SEMS of MEMS Devices

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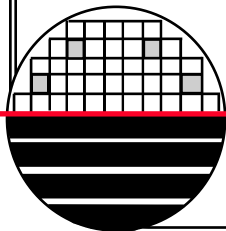

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OUTLINE

Introduction
Scanning Electron Microscope
SEM Micrographs of
- Microphone
- Accelerometers
- Mirrors
- Electrodes
- Pillars and Posts
- KOH Etched Holes in Single Crystal Silicon
- Micromotors and Gears
- Steam Engine

References
Homework

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LEO EVO 50

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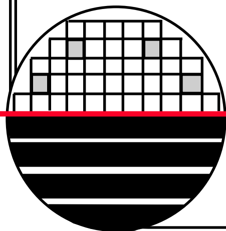
AMRAY 1830 1 & 2



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SCANNING ELECTRON MICROSCOPE (SEM)

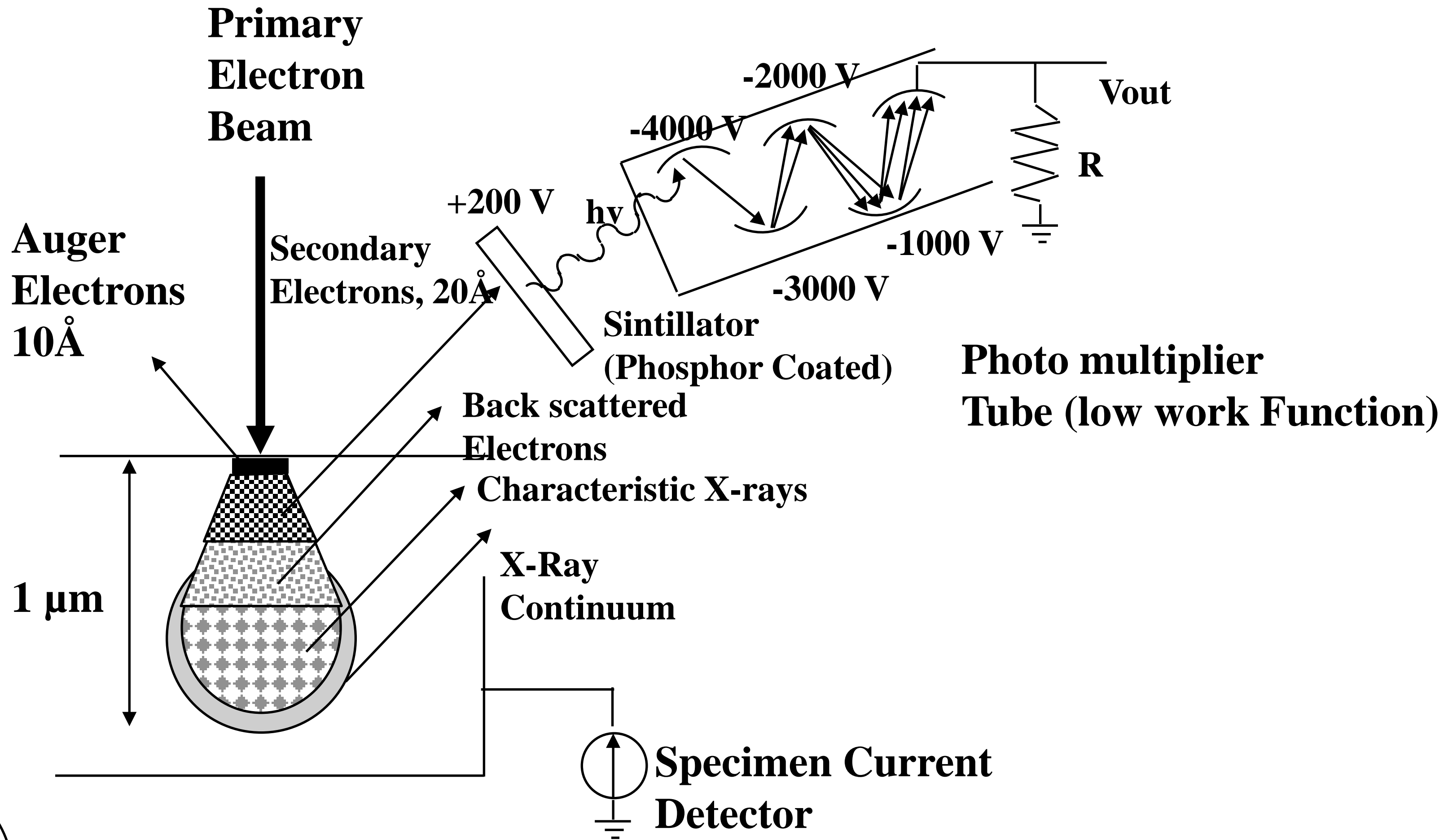

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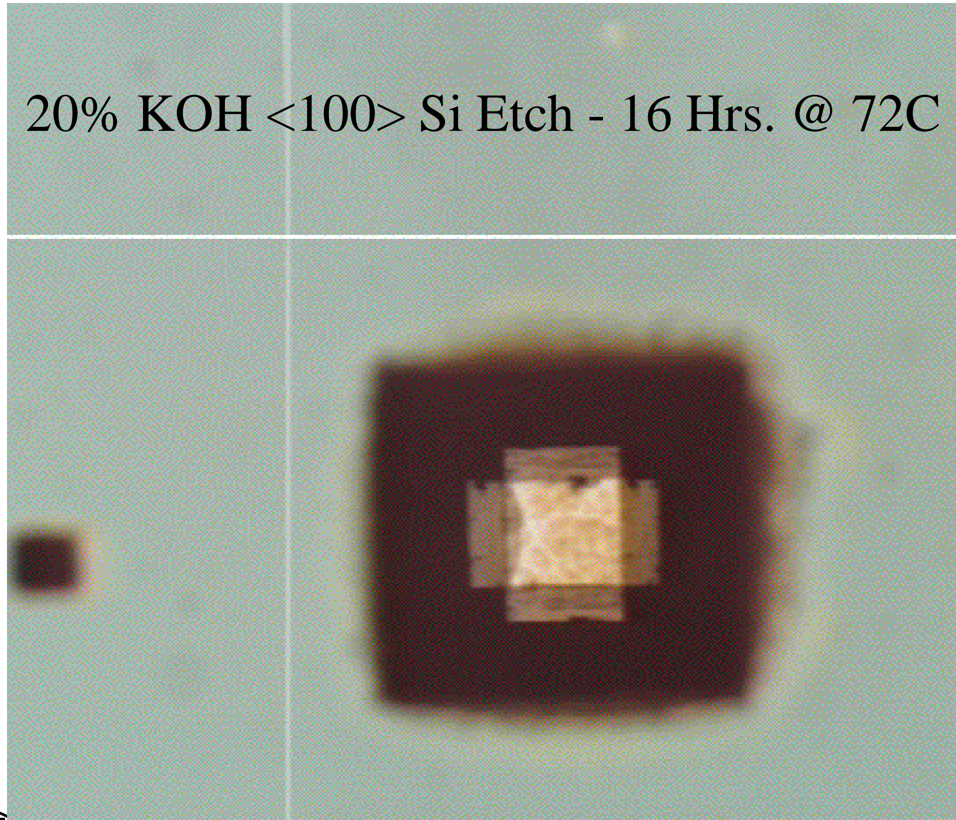
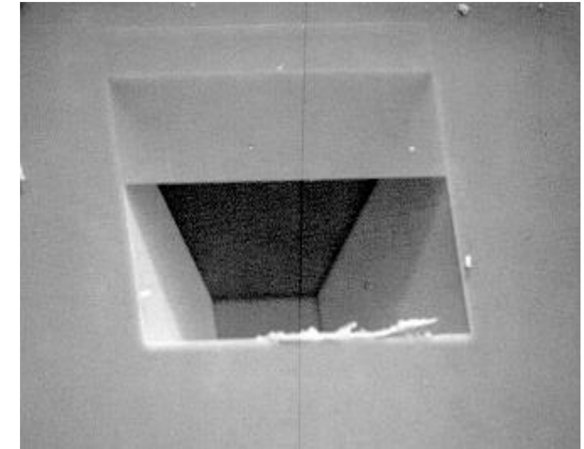
ILLUSTRATION OF LARGE DEPTH OF FOCUS

Optical picture focused on bottom of etch pit





SEM Gives Large Depth of Focus and High Resolution

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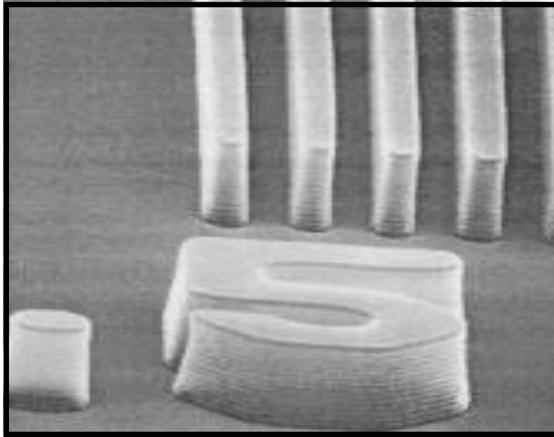
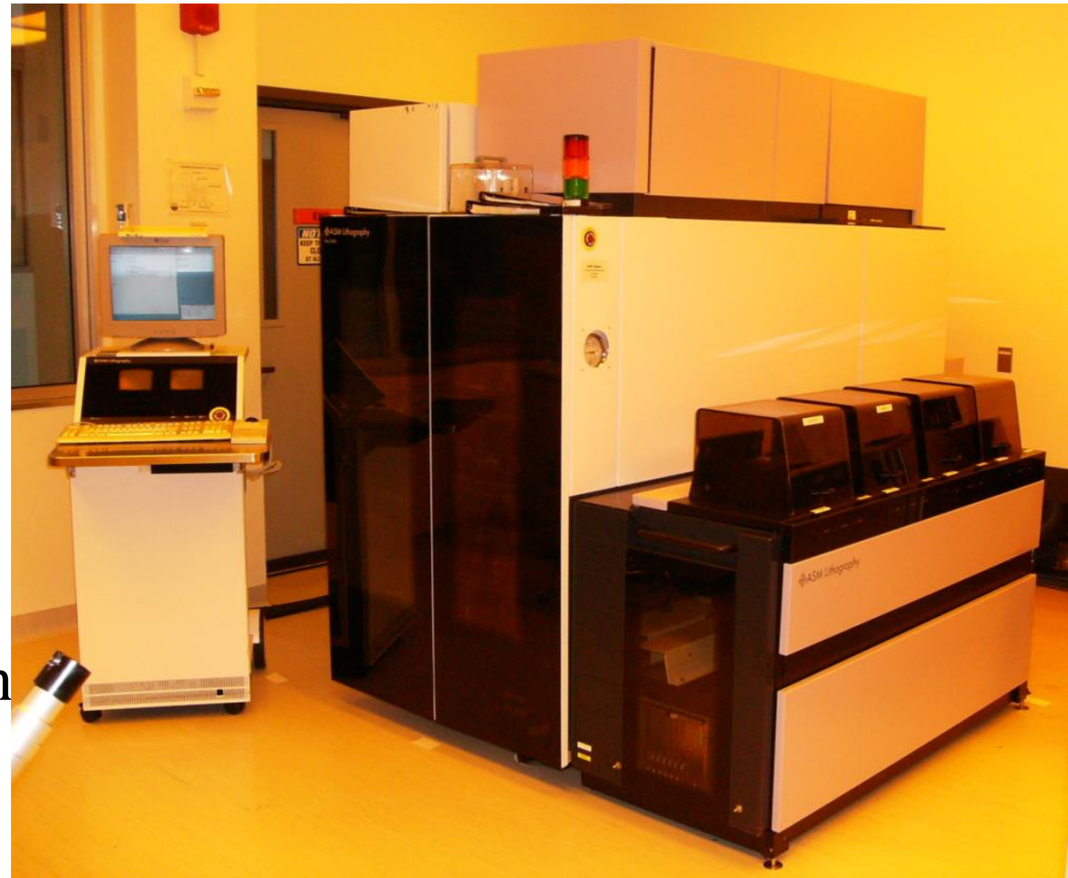
ASML 5500/200



