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# Designing of Thermal Expansion in Rectangular Geometry using Different Materials with Analysis

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**Abstract:** A MEMS thermal actuator is a micromechanical device that naturally produces movement by thermal expansion. In this article we have measured the thermal expansion of various structural materials of thermal actuator and executed utilizing COMSOL. When we utilize SU8 as structural material with 298K as outside temperature, then the greatest temperature is 41  $\mu\text{m}$  for the geometry that is quite high in comparison to different materials. So we conclude by this paper that by utilizing SU8 as structural materials we can get high state of displacement in warm actuators.

**Keywords:** MEMS, FEM, COMSOL, THERMAL EXPENSION, 3D

## I. INTRODUCTION

Various sorts of small scale actuators have risen lately. Every sort of actuators has its own particular novel advantages, for example, giving extensive power, devouring less power, offering long relocation, and holding lofty actuating speed. However, none of them could carry all advantages, in fact, some trade-offs exist between these advantages. An actuator is one that actuates or moves something. More particularly, an actuator is a gadget that coverts energy into movement or mechanical energy. A thermal actuator converts small amount of thermal expansion of one part of the device translates to a large amount of deflection of the overall device. Generally created out of doped Single Crystal Silicon or Poly silicon as a complex agreeable part, by utilizing diverse materials we will endeavor to produce more deflection in the device.

## II. DESIGN AND ANALYSIS

Thermal extension is the sort of actuator i.e. when we change temperature the material grows. In this paper we have outlined and investigated three distinct geometries they are rectangular, triangular and U-shape.

### A. Designing Rectangular Shape

Rectangular shape comprise of eight straight rectangles in parallel with measurement of 10 $\mu\text{m}$ , 110 $\mu\text{m}$ , 10  $\mu\text{m}$  width, length and height separately. With a gap of 20  $\mu\text{m}$  and 10  $\mu\text{m}$  between alternating rectangles as shown in figure 1.

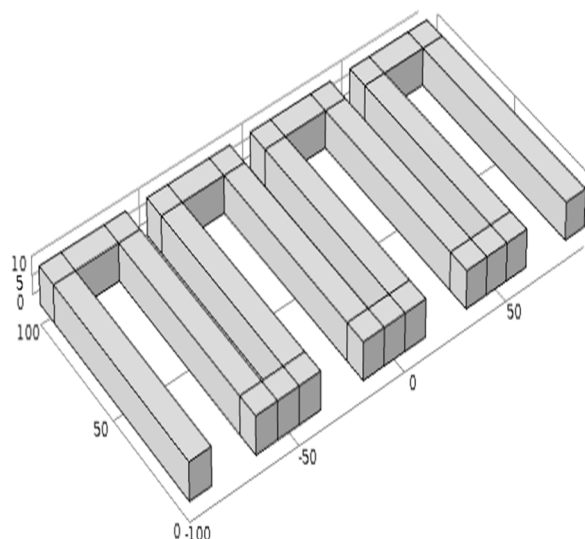


Figure 1: Rectangular Shape

By applying fixed boundaries to lower base of the rectangle so that the expansion only takes place in upwards direction. The region is shown in figure 2 colored grey. The remaining region shown as blue where heat flows can take place.

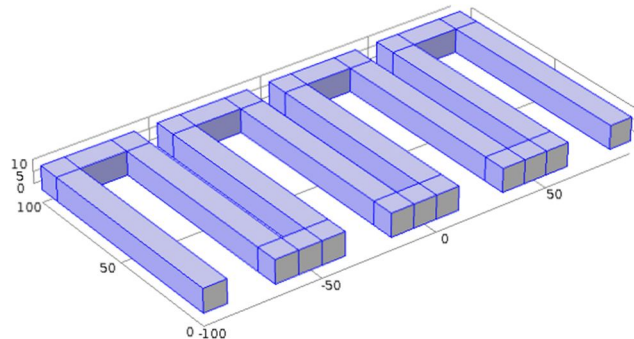


Figure 2: Fixed boundaries (lower base)

Figure 3 indicates applying of structural materials to the geometries found in green shading. A copper beryllium composite is connected to the device to analyze the thermal extension of the geometry. The thermal stress physics is applied to the device to analyze displacement of the device due to thermal expansion of device.

