Improvise Energy Harvesting From Low Frequency Vibrations

Kamlesh Kukreti, Varij Panwar

Department of Electronics and Communication Engineering,

School of Engineering & Technology, Graphic Era (Deemed to be University) Dehradun-248002, India

Abstract— this research paper is an effort to present an imminent for use of technology with natural sources for energy that has led to harvesting of the energy. Some common examples of energy harvesting is bimorph cantilever beam. Consequently, this paper also discusses Bimorph cantilever beam sensors with high sensing ability can be used in harvesting energy from the green environment. In this paper we concentrate on the comparative analysis of the MEMS and piezoelectric materials which is used to sense and convert green energy into electrical energy using MEMS technique [7]. In this paper we have shown designing and working and simulation of bimorph cantilever beam and carried out different types of analysis by applying different materials on it. Designing and the simulation of bimorph cantilever beam is computed in Comsol multiphysics 5.2. Results shows that Lead zicronate PZT-2 and Silicon (Si), suitable materials.

Keywords— MEMS materials, Lead zicronate (PZT-2), gold (Au), Silicon (Si).

In this 21st Century has seen a paradigm shift in use of technology and the thoughts of using the natural sources for energy has led to thinking of using the energy wasted around us, in technical term, we can say harvesting of the energy resources [1-3]. There are various sources for harvesting energy in this green environment which includes solar, wind , biogas, acoustic, mechanical vibrations, thermoelectric etc.

In this paper we have carried out analysis of different types of MEMS and. The material which we have used for comparison are includes, Silicon (Si) and PZT-2.

bimorph cantilever beam mathematical equation for frequency of is given below:-

$$f = \frac{1}{2}\sqrt{\frac{k}{m}}$$

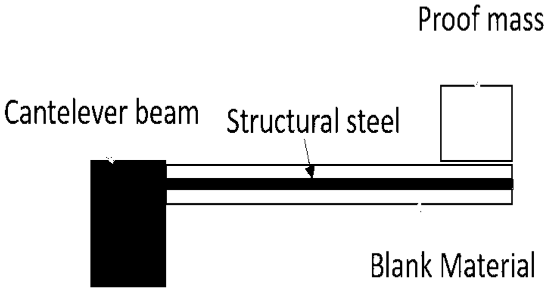

Fig. 1. Structure of Bimorph cantilever Beam which made up of structural steel

I. BIMORPH CANTILIVER BEAM DESIGNING

A. Bimorph Cantilever Beam Design

In this section modelling and simulation of bimorph cantilever beam has been shown. The design and structure of bimorph cantilever beam is illustrated in fig 1.The paper shows 2-Dimensional analysis of vibration based bimorph cantilever beam energy harvester by applying different types of material on cantilever using Comsol Multiphysics5.2.

B. Structure for Canteliver

As shown in fig 1 vibration based bimorph cantilever beam energy harvester is made up of structural steel sandwiched between blank materials. In place of blank materials we used different types of piezoelectric and MEMS materials so that we can analyse on which material better results or output comes. To make a bimorph cantilever beam three rectangles are used in geometry, width and Height of rectangle1 is 1mm. After that another rectangle is used of width 21mm and height 0.16mm. Third rectangle is used as a proof mass of width 4mm and height 1.7mm. In the last build the entire component to make a 2D bimorph cantilever beam

C. Material properties

This section shows the properties of different materials which are used on bimorph cantilever beam for comparative analysis. It also shows density and relative permittivity of different materials which include piezoelectric materials PZT-2 and some MEMS materials silicon(single crystal).

TABLE I. MATERIAL PROPERTIES

Material properties	**Density**	**Relative permittivity**
Silicon(single Crystal)	2329 [Kg/m]	11.6
PZT-2	7600 [Kg/m]	{504 , 504 , 270}

II. SIMULATION RESULTS OF VIBRATION BASED BIMORPH CANTILEVER BEAM

In this section result of vibration based bimorph cantilever beam is shown. In this section we have simulated bimorph cantilever beam with different materials and on the basis of that we carried comparative.

There is a ground electrode in the interior surface of bimorph cantilever beam and two electrodes on the outer surface. Cantilever beam is mount on vibrating places to analyze results. When we will place energy harvester in vibrating place like bridge, Machineries, Railway tracks etc with some movement the device will start vibrating and will get deform from its original position.

