Simulation of Buckled Cantilever Plate with Thermal Bimorph Actuators

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Introduction

Micro Electro Mechanical Systems (MEMS) are fabricated with an in-plane fabrication technology. Out-of-plane structures can be design to be assembled to provide thermal and electrical isolation from the substrate [1-3]. These isolations can potentially improve the performance of a range of MEMS devices by decreasing any unwanted coupling effects or parasitic loses between the devices and a lossy substrate. One of the interesting out-of-plane mechanism is the Buckled Cantilever Plate (BCP) [1,3,4]. We have designed and simulated BCP out-of-plane structures with thermal bimorph actuators to be able to control the angular position of the assembled plate. Fig. 1 show assembled BCP devices with Thermal Bimorph Actuators.

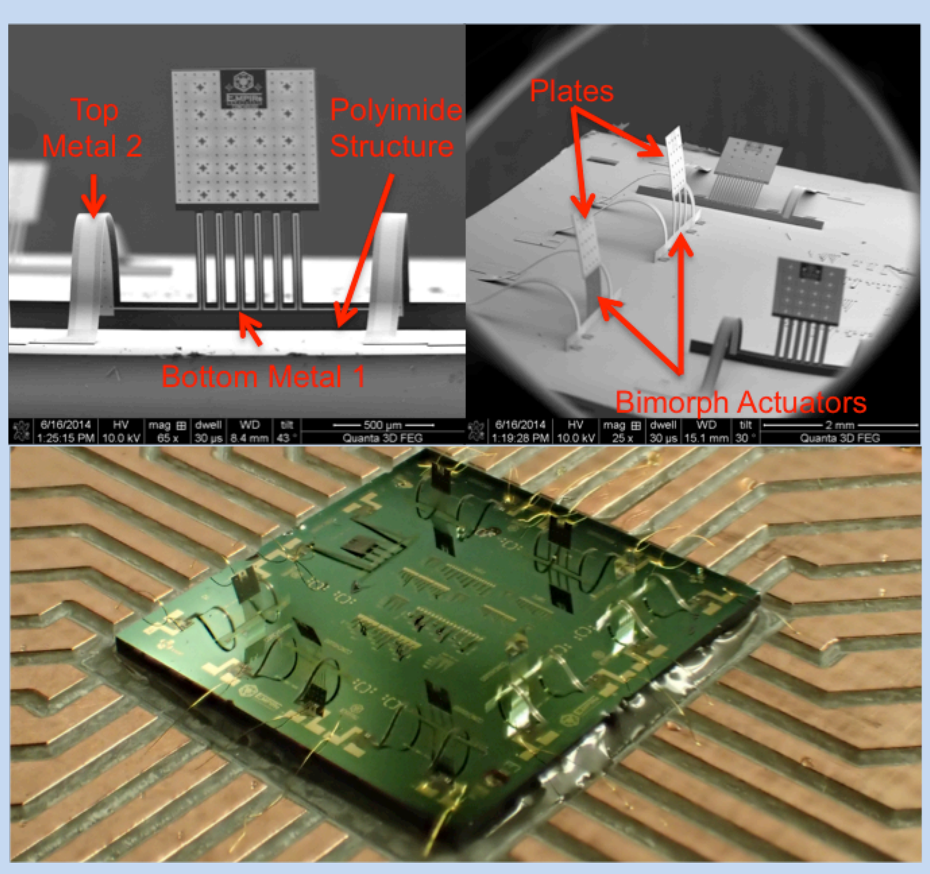

Figure 1 Collage image of assembled BCP. Top: Scanning Electron Microscope image with parts indication. Bottom: Macro 5X Photograph of finalized wire bonded and mounted chip.[3]

Computational Methods

The Joule Heating Model was used for this simulation following the heat equation version of the mathematical model for heat transfer in solids:

$$\rho C_p \frac{\partial T}{\partial t} - \nabla \cdot (k \nabla T) = Q \qquad \ldots(1)$$

Using the following material properties:

- ρ is the material's density.
- C_p is the heat capacity.
- k is the thermal conductivity.
- Q is the heat source, in our case for Joule Heating, the heat source is produced form the electric current, which is handle in the Electromagnetic Heat Source node.

