The Spiral RF MEMS Switch in COMSOL Multiphysics

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Abstract : This work presents the study of spiral RF MEMS switch which has low actuation voltage due to spiral structure. This work is inspired by the superior performance of electrostatic RF MEMS switches over the conventional state-of-the-art solid-state devices and the potential applications in communication field. The customary high actuation voltage limits the reliability and applications especially in wireless communication, and hence focus on the realization of electrostatic low actuation voltage switches is rapidly increasing. The optimization of actuation voltage is achieved by analyzing the flexure design, beam topology, actuation electrodes and gap height using COMSOL models which are validated by simulations. It is observed that with more and more number of spiral ring structure actuation voltages can be reduced.

Keywords : Electrostatic switch, RF MEMS, Spiral Switch

1. Introduction

To develop electrostatically actuated spiral switch, which can be actuated at lower voltages as compared to conventional RF MEMS switches. The proposed design is capable of producing better deflections for lower voltages. This design was verified in COMSOL/Multiphysics. Prior to the spiral actuator the same contact plate was suspended by two and four anchors with anchor dimensions of 100µm*5µm*1µm, pull-in voltages observed are 25.2 V and 50.6 V (Figure 1). To decide the number of coiled structures another investigation is done on a nine coiled spiral switch as shown in Figure 2. For this design, input voltage of 5V resulted in the deflection of 2nm. As coiled structure increases the pull-in voltage decreases. The proposed spiral design reaches pull-in voltage of 4.475V.The simulation results of COMSOL Multiphysics are presented in Figures 3, 4 and 5. Figure 6 shows plot of plate deflection versus applied voltage.

2. Design & Description of contact pads

All the dimensions of contact pad are 20 µm *15 µm *1 µm

1. P1: P1 is voltage input contact pad, used to apply actuation voltage to the spiral switch.
2. P2: P2 is voltage input contact pad, placed right below the center of the spiral end, at distance of 2 µm below it. This terminal is used to apply ground voltage to the spiral switch.
3. P3: P3 is an input signal pad, shown in Figure 8. P3 is placed in front of P2 and right below the center of spiral.
4. P4: P4 is contact pad used to tap out the input signal and shown in Figure 8. P4 is placed in front of P2 and right below the center of spiral, facing against P3.

When 5V of dc voltage is applied to P1, the spiral gets deflected as the electrode P2 is at 0v. When the spiral gets deflected, it establishes a connection between P3 & P4 thus it acts as switch and input signal can be tapped through pad P4.The purpose is to test the design to exhibit the switching operation with low pull-in voltages. Simulation results show that the design operates at pull-in voltage of 4.475V.

3. The device description and dimensions

1. CPW with dimension 20µm*15µm*1µm.
2. Spiral device with dimensions of 100µm*5µm*2µm which reduces by 10µm at each stage, keeping constant width of 5µm and thickness of 2µm.

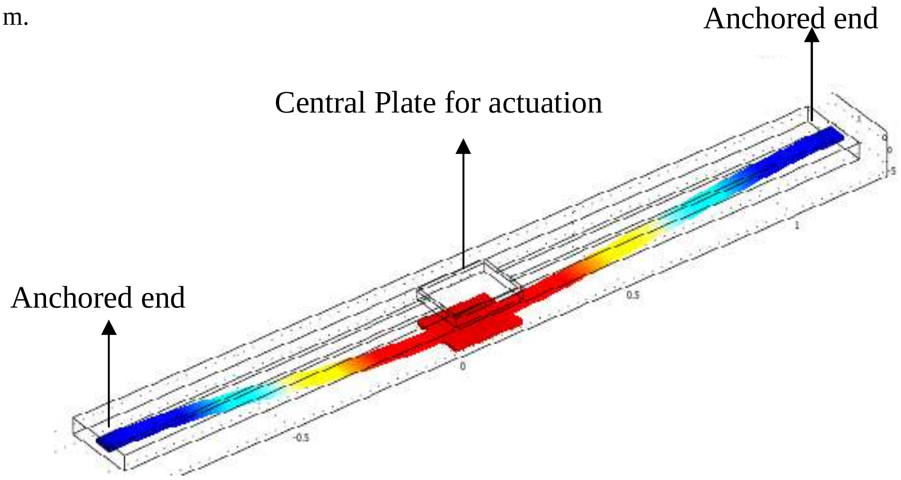

Figure 1 Plate suspended by two anchors showing displacement of 0.66µm for applied voltage of 25.2 V (Pull-in)

