

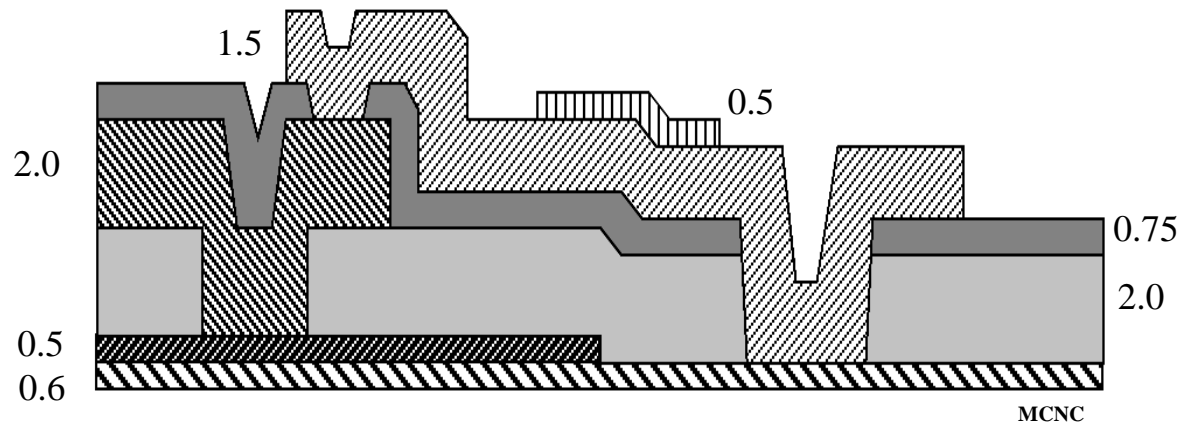
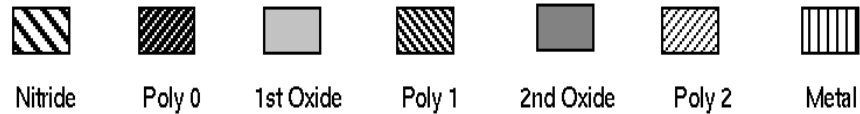
MEMS II: January 23

- Lab 1: Pop-up mirror
 - PolyMUMPS
 - Thermal actuators
 - Mirror
- CoventorWare

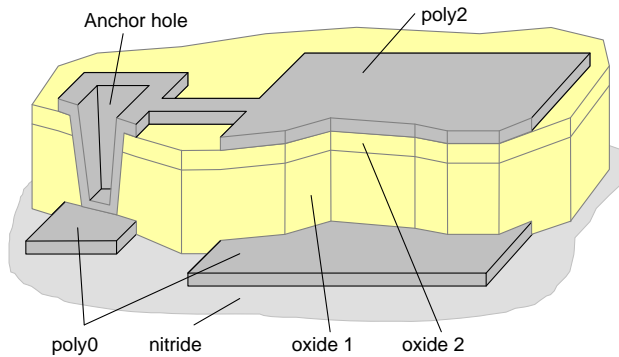
Microelectromechanical Systems (MEMS)

Multi-User MEMS Processes (MUMPS)

