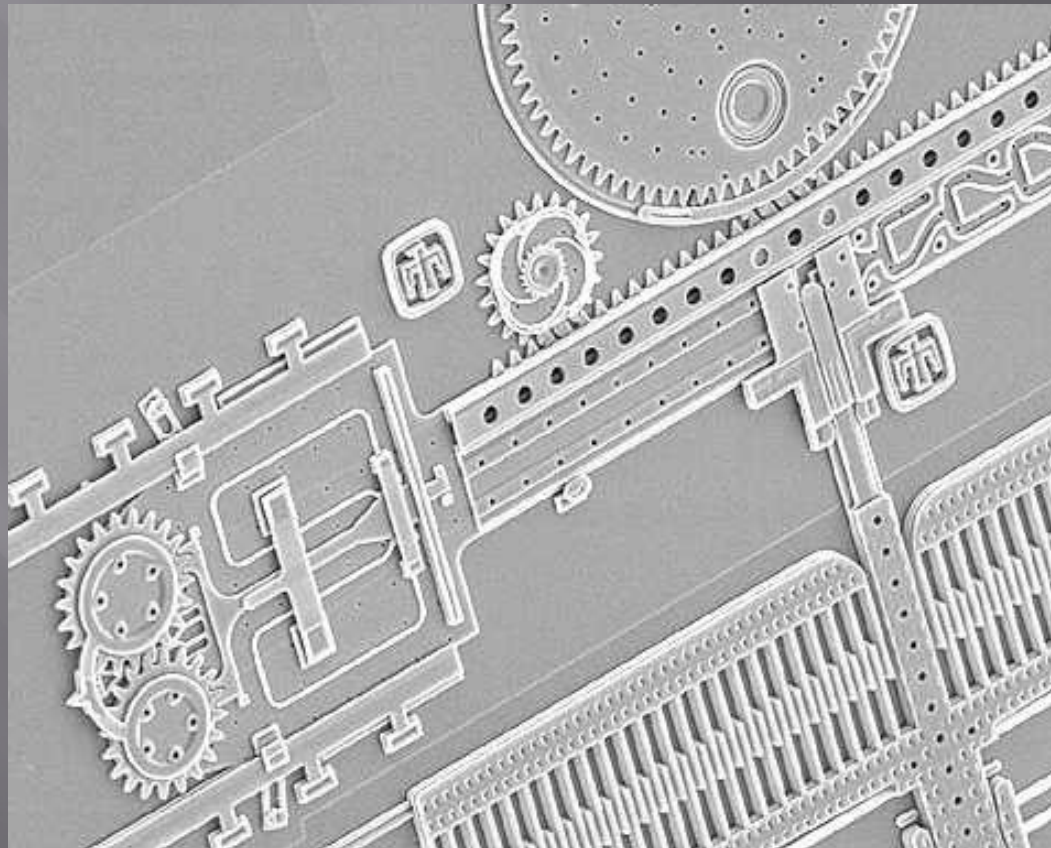


# INTRO TO MEMS

A perspective from the ME354 learning experience...

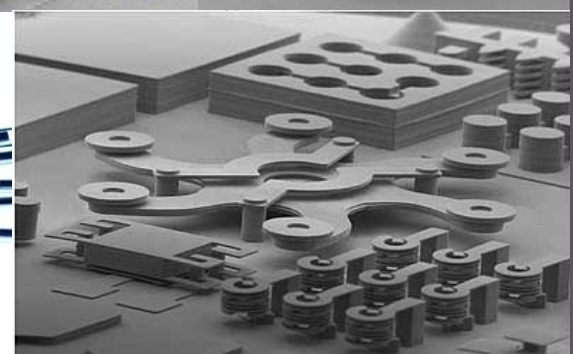
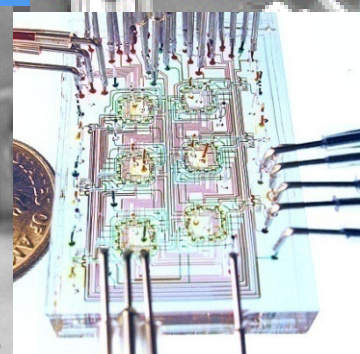
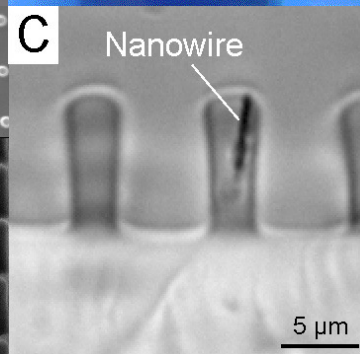
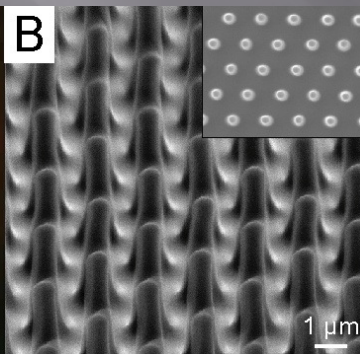
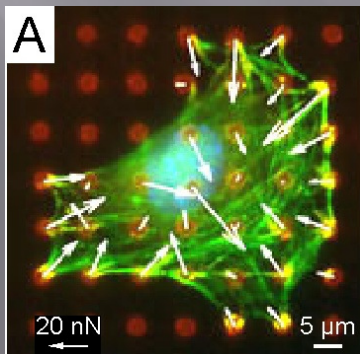
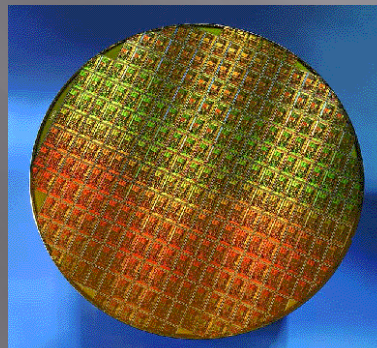


