

Fabrication of Electrostatic Comb-drive Microactuators

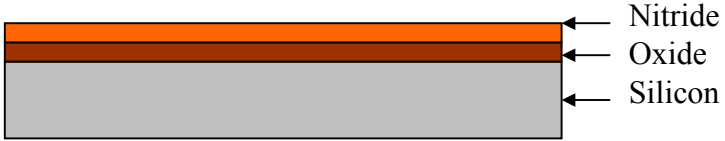
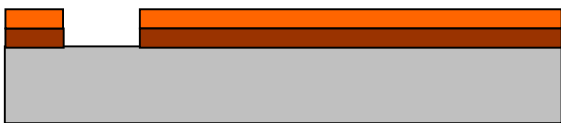

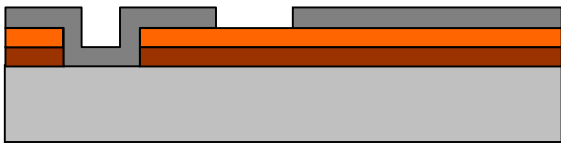
Description of the process

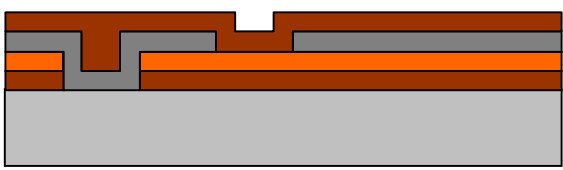
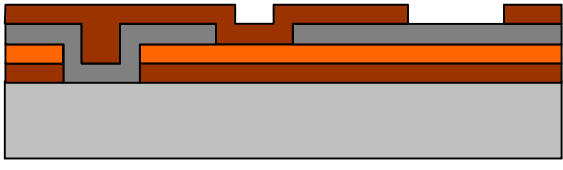
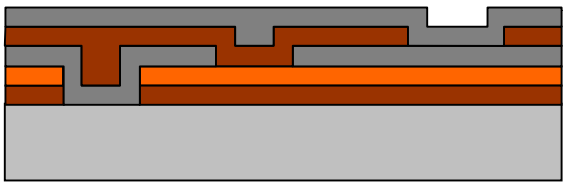
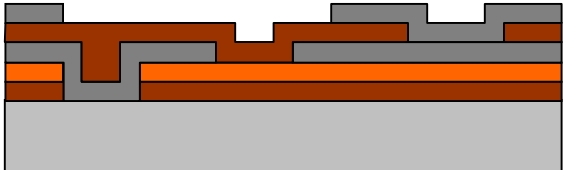
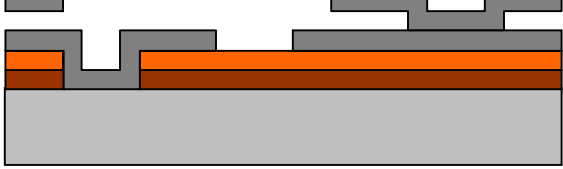
The electrostatic comb-drive was first microfabricated using surface micromachining. Later on, it was fabricated with other processes. In fact, its fabrication is possible with most micromachining techniques with equal ease. Here, we will describe the surface micromachining process that was used in reference [1] with slight modification.

On a silicon substrate that has n+ diffusion on the surface, a 1500 Å thick silicon nitride layer is deposited using LPCVD after a 5000 Å thick thermal oxide is grown. (These two layers serve the purpose of passivation for the ground electrode and contacts for the anchored polysilicon structure.) Using a *ground plane anchor mask (mask #1)*, contact windows are opened in the nitride and oxide layers. This is followed by LPCVD of 3000 Å thick polysilicon structural layer and its patterning using *ground plane mask (mask #2)*. (This polysilicon layer serves as a ground plane that acts like a group electrode.) Then, a 2 μm thick PSG (oxide) is deposited using LPCVD and is patterned using *anchor mask (mask #3)*. (This layer serves as the sacrificial layer and openings in it serve as anchors for the next polysilicon structural layer.) This is followed by LPCVD of 2 μm thick polysilicon layer, which is patterned with *device mask (mask #4)*. (This layer makes the moving and stationary comb arrays as well as the shuttle mass and the suspension springs.) Finally, the sacrificial oxide layer is dissolved.

Process flow

The figures below pictorially illustrate the process. Details such as diffusion and photolithography are not shown.

Grow thermal oxide on an n+ silicon substrate and LPCVD a nitride layer.	
Pattern nitride and oxide layers using mask #1.	
LPCVD polysilicon (poly0) layer.	
Pattern polysilicon (poly0) layer using mask #2.	

LPCVD oxide (PSG) layer.	
Pattern PSG layer using mask #3.	
LPCVD poly1 layer.	
Pattern poly1 layer using mask #4.	
Sacrifice PSG oxide layer.	

