Design and Analysis of Electrostatically Controlled Circular Micromirror using Different Materials

Ankit Kumar¹ & Naveen Rawat²
¹ PG Student, Department Of Electronics and Communication Engineering
² Assistant Professor, Department Of Electronics and Communication Engineering
Prannath Parnami Institute Chaudharywas, Hisar Haryana 125001

Abstract- We have designed a MEMS based electrostatically controlled circular shape Micromirror using COMSOL Multiphysics Software. For simulation, we used parametric nonlinear solver to model the performance of Micromirror. We accomplish that the lift off can be controlled by using different materials combinations of micromirror and cantilever beam. In this paper, Stress level and Lift-off of different materials are analysed. We have observed that few of them have very high lift off and better than others, Titanium as mirror and aluminium as cantilever gives the maximum lift off.

Keywords— Micromirror, prestress, liftoff, MEMS

INTRODUCTION

Various structures with completely different materials are simulated and analyzed w.r.t. their stress level and lift-off, prestress and total displacement. In this, initial stress is taken as 8GPa. One among the most parameters need to verify during this class of drawback is what prestress level is critical to lead to a desired lift-off. Another issue is that what are impact variations of the prestress might need on displacement. This work is classified into micromirror with completely different materials and cantilever with same materials.

MICROMIRROR WITH DIFFERENT MATERIALS

In this method, initial stress is considered to 8GPa. Micromirror is modified to completely different materials with same cantilever material. During this we have to determined completely different parameters as stress level, Lift-off, total displacement w.r.t. completely different prestress levels. Observation is especially on the strain on the edge of micromirror and lift-off of cantilever. During this dissertation, we have chosen aluminum 3003-H18 for cantilever and completely different materials for micromirror.

Figure 1 show that lift-off and stress level of small mirror once aluminum 3003-H18 is used for each cantilever beam and micro mirror. It shows high lift off and stress level that is 5.21e-4. However we have a tendency to required stiff, flat output it's a high lift-off and stress therefore it's not appropriate for that. The graph of this material are shown in Graph 1.

- Aluminum 3003-H18

The total displacement shown in Graph 1 will increase linearly between 0-0.7×10⁻¹⁰ [N/m²²], then it will increase non linearly for higher prestress values.
It provides the entire displacement of 391µm at maximum prestress i.e. 1× 10^10 [N/m^2].

- **Steel AISI 4340**
  In this, lift-off and stress level of small mirrors determined once aluminum 3003-H18 is employed for cantilever beam and steel AISI 4340 for small mirror. It dramatically reduces lift off and stress level that is 2.44e-4 as shown in Figure 2. This can be the most effective combination in all combinations according to stress level and lift-off values.

The total displacement shown in Graph 2 will increase linearly between 0-0.0010^10 [N/m^2], then it will increase non linearly for higher prestress values. It provides the total displacement of 200µm at most prestress i.e. 1× 10^10 [N/m^2].

- **Silver**
  Figure 3 shows that lift-off and stress level of micromirror once aluminum 3003-H18 is employed for cantilever beam and Silver is used for micro mirror. It's high lift off and stress level that is 4.672e-4 however as compared to above work it's low.

The total displacement shown in Graph 3 will increase linearly between 0-0.8× 10^10 [N/m^2], then it will increase non linearly for higher prestress values. It provides the total displacement of 363µm at most prestress i.e. 1× 10^10 [N/m^2].

- **Gold**
  Figure 4 shows that lift-off and stress level of micromirror once aluminum 3003-H18 is employed for cantilever beam and Gold is employed for micro mirror. It has very high lift off and stress level that is 4.93e-4. It has very high lift off.
The total displacement shown in Graph 4 will increase linearly between $0-0.1 \times 10^{10} \text{[N/m}^2\text{]}$, then it will increase non linearly for higher prestress values. It provides the entire displacement of 376 µm at most prestress i.e. $1 \times 10^{10} \text{[N/m}^2\text{]}$.

- **Titanium**
  Figure 5 shows that lift-off and stress level of micromirror once aluminum 3003-H18 is used for cantilever beam and titanium is used for micro mirror. It has high lift off as compared all and stress level that is $6.142 \times 10^{-4}$.

The total displacement shown in Graph 5 will increase linearly between $0-0.7 \times 10^{10} \text{[N/m}^2\text{]}$, then it will increase non linearly for higher prestress values. It provides the whole displacement of 400 µm at most prestress i.e. $1 \times 10^{10} \text{[N/m}^2\text{]}$.

- **Structural Steel**
  Figure 6 shows that lift-off and stress level of micromirror once aluminum 3003-H18 is employed for cantilever beam and structural steel is used for micro mirror. It’s comparatively low lift off and stress level that is $2.503 \times 10^{-4}$.

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<th>COMPARISON OF RESULTS</th>
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<td>The Graph 7 shows the comparison Graph between total displacement and prestress level for various materials. It also shows the mirror response to the different levels of applied prestress. According to this,</td>
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The total displacement shown in Graph 6 will increase linearly between $0-0.9 \times 10^{10} \text{[N/m}^2\text{]}$, then it will increase non linearly for higher prestress values. It provides the entire displacement of 205µm at most prestress i.e. $1 \times 10^{10} \text{[N/m}^2\text{]}$. 

**GRAPH 4: PRESTRESS VS TOTAL DISPLACEMENT**

**GRAPH 5: PRESTRESS VS TOTAL DISPLACEMENT**

**GRAPH 6: PRESTRESS VS TOTAL DISPLACEMENT**

**GRAPH 7: COMPARISON**
the middle purpose deflection is nearly linearly dependent of the prestress. From this we will simply determine that the results of device in terms of displacement according to prestress. It’s clearly shown that Steel AISI 4340 has lowest displacement i.e. 200 µm that is shown by red color line and titanium highest displacement or lift off i.e. 400 µm

Graph 7 : Comparison Graph for different materials

CONCLUSION

We conclude that the lift off can be controlled by using different materials combinations of micromirror and cantilever beam. Because of using these different materials the stress and lift-off can be varied. In these comparisons Aluminum 3003-H18 + Titanium gives the best results as compared to all. Furthermore the distance between mirror and the bottom plate are reasonably close and the voltage required to adjust the micromirror will be reasonably low.

As known theoretically, if the micromirror are far apart from the electrode, it would bend and create stress at its four legs.

REFERENCES


