Energy harvesting using a piezoelectric-flexoelectric nanobeam

Fehmi Najar[1], Hatem Samaali[1,2], Sourour Baroudi[1]

[1]Applied Mechanics and Systems Research Laboratory, Tunisia Polytechnic School, University of Carthage, BP 743, La Marsa 2078, Tunisia.
[2]Sousse National Engineering School, BP 264 Sousse Erriadh 4023, University of Sousse, Tunisia.

ABSTRACT

Flexoelectricity can be defined as an electromechanical coupling between polarization and strain gradient. In contrast with piezoelectricity, flexoelectricity is largely dominant at the nanoscale. Using a developed electromechanical model of a $BaTiO_3$ nanobeam, we simulate the dynamic behavior of the device when it is subject to a base harmonic excitation representing mechanical vibrations from the environment.

The coupled electromechanical model is first derived using the Hamilton's principle and accounting for the von Karman strain for relatively large displacements. Therefore, the Differential Quadrature Method is used to discretize the space domain for the transverse displacement and the electric potential. The obtained reduced-order model is solved in time for the deflection of the nanobeam and the generated electrical voltage across a resistance load.

The nonlinear dynamic response of the nanobeam and the generated electrical power are solved using a continuation technique. The results depicted higher power density generation when the aspect ratio of the nanobeam is reduced. The scale effect due to the nonlocal aspect of the formulation mitigate the expected performance of the device.

Keywords: Flexoelectricity, nanobeam, energy harvesting, strain gradient theory.