The heat flux is given conduction only. The heat source is a constant heat source of  $1 \times 10^8 \text{ W/m}^3$ . The air cooling at the limits is communicated utilizing a consistent warmth exchange coefficient of  $7000 \text{ W/m}^2$  and a surrounding temperature of  $298 \text{ K}$ . The articulation for warm development requires strain reference temperature for the copper beryllium compound, which for this situation is  $293 \text{ K}$ . [6]

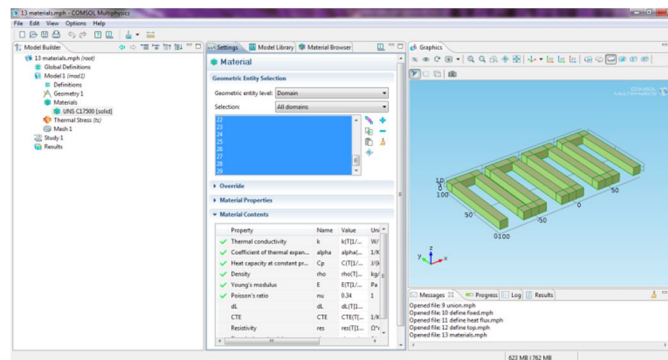


Figure 3: Applying material

Figure 4 shows the meshed geometry. Mesh generation is one of the most critical aspects of engineering simulation. Too many cells may result in long solver runs, and too few may lead to inaccurate results. COMSOL Meshing innovation gives a way to adjust these prerequisites and acquire the correct work for every recreation in the most robotized way possible

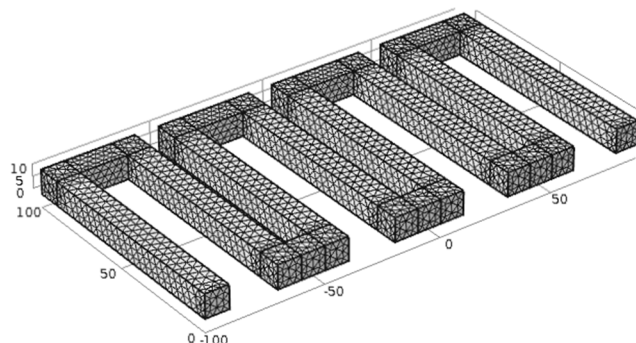


Figure 4: meshed geometry

### III. RESULTS

When we utilize 298K as outer temperature then the greatest displacement is  $0.0453 \mu\text{m}$  for the geometry. The accompanying figure 5 demonstrates the aggregate displacement in the device utilizing copper beryllium amalgam