Results

In our simulation we first created a 3D model of the structure using COMSOL's environment. Each domain was assigned its corresponding material, using Polyimide as the structural layer. We setup the boundary condition that represent the physical assembly using the Solid Mechanics Module. Anchors where fixed and the free end edge was given a prescribed displacement in the Y-axis. A second study was performed to simulate the heat transfer physics using the Joule Heating module. Boundary conditions applicable to the study such as: the structure temperature, environment temperature, the heat fluxes present in the system and heat flux dissipation were set accordingly. In Fig. 2 we can see the results of the simulation of an assembled BCP with active bimorph actuators.

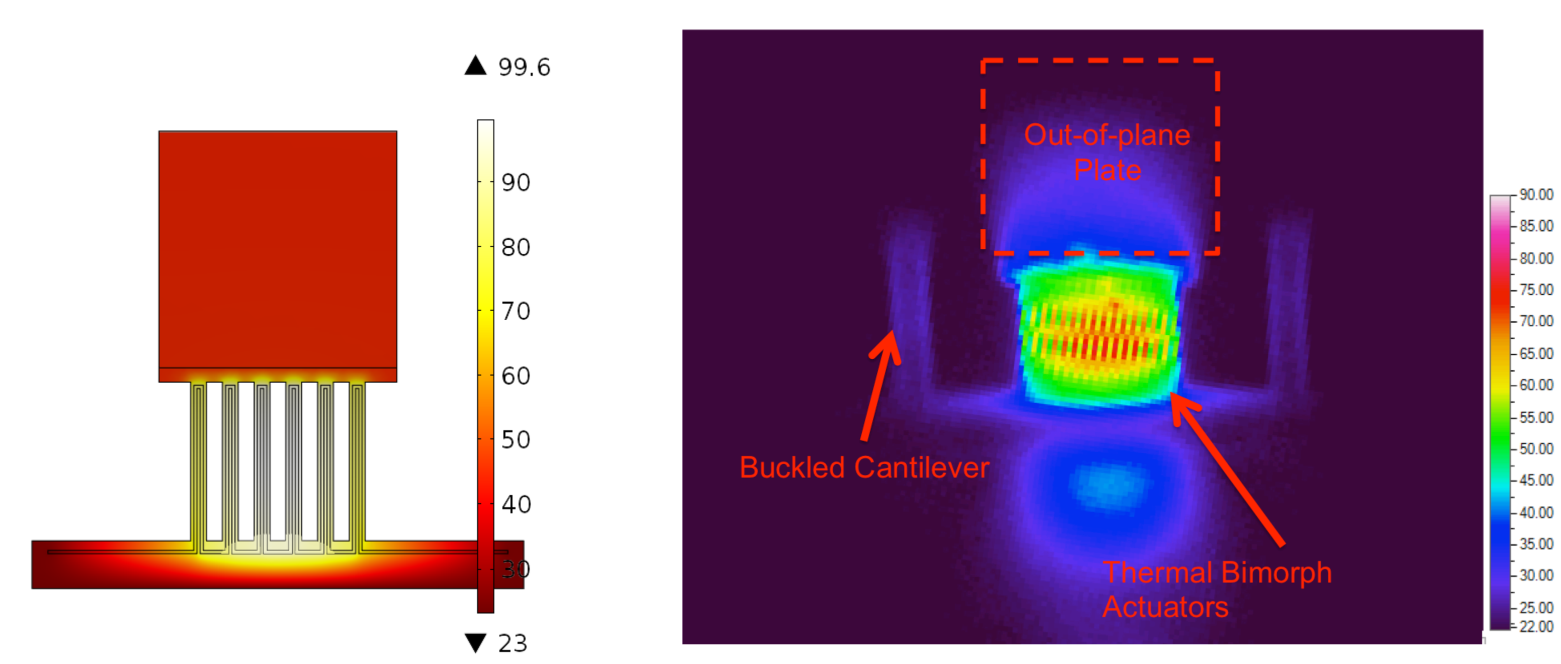

Figure 2 Comparison of the simulation of the generated heat (left) and the experimental measurement using an infrared camera (right).

Conclusions

COMSOL Multiphysic simulations gave good agreement with our experimental results. We achieved displacements in the order of hundreds of microns. Our next steps are to simulate more designs and use this validated model as a design tool to help in the optimization of the design parameters. The devices are potentially actuators for use in an optical bench and suitable for RF systems implementing an scanning antenna.

References

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