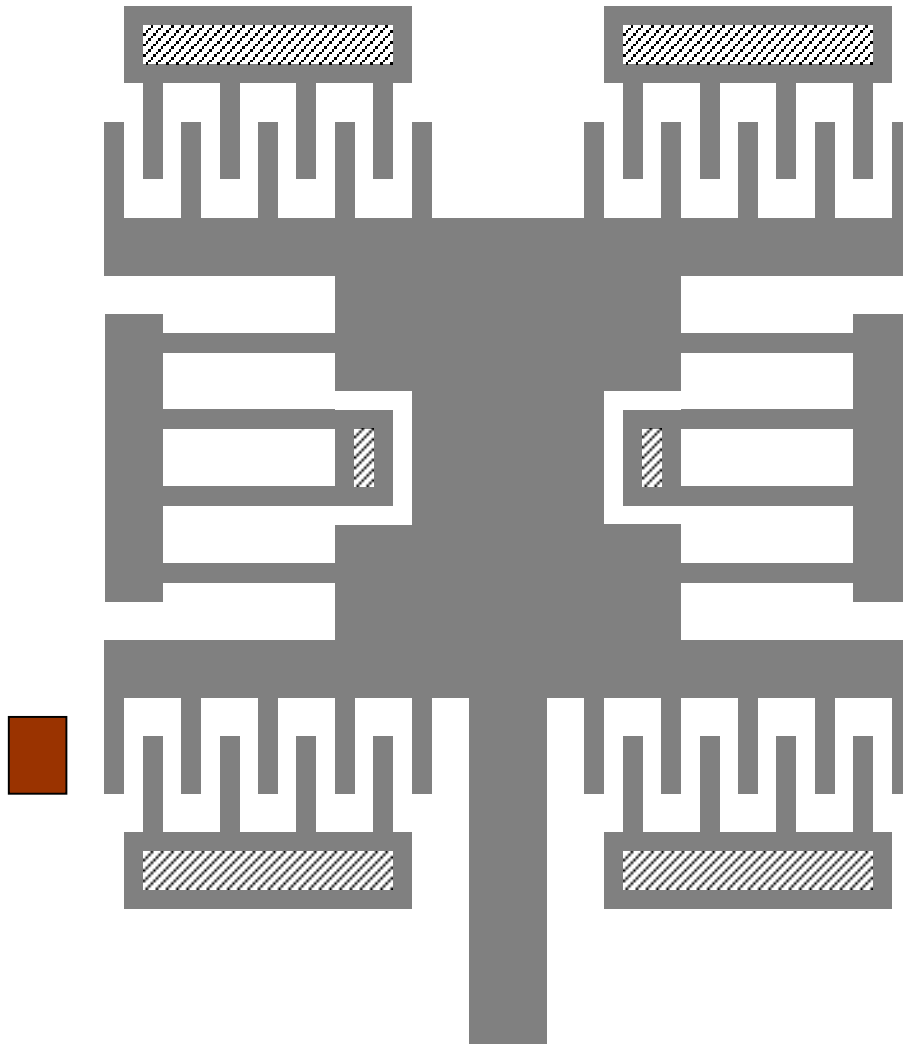
Masks

For clarity, four photolithography masks are overlaid on top of the schematic sketch of the comb-drive microactuator in four separate figures.

