

A.M. Matos[1], J.M. Guedes[1], K.P. Jayachandran[1] and H.C. Rodrigues[1]

[1] LAETA, IDMEC, Lisbon University

Abstract

This work presents piezoelectric material tailoring by the method of asymptotic homogenization to create piezoelectric vibrations energy harvesters capable of producing higher electrical power. The considered piezoelectric materials are BaTiO3 and PZN-4.5%PT single crystals. A computational model is developed to optimize the harvester output power considering the unimorph and bimorph traditional vibration harvesters configurations. These configurations are tuned for ambient vibrations and modelled using the finite element method. Single crystal, polycrystalline materials and piezocomposites made by piezoelectric and polymer materials are considered in the optimization procedures. Polycrystalline and piezocomposites properties are computed through a computational model based in the homogenization theory and implemented using the finite element method. As design variables one considers, for the single crystal case its orientation, for the polycrystalline material the microstructural orientation distribution of the grains and for the piezocomposite the piezoelectric material orientation or grains orientations in the case of polycrystalline, the unit cell piezoelectric material volume fraction and polymer orientation. A simulated annealing algorithm is used as optimizer. Several examples are presented and discussed considering excitation near and far away of resonance frequency for both unimorph and bimorph configurations. Also sensitivity for the electric circuit resistance is performed.