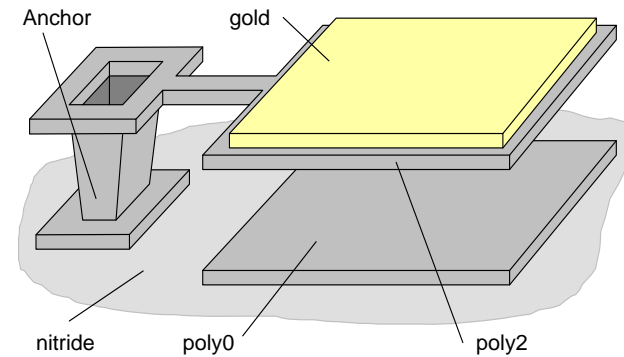
Layers and Nominal Thickness in Microns



Example Design



(a) After Poly2 Deposition



(b) Released Device

**Add nitride
(600 nm, LPCVD
(low pressure chemical vapor deposition)**



100 mm, n-type, 1-2 Ohm-cm, surface doped with phosphorus

**Add Poly0
(500 nm, LPCVD)**



Silicon Substrate

Patterning through 1st level mask (Poly0) using Photolithography



Removal of Unwanted Poly0 using Reactive Ion Etching



1st Oxide Deposition 2 um using LPCVD



**Patterning through
2nd level mask (Dimple)
750 nm using Photolithography...
and Deep RIE**



Patterning through 3rd level mask (Anchor1) using Photolithography and Deep RIE

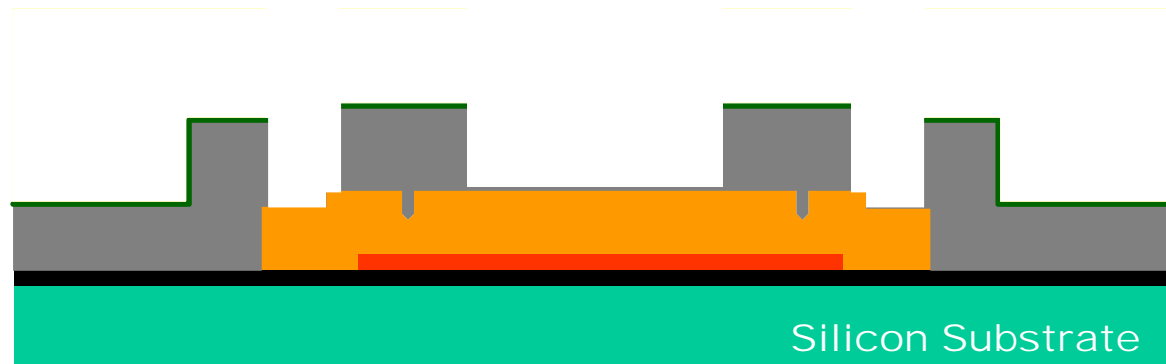


**Blanket un-doped polysilicon
deposition(Poly1) 2 um using LPCVD...**

**followed by 200 nm PSG deposition
and annealing at 1050 C for 1 hr**

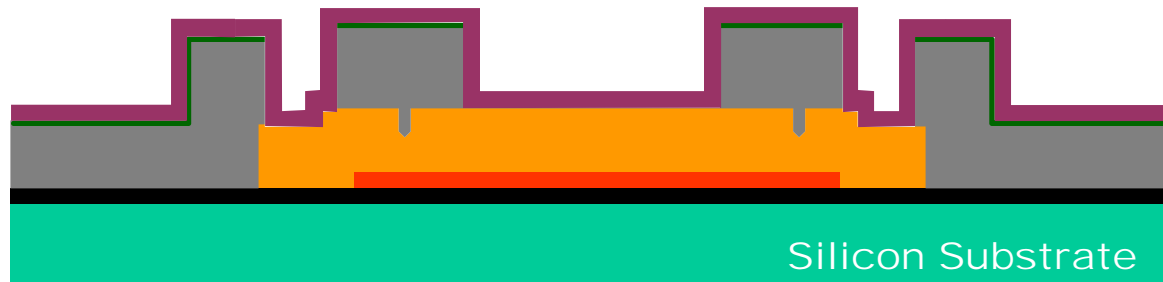


Patterning through 4th level mask (Poly1) using Photolithography... and Deep RIE

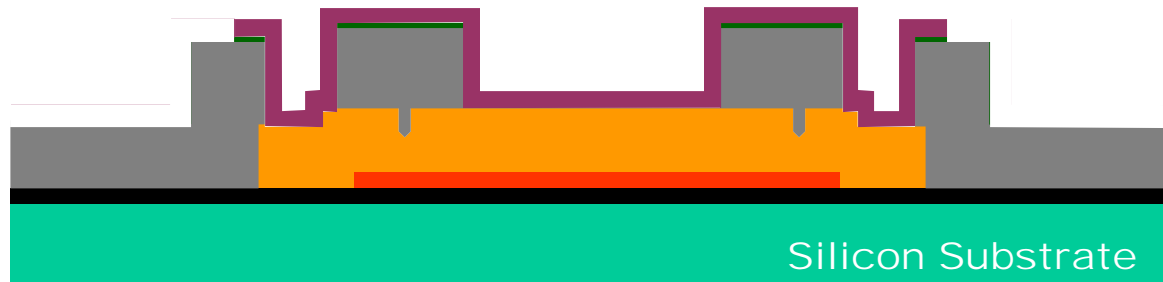


PSG layer etched first to form the RIE hard mask

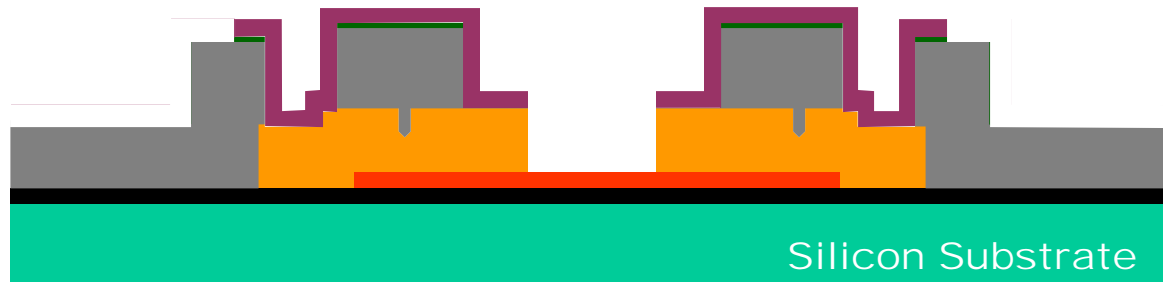
Deposition of 2nd Oxide Layer



Patterning through 5th level mask (p12via) using photolithography and deep RIE



Patterning through 6th level mask (anchor2) using photolithography and deep RIE



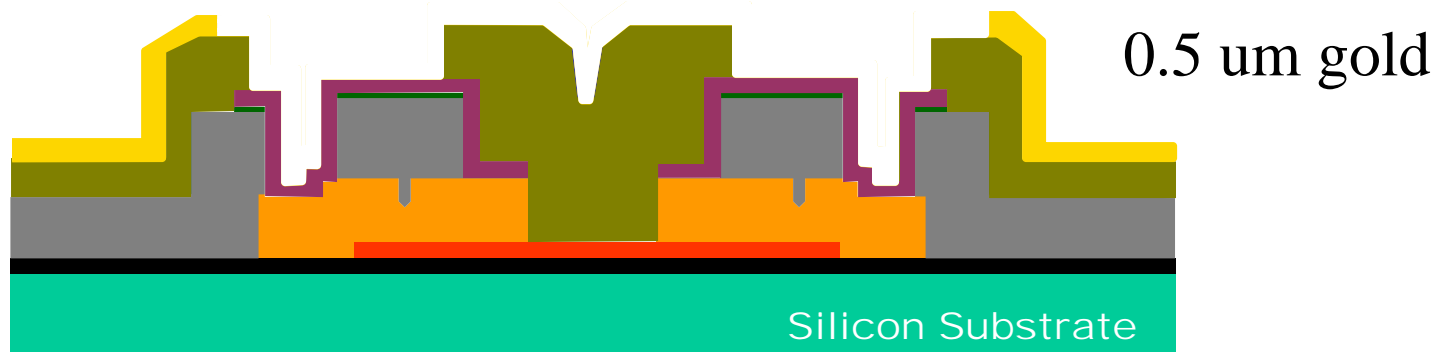
Deposition of 1.5 μm
undoped polysilicon,
followed by PSG hardmask layer,
then anneal



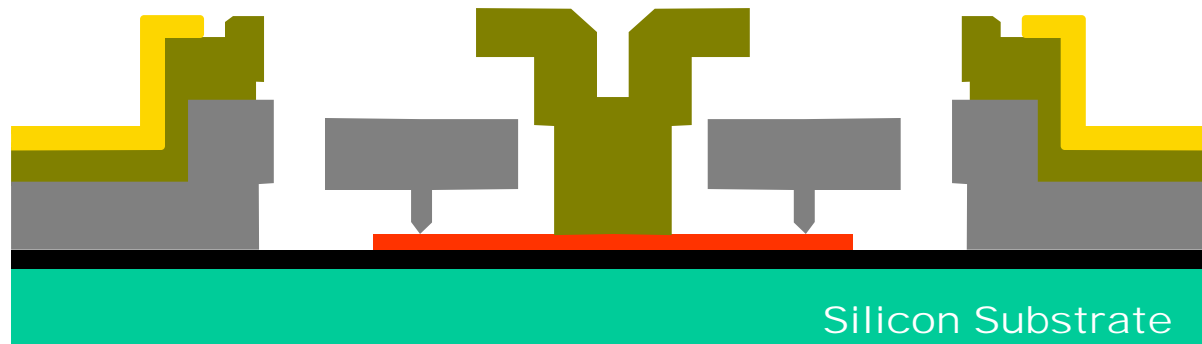
Patterning through 7th level mask (poly2) using photolithography and deep RIE



**Patterning through 8th level mask
(metal) using photolithography and liftoff,
followed by removal of unwanted
resist and metal in solvent bath**

