Optimizing the Performance of MEMS Electrostatic Comb Drive Actuator with Different Flexure Springs

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Introduction: An electrostatic comb drive actuator is discussed with various spring designs and folded beam lengths. Comb drive actuators consist of two interdigitated finger structures, where one comb is fixed and the other is connected to a compliant suspension. The driving voltage between the comb structures causes the displacement of the movable fingers towards the fixed fingers by an attractive electrostatic force. The position of the movable finger structure is controlled by a balance between the electrostatic force and the mechanical restoring force of the compliant suspension.

The capacitance of comb drive is:

$$C = \frac{2n\varepsilon_0 t(y_0 + y)}{g}$$

The lateral electrostatic force (Fel) in y direction can be expressed as:

$$\text{Fel} = \frac{1}{2}\frac{\partial C}{\partial y}V^2 = \frac{n\varepsilon_0 t}{g}V^2$$

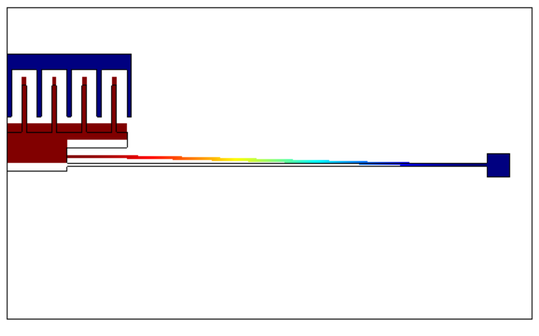

Figure 1. Comb drive displacement in Fixed-Fixed Flexure

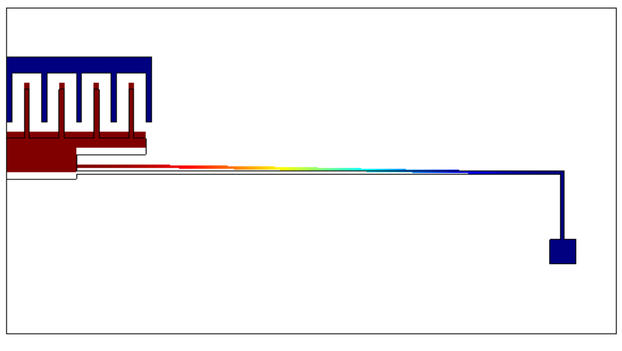

Figure 2. Comb Drive displacement in Crab Leg Flexure

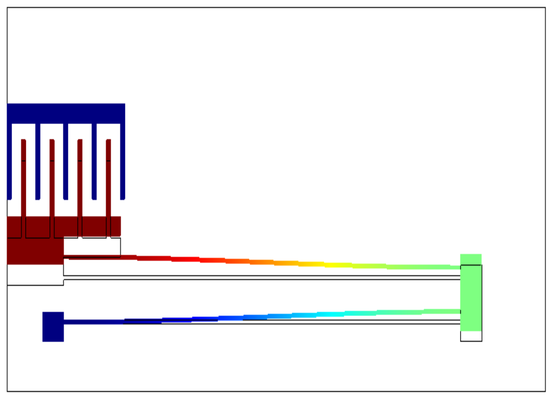

Figure 3. Comb Drive Displacement in Folded Flexure

Dimensions of Actuator	
Comb length (Lc)	30µm
Comb Width (Wc)	3µm
Gap between moving comb and fixed combs (g)	7µm
Overlapping area (y0)	20µm
Spring length(Ls)	280µm
Spring width (Ws)	2µm
Gap between spring legs (Lg)	19µm
Thickness of Actuator (t)	2µm
No.of Moving combs (n)	4
No. of Fixed Combs	5

Table 1. Geometrical Dimensions of Comb Drive Actuator

Results: Folded flexure with high spring length gives large deflections at low driving voltage.

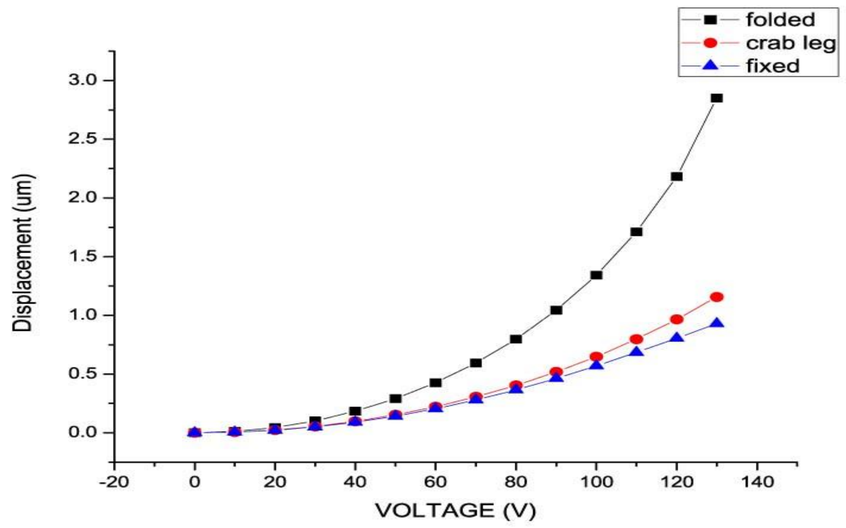

Figure 4. Comb drive displacement for different flexures at low driving voltage.

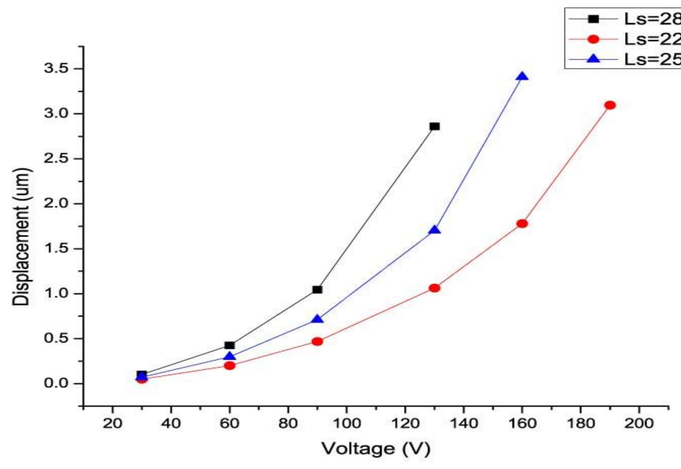

Figure 6. Displacement vs. driving voltage for several folded flexure designs with folded-beam width 2µm

Conclusions:

1.Spring stiffness in actuation direction is decreased with the increase of comb drive folded flexure length.

2.Large deflection at low driving voltage is highly desirable.

3.These actuators can be used for microtweezer applications.

References:

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2. Rob Legtenberg, A W Groeneveld and M Elwenspoek “Comb-Drive Actuators for large displacements” Micromech. Microeng. IOP published, pp 320-329 (1996).