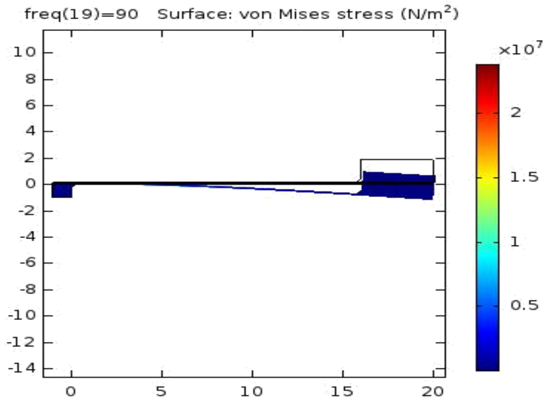

Fig.2. 2D stress view of bimorph cantilever beam when vibration is applied

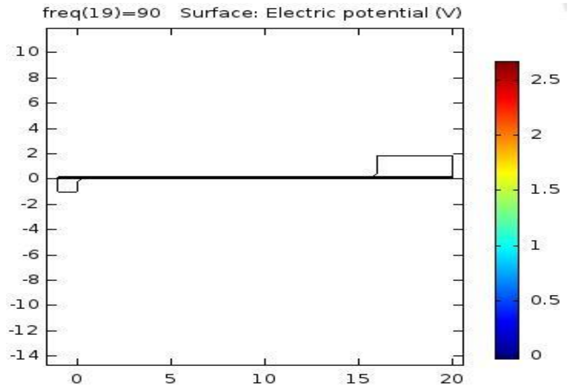

Fig 3. 2-D view of electric potential when vibration is applied

Fig 2 and Fig 3 shows the 2-dimensional stress view of bimorph cantilever beam when vibration is applied on the beam and electric potential. Stress of beam is depends on the materials and its properties. The bimorph cantilever beam is designed using comsol multiphysics 5.2.

IV. MATERIAL ANALYSIS FOR BIMORPH CANTILEVER BEAM ENERGY HARVESTER

There are so many materials in the library of comsol multiphysics 5.2 but in this section shows analysis of only MEMS and piezoelectric material. Mac Donald and et.l [6] in their paper has recognized that there should to be three essential properties of the materials that we will be utilized as a part of MEMS Technology which are as follow material should be better matching with semiconductor fabrication technology, (b) properties of the material should be better whether its mechanical or electrical property, (c) The rise of high stresses is slow down by intrinsic properties during process. Applying Mechanical load and stress and vibration on piezoelectric material result in Electromagnetic, Electrostatic, piezoelectric energies which we can harvest. In this section shown study and piezoelectric materials and their results coming from bimorph cantilever beam.

A. Silicon (Single crystal)

Silicon is a component with symbol Si and nuclear number 14. A hard and weak crystalline solid with a blue-dim metallic gloss, it is a tetravalent metalloid. It is present in group 14 in the periodic table, alongside carbon above it and germanium, tin, lead, and flerovium beneath. It is not extremely reactive chemical element, but sufficient to react then germanium [8]. . Fig 4, 5, 6 shows the frequency response, Load dependence, Acceleration dependence graph for voltage and power for Silicon material which is showing maximum output generated. Table II shows maximum output for different response.

