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An electromagnetic micro power generator for low frequency environmental vibrations based on the frequency up conversion technique

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ABSTRACT

Micro Electro Mechanical System (MEMS) *controlled* electromagnetic micro power generator was designed with basic cantilever structure using comsol software. This paper presents a micromechanical-system-based electromagnetic vibration-to-electrical power generator that can harvest energy from low-frequency external vibrations. The efficiency of vibration-based harvesters is proportional to excitation frequency, so the proposed generator is designed to convert low- frequency environmental vibrations to a higher frequency by employing the frequency upconversion (FupC) technique. It has been shown that the generator can effectively harvest energy from environmental vibrations of 70-150 Hz and generates 0.57-mV voltage with 0.25-nW power from a single cantilever by up converting the input vibration frequency of 95 Hz-2 kHz. The fabricated generator size is 8.5*7*2.5 mm^3,and a total of 20 serially connected cantilevers have been used to multiply the generated voltage and power. The generator demonstrated in this paper is designed for the proof of concept, and the power and voltage levels can further be increased by increasing the number of cantilevers or coil turns.

Introduction

With increasing global warnings on environmental issues, clean energy sources have particularly become important in the past decades. In the meantime, low-cost, low-power, and miniaturized devices can easily be manufactured using advanced techniques of micro electromechanical-system technology and the electronics industry. These improvements enabled many of the electronic devices to be miniaturized and operated at considerably low power levels, leading to batteries an dother conventional capacitive sources to be replaced by environmental sources.

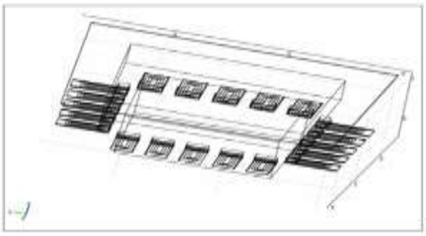

Fig 1 Cross sectional plot of cantilever the diaphragm and magnet

Structure:

Based on the discussion made in the introduction, the power output from vibration-based generators is proportional to excitation frequency. For this reason, the main objective of the proposed design is to accept low-frequency vibrations as input and create high-frequency vibrations to act as a linear motion transformer or, literally, to be a "frequency upconverter. "This is achieved using the basic mechanical vibration theory, which states that when underdamped structures are excited by an initial condition such as displacement or velocity, their response will be an exponentially decaying out oscillatory motion. This virtually enables a converter mechanism with enough design freedom to be implemented. In order to realize such a design, the necessary condition is to construct a mechanism that periodically excites the generator beam. Fig. no.2 shows the top view of the spacer for a single pixel. The spacer is designed with air gaps (Cheng-Yao Lo (2010)) in order to improve color purity and pixel clarity.

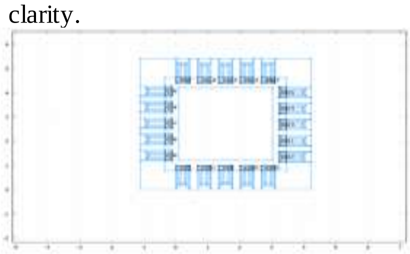

Fig 2 Top view of cantilever beam and magnet in the model

Concept:

When the environmental vibrations are applied to the diaphragm, the magnet gets closer to the cantilever beam. From there the magnet attracts the cantilever beam. After the magnet goes up, the cantilever beam vibrates. Finally the vibration energy is converted in to the electrical energy using the generator. It generates the current of 5 mv to 10 mV.

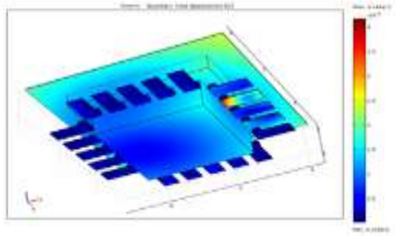

Fig .3: Electric potential distribution for Parylene material.

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Analysis:

Electro static analysis was done in MEMS controlled electromagnetic micro power generator. This analysis explains the potential distribution under various electric potential levels based on applied voltages applied between the electrodes. Electric potential is applied to any one of cantilever. Potential applying to the cantilever may be of any kind. This analysis presents the stability of the device under high voltage application more over these results shows that proper working of the device under low voltage condition. Table.no.2 provides the maximum and minimum voltage distribution as per our analysis result.

We have done analysis for different material under different driven voltage levels. Fig.no.3a, 3b, 3c shows the electric potential distribution of Nickel (Ni), copper (Cu) and Parylene under various voltages respectively.

According to simulation results 20nm copper shows maximum distribution under low voltage itself but maximum distribution is happened at the edges of the pixel. While comparing copper and Nickel, since Cu had more conductivity, Ni is chosen for its uniform distribution based on analysis.

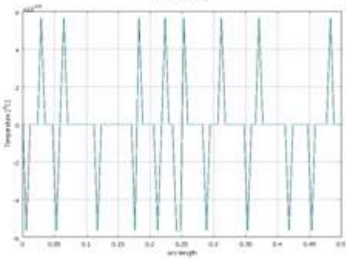

Fig. 4: Electric potential distribution for materials

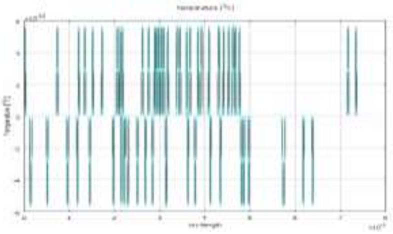

Fig 5: Temperature distribution for Cantilever

Conclusion:

MEMS technology evolves from microelectronics fabrication technology. Consequently; many of the fabrication techniques used in producing integrated circuits have been adopted to create the complex 3-D shapes of many MEMS and Microsystems. It also explains about standard process steps used to manufacture integrated circuit.

The MEMS based vibration to electricity converter will be designed using COMSOL. The cantilever beam will be designed and it will be used to convert the vibration to electrical signals using the modules in COMSOL.

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