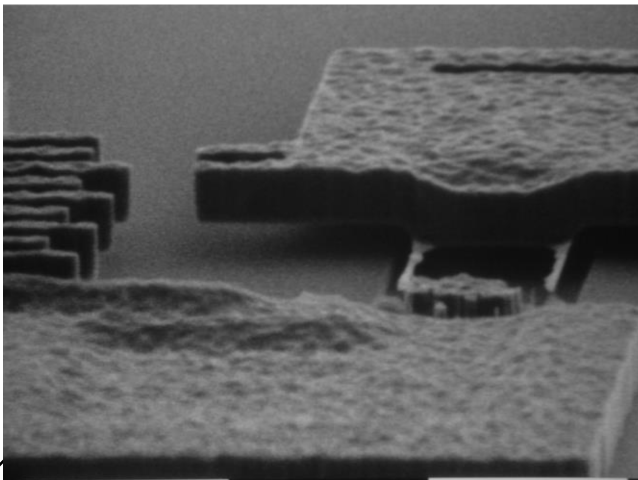
NA = 0.48 to 0.60 variable
σ= 0.35 to 0.85 variable
With Variable Kohler, or
Variable Annular illumination
Resolution = K1 λ/NA
= ~ 0.35µm
for NA=0.6, σ =0.85
Depth of Focus = k_2 $\lambda/(NA)^2$
= > 1.0 µm for NA = 0.6

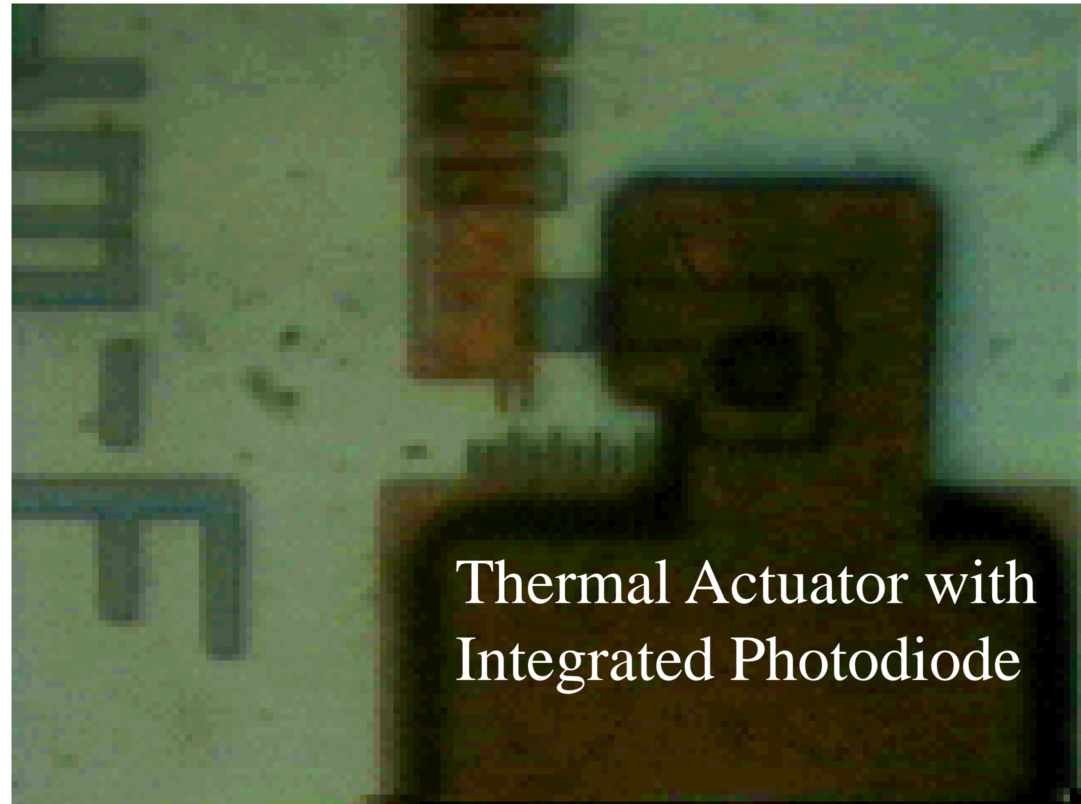


i-Line Stepper λ = 365 nm
22 x 27 mm Field Size

INTEGRATION OF PHOTODIODE AND MEMS

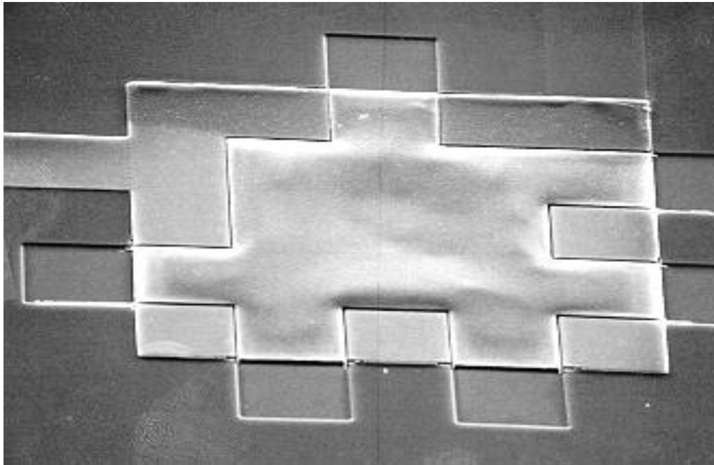
December 2001
Kevin Munger. joined
IBM Burlington, VT

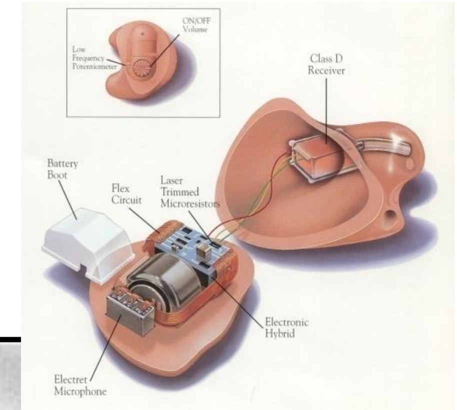


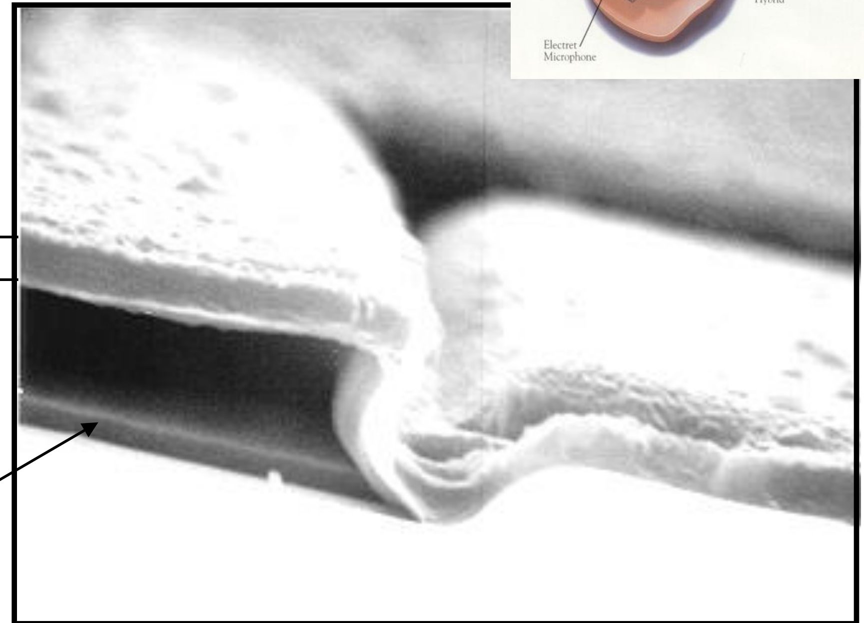


Maximum Deflection 9 µm at 30 µw
162,000 cycles, 6 msec.,

ALUMINUM DIAPHRAGM CAPACITIVE MICROPHONE







1 µm Aluminum

Jon Stephan, 1995, now at Intel Corporation Folsom, CA

2.0 µm Gap

ACCELEROMETER

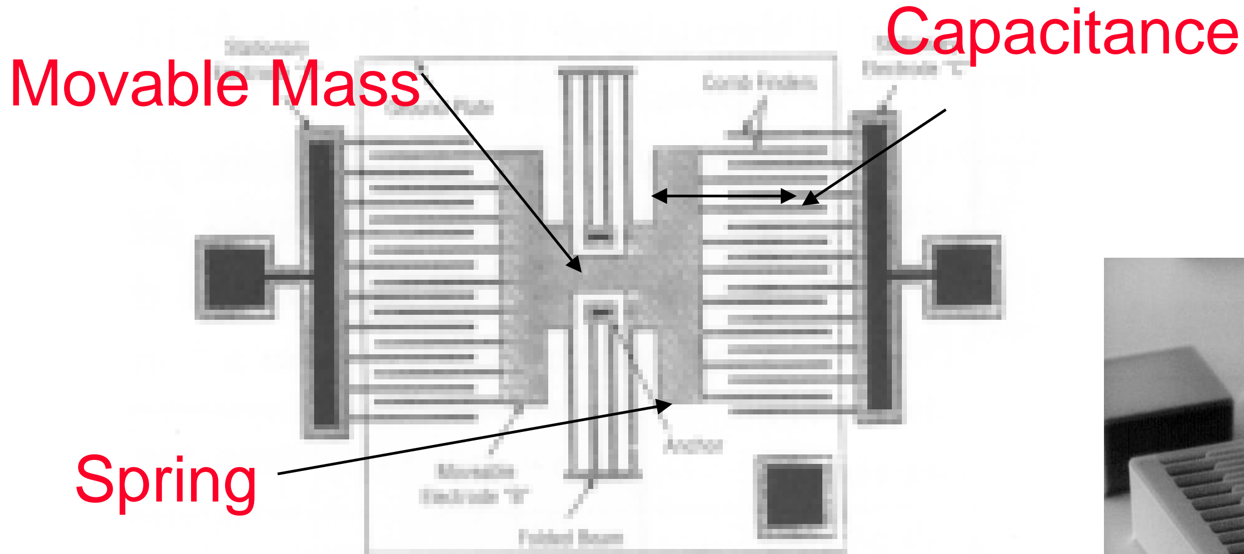


Figure 1: Capacitive Accelerometer Structure

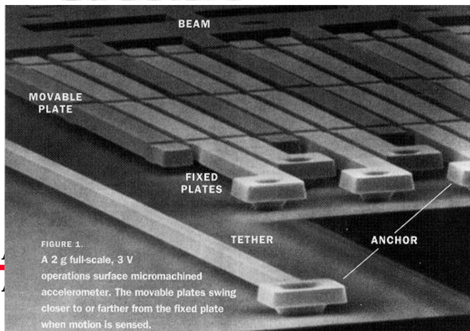
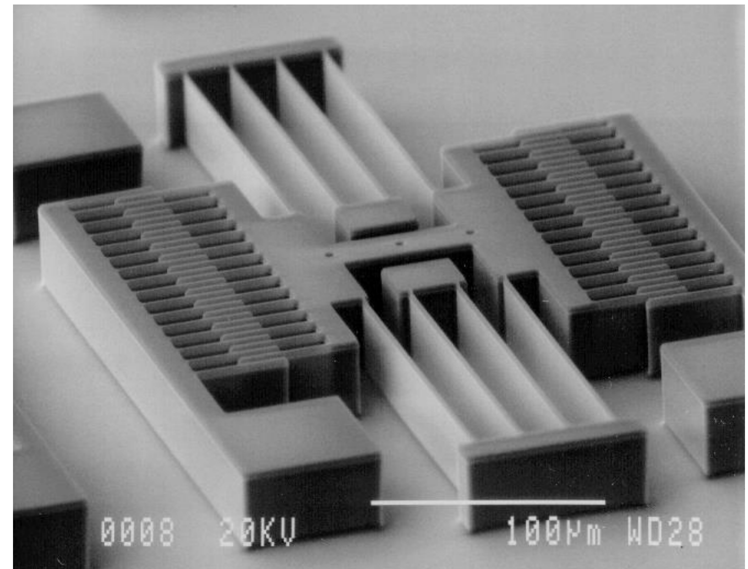
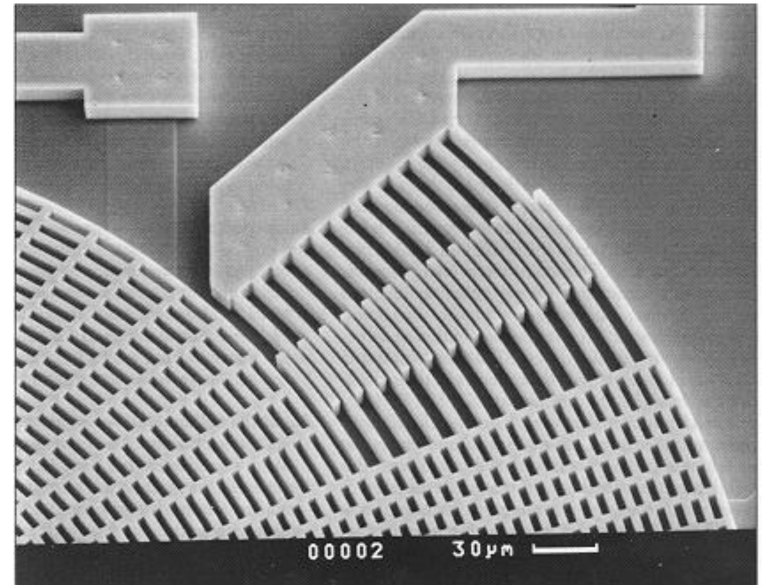