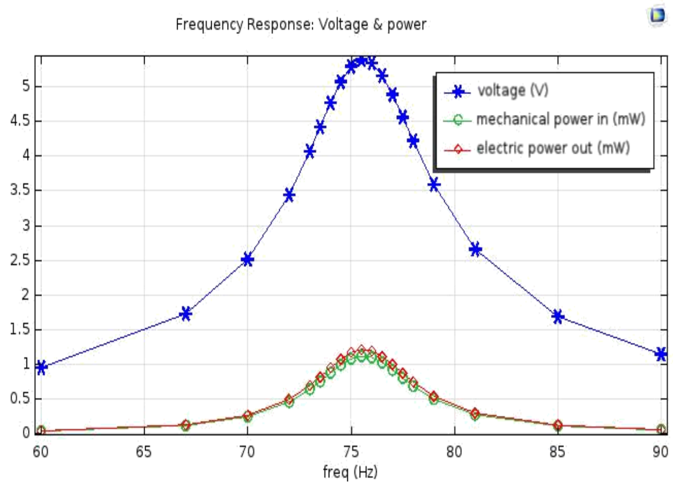

Fig. 4. Frequency Response: Voltage and power

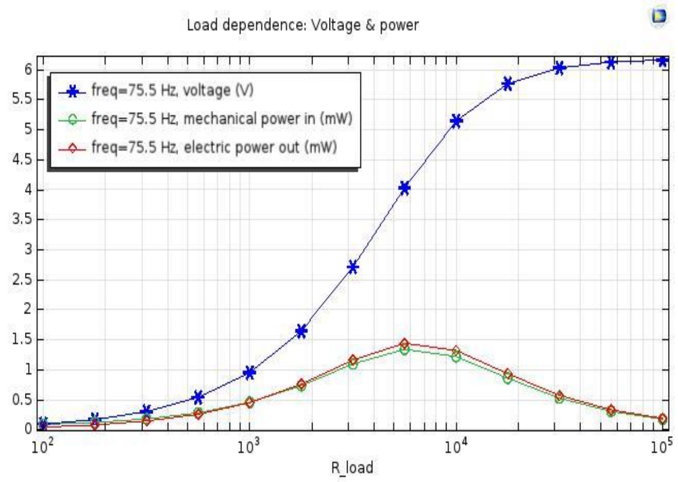

Fig. 5. Load Dependence: voltage and power

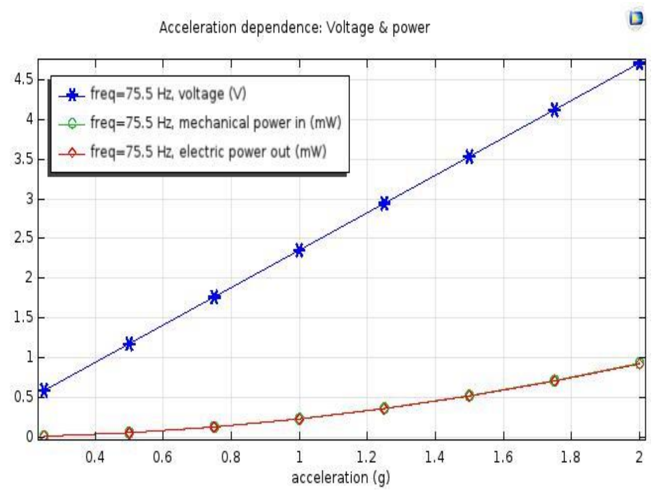

Fig. 6. Acceleration dependence: Voltage and Power

TABLE II. MAXIMUM INDUCED VOLTAGE, MECHANICAL POWER OUTPUT, ELECTRIC POWER OUTPUT FOR SILICON

Different outputs for different response	voltage	Mechanical power output(Mw)	Electric power Output(Mw)
Frequency Response (Hz)	6V	1.25Mw	1.2Mw
Load Dependence(kΩ)	6.8V	1.48Mw	1.4Mw
Acceleration Dependence (g)	5V	0.9Mw	0.9Mw

B. Lead zirconate titanate (PZT-2)

These materials are piezoelectric materials or piezo ceramic material. These materials are used in both zx-plane and zy-plane orientation. Coupling Co-efficient, piezoelectric charge co-efficient, permittivity of PZT-2 is high. Fig 7,8,9 shows the frequency response, Load dependence, Acceleration dependence graph for voltage and power forPZT-2 material which is showing maximum output generated. Table III shows maximum output for different response