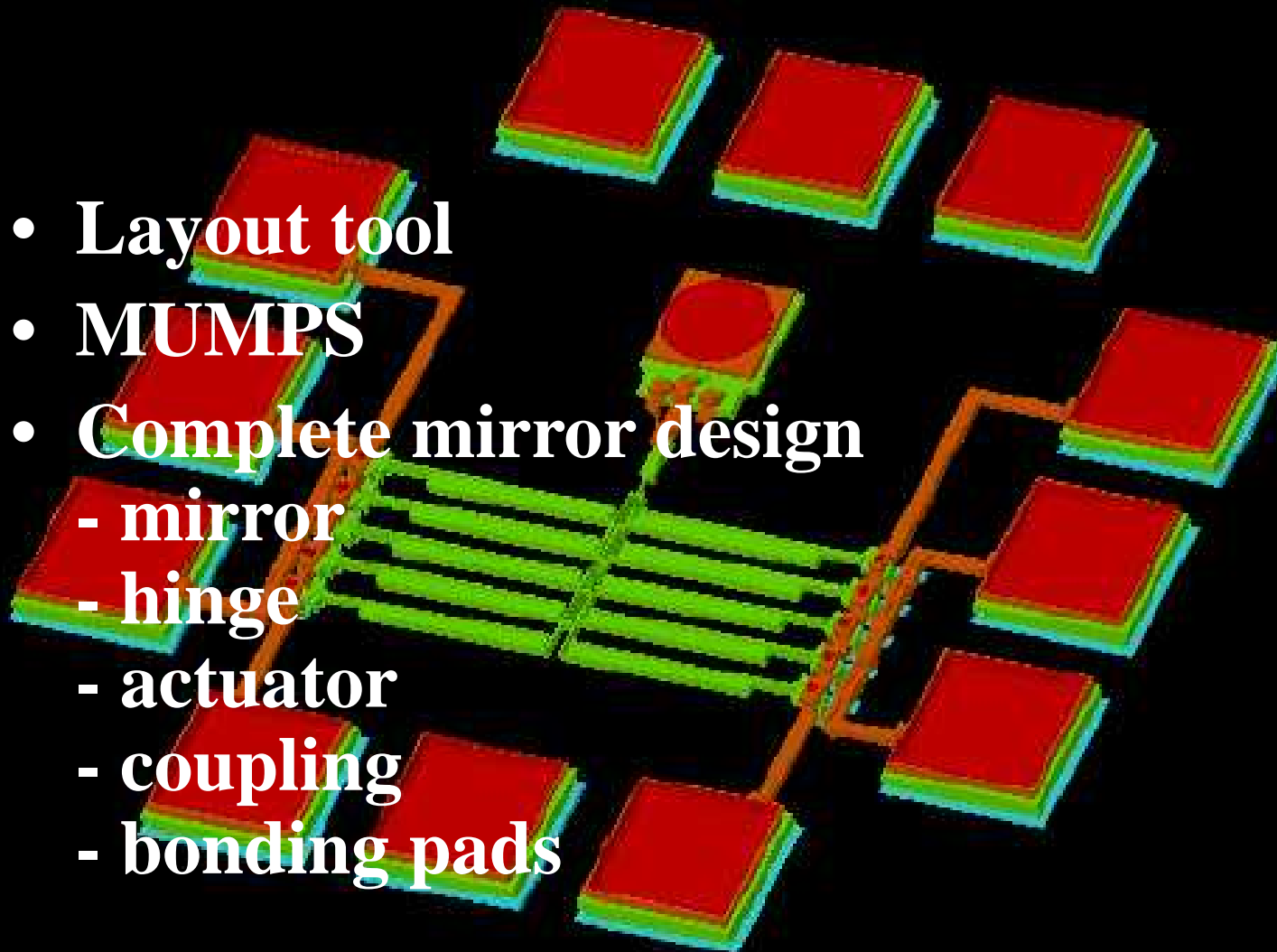


Release of structures using HF
(46% HF, room temperature,
1.5-2 minutes; followed by several
minutes in DI water and then alcohol by at
least 10 minutes in an oven at 110 C



Lab. #1

- **Layout tool**
- **MUMPS**
- **Complete mirror design**
 - mirror
 - hinge
 - actuator
 - coupling
 - bonding pads



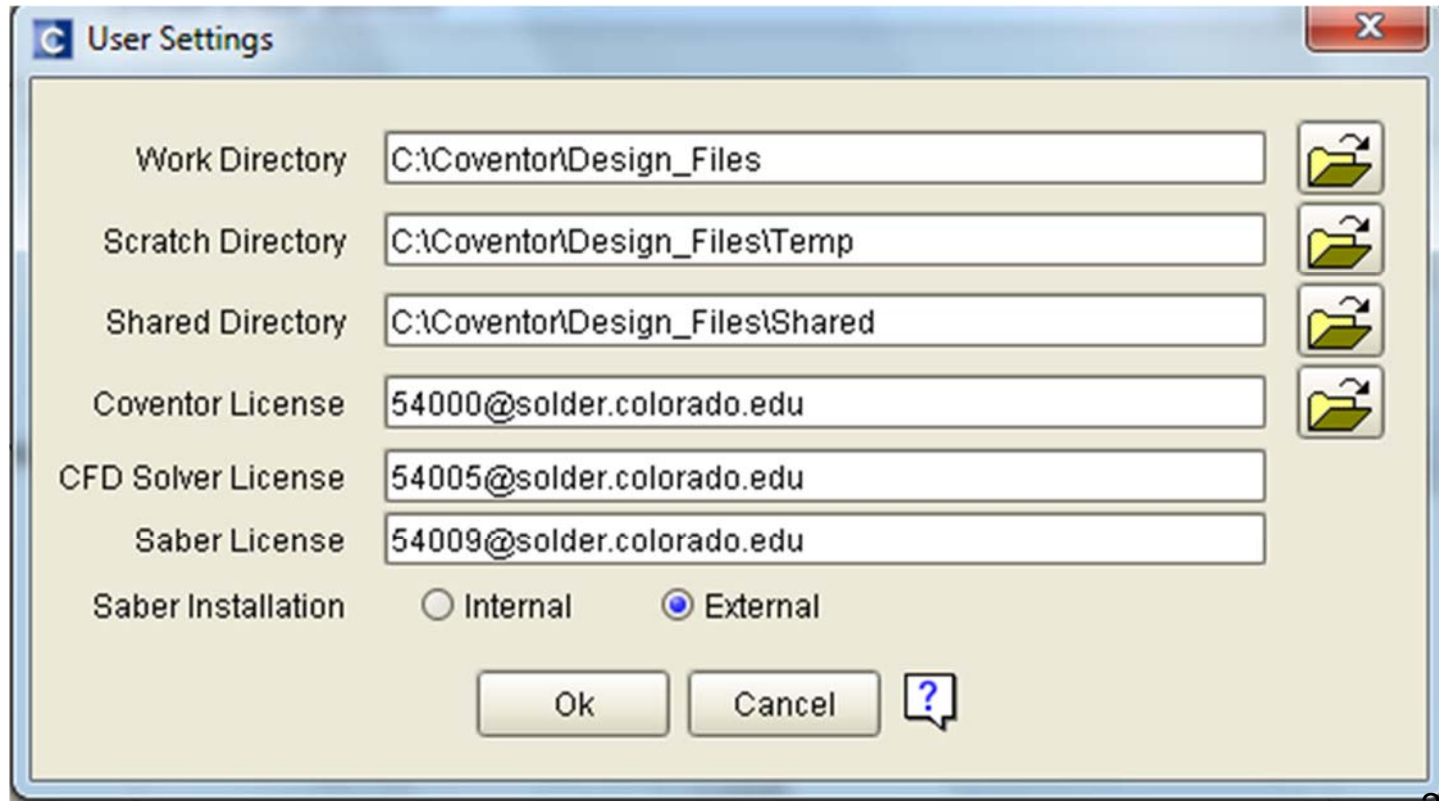
Get Started!

- You can install CoventorWare in your own PC and run it through on-campus network or off-campus network by using VPN.
- Or, you can run CoventorWare from the PCs in room DLC1B40. Email leeyc@colorado.edu with your Buffone card number in order to access DLC1B40. Login is “microsystem” and the password is to be given on the blackboard. These PCs are not connected, so save all your files in your USB drives.