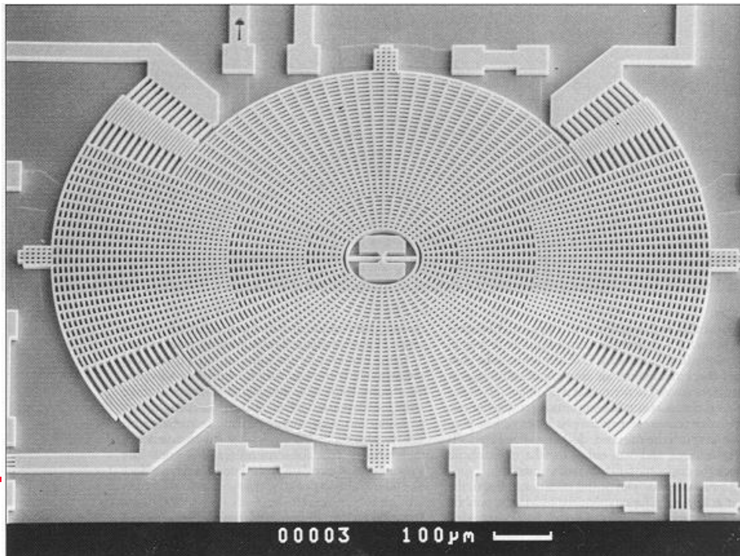
FIGURE 1.
A 2 g full-scale, 3 V operations surface micromachined accelerometer. The movable plates swing closer to or farther from the fixed plate when motion is sensed.

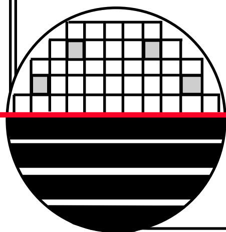


Bulk Silicon Accelerometer (Courtesy of MCNC)

ANGULAR RATE MEASUREMENT







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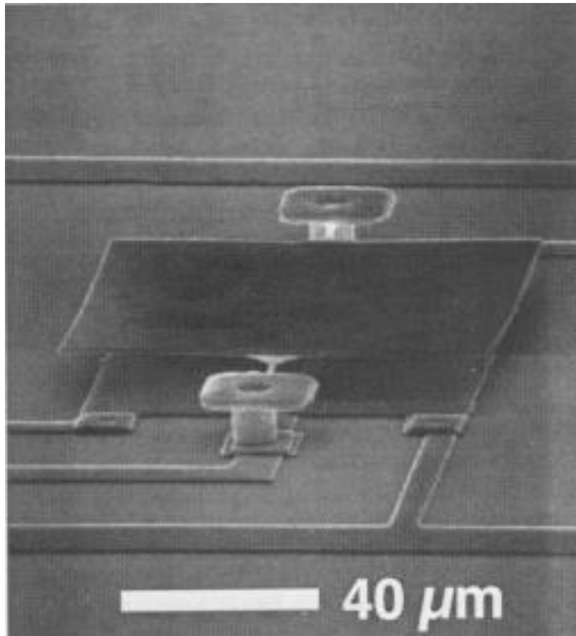
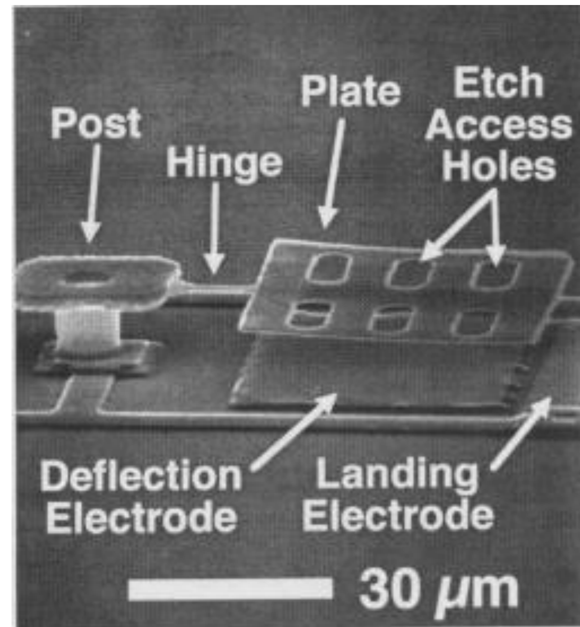
MIRRORS





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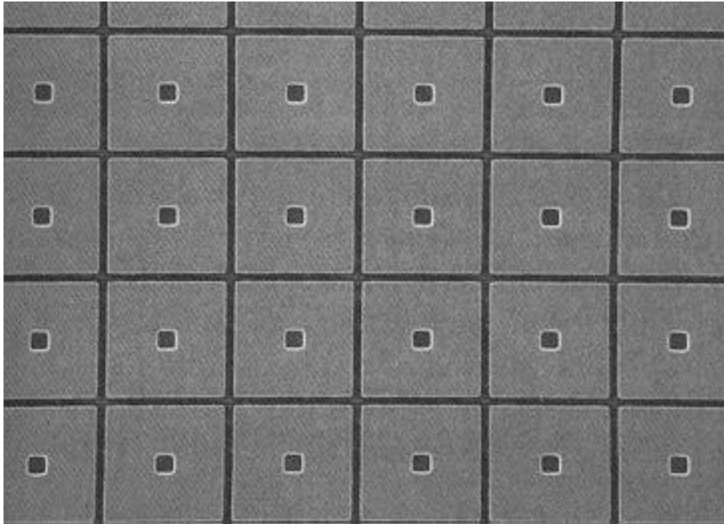

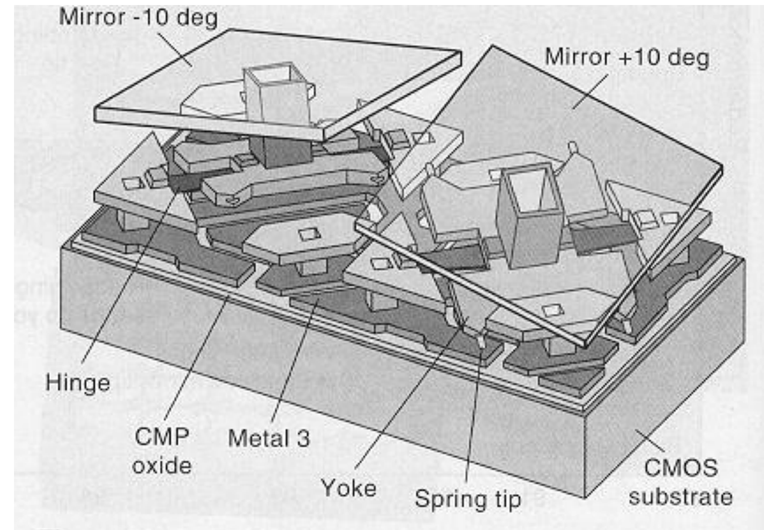

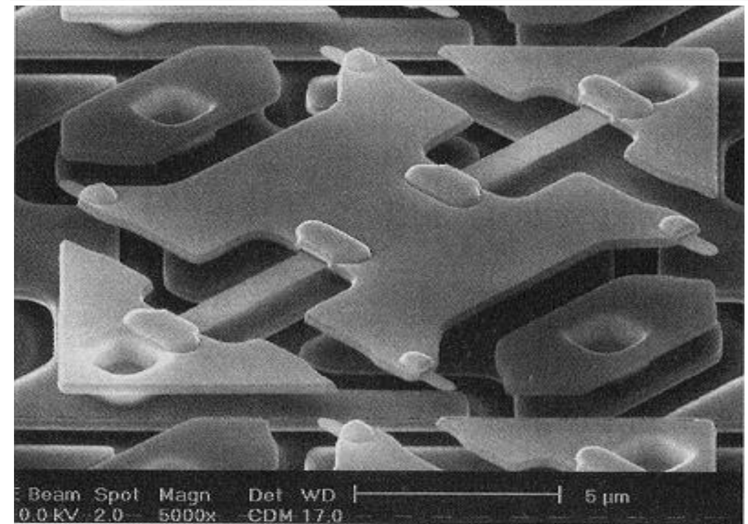

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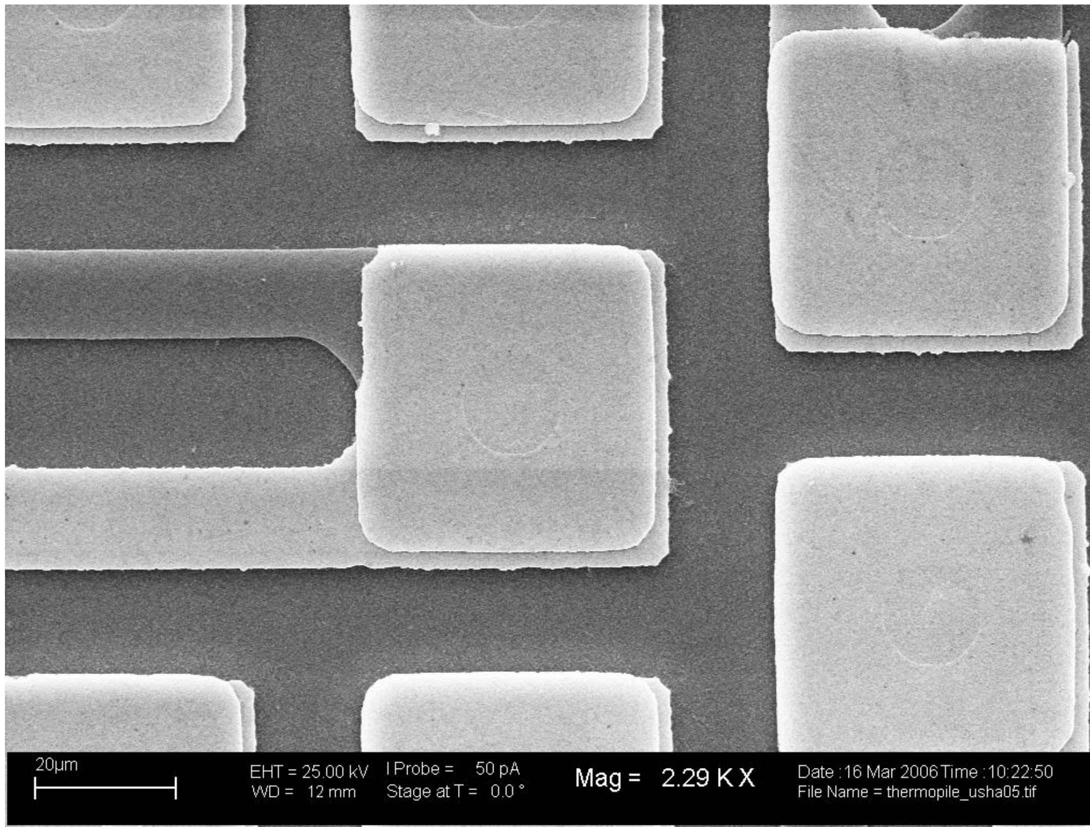
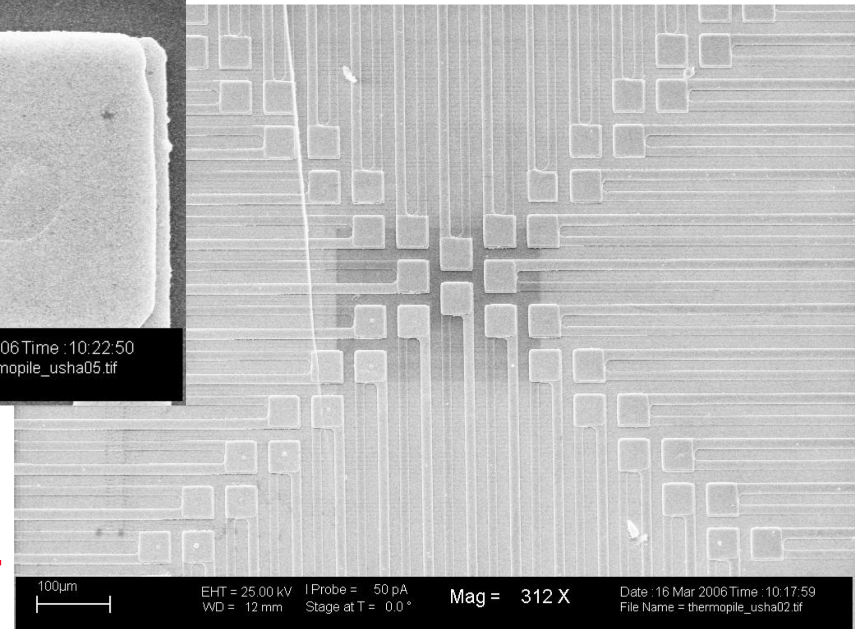
THERMOPILE