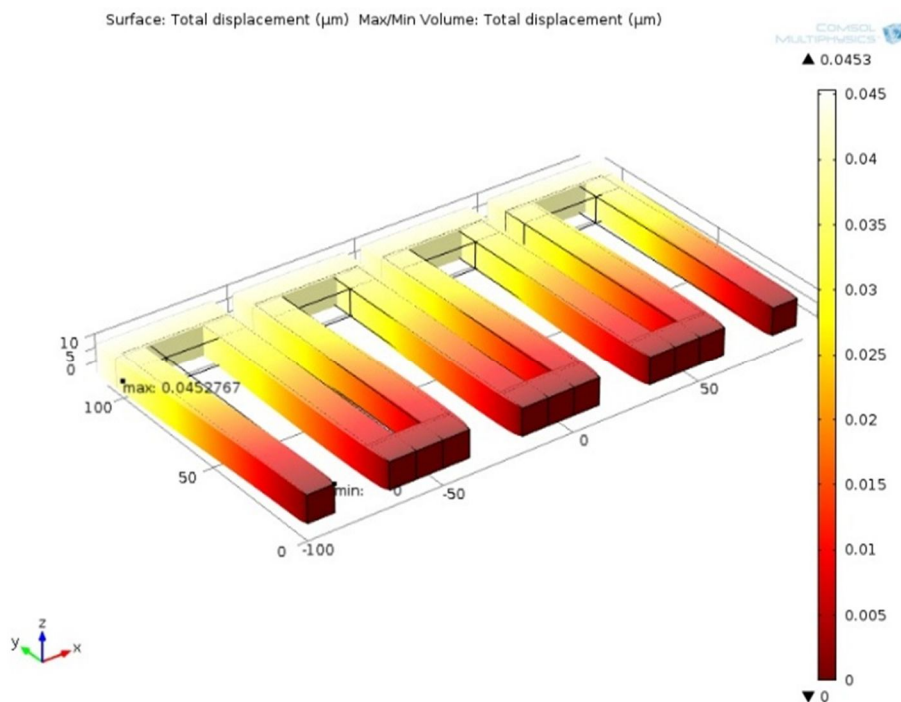


Figure5: Displacement of the Device

The accompanying figure demonstrates the displacement of a bend that takes after the top inward edges of the device from left to right

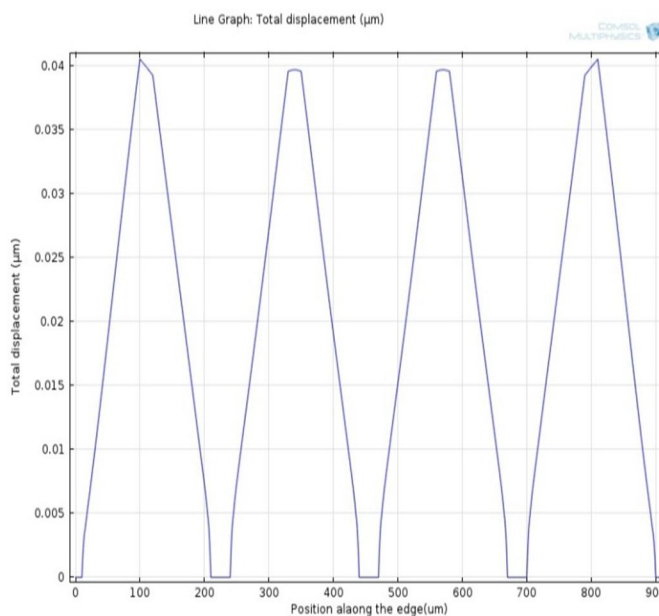


Figure6: Displacement vs Position graph

When we use 298K as external temperature then the maximum displacement is  $0.0071 \mu\text{m}$  for the geomtry. The following figure 7 shows the total displacement in the device using polysilicon.

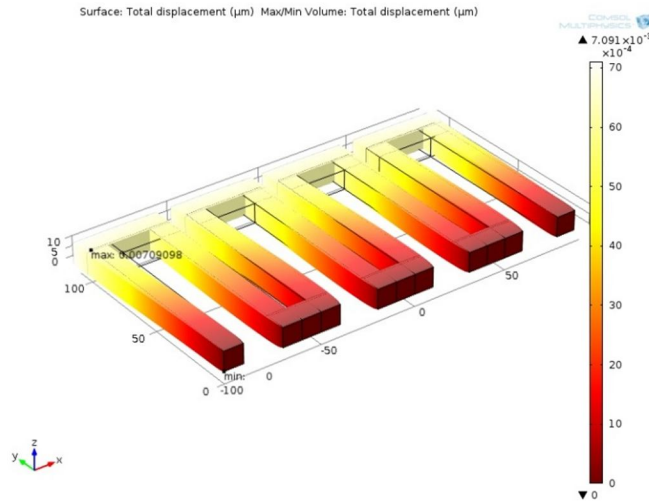


Figure7: Displacement of the Device

The following figure shows the displacement of a curve that follows the top inner edges of the device from left to right.