# MicroElectroMechanical Systems

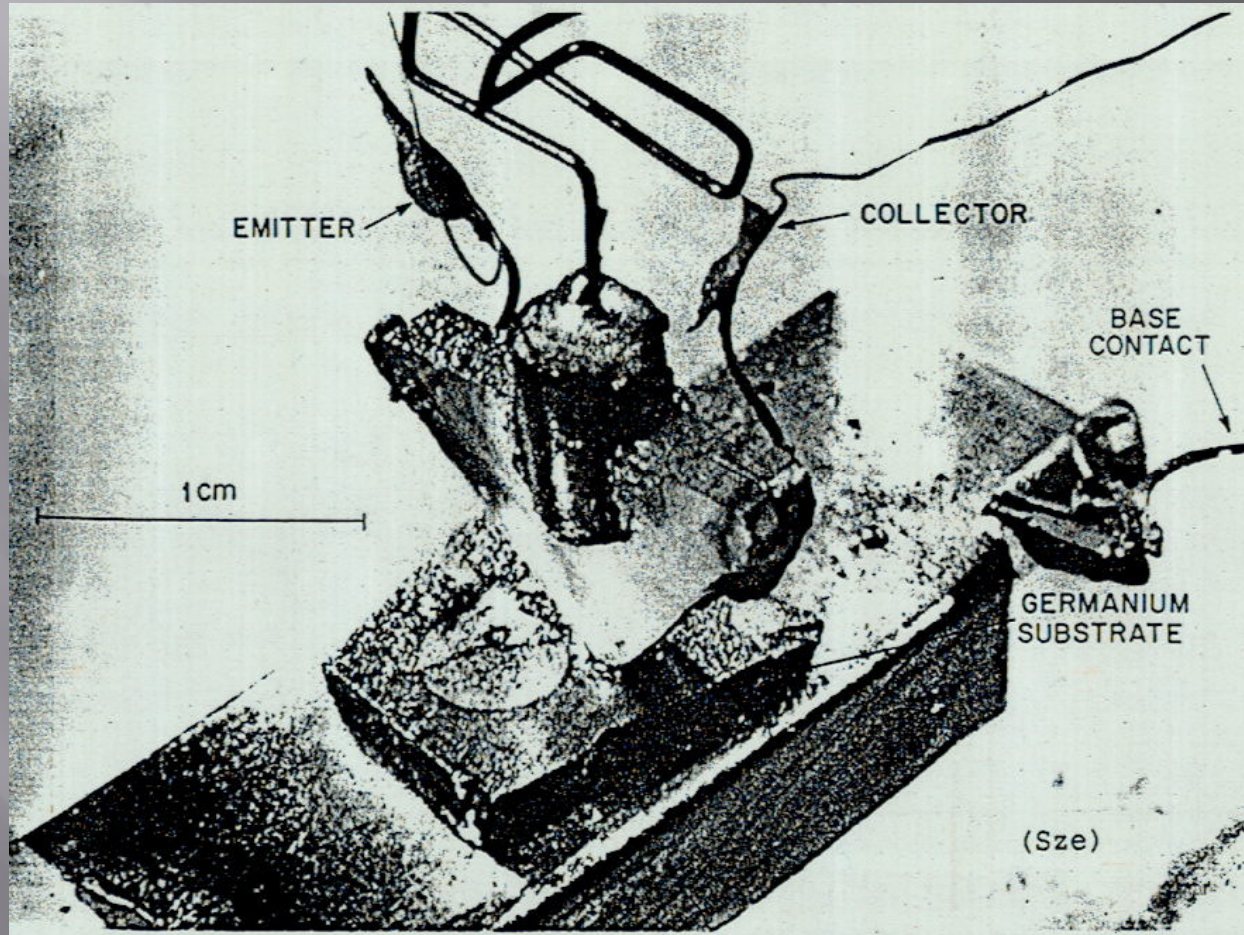
## *Sensors & Actuators*

- Strain gauges, Pressure Sensors, Accelerometers  
Micromirrors, BioMEMS, etc.
- Combined electrical, mechanical, optical,  
material, fluid, chemical,  
and/or biological  
systems