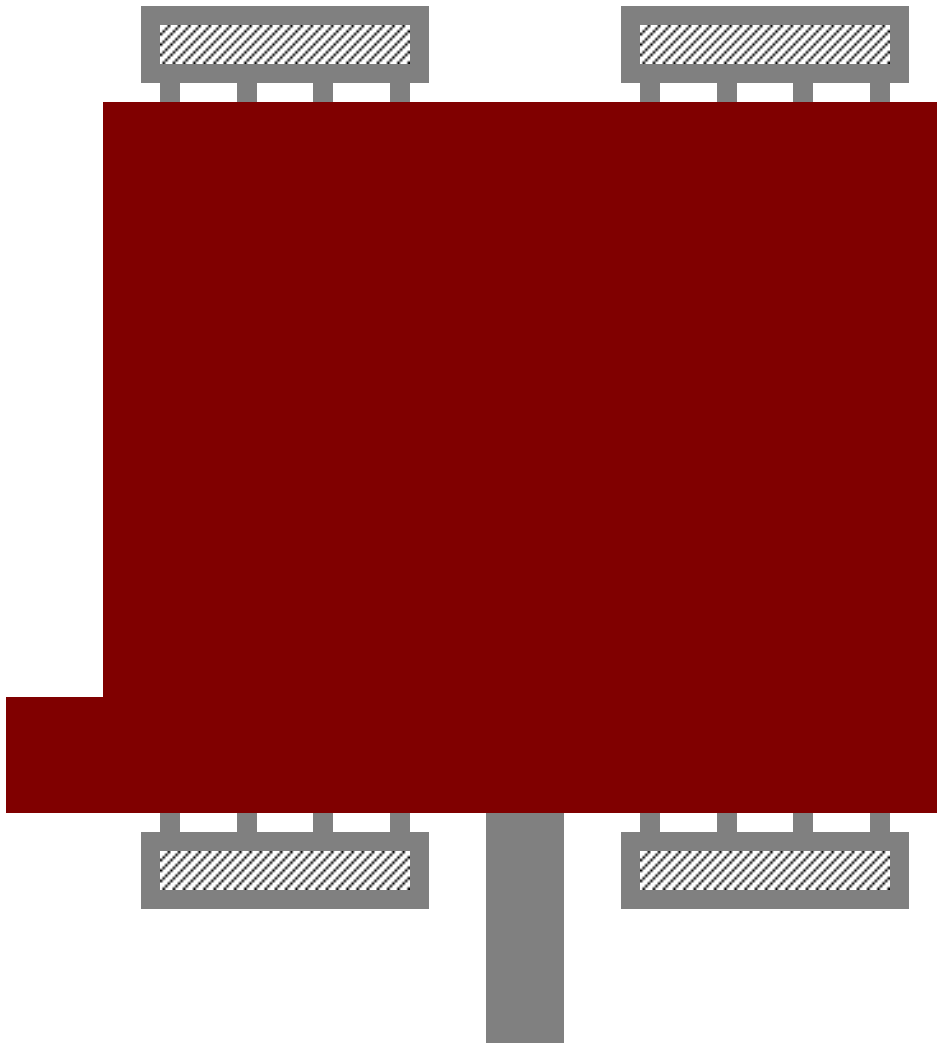
Reference

1. Tang, W. C., Nguyen T.-H., and Howe, R. T., "Laterally Driven Polysilicon Resonant Microstructures," *Proceedings of the IEEE Microelectromechanical Systems Conference*, February, 1989.

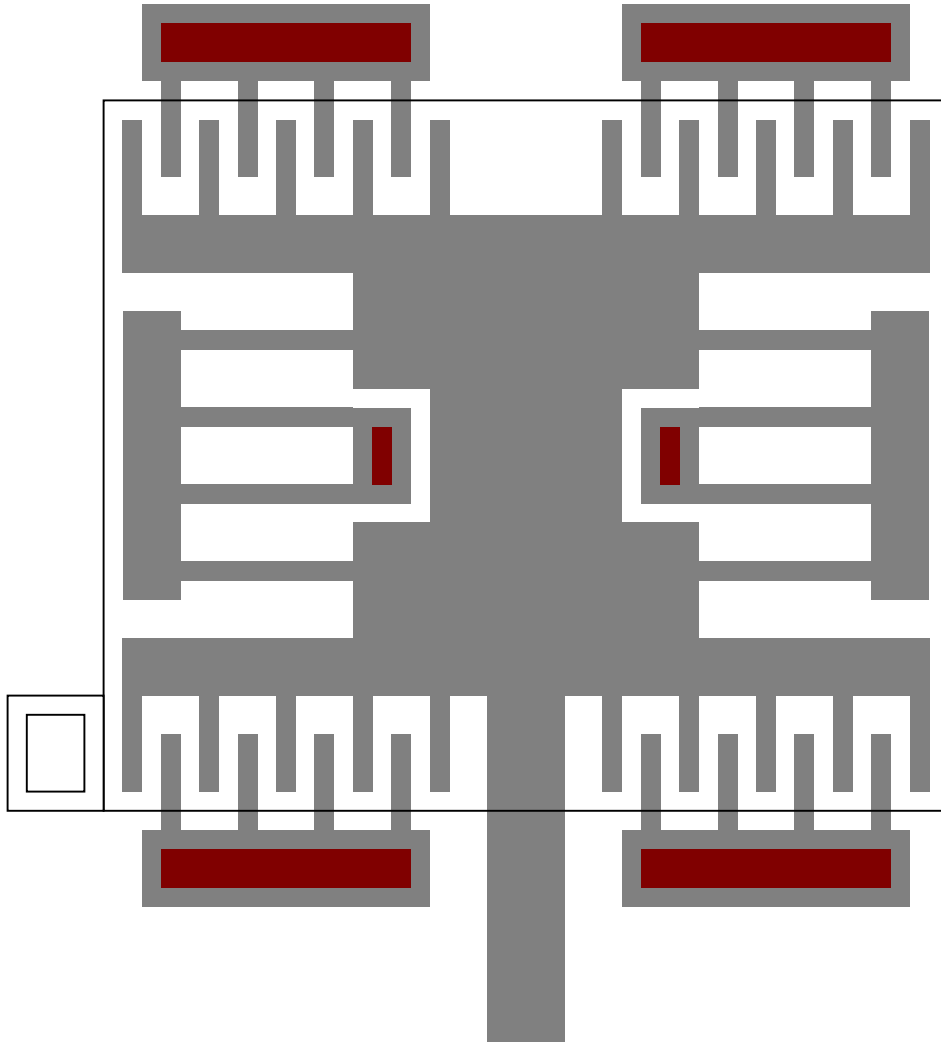
Mask #1: Ground plane anchor mask (negative mask, i.e., this part will be removed.)



Mask #2: Ground plane mask (positive mask, i.e., this part will be retained.)



Mask #3: Anchor mask (negative mask, i.e., this part will be removed.)



Mask #4: Device mask (positive mask, i.e., this part will be retained.)