2006





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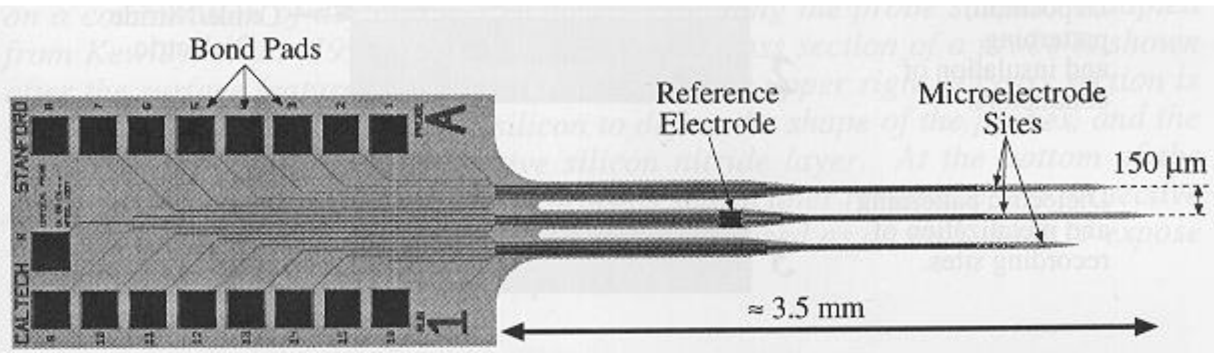
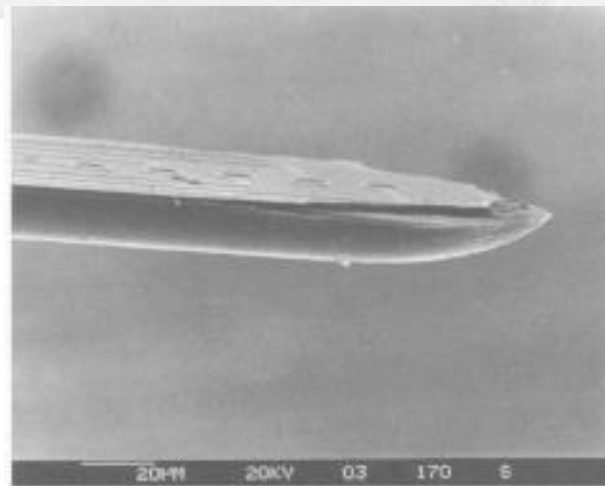
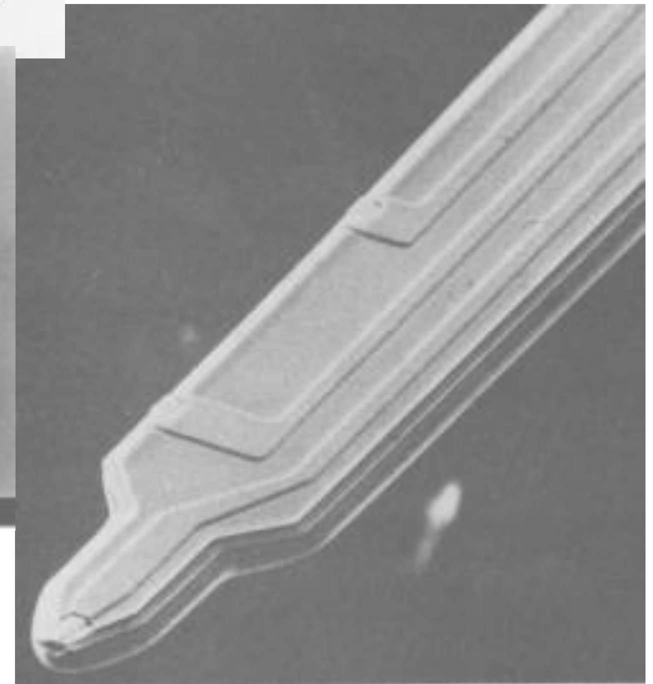
SENSING ELECTRODES







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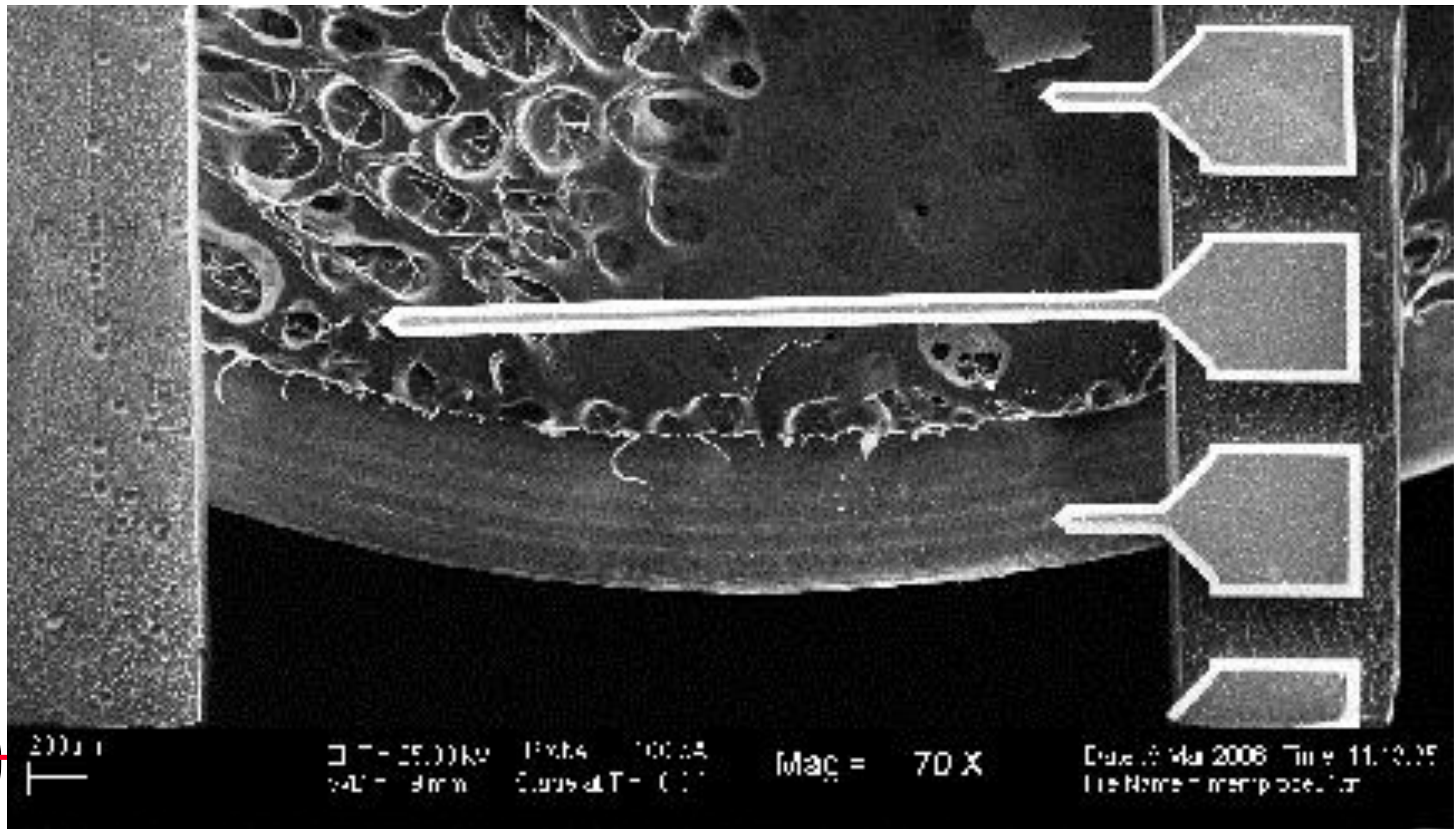
SEM AFTER RELEASE

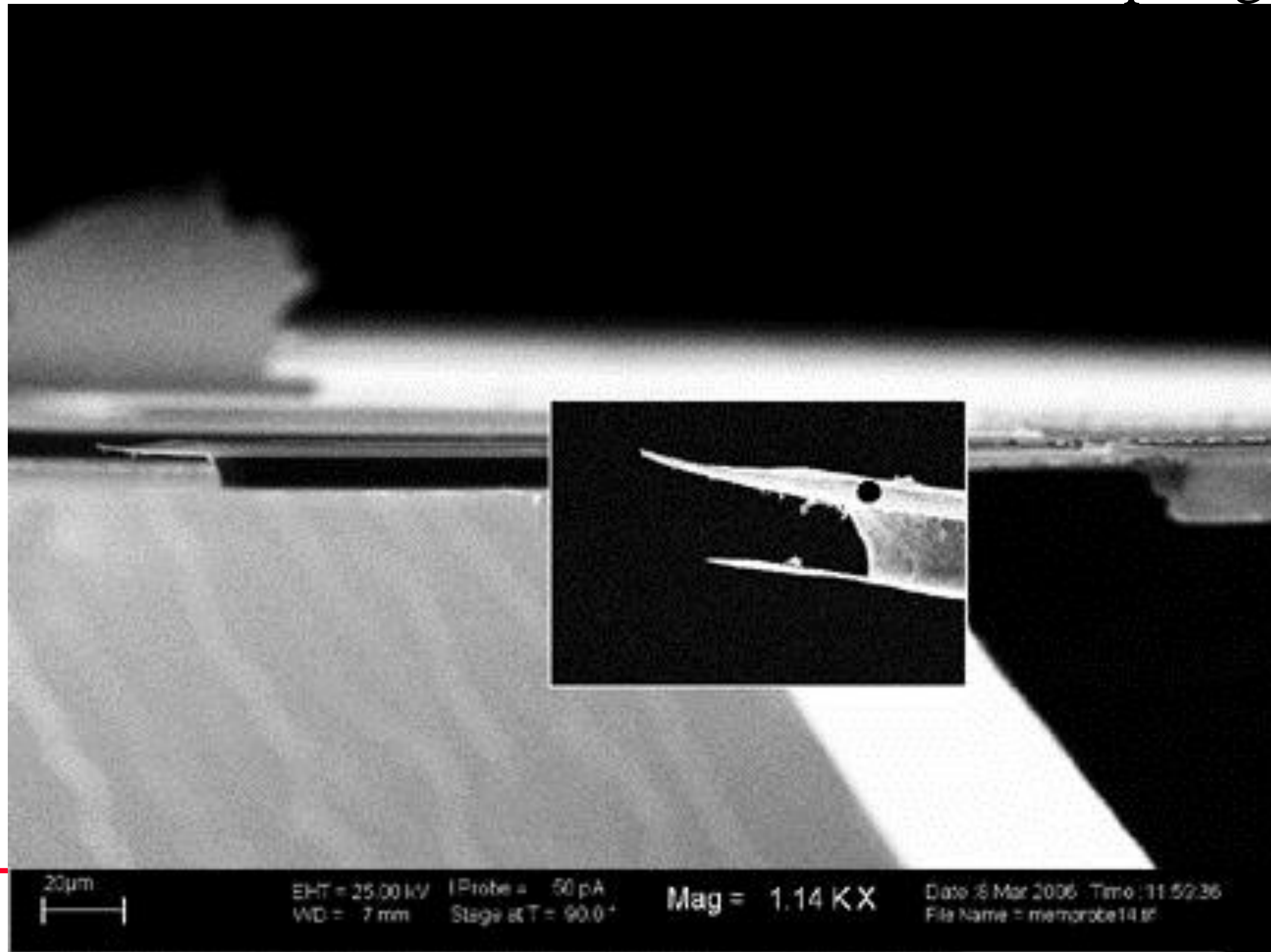
The bright white outline is the undercut of the aluminum during plasma etch of the silicon. ~30μm