**MEMS**



# First Transistor Device

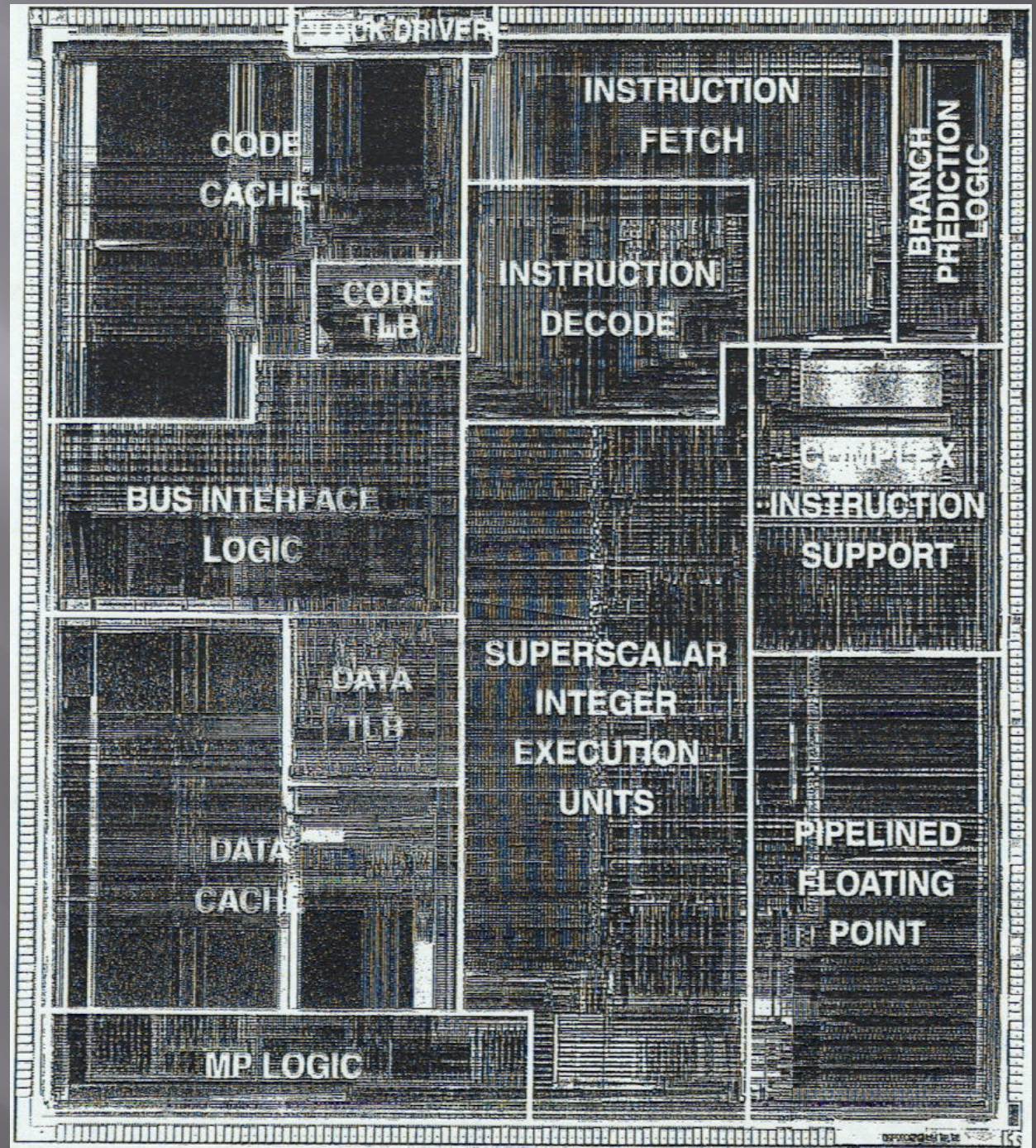


Shockley, Bardeen & Brattain (Bell Labs)

