Simulation of a Polyimide Based Micromirror

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Introduction

In this work we present the simulation of a micro-mirror using polyimide as the structural material. The device is designed in such a way that it has three different configurations in which the actuation voltage can be applied and the structure can be pulled in to either side depending on these configurations. The results of this simulation are used to verify the initial design parameters and different device's electromechanical characteristics.

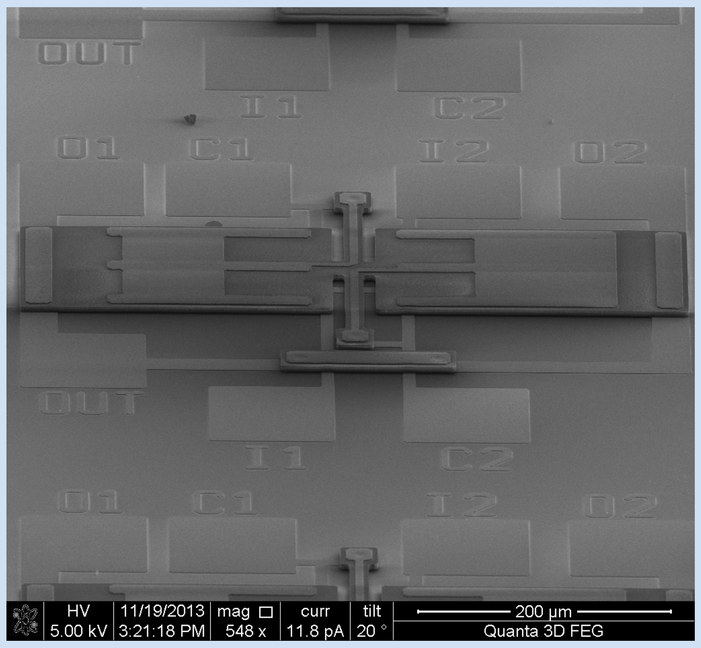

Figure 1 SEM image of fabricated micro-mirror using our In-House Multiuser microfabrication process.

Design and Simulation

The micro-mirror is similar to a mechanical relay switch. The design consists of a bridge with two extended wings from the middle creating a long pinned cantilever. Figure 2 shows such structure. are initially separated by 2 µm from the substrate. Two pairs of electrodes are located on the bottom of the structure in each side of the wing like plates, two left electrodes (80 µm X 30 µm) and two right electrodes (125 µm X 42.5 µm), see Figure 3. The micro-mirror and electrodes are initially separated by 2 µm from the substrate.

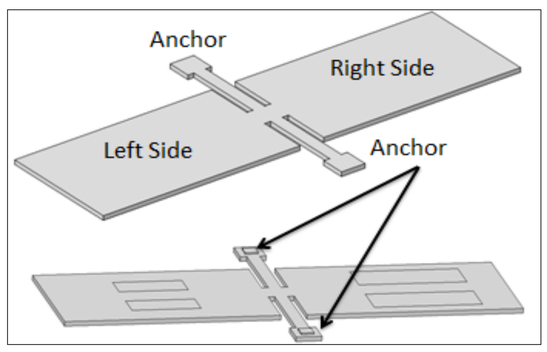

Figure 2 Top and bottom view of the 3D model of the proposed micro-mirror.

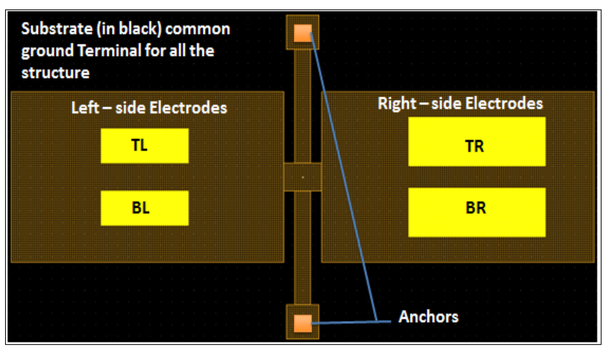

Figure 3 Top layout view of the micro-mirror, emphasizing the location of the top electrodes.

The electrodes can be in two different states: active (when a voltage different than 0 Volts applied to the electrode) and inactive (when no voltage is applied to the electrode). The different configurations that we are interested in are:

1. When TR (Top Right) and BR (Bottom Right) electrodes are active and the other two are inactive.
2. When TR (Top Right) and BL (Bottom Left) electrodes are active and the other two are inactive.
3. When TL (Top Left) and BL (Bottom Left) electrodes are active and the other two are inactive.

Results

The particular moment when this occurs is called the pull-in voltage. When the applied voltage is lower than the pull-in voltage, the structure stays in an equilibrium position where the stress forces are in balance with the electrostatic forces. Figure 4 shows the simulation results of an applied voltage, which is lower than the pull-in voltage and the corresponding displacement of the structure.

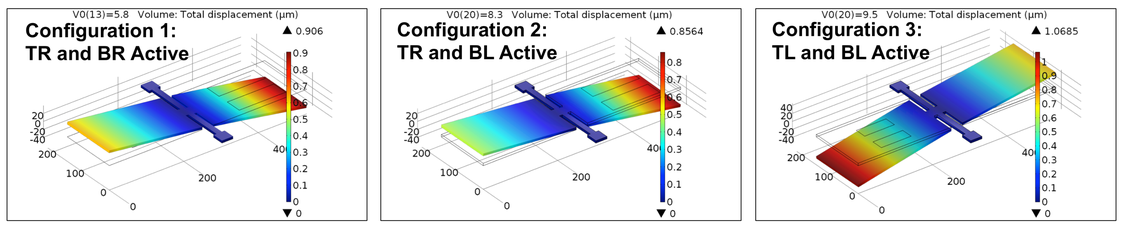

Figure 4 Micro-mirror simulation for the different active electrodes configuration, showing the displacement at a lower voltage than the pull-in voltage. The deformation is exaggerated by 50 times for visualization purposes and displacement is not greater than the gap between the electrodes.