2006



SEM OF TIP AFTER RELEASE

This picture of the tip shows aluminum on top, undercut silicon and thin film of nitride from the bottom of the diaphragm



2006

SEM OF TIP

1.1 µm of aluminum, 16.5µm silicon

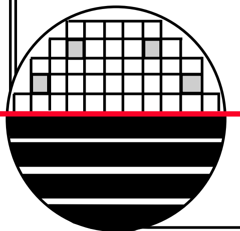
1.1 µm

16.5 µm

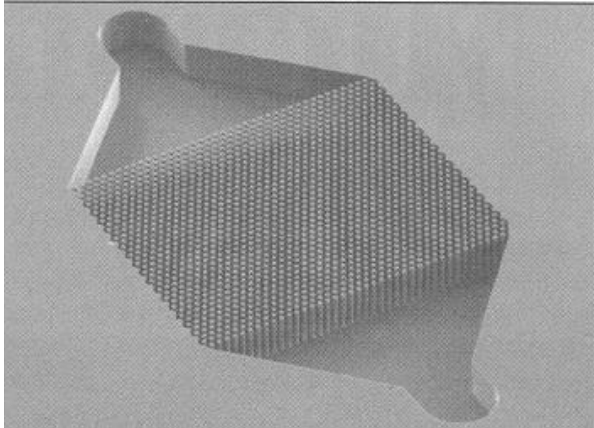
10µm

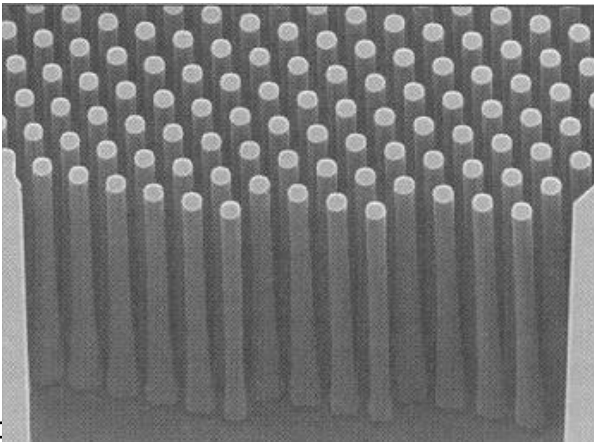
Mag = 4.37 K X

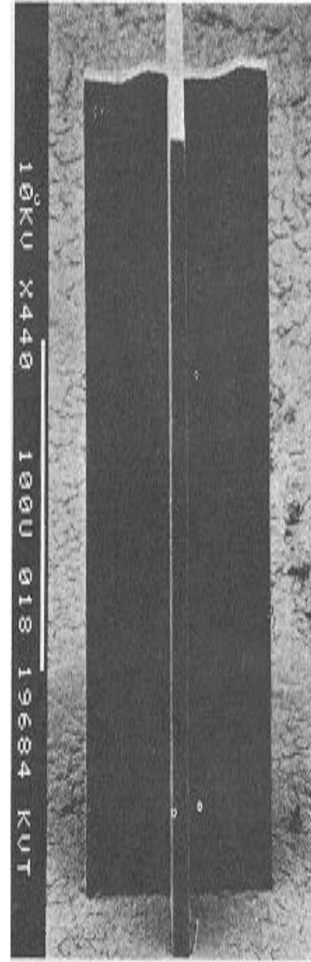
2006

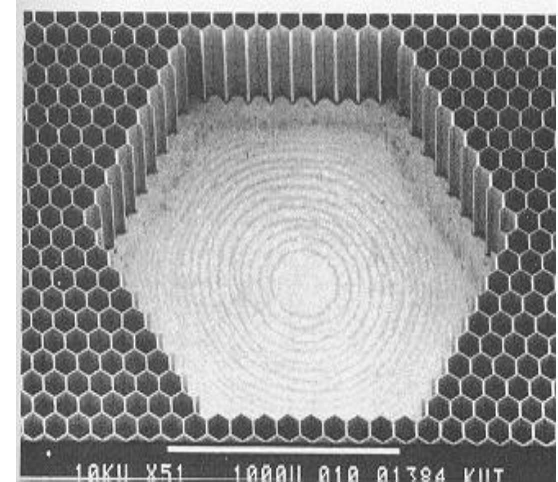


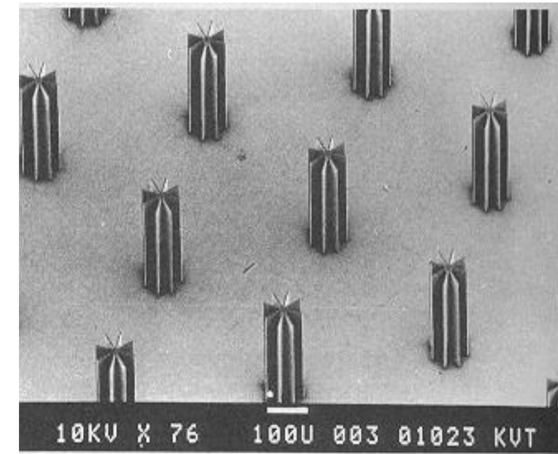
PILLARS AND POSTS



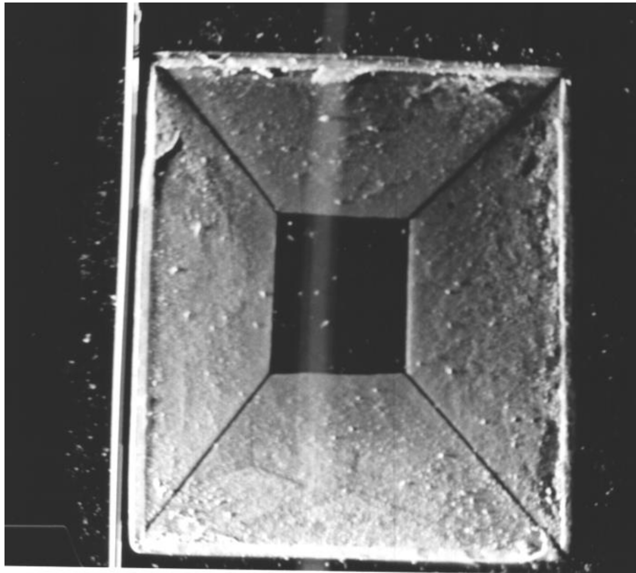


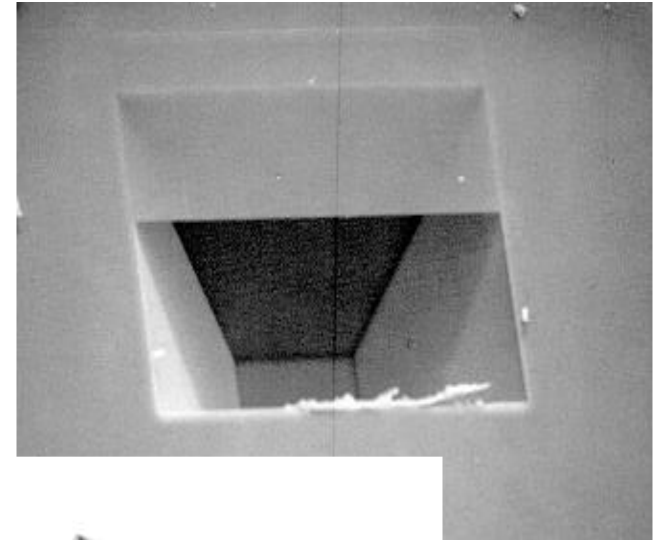


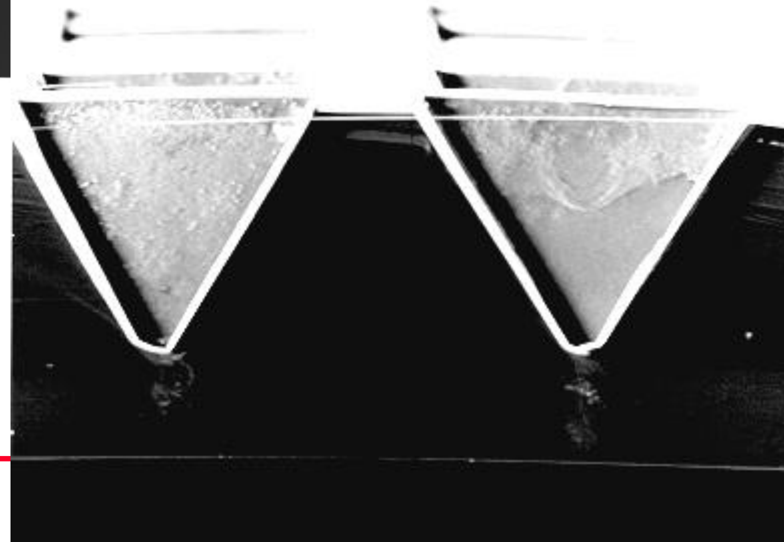




KOH ETCHED HOLES IN SINGLE CRYSTAL SILICON







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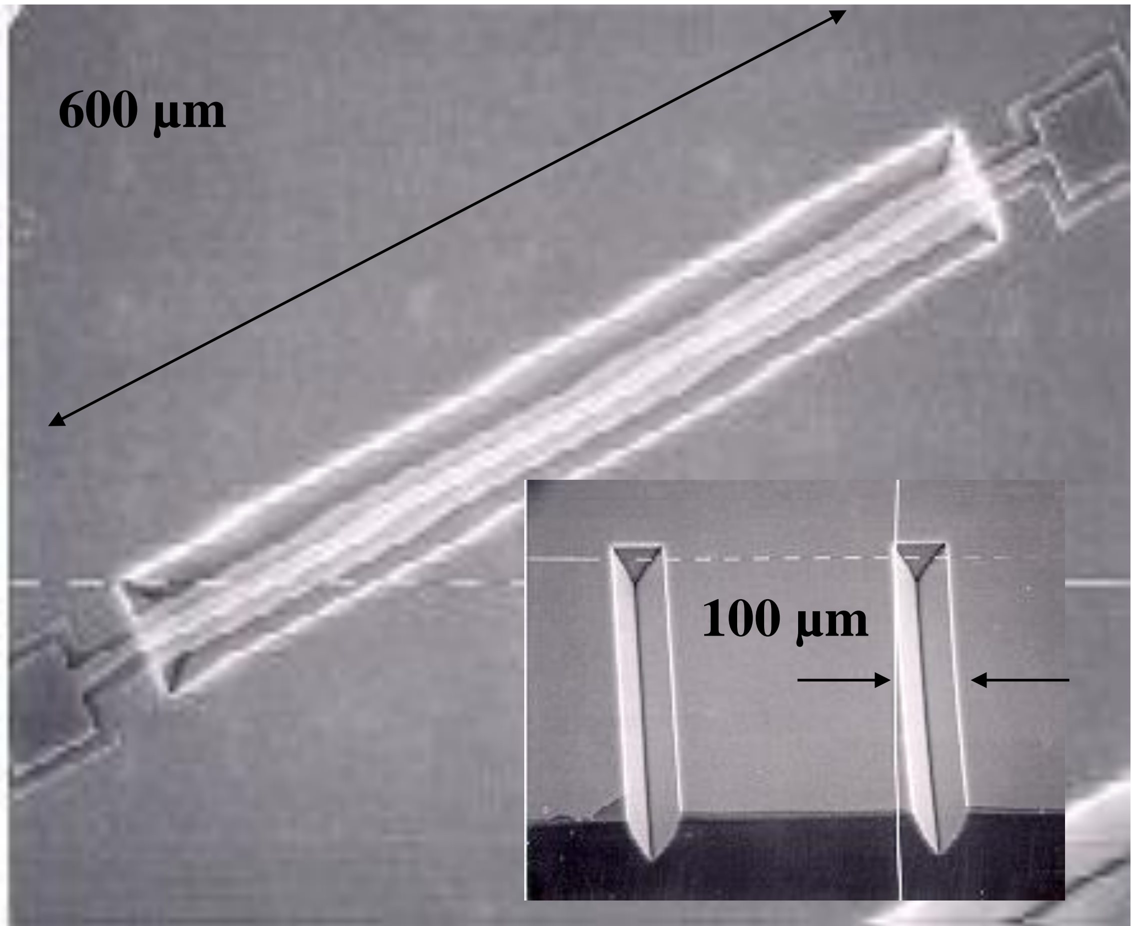
HOT FILIMENT LIGHT SOURCES