J. Bardeen, W.H. Brattain, *"The first transistor, a semiconductor triode"*, Phys. Rev., 74, 230 (1948).

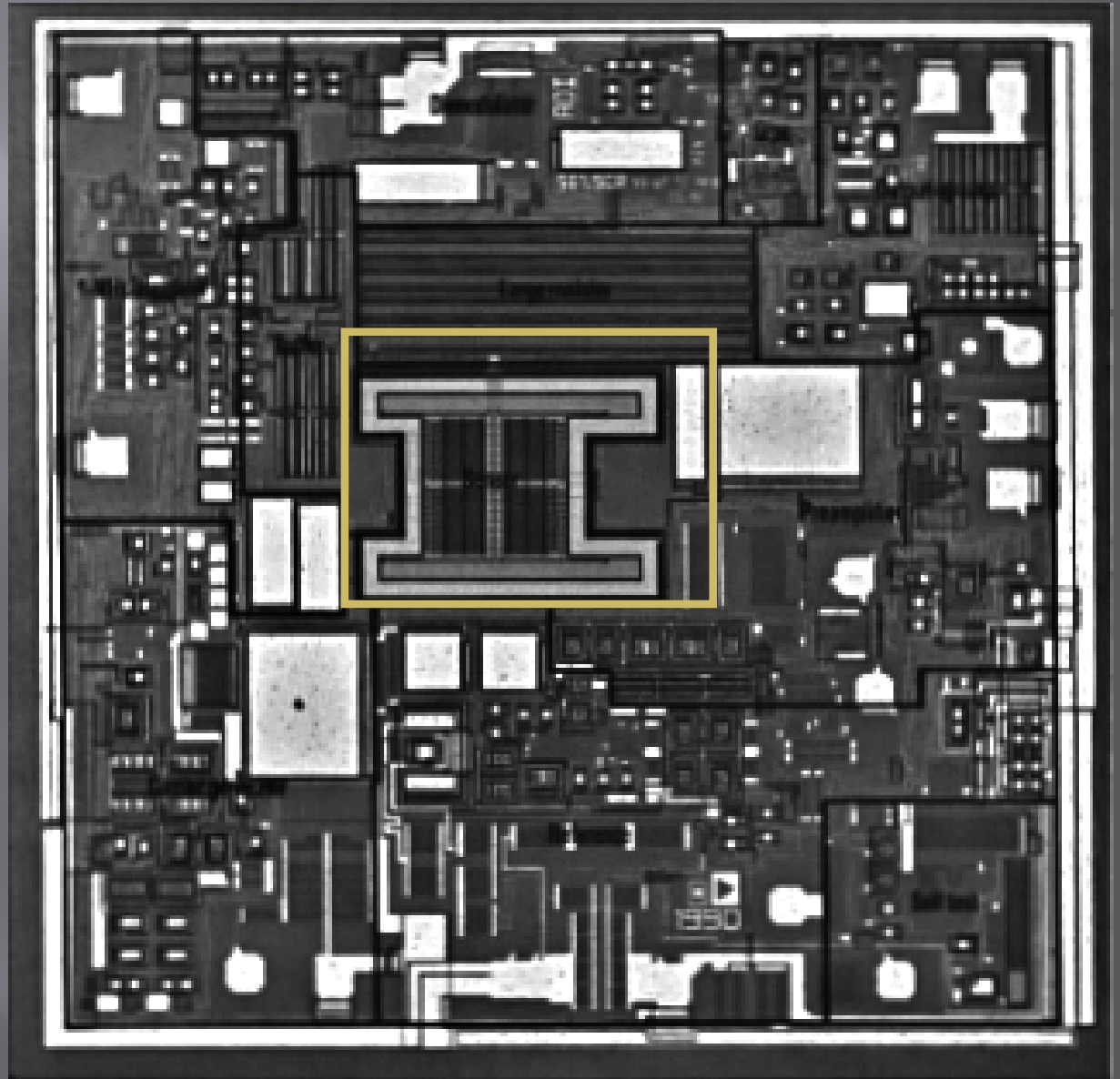
# Intel 133 MHz Pentium Processor

3.3 million transistors  