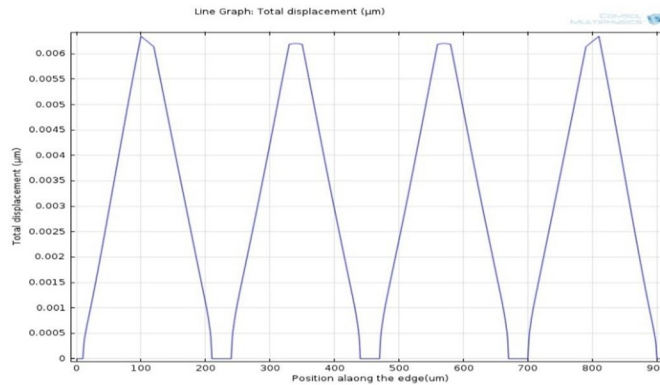


Figure8: Displacement vs Position graph

When we use 298K as external temperature then the maximum displacement is 0.0642 µm for the geometry. The following figure 9 shows the total displacement in the device using aluminum.

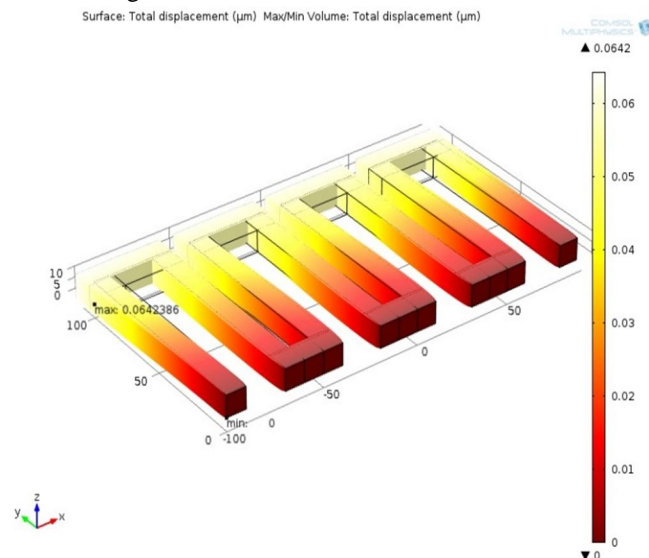


Figure9: Displacement of the Device

The following figure shows the displacement of a curve that follows the top inner edges of the device from left to right.

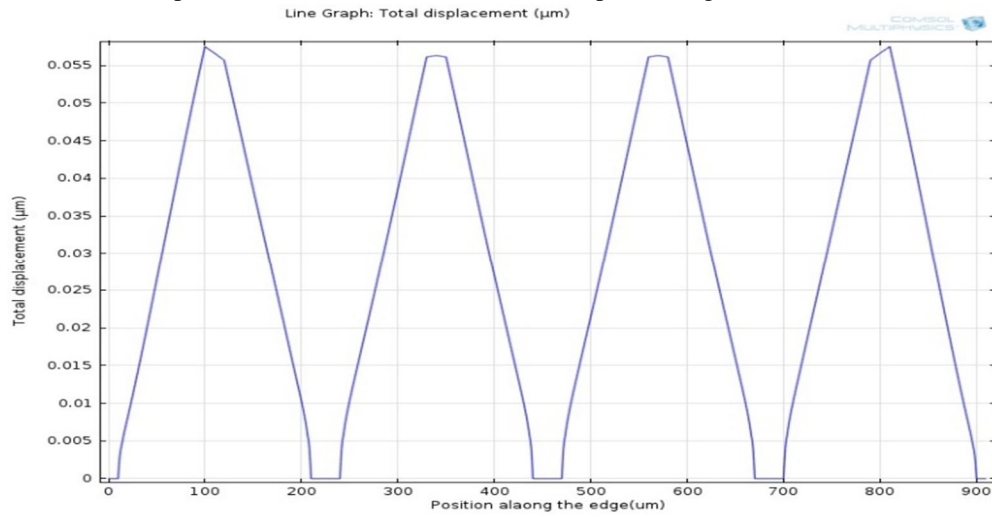


Figure10: Displacement vs Position graph

When we use 298K as external temperature then the maximum displacement is 0.0709 µm for the geomtry. The following figure 11 shows the total displacement in the device using magnesium.