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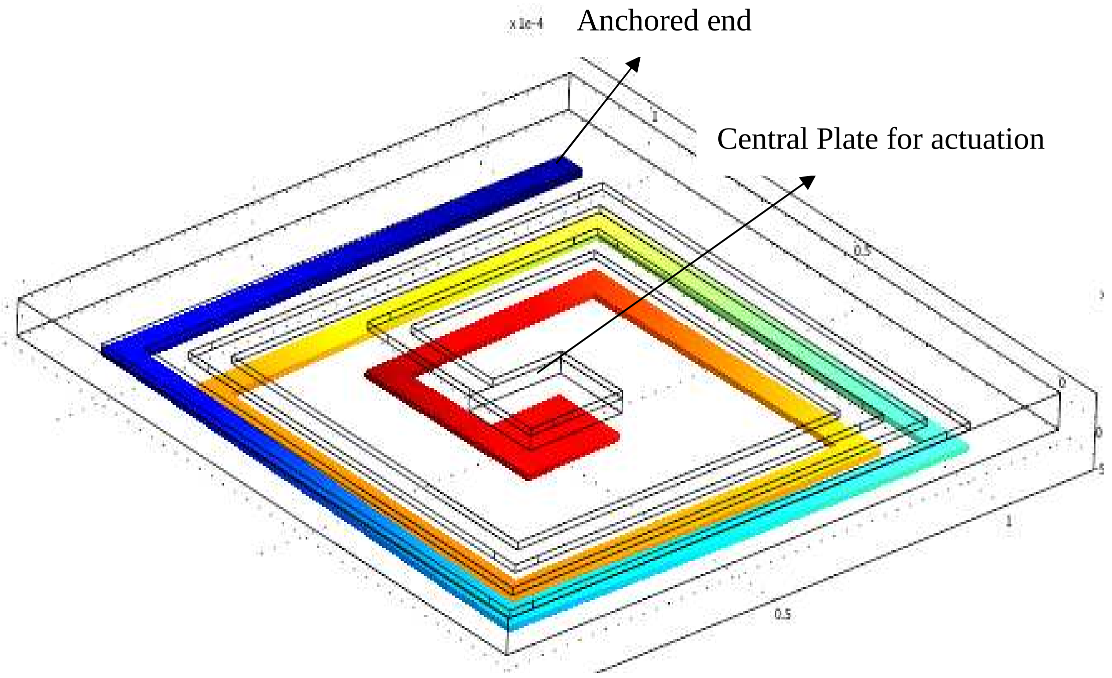


Figure 2 Three spiral electrostatically actuated switch showing displacement of 2nm for applied voltage of 5V.

