# Design and Analysis of MEMS Micro Mirror Using Electro Thermal Actuators

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**Introduction**: Micro-mirrors are versatile devices which finds ingenious application in the fields such as optical switching, display and in medical fields for non-invasive imaging. Here we have addressed the design and simulation results of an electro thermally actuated micro-mirror which can tilt either in horizontal or vertical direction. An electro-thermally actuated micro-mirror works on the principle that when current is passed through the actuator, which has one thin and one broad arm, it bends due to heating at the thin arm. The thin arm bends since current density increases at the junction of thin and broad arm and thereby heating the arms and this results in displacement.

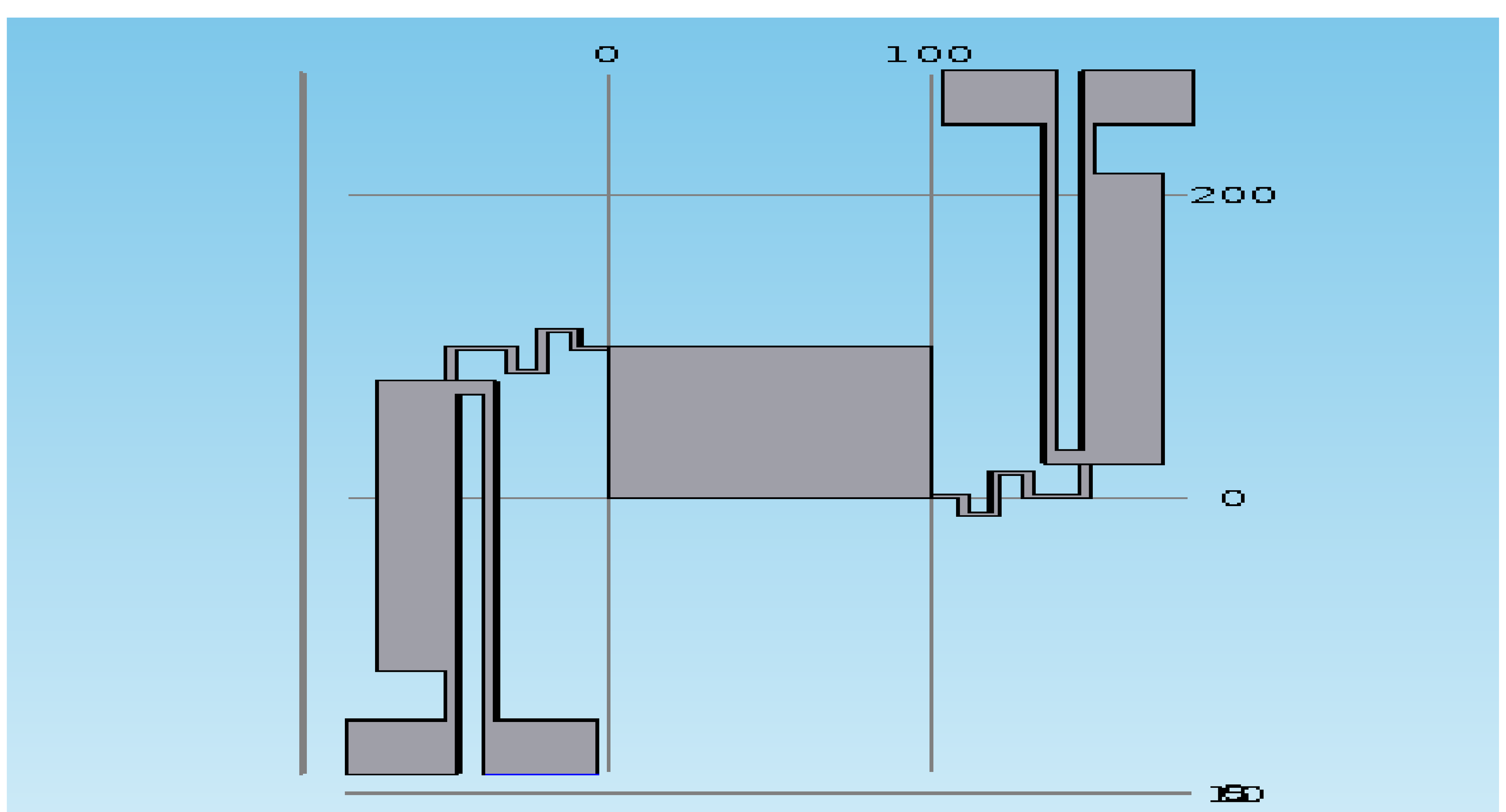


**Figure 1**. Structure of Micro-mirror with ETA

**Computational Methods**: The principle of operation of electro-thermal actuation is non-uniform joule heating which leads to differential thermal expansion resulting in deformation of the structure. This is simulated using COMSOL Multiphysics. The fundamental equation known as Heat Diffusion describes the heat transfer as a function of resistivity.

