EPH - International Journal Of Science And Engineering
ISSN (Online): 2454 2016
Volume 03 Issue 02 June 2017

DOI:https://doi.org/10.53555/eijse.v3i2.65

MEMS BASED TEMPERATURE TO VOLTAGE CONVERTER

Dr. M.Saravanan[1*], G.V.Sunil Kumar[2]
*[*1,2]Department of Electronics and Instrumentation Engineering Sree Vidyanikethan Engineering College A.Rangampet, Tirupati*
[2]Email: gvsunilkumar@rediffmail.com

***Corresponding Author:-**
Email:mgksaran@yahoo.com

Abstract:-
Source of energy for the MEMS devices became the unavoidable requirement for any application. Even though many renewable energy sources are available, the optimal utilization of those resources are not attained till now. This paper presents a design and implementation of Passive MEMS based voltage generation using temperature. The design is made with two stages, in the first part the temperature is converted to displacement using Micro actuators and then in the second stage the displacement is converted to pressure and then to voltage using piezoelectric sensors. It is simulated using COMSOL multiphysics software at a temperature of 100^o C.

Keywords:- *MEMS, Thermal Microactuator, Comsol Multiphysics*

INTRODUCTION

Micro-Electro-Mechanical Systems or MEMS, is a technology that in its most general form can be defined as miniaturized mechanical and electro-mechanical elements (i.e., devices and structures) that are made using the techniques of micro fabrication. The critical physical dimensions of MEMS devices can vary from well below one micron on the lower end of the dimensional spectrum, to several millimeters. Likewise, the types of MEMS devices can vary from relatively simple structures having no moving elements, to extremely complex electromechanical systems with multiple moving elements under the control of integrated microelectronics. The one main criterion of MEMS is that there are at least some elements having some sort of mechanical functionality whether or not these elements can move.

COMSOL is an interactive program for solving coupled Partial Differential Equations in one or more physical domains simultaneously. The model tree in the Model Builder gives a full overview of the model and access to all functionality – geometry, mesh, physics settings, boundary conditions, studies, solvers, post processing, and visualizations.

What is Micro Actuator?

Actuators are structures that allow input energy in one domain to get a certain type of motion (translation, rotation) in the mechanical domain.

Different types of micro-actuators can be broadly classified as follows: Thermal Actuators
Electrostatic Actuators
Piezoelectric Actuators

Thermal Micro Actuators

A MEMS thermal actuator is a micromechanical device that typically generates motion by thermal expansion amplification. A small amount of thermal expansion of one part of the device translates to a large amount of deflection of the overall device. Usually fabricated out of doped Single Crystal Silicon or Poly-silicon the increase in temperature can be achieved internally by electrical resistive heating or externally by a heat source capable of locally introducing heat. Micro-fabricated thermal actuators can be integrated into micro-motors. Different types of Micro Thermal Actuators are as follows:

Symmetric Type: These actuators mostly work in-the-plane and shows linear deflection Examples are V-shaped and U-shaped thermal actuators.

Asymmetric Type: These actuators show outof-the plane deflection and are used to produce rotational effects. Examples are thermostat, bimorph etc.

Thermal actuator design: Surfacemicromachined thermal actuators utilize constrained thermal expansion to achieve amplified motion. The thermal expansion is most commonly caused through Joule heating by passing a current through thin actuator beams. There are two different thermal actuator designs that have been demonstrated and commonly used in the literature, the pseudo bimorph or “U” shaped actuator, and the bent-beam or “V” shaped actuator. Both designs amplify the small input displacement created by thermal expansion, at the expense of a reduction in the available output force

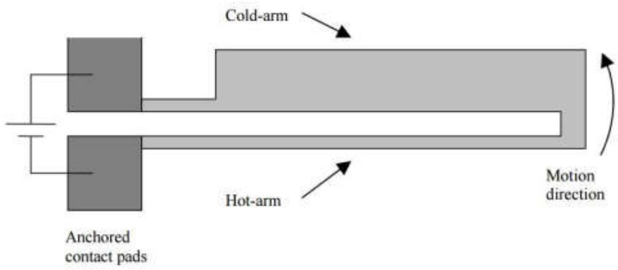


Fig. Illustration showing U shaped thermal actuator.

