Optimization Of The Geometry Of MEMS Piezoelectric Energy Harvester Cantilevers

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Abstract

Here we optimize the geometry: proof mass length Lm to total length L, thickness of the piezoelectric material (Tp) to total cantilever thickness (T) for obtaining the maximum stress distribution (Smax), output voltage (Vout) and power performance (Pout) of the unimorph Cantilever beam based PEH. . The MEMS cantilever design has a piezoelectric material Lithium Niobate, placed on a silicon (Si) cantilever based on SOI wafer on 350 µm handle layer and 1 µm oxide layer with one end fixed and others free to vibrate . Solid mechanics, electrostatics, electrical circuits are the modules/physics used for FEM in this work. Triangular mesh with the minimum element size of 500 nm was used. The isotropic damping loss factor of 5% was considered for cantilever the beam during the simulation under a force of 1 N and acceleration 1g. The PEH is designed to work in d31 mode by applying floating potential for the upper electrode and grounding the lower electrode while all other faces of the piezoelectric layer are kept at zero charge constraint. The maximum output power (Pout) was obtained at the Lm/L ratio ~ 0.4. Also, it was obtained that the maximum stress developed inside the beam is near the root of the beam when the ratio r= Tp/T is close to 2. The results are compared with the analytical equations involving Euler-Bernoulli model with single clamped beam. This study therefore throws insight on increasing the electromechanical coupling for a given geometry and therefore the electrical outputs of the harvester.

Figures used in the abstract

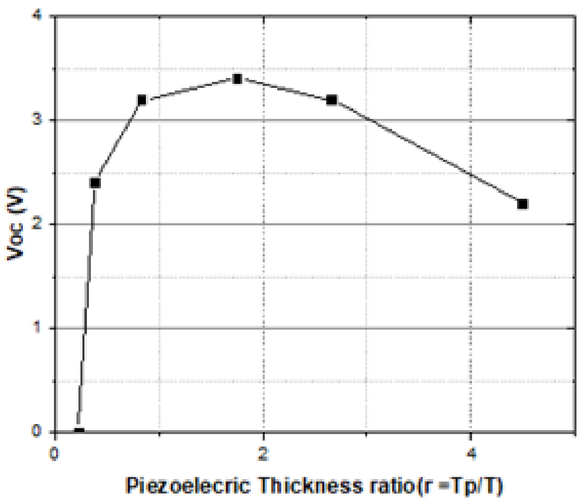

Figure 1 : Dependence of the Open circuit Voltage (Voc) with the piezoelectric thickness ratio (r=Tp/T)

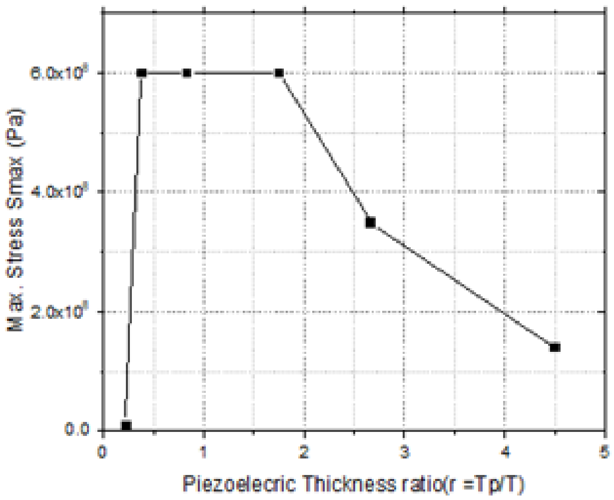

Figure 2 : Dependence of the (a) Maximum stress with the piezoelectric thickness ratio (r=Tp/T)

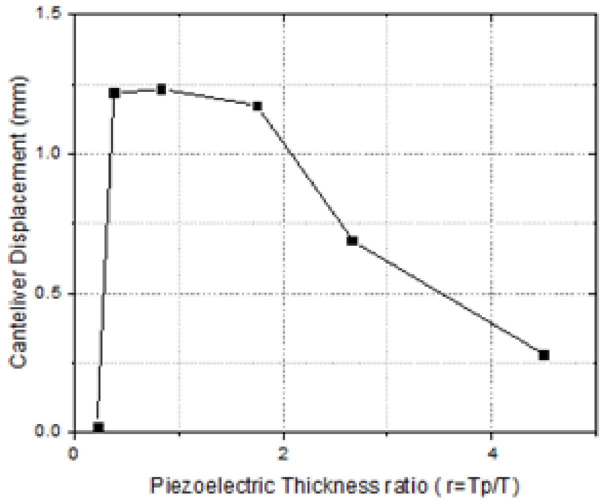

Figure 3 : Dependence of the Cantilever displacement on thickness ratio (r=Tp/T)