In Figure 4, the three graphs show the DC Capacitance – Voltage curve that are predicted for the micro-mirror structure. The simulation is consistent to that of the behavior of an ideal parallel plate capacitor. In such ideal configuration, the capacitance increases with the decrease in distance between the plates. In Figure 5, the shape of the cantilever's deflection is presented for each applied voltage. This was done by plotting the z-displacement of a 3D Cut Line defined in the middle and across the length of the structure.

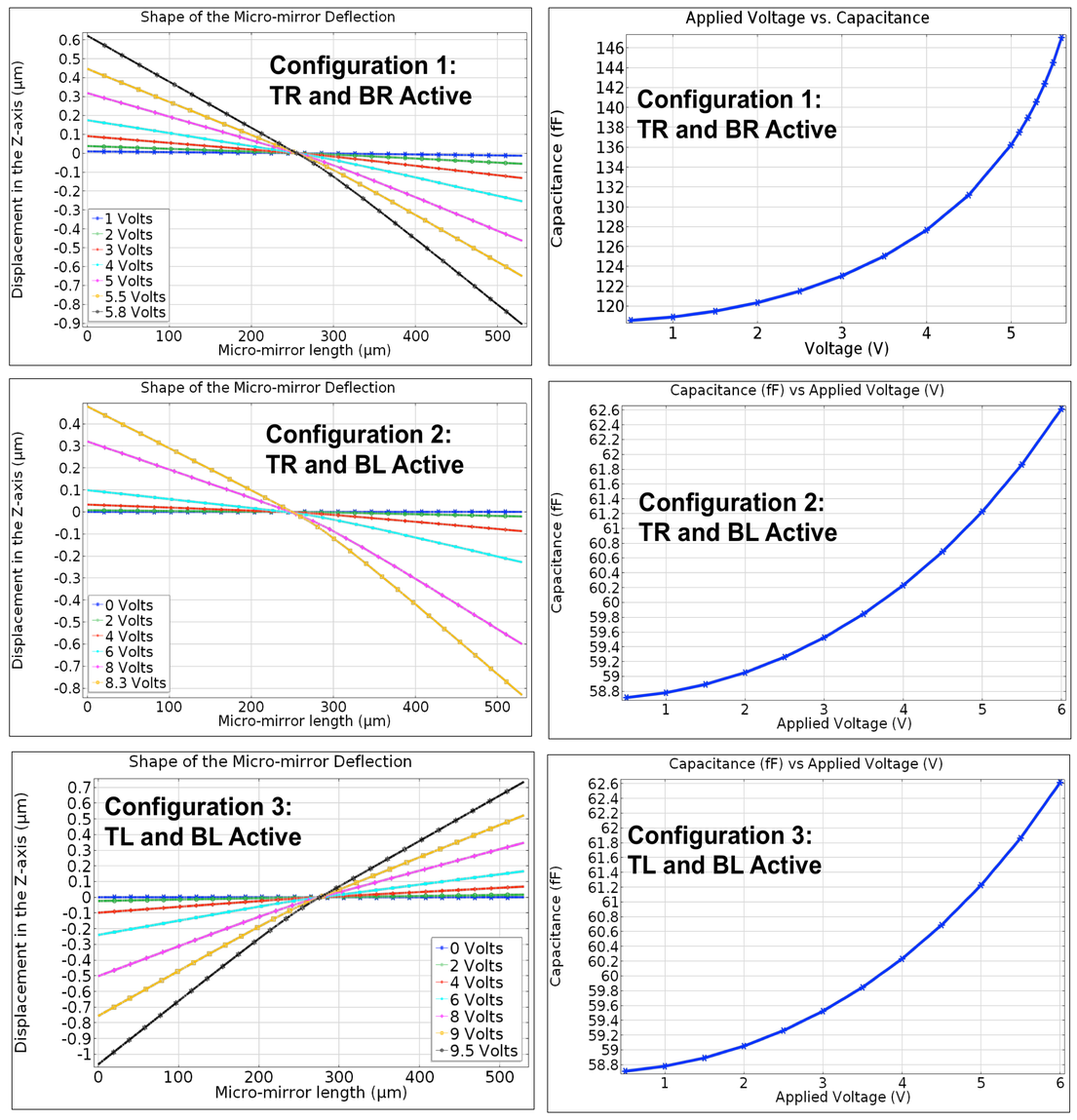

Figure 5 (Left)Shape of the Micro-mirror deflection for different applied voltages and different active electrodes configuration. (Right) Micro-mirror tip displacement vs. capacitance plot for the different active electrode configuration.

Conclusions

Simulation results of the proposed micro-mirror showed that there exist, three different operating voltages and each causes the device to pull in to one or the other side depending on the design parameters such as the electrodes dimensions. This feature of the micro-mirror opens up prospects for using such a switch to realize various kinds of logic operations such as AND, NAND, Inverter etc. Future work will be focused on further improving the design to implement various logic operations using same structure.

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