Proposed work

The U shaped actuator operation depends on creating a temperature difference between a hot-arm and cold-arm. The temperature difference is due to the reduction in Joule heating in the cold-arm because of its decrease in electrical resistance resulting from the increase in cross-sectional area. This results in a thermal expansion difference between the two segments. Since both segments are constrained at their base the actuator end experiences a rotary motion. Multiple actuators can be connected together in parallel to increase the output force and to create a linear output motion.

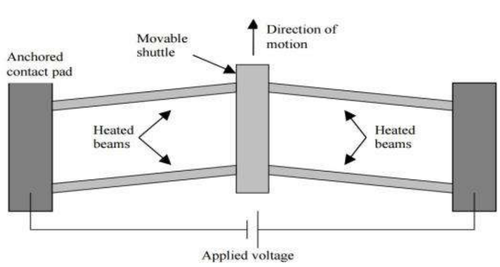
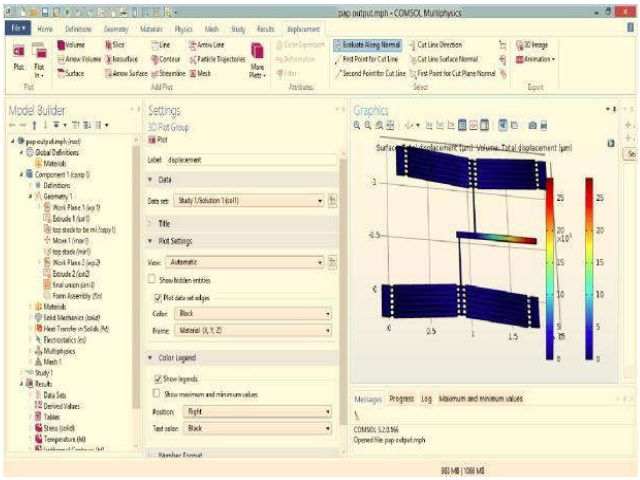


Fig. Illustration of V shaped actuator.

The V shaped actuator is characterized by one or more V shaped beams, also commonly called legs, arranged in parallel. As current is passed through the beams they get heated and expand, and because of the shallow angle of the beams, the center shuttle experiences an amplified displacement in the direction of the offset. This work will focus on the V style actuator as it has proven to be robust and offers design flexibility.

Result and Discussion



Different temperatures are given to the proposed thermal actuator and the output at each temperature for displacement is noted which is plotted using Matlab. The distance between the two stacks is varied and same temperature difference is applied for every distance from 100um to 400um and graphs are plotted for each case. The following graphs show the temperature Vs Displacement for different distances between the stacks. Displacement (um) for the distance between the stacks fixed as 100um is shown in figure.

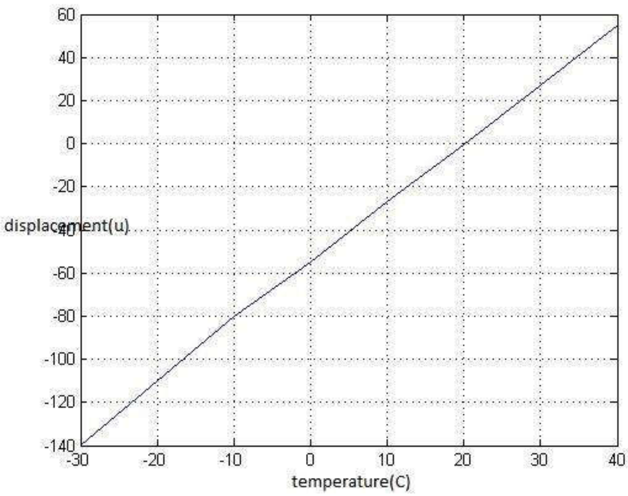


Fig: Displacement for 100um gap

A bimorph is introduced to the one stack of actuator which takes the stress and other end of the bimorph is fixed. A quartz crystal enclosed by two nickel layers and surrounded by foam is used as bimorph.