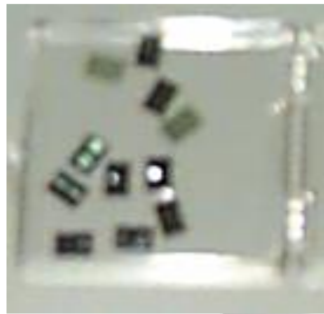
Dave Borkholder,
Professor EE at RIT
Stanford University
Palo Alto, CA

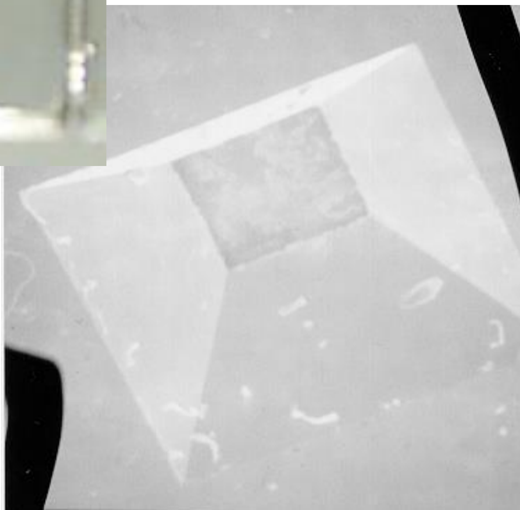


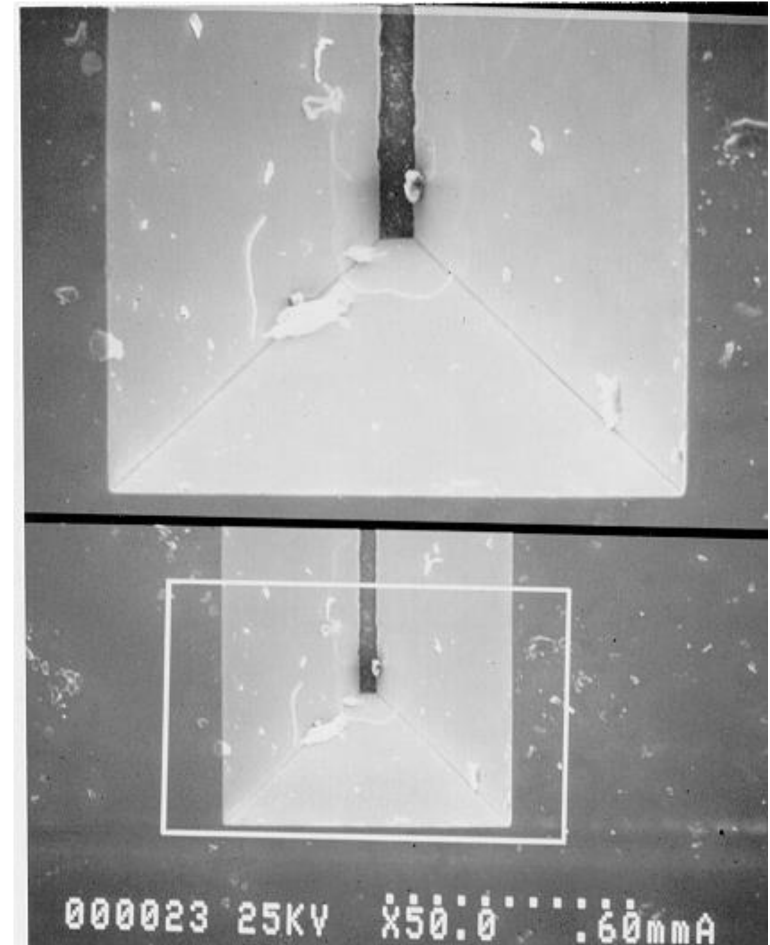
FLOW PLATES FOR FULE INJECTION

Variety of different size and shape holes etched through 500 µm thick silicon wafer

Dr. Risa Robinson
Delphi Products, Inc.







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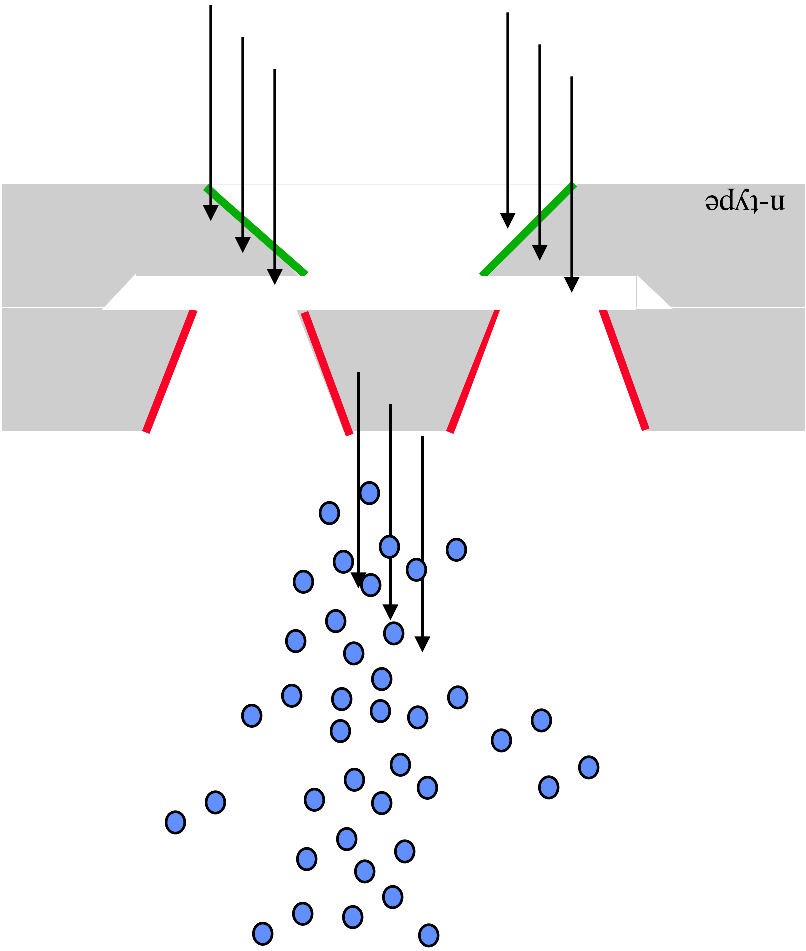
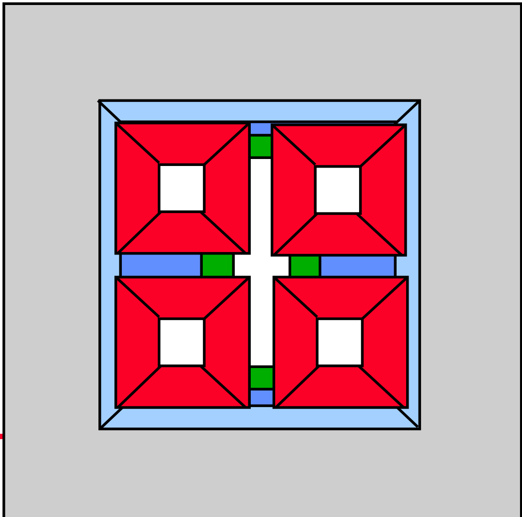
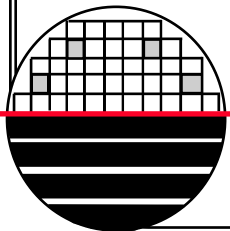
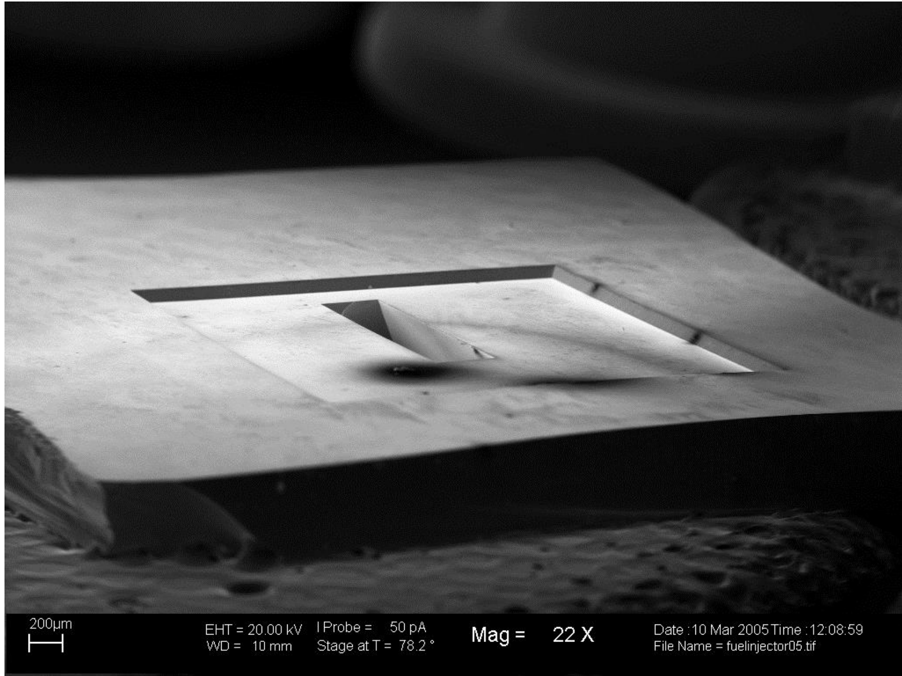
FULE INJECTION

