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Electromechanical simulation and analysis of perovskite piezoelectric unimorph cantilever nanogenerator with interdigitated electrodes in vibration energy harvesting application

H Nikbakht Kashkooli[1], A Assadi[2], and P Boroojerdian[1]

1. Department of Applied Science, Malek Ashtar University of Technology (MUT), Shahin Shahr, Iran.
2. Faculty of Mechanics, Malek Ashtar University of Technology (MUT), , Iran

E-mail: assadi@mut-es.ac.ir

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Abstract

This paper addresses a unimorph cantilevered piezoelectric nanogenerator having high output power through vibrational energy harvesting that is simulated using finite element method (FEM). The simulations are done for three types of perovskite piezoelectric materials including PZT, PMN-PT and MAPbI3. The interdigitated electrodes were exploited to obtain longitudinal vibration mode using d33 mode of piezoelectric layer during the bending of nanogenerator structure. The presented structure consists of a piezoelectric nanolayer with gold interdigitated electrodes on it, which is placed on a flexible PET polymeric substrate. To encapsulate the piezoelectric layer, an SU-8 epoxy is placed over the surface. The poling process is also simulated by applying high voltage through IDs to piezoelectric layer. Generally, the electric potential distribution of the piezoelectric layer must be performed by applying mechanical loadings. Then the output voltage, power for free vibrations and base excitation (0.25-2g) of the nanogenerator at resonance frequency are investigated. The resonance frequency of the PZT, PMN-PT, and MAPbI3 were calculated to be 549 Hz, 560.5 Hz and 631 Hz, respectively. We found that PZT piezoelectric materials yields maximum output voltage and electrical power values of 91.69 V and 350 mW which shows better performance in vibrational energy harvesting application. In comparison, the results of the simulation implied a good agreement with other experimental studies. The unimorph piezoelectric energy harvester system generates high voltage and output power in response to sub-kilohertz ambient vibration.

Keywords: perovskite piezoelectric nanogenerator, interdigitated electrodes, high output power, fem electromechanical simulation, vibration response

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