Lab #1 is assigned today.

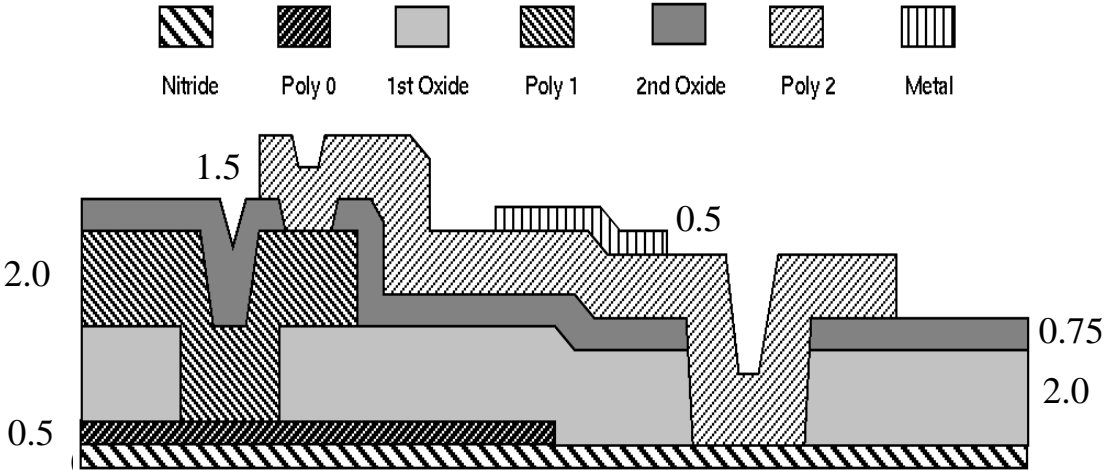
CoventorWare License

- Coventor License: 54000@solder.colorado.edu. Information of other licenses is not important since we do not have those licenses anyway.
- You can input this information during the installation. Or, get the menu after the installation. From the main menu to be opened automatically when you run CoventorWare, you can select “Tools” followed by “User Setting”.



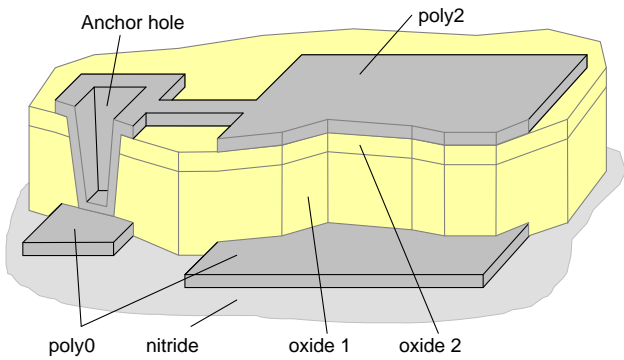
Foundry Process: Multi-User MEMS Process (MUMPs)

- 3 structural levels of polysilicon
- 2 sacrificial levels of oxide
- gold (on poly2)

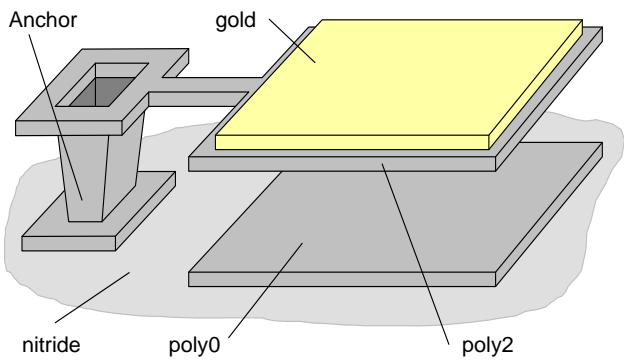


Layers and Nominal Thickness in Microns

Example Design



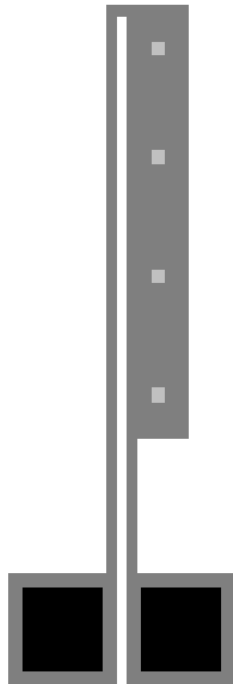
(a) After Poly2 Deposition



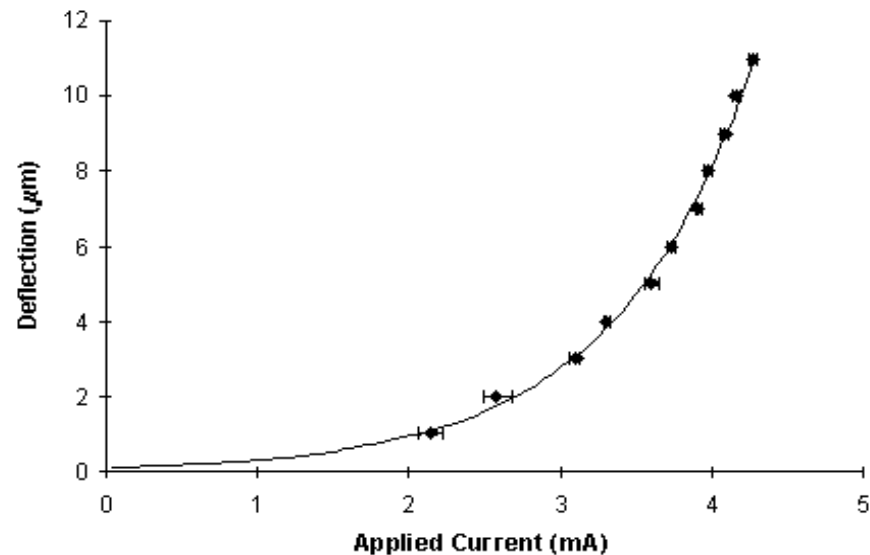
(b) Released Device

Polysilicon Actuator

- 3 V, 3.5 mA, 10.5 mW
- 300 Hz, faster if attached to heat sink
- 4.4 μN forward bending
- 15.5 μN backward bending
- 16 μm deflection
- 220 x 20 x 2 μm
- 800 Ω