0.35 um lithography  
4 layer metalization  
May 1995



# ADXL50 Accelerometer

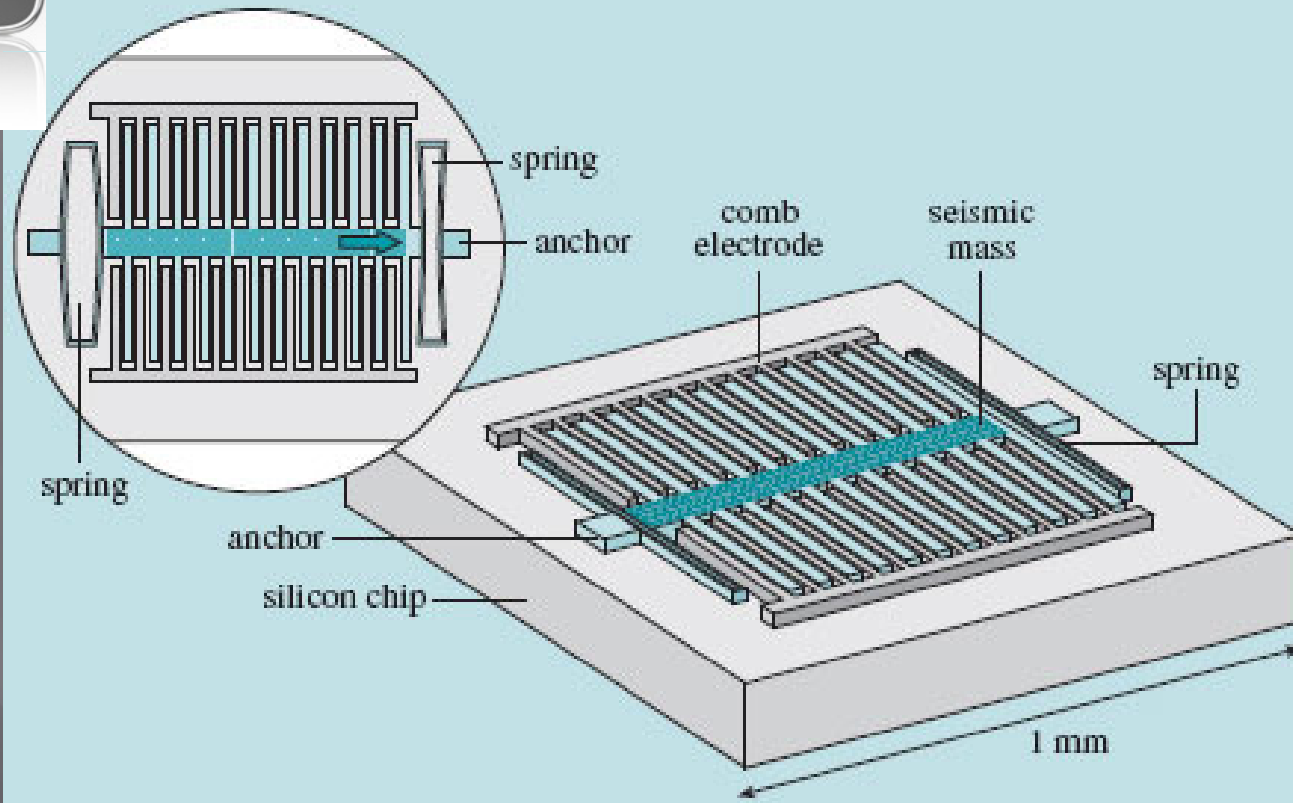
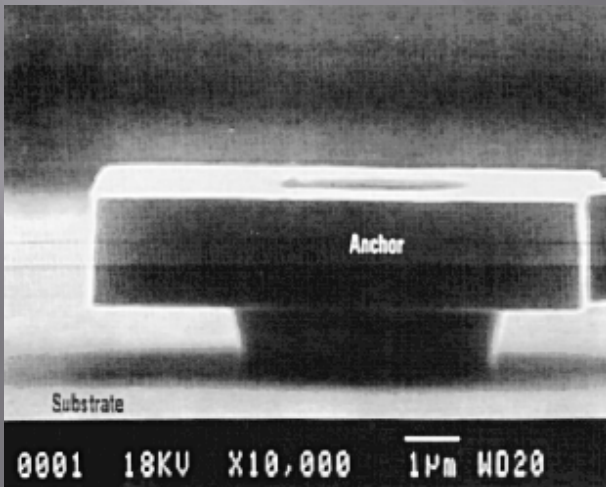
- ▣ +/-50g
- ▣ Suspended capacitive sensor
- ▣ 3x3mm die