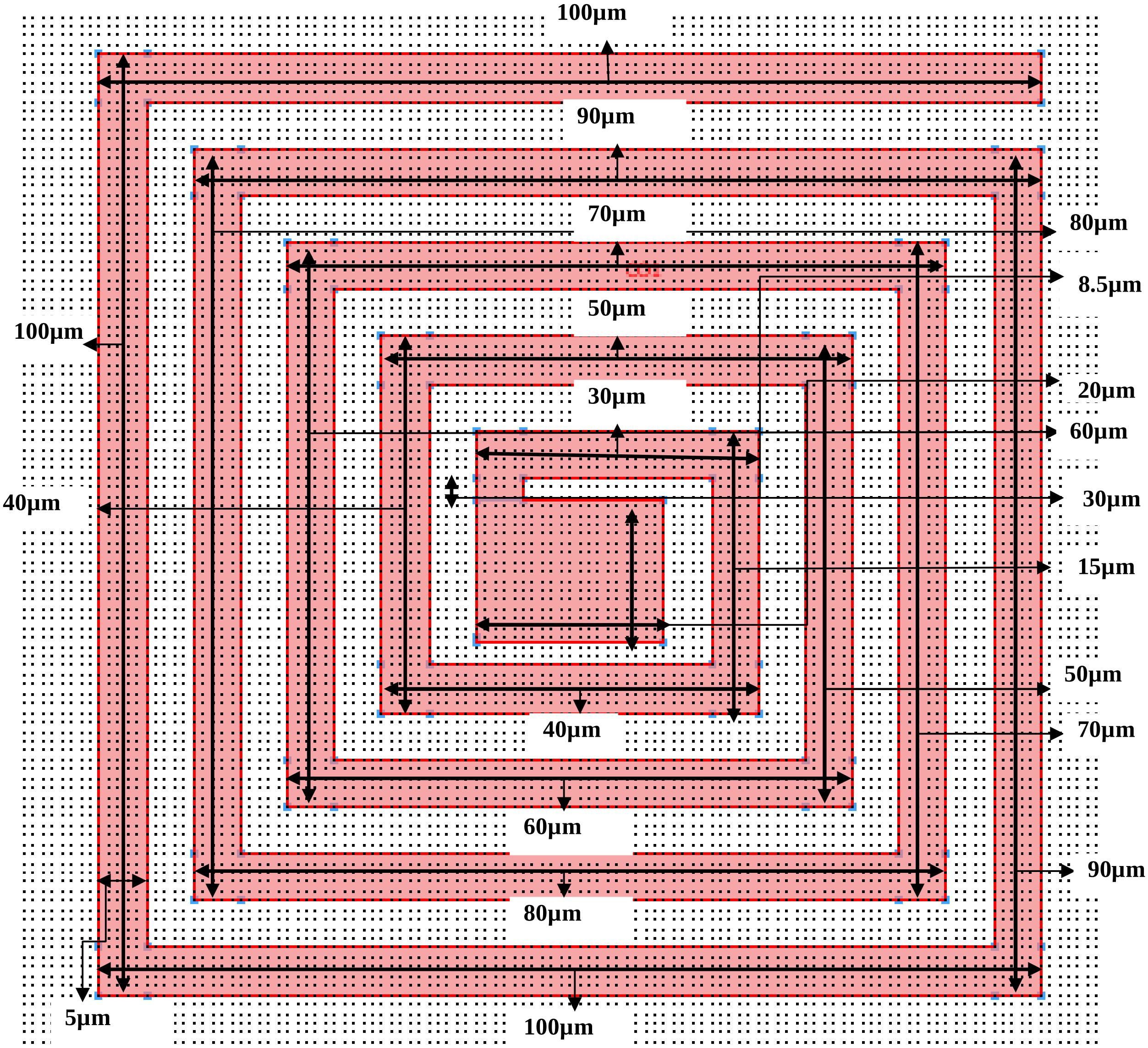


Figure 3 2D model of electrostatically actuated spiral RF MEMS switch in COMSOL multiphysics showing dimensions.

The 2D model developed in COMSOL Multiphysics having width of 5µm is maintained all over the geometry and thickness of 2-3µm. The area of contact metal plate is 20µm*15µm as shown in Figure.3.