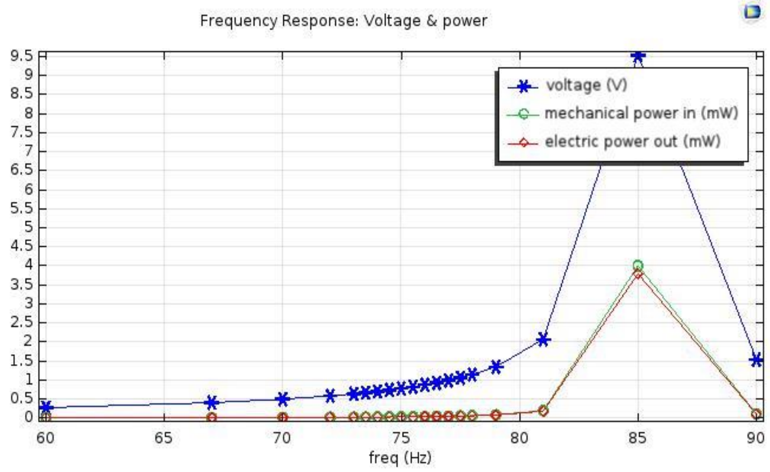

Fig .7. Frequency Response: Voltage and power

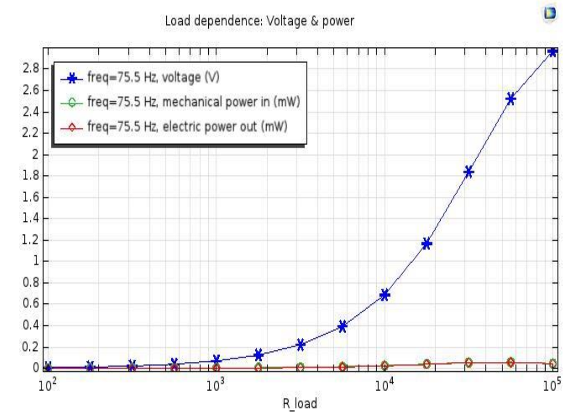

Fig.8. Load Dependence: Voltage and Power

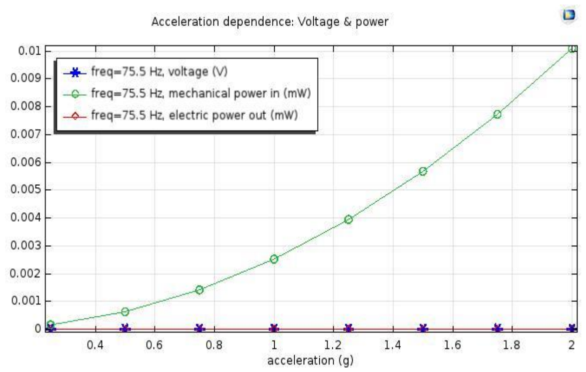

Fig. 9 Acceleration dependence: Voltage and Power

TABLE III MAXIMUM INDUCED VOLTAGE, MECHANICAL POWER OUTPUT, ELECTRIC POWER OUTPUT FOR SILICON

Different outputs for different Response	**Voltage**	**Mechanical power output(Mw)**	**Electric power Output(Mw)**
Frequency Response (Hz)	9.5V	4Mw	3.7Mw
Load Dependence(kΩ)	3V	0.02Mw	0.02Mw
Acceleration Dependence (g)	0V	0.01Mw	0 Mw

V. CONCLUSION

In this paper we concentrate on the comparative analysis of the MEMS and piezoelectric materials which is used to sense and convert green energy into electrical energy using MEMS technique [7]. In this paper we have shown designing and working and simulation of bimorph cantilever beam and carried out different types of analysis by applying different materials on it. Designing and the simulation of bimorph cantilever beam is computed in Comsol multiphysics 5.2. Results shows that Lead zicronate PZT-2 and Silicon (Si), suitable materials and out of all these two material. The bimorph cantilever beam can be used for harvesting energy, for feeding low power electronic device and for wireless sensor nodes and also used for monitoring buildings.

REFERENCES

[1] S. S. Chalasani,, & J. M Conrad, "A survey of energy harvesting sources for embedded systems". Southeastcon, pp. 442-447, 2008.

[2] F. U Khan & M. Iqbal, "Electromagnetic-based bridge energy harvester using traffic-induced bridge's vibrations and ambient wind", (ICISE), pp.380-385 January 2016.

[3] D Belo, A Georgiadis & N. B. Carvalho, "Increasing wireless powered systems efficiency by combining wpt and electromagnetic energy harvesting", In Wireless Power Transfer Conference (WPTC), pp. 1-3, May 2016.

[4] P. Panthongsy, , & D. Isarakorn, "Comparative study of piezoelectric energy harvesters based on polycrystalline PZT and single-crystalline PMN-PT materials", (ECTI-CON), pp. 1-5, June 2016.

[5] B Deepti & Sukesha Sharma, "Energy Harvesting using Piezoelectric for Wireless Sensor Networks", IEEE, 2016.

[6] N.C.MacDonald,SCREAM, "microelectromechanical systems" Microelectronic Engineering, 32(1-4), 49-73, 1996.

[7] M.Shadoufa, , M. Mahmoud, , M. Ghoneima, & M. Dessouky, "Optimization of the output power of a frequency-up conversion piezoelectric energy harvester", MWSCAS, pp. 1-4, October 2016.

[8] Haluk Kulah and Khalil Najafi " An Electromagnetic Micro power Generator for Low –Frequency Environmental Vibrations", pp 237-24, 2004, Nov. 2013.