# iPhones have Accelerometers

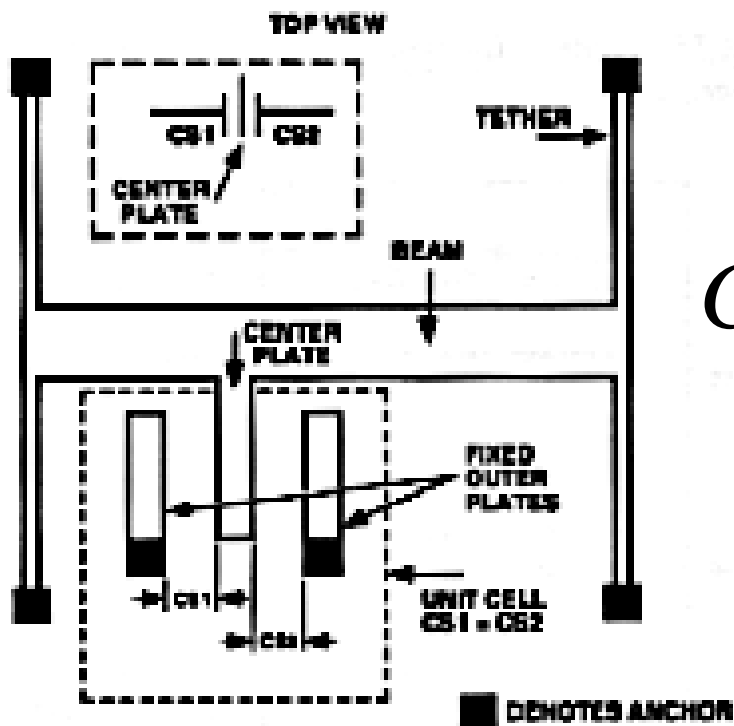


- ▣ Suspended Si Mass
- ▣ Spring
- ▣ Comb electrodes

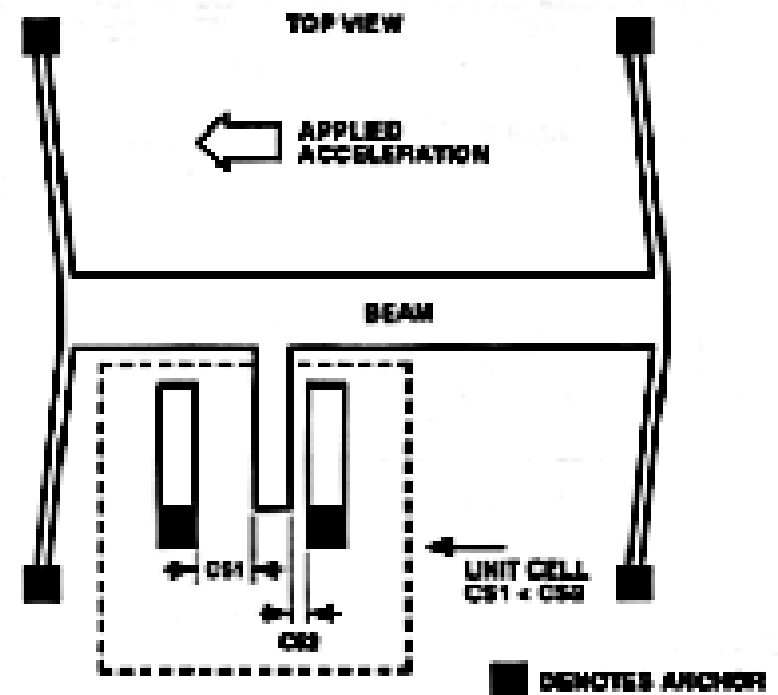


# Balanced Differential Capacitance Sensor

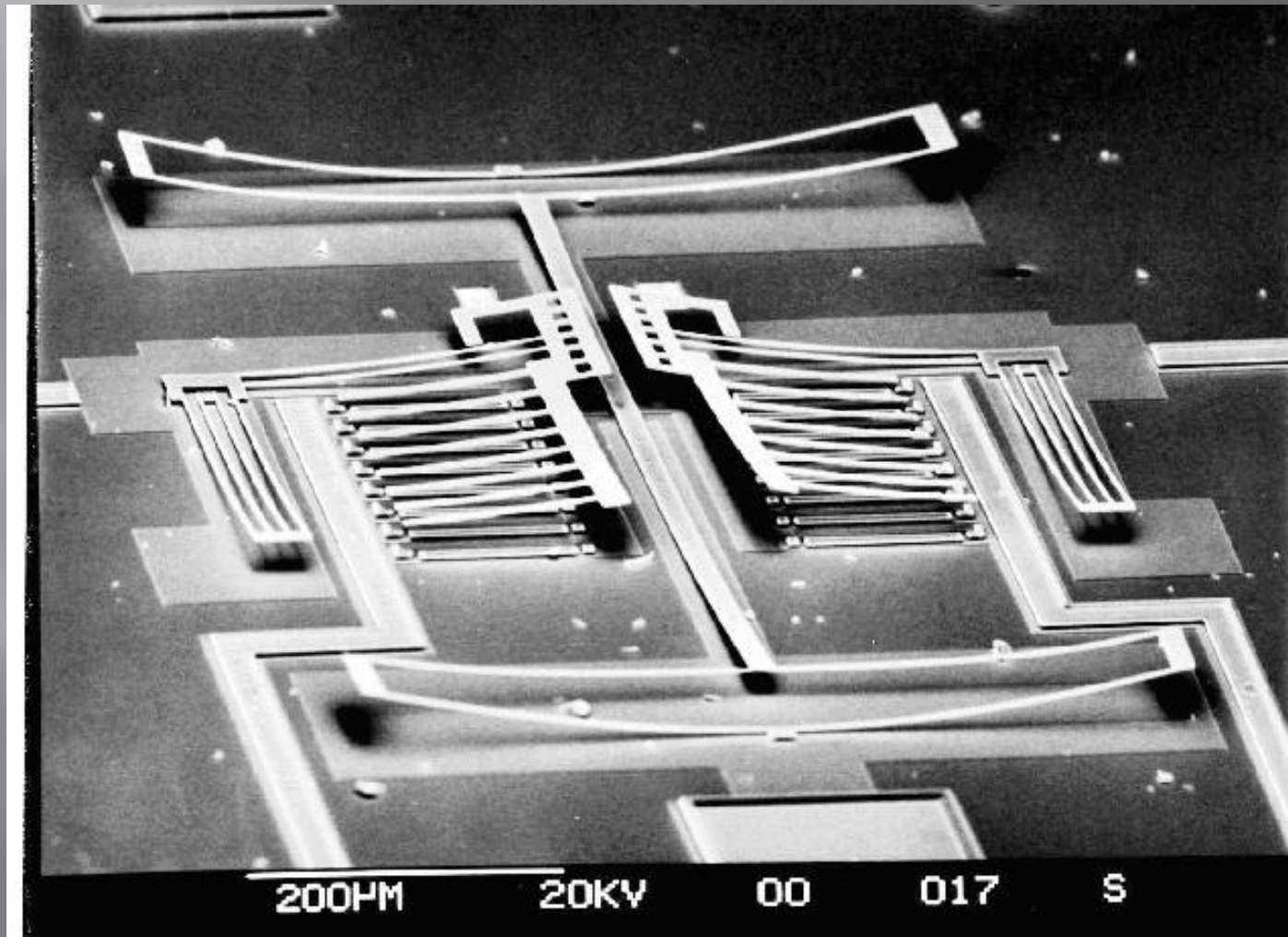
- Under acceleration, center beam moves and changes distance between capacitor plates
- Capacitance (C) is function of distance (d) and hence output voltage changes.