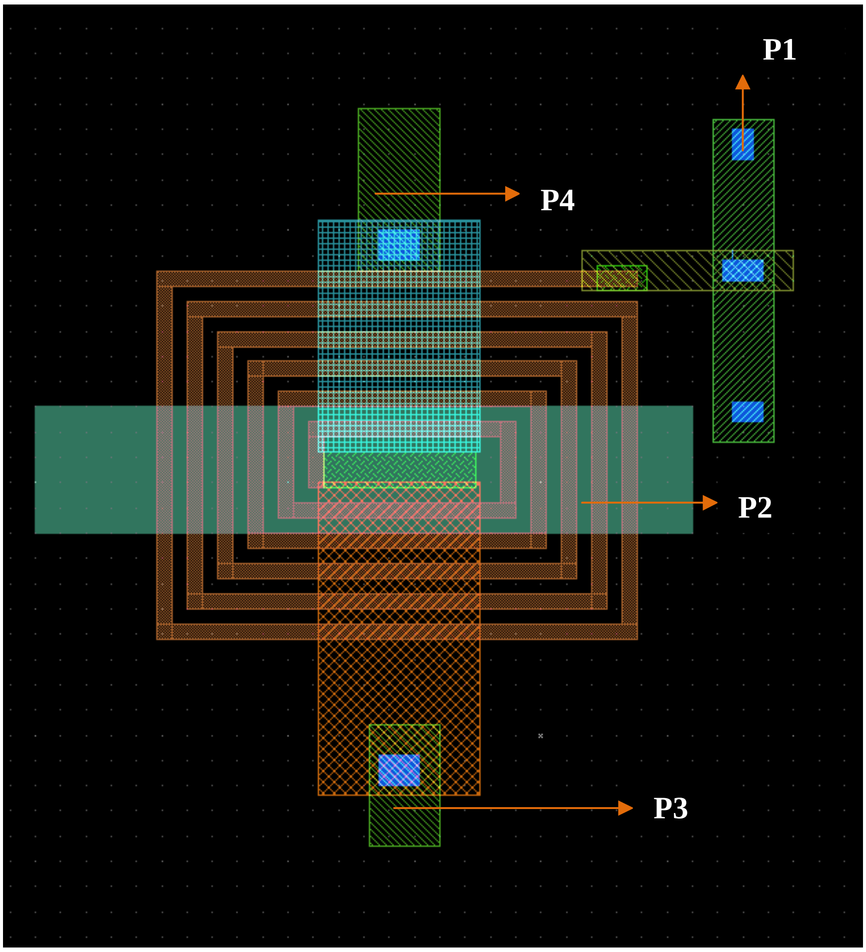
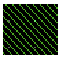


Figure 4 Electrostatically actuated spiral RF MEMS switch in Layout Editor showing two communication channels (CPW).


Metal contact


Communication channel (CPW of 20µm*15µm*2µm)


Other communication channel (CPW of 20µm*15µm*2

Where

P1 is input voltage pad ('5' volts)
P2 is grounded pad
P3 is Signal input pad
P4 is Signal output pad

The electrostatically actuated spiral serial RF MEMS switch in Layout Editor showing two communication channels (CPW) as shown in Figure 4 shows the coupling of two CPW's is done by suspended spiral plate [3-4].

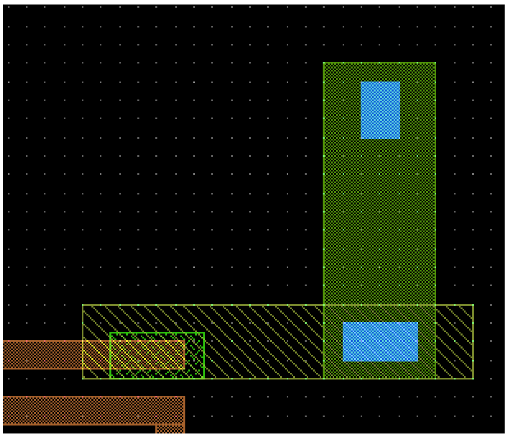


Figure 5 Electrostatically actuated spiral RF MEMS switch in Layout Editor showing contact pad to other CPW

In the proposed switch anchor fixes the total structure and also provides drive voltage that is '5'volts as shown in Figure 5.

