Study of Effect on Resonance Frequency of Piezoelectric Unimorph Cantilever for Energy Harvesting

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Objective: In this work the effect on resonance frequency and power enhancement techniques of piezoelectric MEMS is studied .The ambient vibration energy is used as a source of mechanical energy to power a piezoelectric cantilever. The modeling is done using COMSOL Multiphysics, the obtained simulation results are compared with theoretical analysis done with a user-friendly MATLAB/Simulink.

Construction of Simulink model: The equations for Unimorph piezoelectric cantilever is given by:

$$\frac{V_{in.ave}}{F} = \frac{1}{2} L_1 g_{31} \frac{E_p}{wD_1}\left(t_{n1}t_p + \frac{1}{2}t_p^2\right)$$

$$\frac{V_{in.ave}}{h_{tip}} = \frac{3}{4}\frac{g_{31}E_s t_s E_p t_p (t_s + t_p)}{L^2(E_s t_s + E_p t_p)}$$

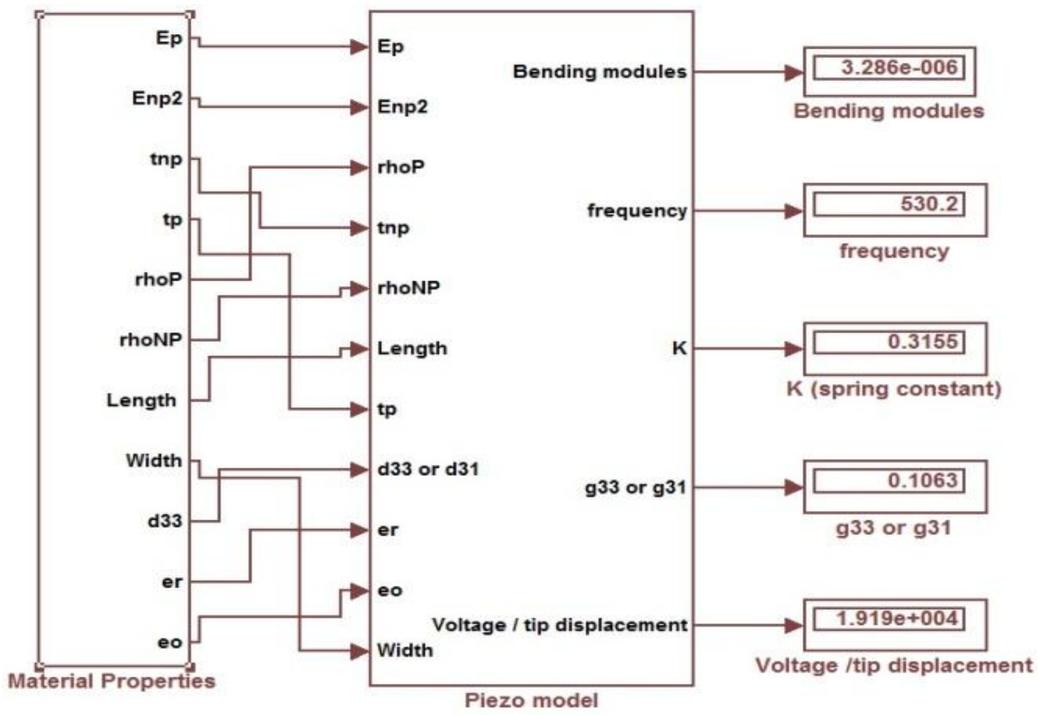

Fig. 1 Simulink model of piezoelectric unimorph cantilever

Results:

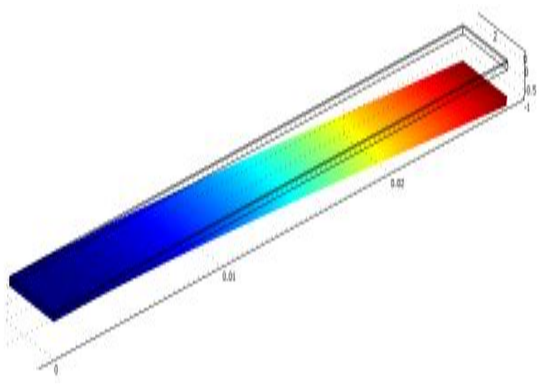

Fig . 2 Piezoelectric Microcantilever in COMSOL

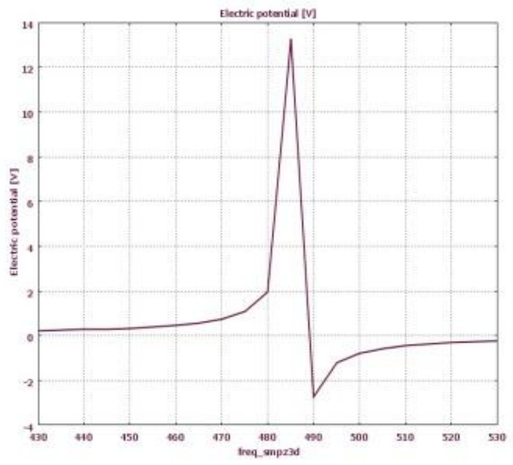

Fig. 3 Frequency Response of piezoelectric micro cantilever

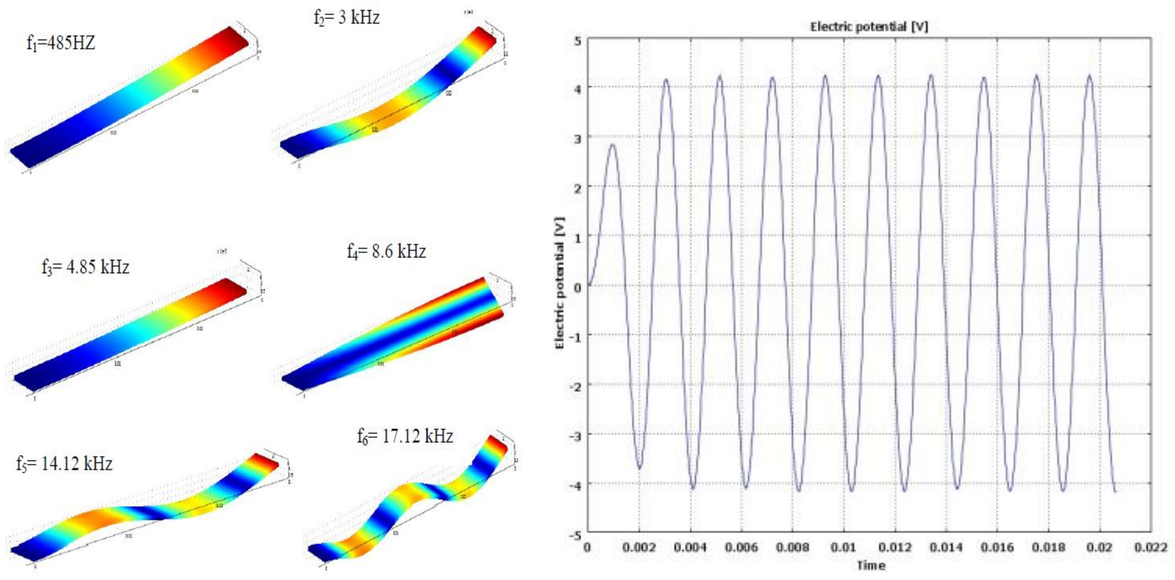

Fig. 4 Model frequency .

Fig. 5 Transient Response .

Table 1. Performance Comparison With Reported MEMS Harvesters

Ref	Device	Dimension	Vpeak	F(Hz)	FOM
[1]	d_{31} PZT	2mm X .6mm X 1.64μm	0.45	608	228.7
[2]	d_{31} PZT	2mmX3.2mmX1.39μm	16	60	142.3
[3]	d_{33} PZT	0.8mmX1.2mmX2μm	1.6	870	416.6
Propos-ed	**d_{31} ZnO**	**2.5mm x .5mm x 2μm.**	**1.05**	**485**	**420**
Propos-ed	**d_{33} ZnO**	**2.5mm x .5mm x 2μm**	**4.2**	**485**	**1680**

Conclusion: Cantilever beam was operated at a resonance frequency of 485 Hz, for load of 1g and the o/p voltage obtained was 1.05V for d_{31} and 4.2V for d_{33}. Compared to reported microgenerators, the proposed device offers good FOM and promising output voltage.

References:

[1] Hua Bin Fanga, "Fabrication and performance of MEMS-based piezoelectric power generator" *Microelectronics Journal*, vol. 37, pp.

[2]Wen G. Li, Siyuan He and Shudong Yu, "Improving power density of a cantilever piezoelectric power harvester through a curved L-shaped proof mass," *IEEE Transactions On Industrial Electronics*, vol. 57, pp. 868 – 876, March 2010.(5)

[3] P. Muralta, M. Marzenckib, "Vibration energy harvesting with PZT micro device,"