Deflection Versus Current

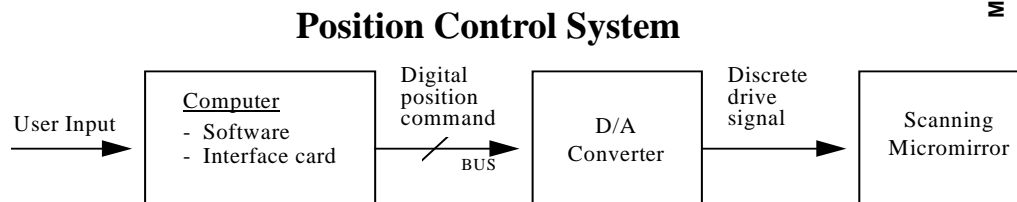
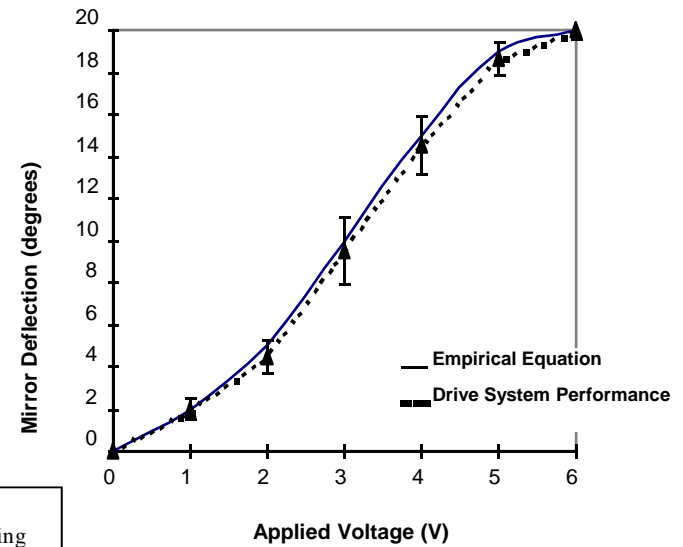
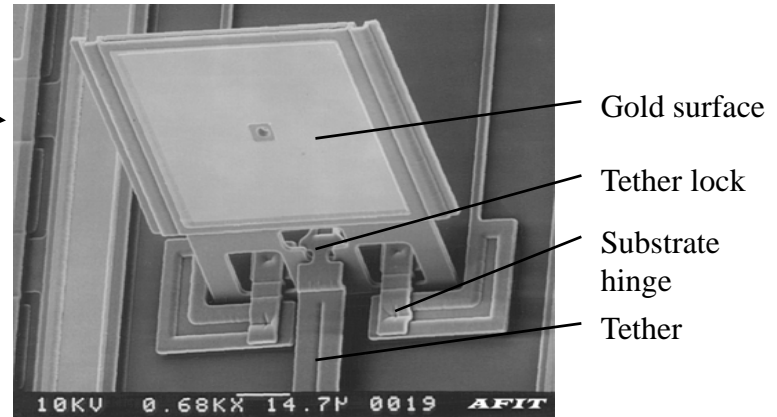
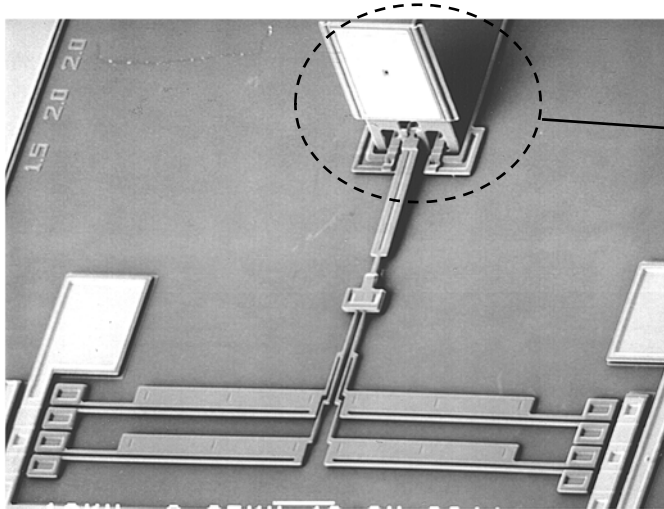


Actuator Dimensions

2 μm thick, 200 μm long

flexure 35 μm long, hot arm 2 μm wide

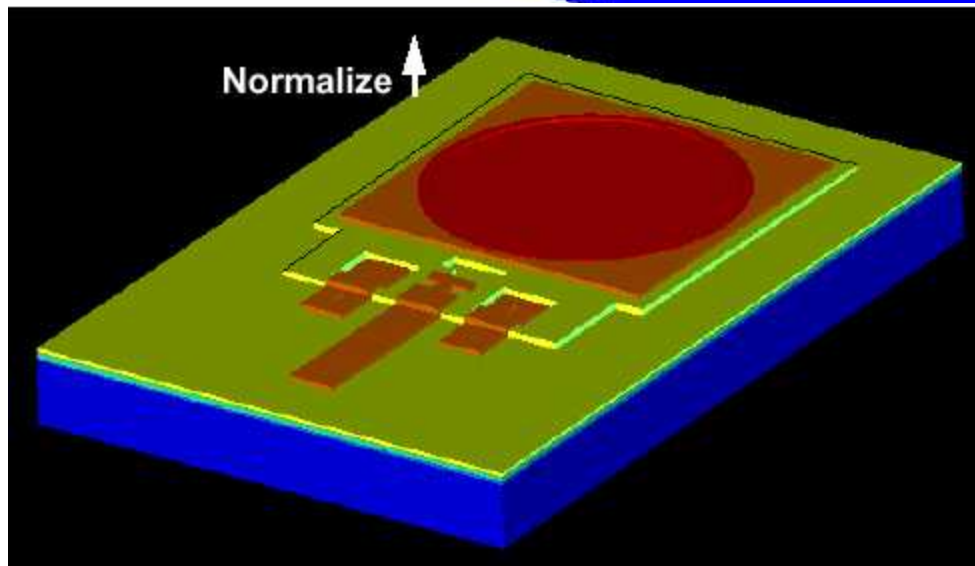
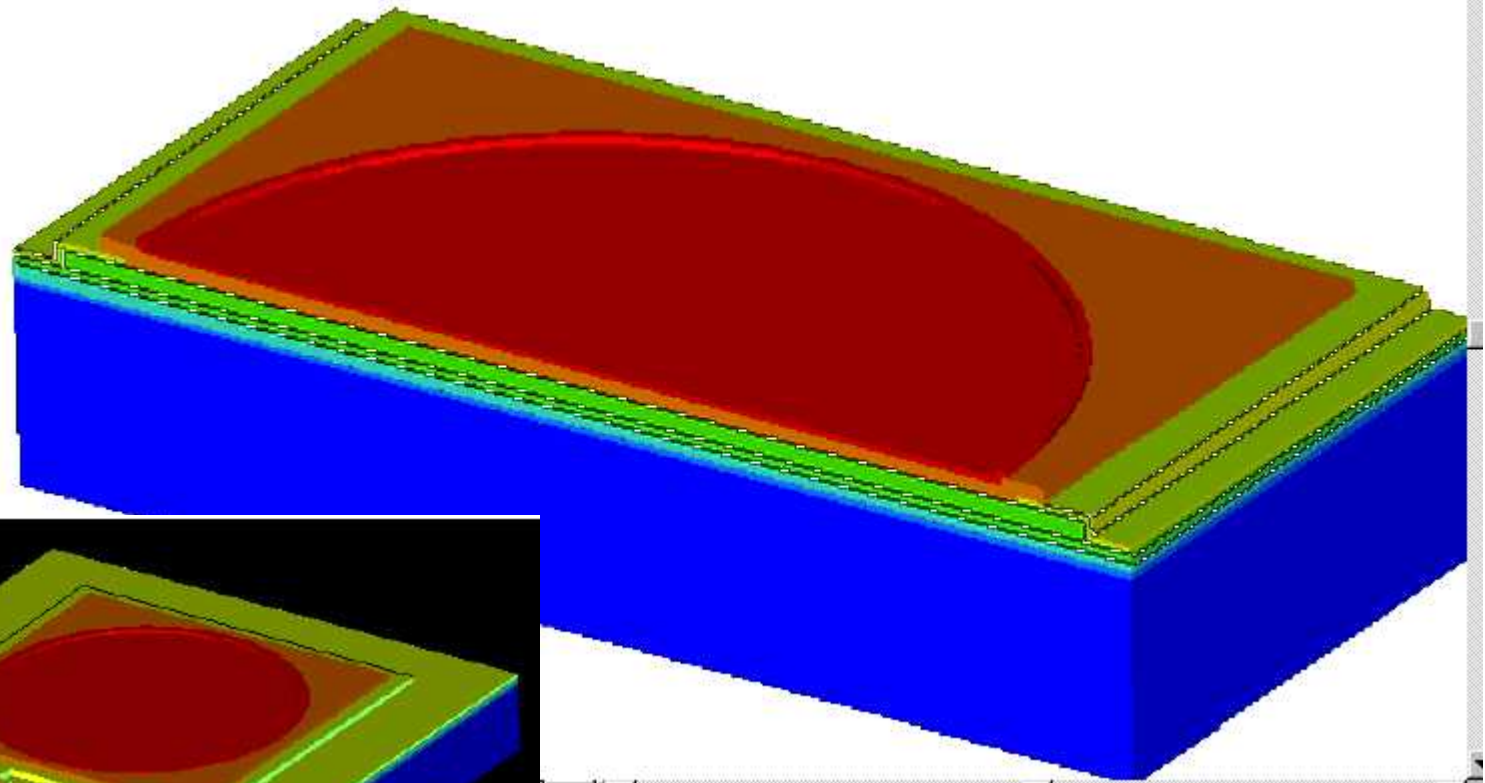
Scanning Micromirror