$$\nabla^2 T + \frac{q}{k} = \frac{1}{\alpha}\frac{\partial T}{\partial t}$$

$$\alpha \ \left(=\frac{k}{\rho c}\right)$$

Where $\alpha$ is the thermal diffusivity, $T$ is the temperature distribution, K is the thermal conductivity of the material, $\rho$ represents the density, $c$ is the specific heat capacity and $q$ represents volumetric heat loss. Application of voltage causes the thin arm of the actuators to expand more than the wide arm. Thus the expansion of wide arm can be neglected compared to that of thin arm. The new length of the arm due to thermal expansion is

$$L_{new} = \int_0^{L_t} [1 + \alpha(T(x) - T_0)]dx$$

When voltage is applied to both the actuators, the mirror plate will move diagonally.

**Results**: The tilt produced by the micro mirror is observed by measuring the change in displacement with respect to voltage in X, Y & Z directions. The variation in temperature is also observed which increases with respect to voltage. The change in displacement is higher at lower voltages and it gradually decreases at higher voltages due to high temperature which reduces the response of the device.

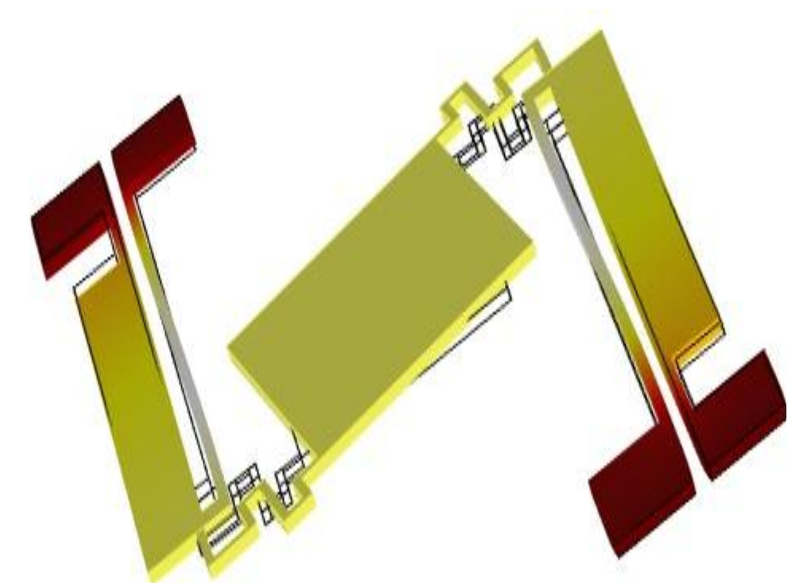