$$C = \frac{\epsilon}{d} A$$



# Fabrication Residual Stresses

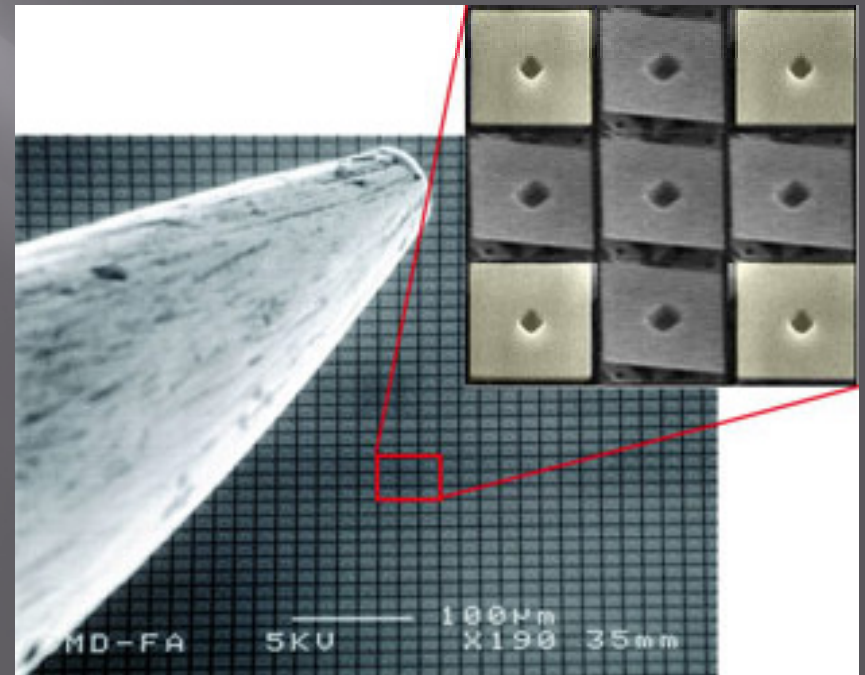
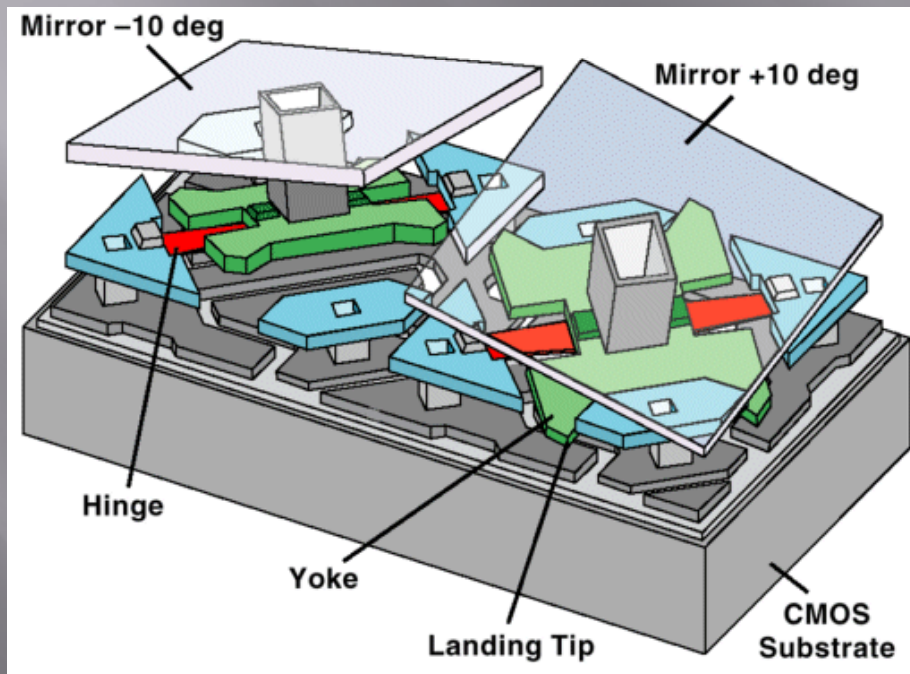


- ▣ A bad day in 1996

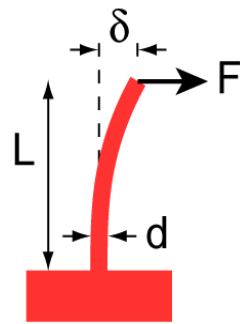
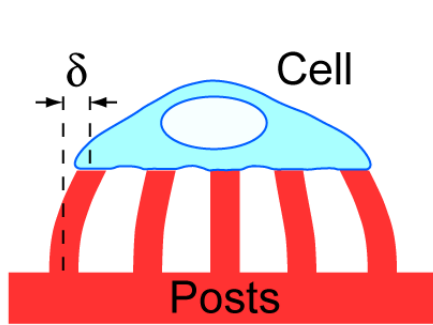