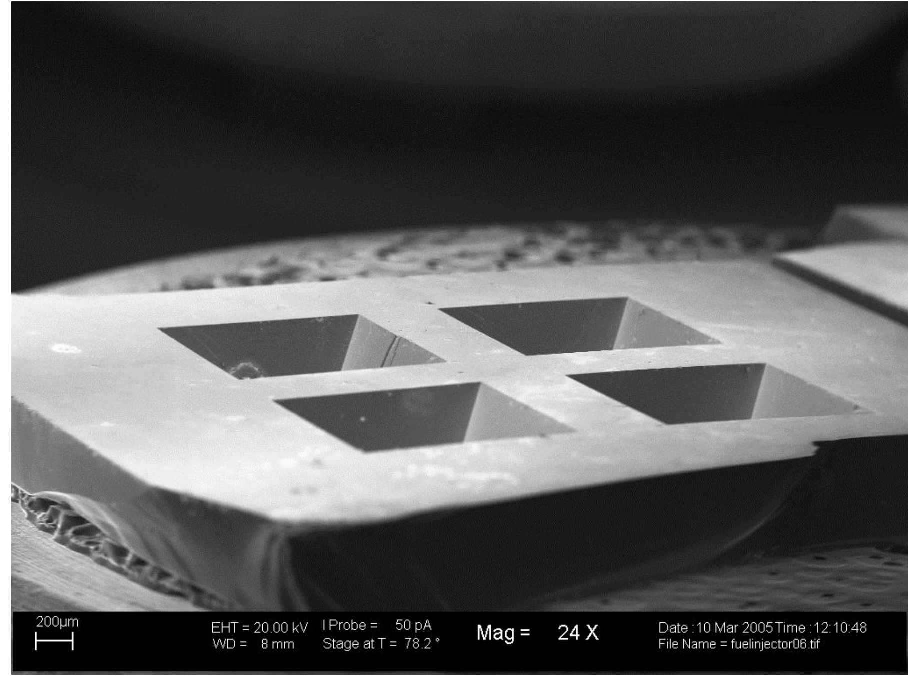




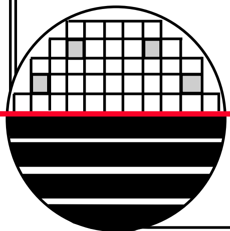


FULE INJECTOR





2005



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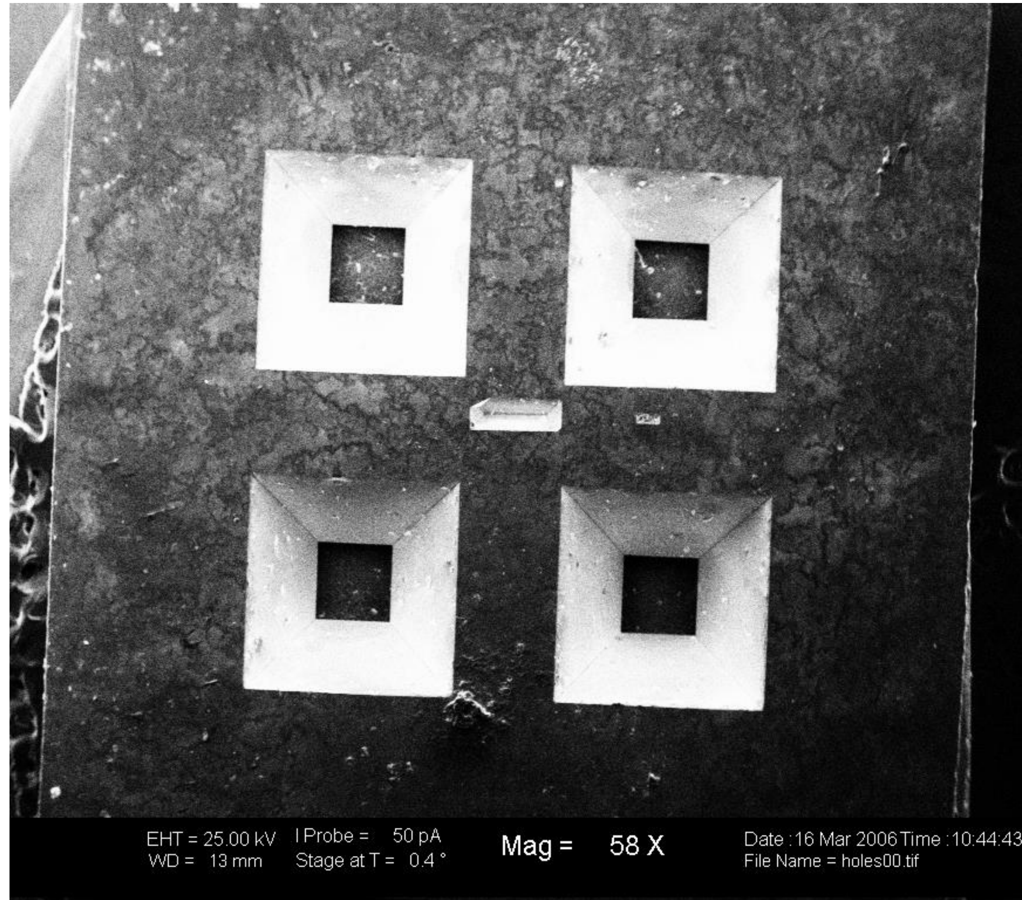
FULE INJECTOR



2006

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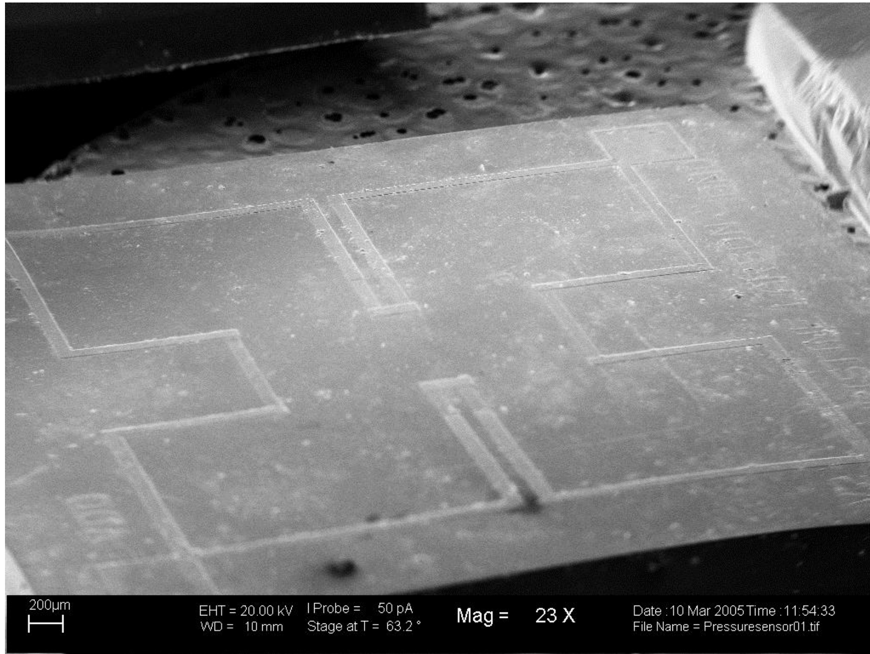
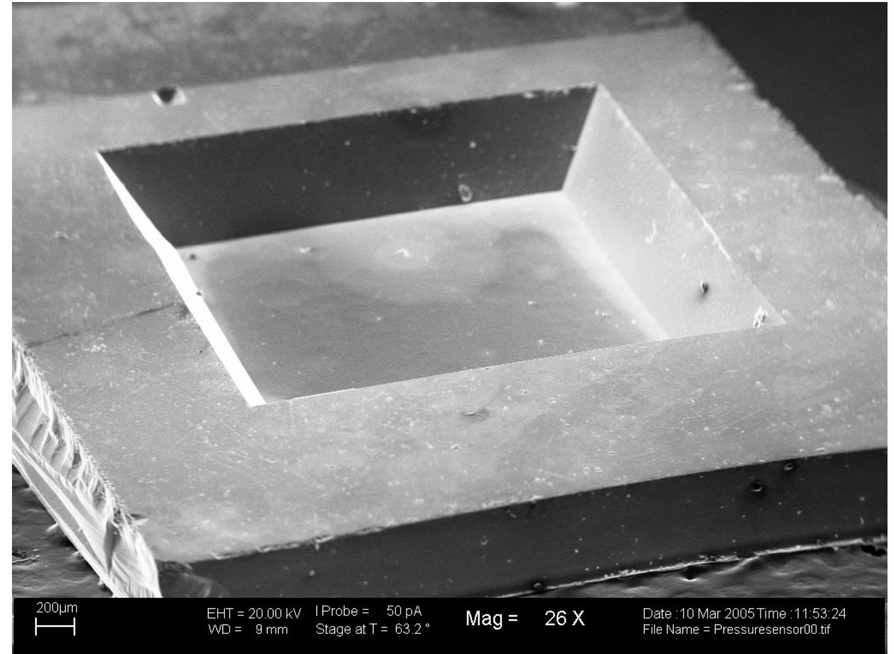
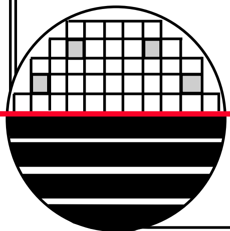
PRESSURE SENSOR







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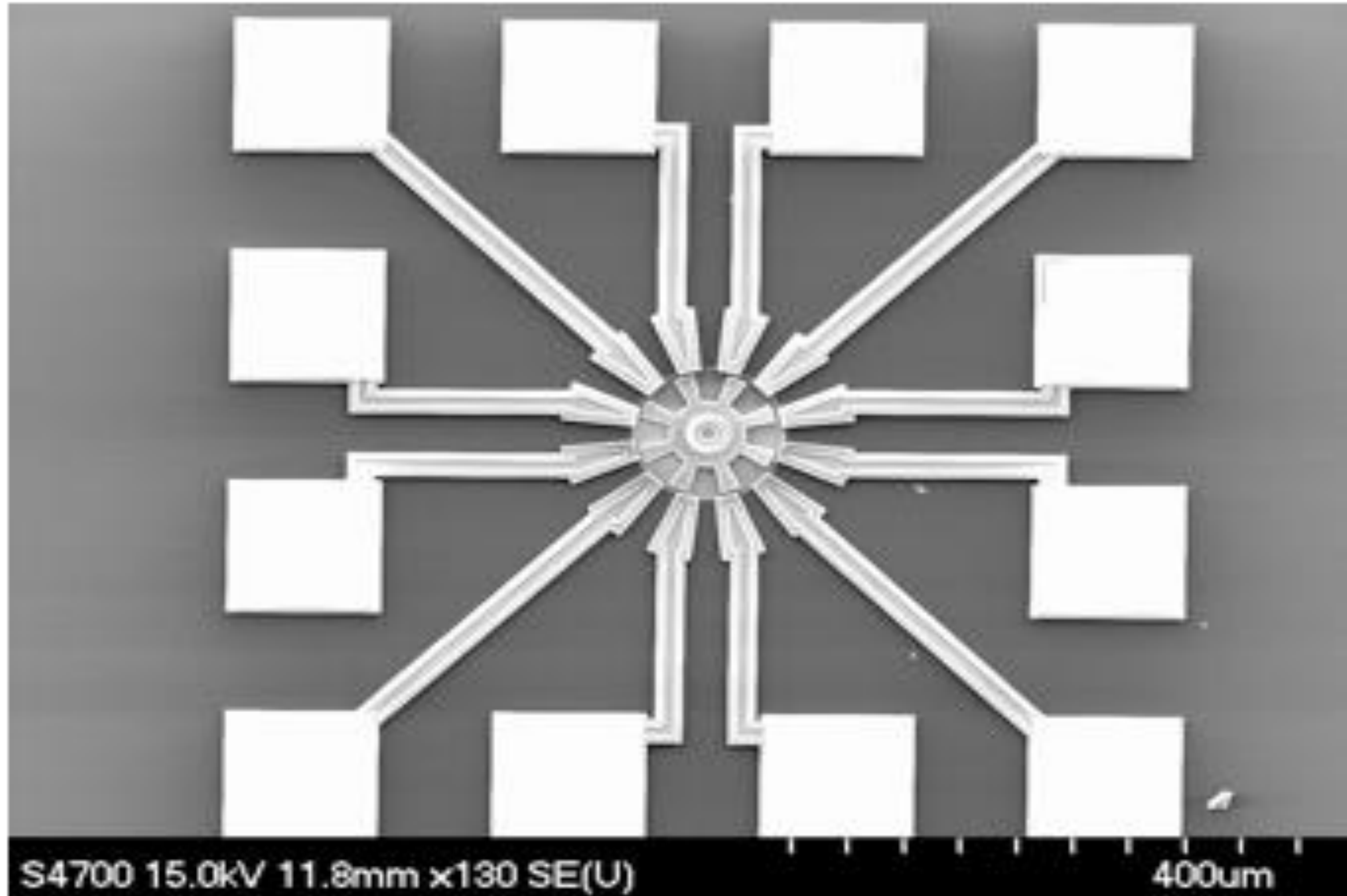
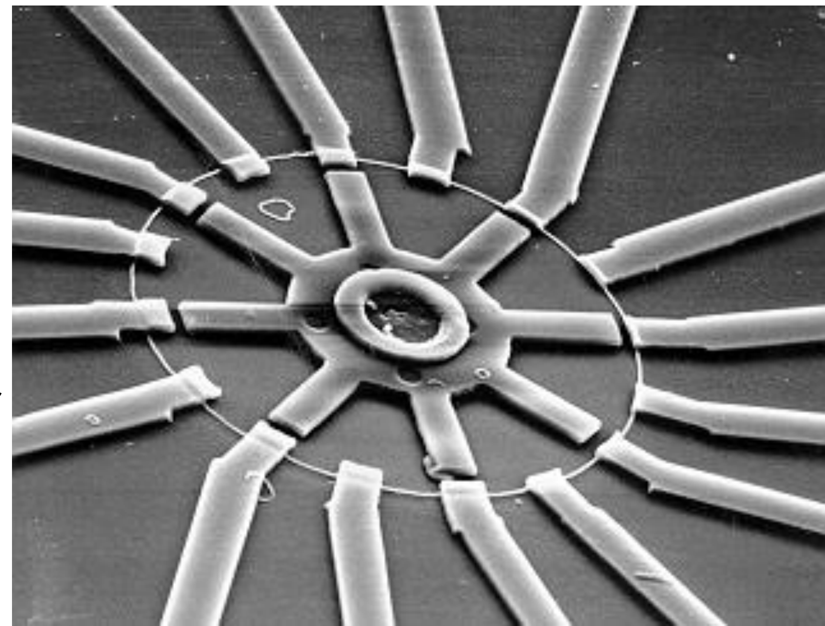
MICROMOTOR