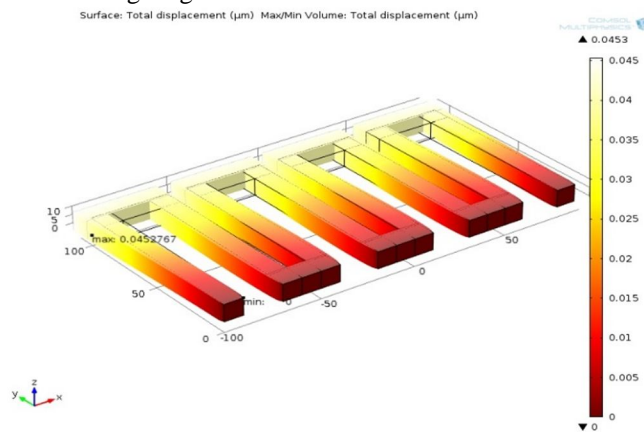


Figure 1: Displacement of the Device

The following figure shows the displacement of a curve that follows the top inner edges of the device from left to right.

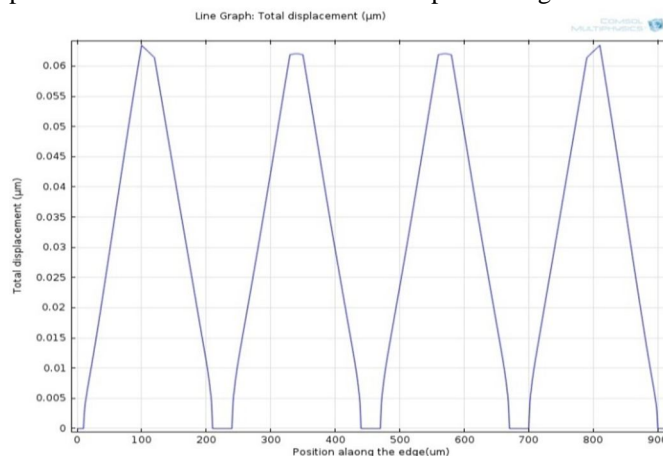


Figure12: Displacement vs Position graph

When we use 298K as external temperature then the maximum displacement is 0.0812  $\mu\text{m}$  for the geomtry. The following figure 13 shows the total displacement in the device using lead.

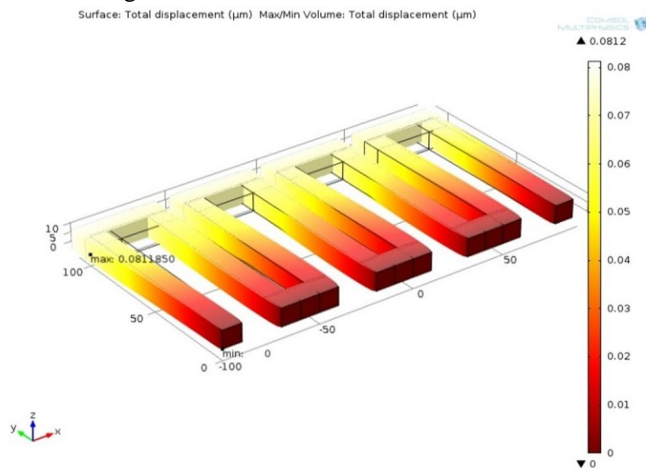


Figure13: Displacement of the Device

The following figure shows the displacement of a curve that follows the top inner edges of the device from left to right.

