Study of Pull-in Voltage in MEMS Actuators

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Introduction: As the voltage bias increases from zero across a pair of parellel plates,the distance between such plates would decrease until they reach 2/3 of the original spacing,at which point the two plates would be suddenly snapped into contact.This behavior is called the pull-in effect.And the voltage that is required for this pull-in operation to take place is called the pull-in voltage..

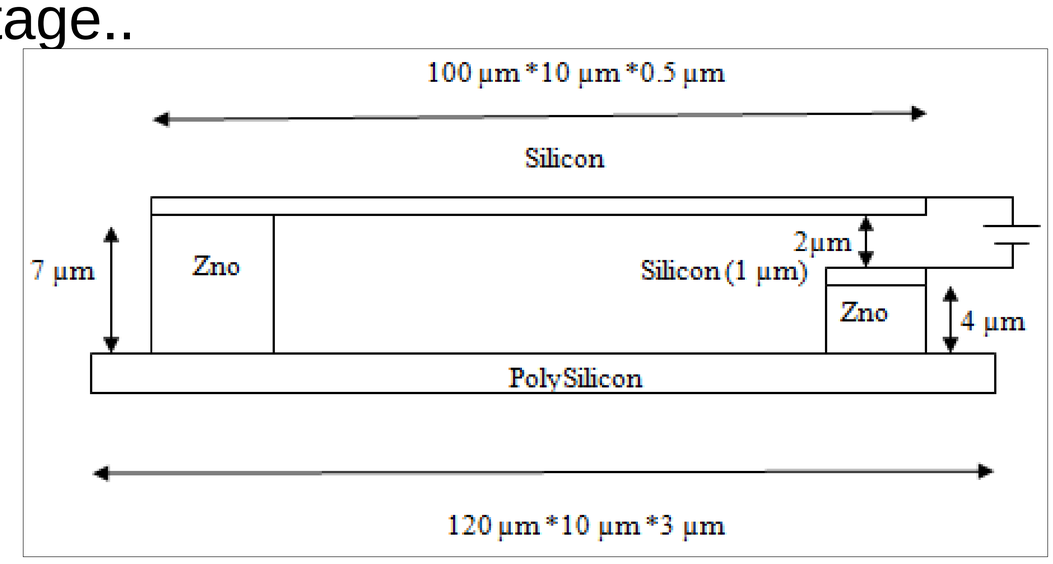

Figure 1. Schematic diagram of MEMS actuator

Pull-in voltage(Vpi) calculation:

The stiffness constant of the actuator is given by

$$K=\frac{EWt^3}{4L^3}\text{.....(1)}$$

The pull-in voltage equation is given by

$$\text{Vpi} = \sqrt{\frac{8\text{k}d^3}{27€0\text{A}}}\text{..... (2)}$$

Features of Actuators:

Variable	Value	Units
Length	100	µm
Width	10	µm
thickness	0.5	µm
density	2329	Kg/m3
Poison's ratio	0.28	

Results: Therotical calculation can be made using the equation 7 and 8 we will get the stiffness constant as K=0.0531 N/m and Vpi as 3.77V. And simulated value of pull-in voltage is 19.7V.

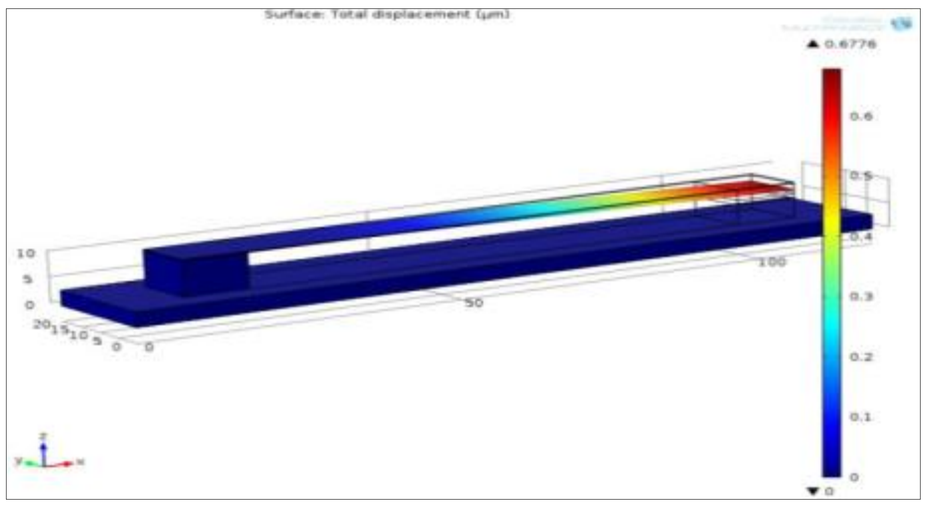

Figure 2. Simulated model of MEMS actuator

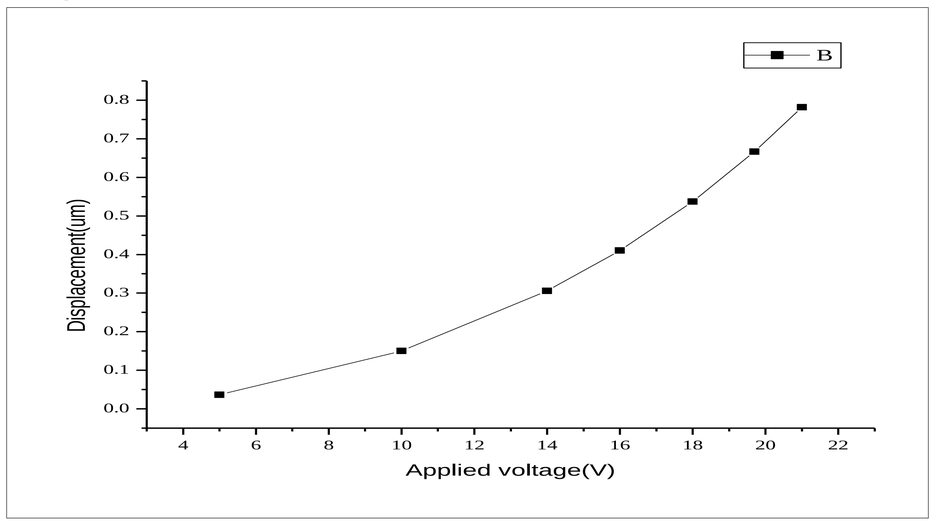

Figure 3. Deflection v/s applied voltage

Conclusions: Vpi can be reduced by increasing the area of actuator, and also by reducing gap and thickness of actuator and hence vpi reduced 19.7V to 12.1 V.

References:

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2. Design of low actuation voltage RF MEMS Switch Serigo P.Pacheo [1] Linda P.B.Katehi [1]Clark T-C.Nguyen[2]
3. Performance Analysis and Optimization of Lumped Parameters of Electrostatic Actuators for Optical MEMS Switches by D M.Madheswaran , International Journal of Computer Science and Information Security, Vol. 7, No. 1, 2010