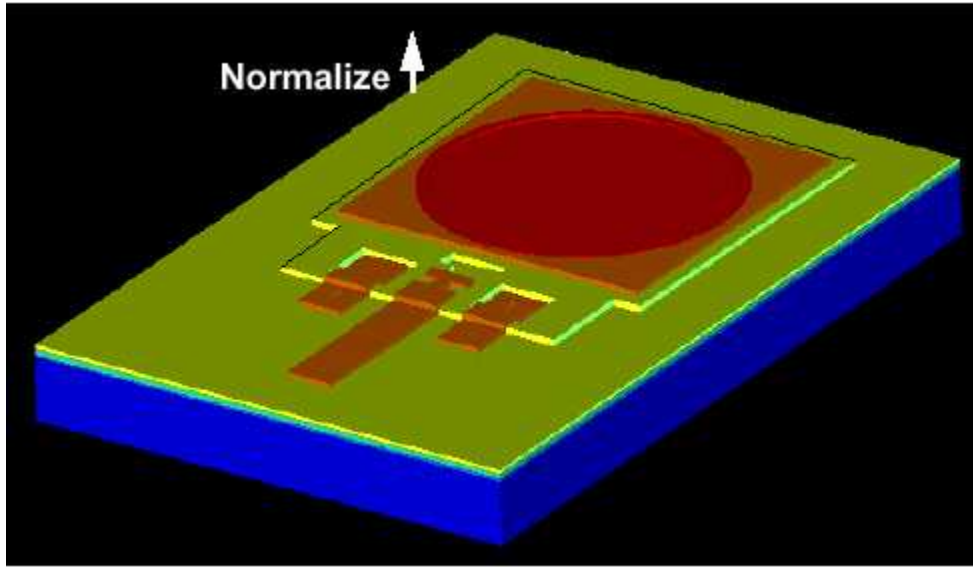


Video Clips

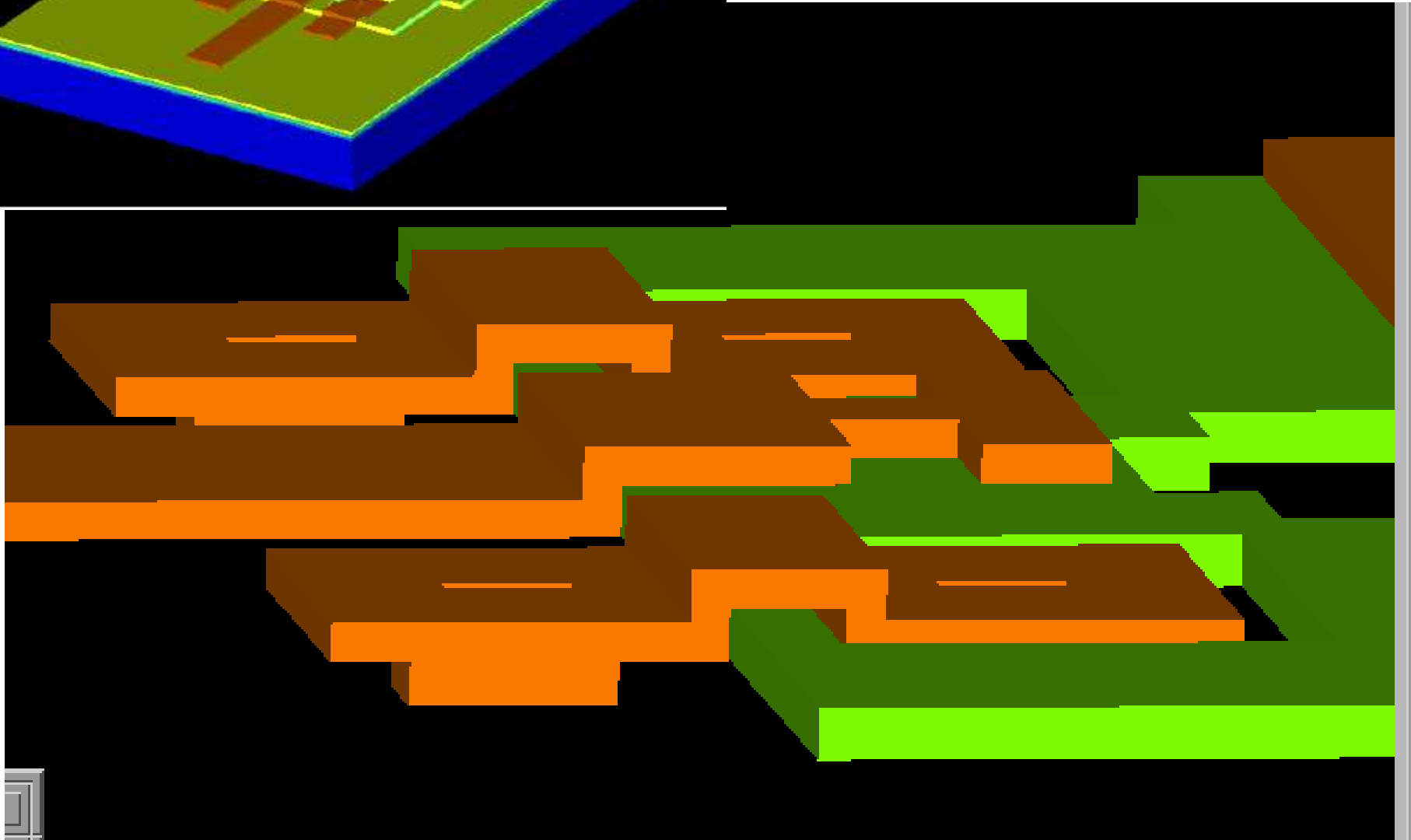
- Thermal Actuator
- Array of Thermal Actuators
- Scanner