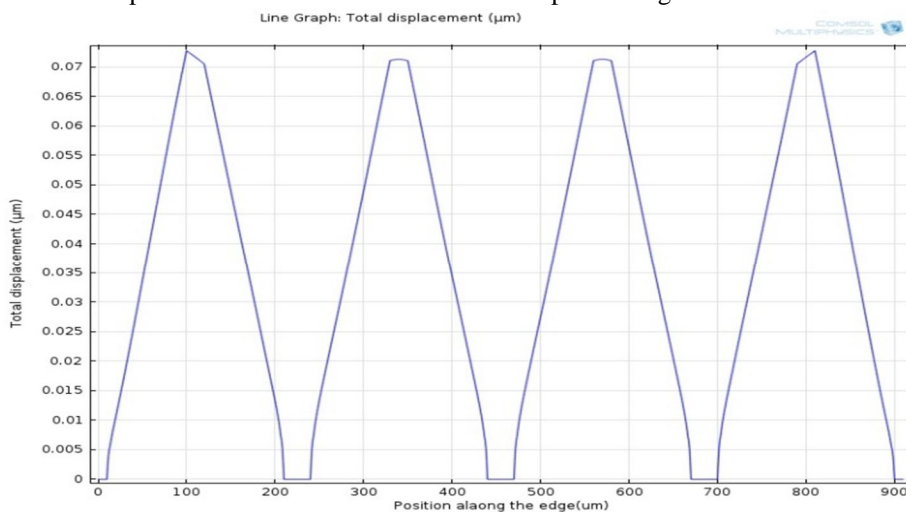


Figure14: Displacement vs Position graph

When we use 298K as external temperature then the maximum displacement is 41  $\mu\text{m}$  for the geomtry. The following figure 15 shows the total displacement in the device using SU8.

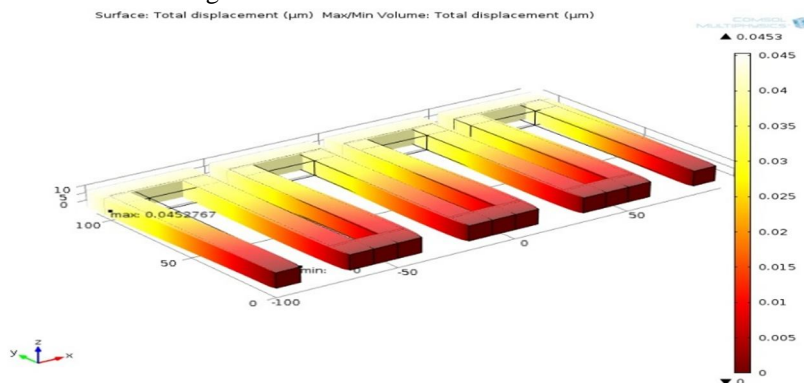


Figure15: Displacement of the Device

The following figure shows the displacement of a curve that follows the top inner edges of the device from left to right.

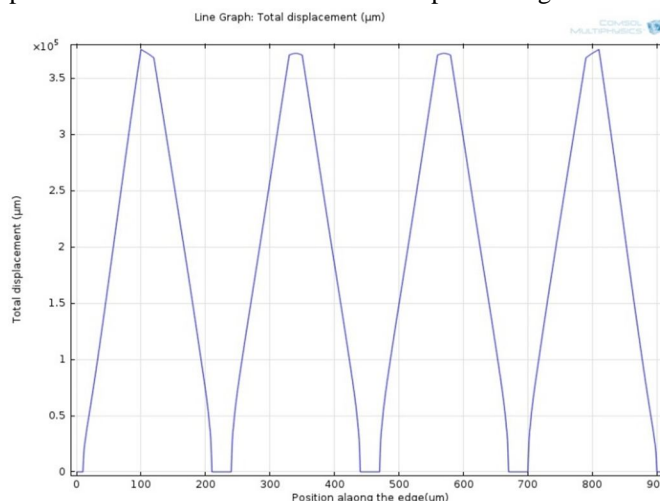


Figure16: Displacement vs Position graph

#### IV. CONCLUSION

It is concluded that when we utilize 298K as outside temperature and copper beryllium composite as structural material then the most extreme displacement is  $0.0453 \mu\text{m}$  for the geometry. When we utilize same outside temperature and poly silicon as structural material then the most extreme displacement in the device is  $0.0071 \mu\text{m}$ . Again with same outside temperature and aluminum as structural material then the greatest displacement in the gadget is  $0.0642 \mu\text{m}$ . With same outside temperature and magnesium as structural material then the most extreme displacement in the device is  $0.0709 \mu\text{m}$ . When we utilize 298K as outer temperature then the most extreme displacement is  $0.0812 \mu\text{m}$  for the device utilizing lead as structural material. When we employ SU8 as structural material with 298K as external temperature then the highest displacement is  $41 \mu\text{m}$  for the geometry, which is very lofty as compared to other materials. So we conclude that by using SU8 as structural materials we can get high level of displacement in thermal actuators.

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