4. Results from COMSOL Multiphysics

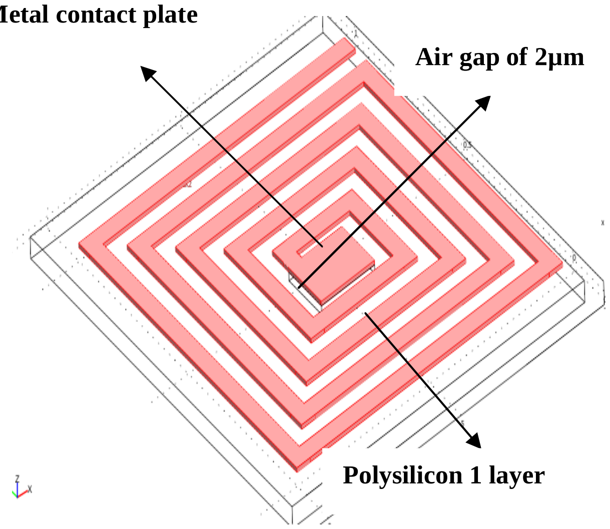


Figure 6 Solid model of electrostatically actuated spiral RF MEMS switch.

The spirally suspended plate of dimension 20µm*15µm*1µm* is separated by an air gap of 2µm as shown in Figure 6. The solid model is constructed by a beam of length 100 µm initially and the length of the beam reduces by 10 µm successively and reduces to 50 µm which holds the contact plate.

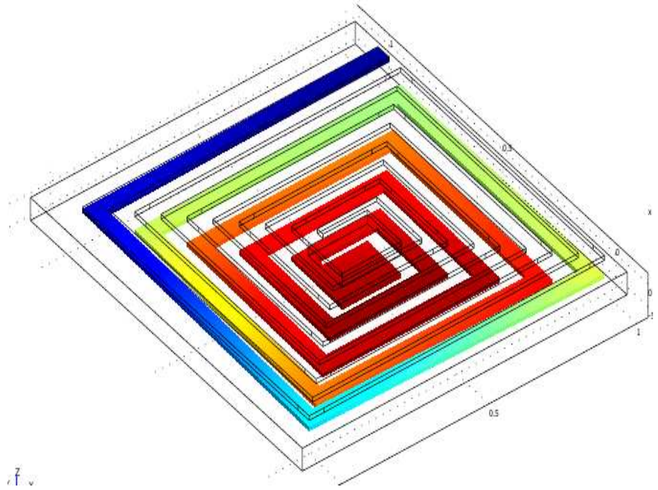


Figure 7 Simuation result of Electrostatically actuated spiral RF MEMS switch showing displacement in COMSOL multiphysics.

The main effort in designing this model is bring down the actuation voltage by using serpentine like structure. The plate is adhered to serpentine structure which anchors the whole structure. The solid model as shown in Figure 7 shows the deflection observed due to applied voltage.

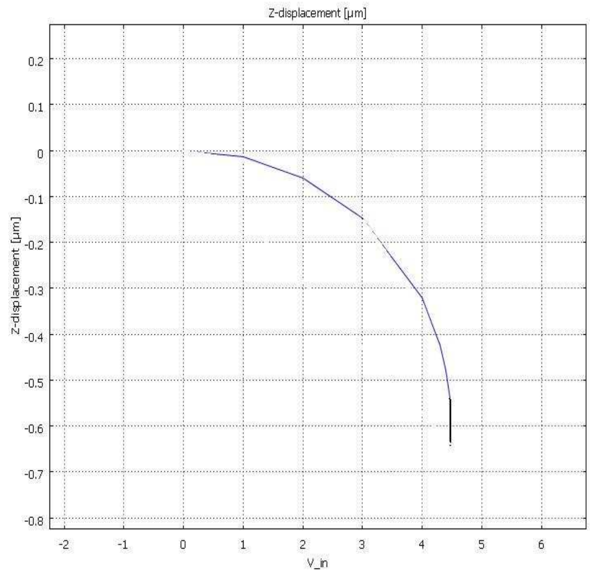


Figure 8 Plot of plate deflection v/s applied Voltage.

Figure 8 shows that hold on occur at 0.4 V and pull-in occurs at 4.475 V.

5. Conclusion

The serpentine structure is suitable for low actuation switch is modeled and simulated in COMSOL. This developed switch has pull-in voltage compared to other two geometries as shown in Figure 1, 2 and 3.

References

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