Modeling and Analysis of Thermal Bimorph Using COMSOL Multiphysics®

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Abstract

In this paper the modeling and simulation results of a thermal bimorph which is capable of producing a displacement for temperature rise are presented. Thermal bimorphs are popular actuation technology in MEMS (Micro-Electro-Mechanical Systems). Bimorph actuators consist of two materials with different coefficients of thermal expansion.

The main objective of this work is to investigate the deformation in bimorph actuator for varying temperatures. Deformation increases with increase in length of actuator. Thus, temperature produces thermal strain and thermally induced deformation and this makes the microstructure into a thermal actuator. In this work, the coupled multiphysics simulation for thermal behavior of a thermal bimorph is carried out using COMSOL Multiphysics®. The simulation and analytical results are also compared.

Their operating principle is based on differential thermal expansion induced by Joule heating. COMSOL simulations are performed on the thermal bimetallic actuator to investigate the change in deformations with respect to temperature. In this work it is observed that by increasing the temperature from 300K to 2500K the deflection also increases from 0.1705µm to 54.93µm. Figure 1 shows the simulated total displacement 17.594µm at 1000K and L=100µm ($\alpha 2 > \alpha 1$) and Figure 4 shows the simulated total displacement 31.381µm at To =1000K and L=100µm ($\alpha 1 > \alpha 2$). Two observations are done 1) When $\alpha 2 > \alpha 1$ and 2) when $\alpha 1 > \alpha 2$. Initially aluminum block is placed at bottom and polysilicon block is placed at top. As two-layered materials are tightly joined at the interface, the beam bends downwards as shown in Figure 1 & 2. Later aluminum block is placed at top and polysilicon is used in bottom layer. Here, it is observed that the beam bends in the upward direction, as shown in Figure 3 & 4. When the CTE of bottom beam is more, it bends in upward direction; whereas when CTE of top beam is more, beam bends in downward direction.

The simulation results obtained in this work are compared with their analytical results and with permissible values one can use the analytical expressions.
Thermal bimorphs and other thermal actuators have been used in many applications, like micro grippers, micro-optical mirrors etc. In most cases open loop control is used due to difficulties in fabricating positioning sensors together with actuator.

Key words: Thermal Bimorph, microactuator, thermal actuator.

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Figures used in the abstract

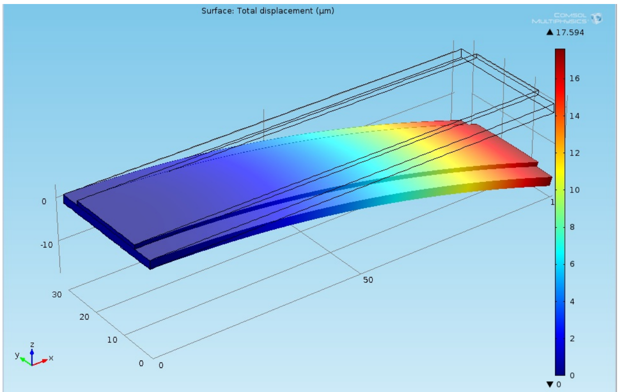

Figure 1: Total displacement is 17.594µm at 1000K and L=100µm (α2> α1).

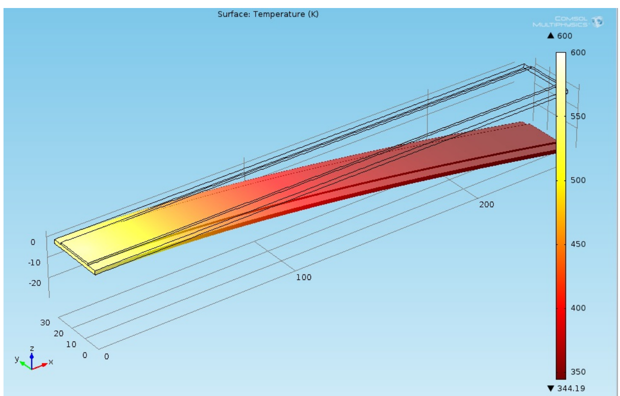

Figure 2: Temperature distribution of thermal bimorph (α2> α1) at To =1000K and L=100 µm, resulting deformation is 29.861 µm.

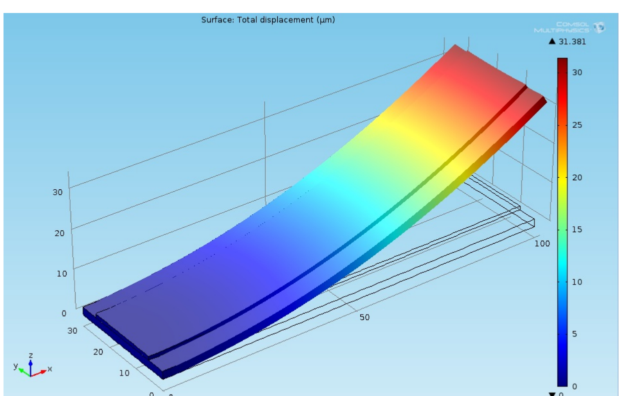

Figure 3: Total displacement is 31.381µm at To =1000K and L=100µm (α1> α2).

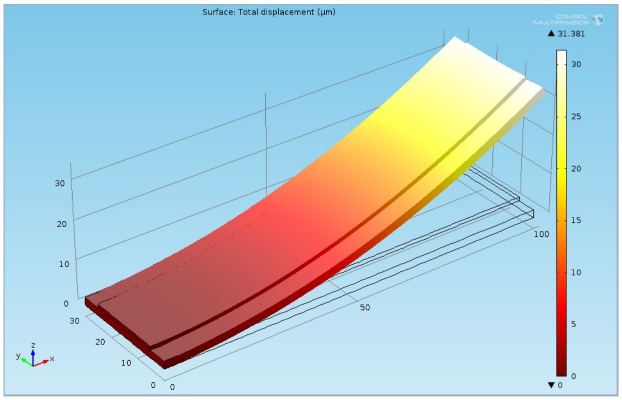

Figure 4: Temperature distribution of thermal bimorph (α1> α2) at To =600K and L=250µm, resulting deformation is 31.38 µm.