# Micromirrors

- ▣ Digital Light Processing (DLP)
- ▣ Digital Mirror Device (DMD)

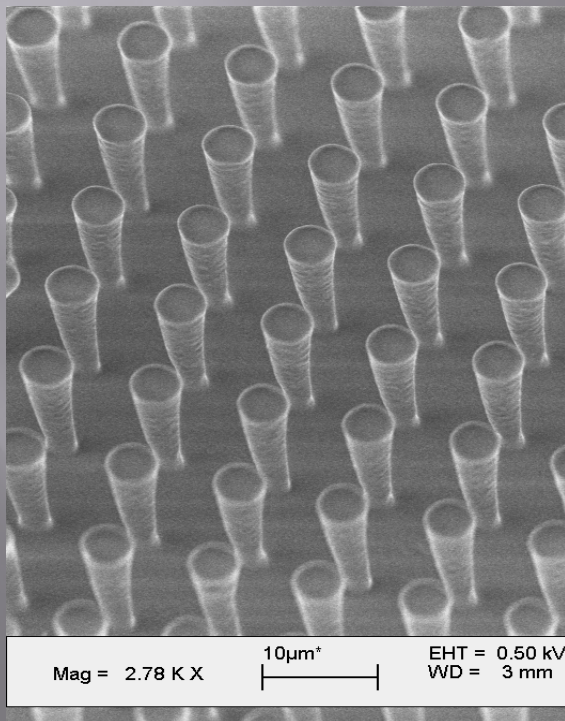


# Microposts to Measure Cell Forces

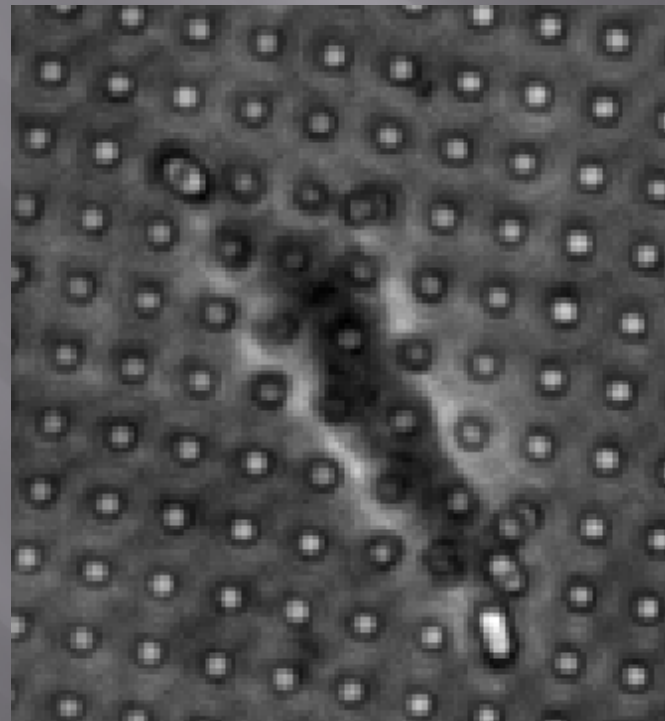


$$F = \left( \frac{3\pi E d^4}{64 L^3} \right) \delta$$

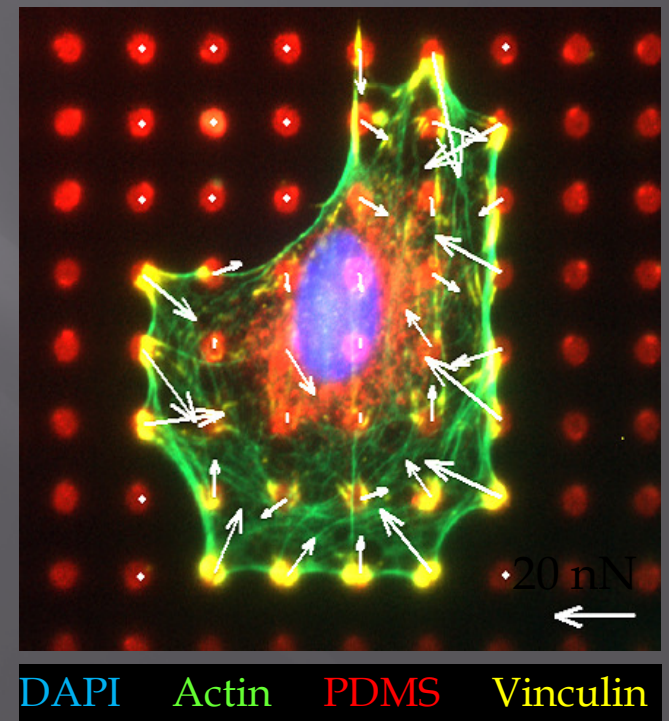
- F Traction Force
- $\delta$  Displacement
- E PDMS Modulus of Elasticity
- d Post Diameter (3  $\mu\text{m}$ )
- L Post Length (5-11  $\mu\text{m}$ )



PDMS microposts



Deflection Measurements



DAPI Actin PDMS Vinculin

Immunofluorescence