**Figure 2**. Tilting of the micro-mirror With temperature profile

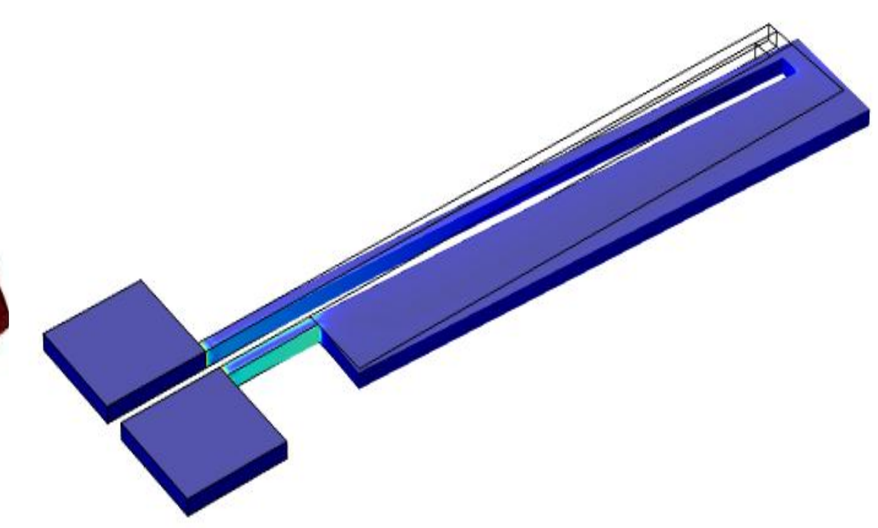

**Figure 3**. Displacement of the actuator

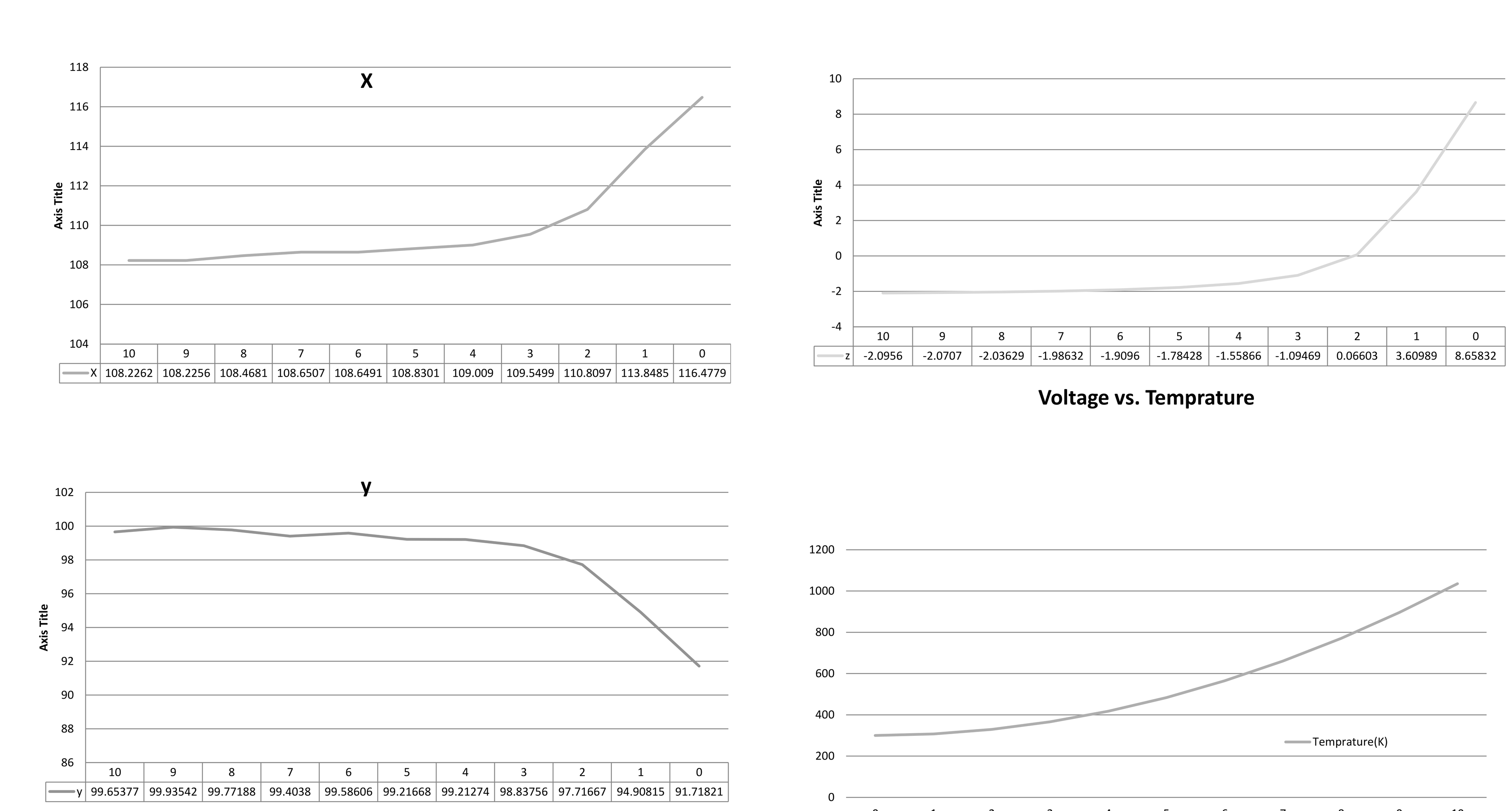


**Figure 4**. Displacement in X,Y&Z directions and temperature profile

**Conclusions**: Thus we have investigated MEMS based micro-mirror using Electro thermal actuators . This electro thermal actuation causes the mirror to tilt. Finite element based simulations are done using COMSOL Multisphysics to analyze the performance of micro-mirror. The displacement and the temperature produced by the mirror has been analyzed and calculated for various voltages.

**References**:

1. John V. Crosby and Mustafa G. Guvench, Experimentally Matched Finite Element Modelling of Thermally Actuated SOI MEMS Micro-Grippers Using COMSOL Multiphysics
2. Comtois, Bright, Applications for surfacemicromachined polysilicon thermal actuators and arrays, *Sensors Actuators A, 58, 95-98(97)*
3. D. Mallick, A. Bhattacharyya, Design and Simulation of MEMS Based Electrothermal Micromirror for 3D Spatial Movement,Comsol conference 2011,Banglore,1-9(2011)

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