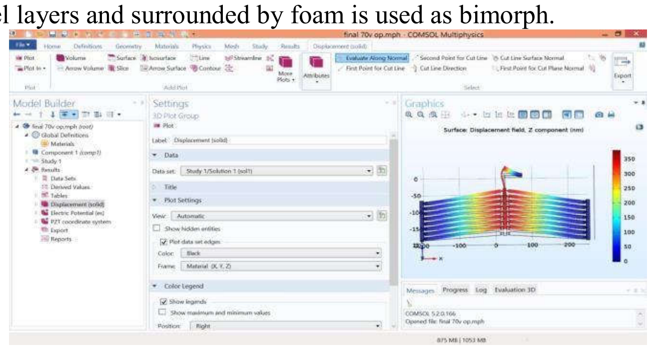


Fig: modified design for the voltage

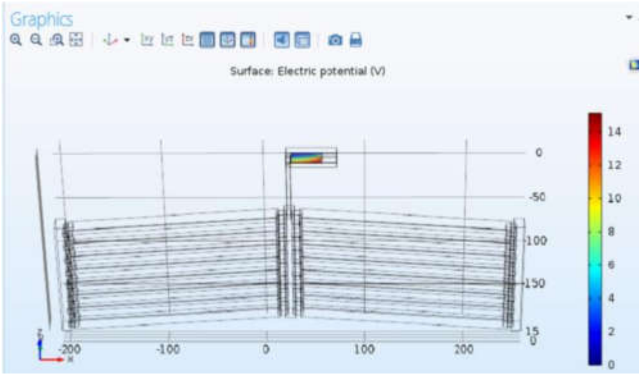


Fig: voltage output for 353K

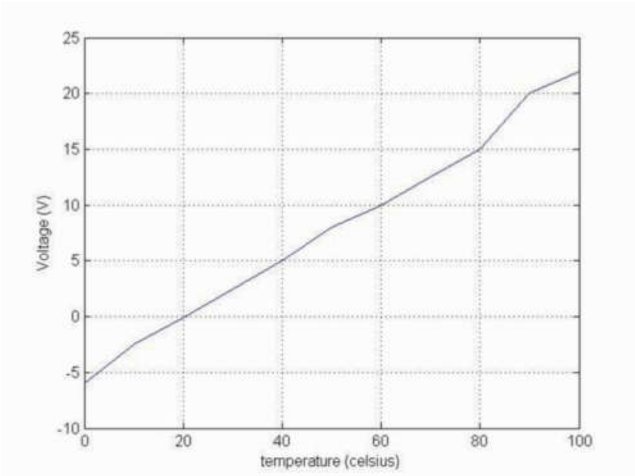


Fig: Temperature Vs Voltage Graph

Conclusion

Thus an efficient thermal microactuator has been simulated which can be used to convert temperature into voltage.

References

[1]. Harald Steiner, Franz Keplinger, Johannes Schalko, Wilfried Hortschitz, and Michael Stifter, *Highly Efficient Passive Thermal Micro-Actuator* Journal of Micro Electro Mechanical Systems, Vol. 24, No. 6, December 2015, pp-1981-1988.

[2]. N.-T. Nguyen, S.-S. Ho, and C. L.-N. Low, *A polymeric microgripper with integrated thermal actuators, J. Micromech. Microeng.*, vol. 14, no. 7, pp. 969–974, Jul. 2004.

[3]. J. J. Khazaai, M. Haris, H. Qu, and J. Slicker, *Displacement amplification and latching mechanism using V-shape actuators in design of electro-thermal MEMS switches,* in *Proc. IEEE Sensors*, Nov. 2010, pp. 1454– 1459.

[4]. G.-K. Lau, J. F. L. Goosen, F. van Keulen, T. C. Duc, and P. M. Sarro, *Polymeric thermal microactuator with embedded silicon skeleton: Part I—Design and analysis*, *J. Microelectromech. Syst.*, vol. 17, no. 4, pp. 809–822, Aug. 2008.

[5]. T. C. Duc, G.-K. Lau, and P. M. Sarro, *Polymeric thermal microactuator with embedded silicon skeleton: Part II—Fabrication, characterization, and application for 2-DOF microgripper*, *J. Microelectromech. Syst.*, vol. 17, no. 4, pp. 823–831, Aug. 2008.

[6]. J. Wei, T. C. Duc, and P. M. Sarro, *An electro-thermal silicon-polymer microgripper for simultaneous in-plane and out-ofplane motions*, in *Proc. Eurosensors*, 2008, pp. 7–10.

[7]. A. Unamuno, R. Blue, and D. Uttamchandani, *Modeling and char- acterization of a vernier latching MEMS variable optical attenuator*, *J. Microelectromech. Syst.*, vol. 22, no. 5, pp. 1229–1241, Oct. 2013.