Clipped Model

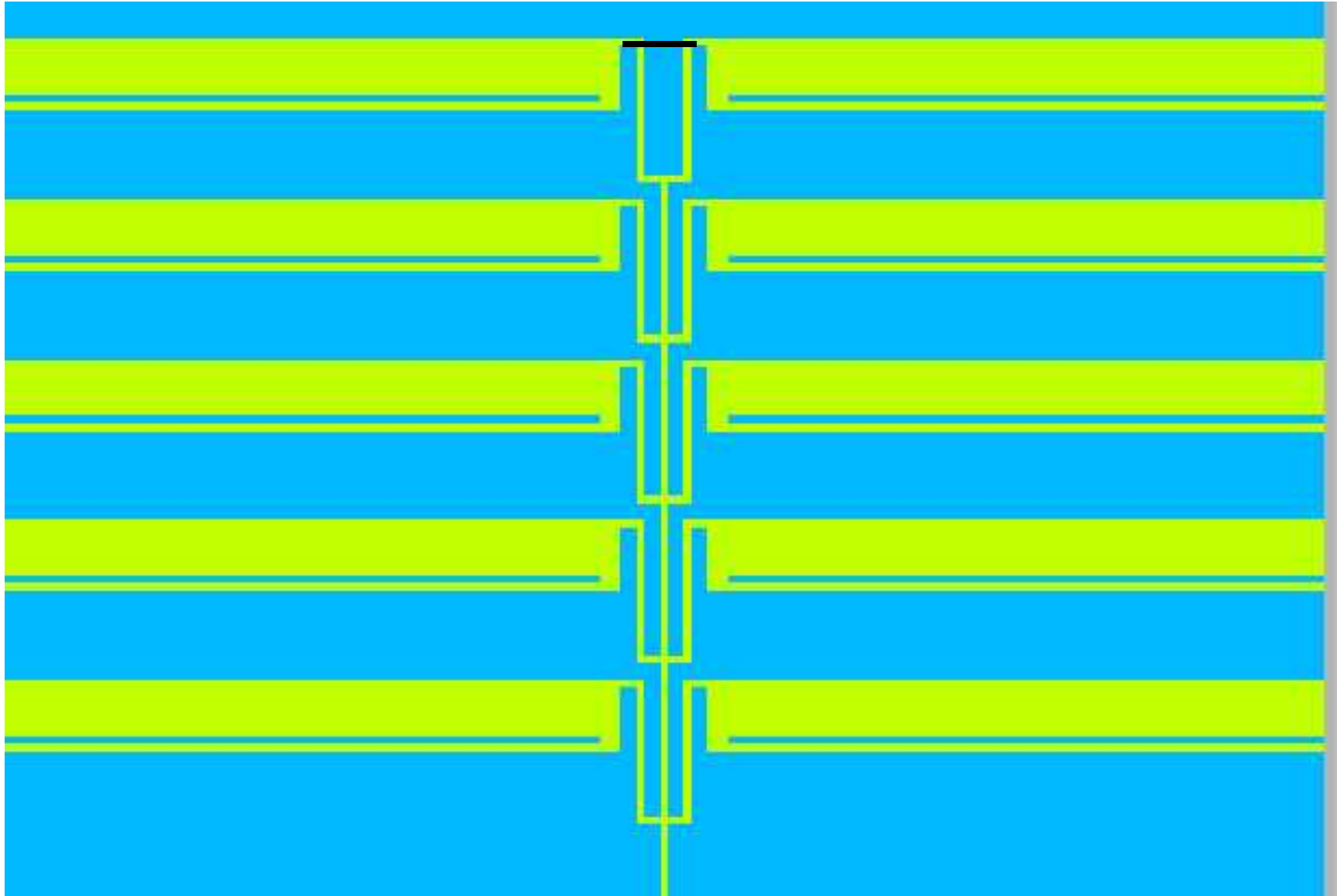




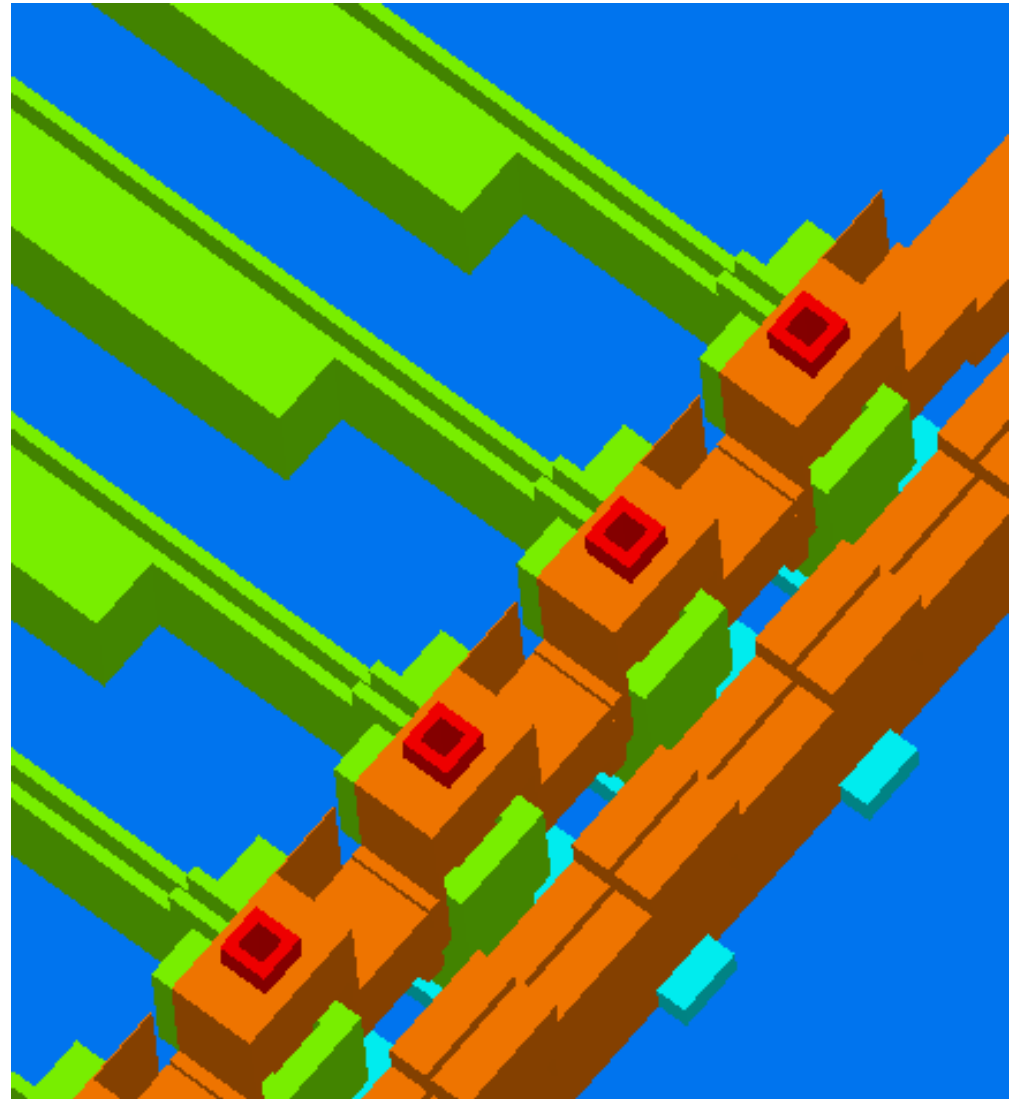
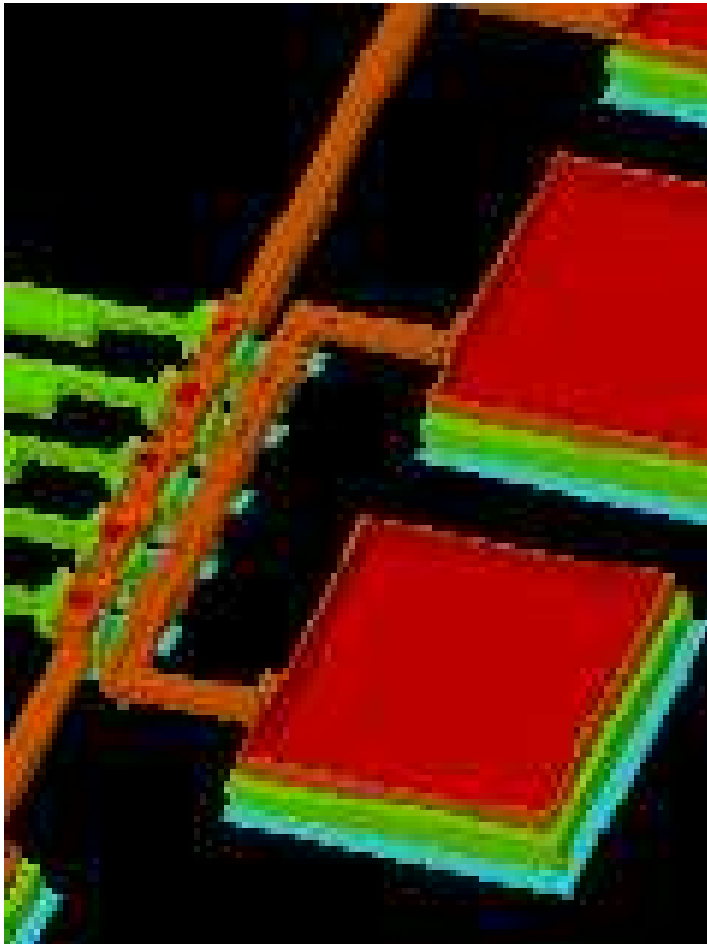
Hinge



Couplings








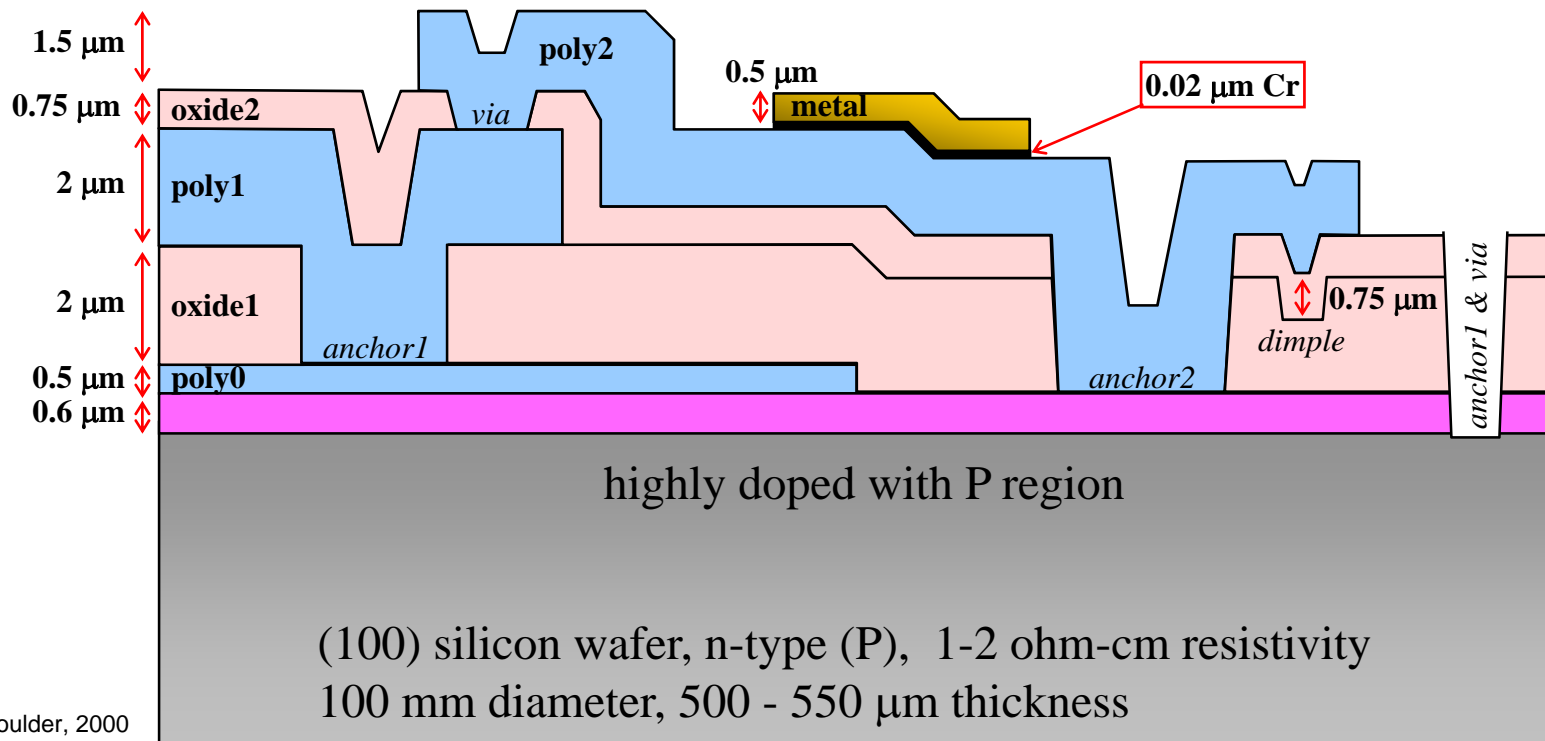
Poly2-on-Poly1 or 0



PolyMUMPs

PolyMUMPs

-  Metal (gold)
-  Polycrystalline Silicon (doped with P)
-  Oxide (PSG: SiO₂ doped with P)
-  Nitride (Si₃N₄)
-  Crystalline Silicon



MEMS II: January 23

- Lab 1: Pop-up mirror
 - PolyMUMPS
 - Thermal actuators
 - Mirror
- **CoventorWare**