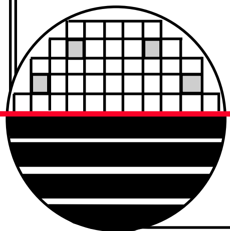


MICROMOTORS

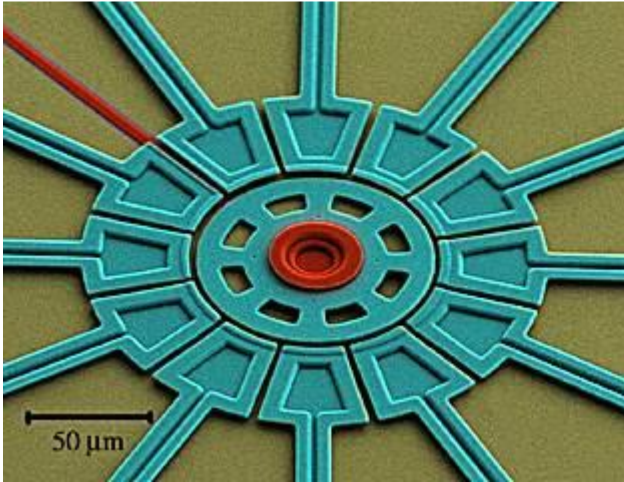
100 µm

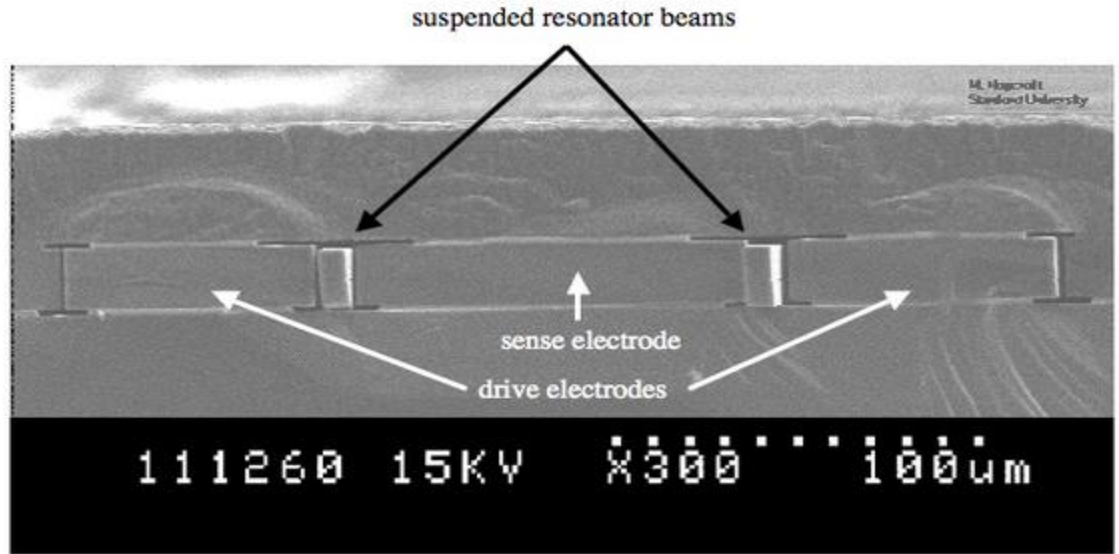


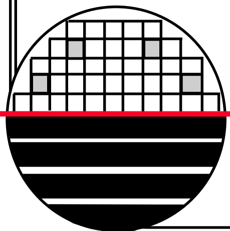
Matt Matessa, 1991, now at Cypress Semiconductor San Jose, CA



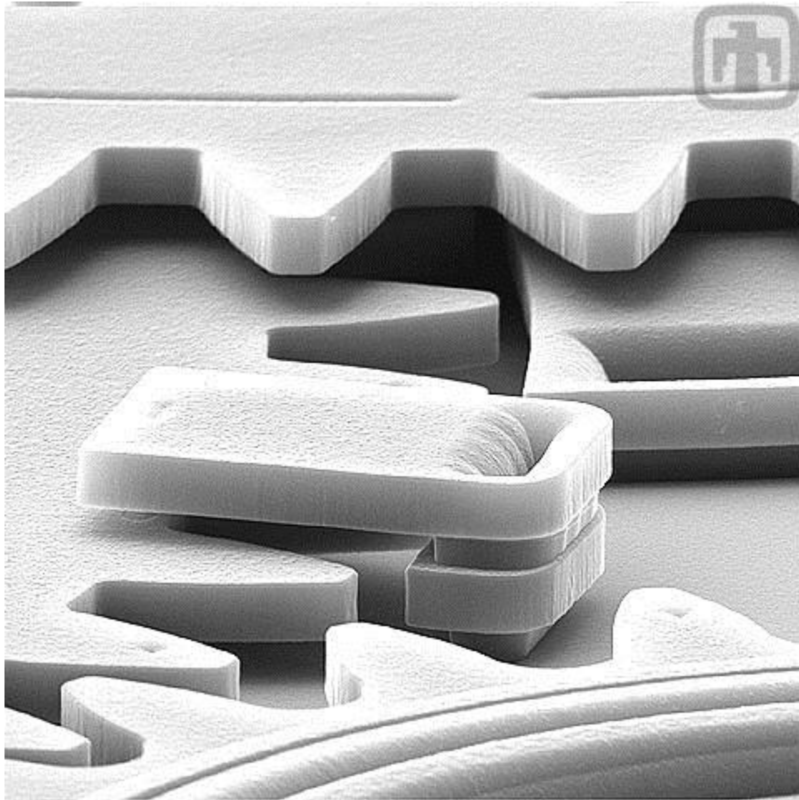
MICRO MOTORS

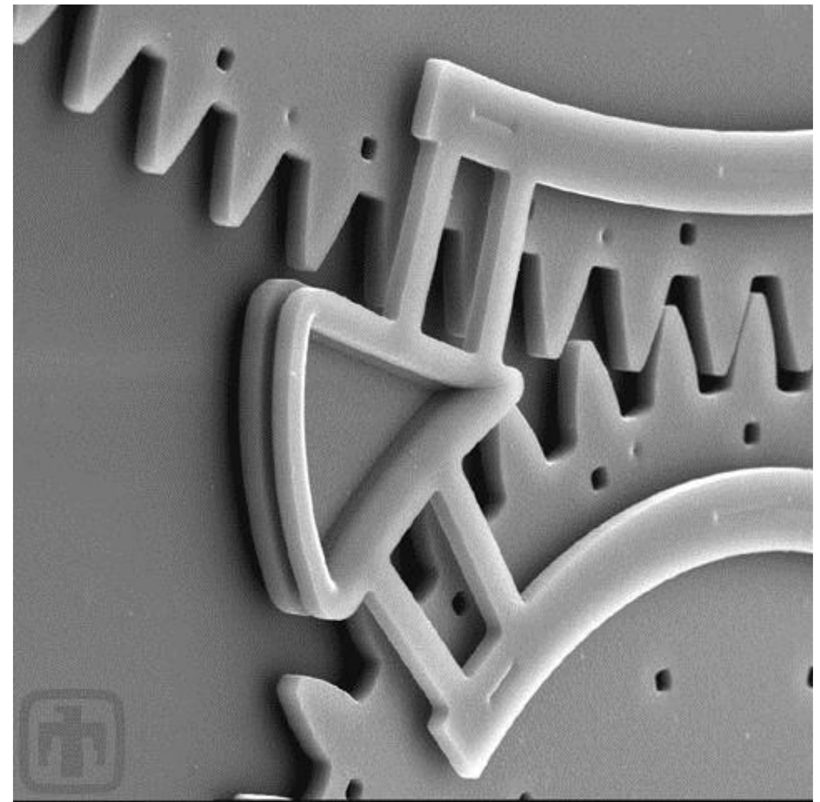






SANDIA GEARS AND LINKAGES





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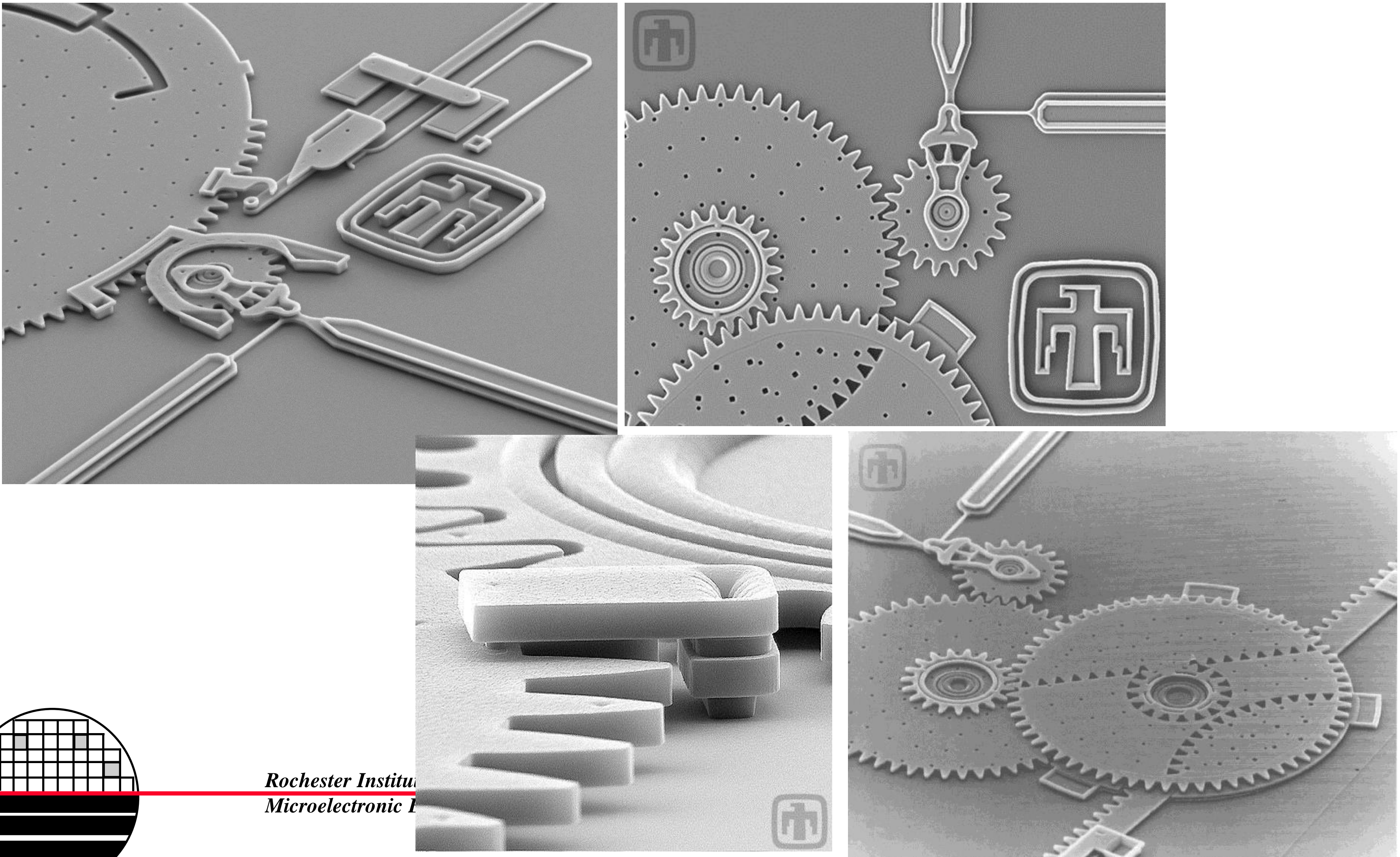
SANDIA GEARS AND LINKAGES



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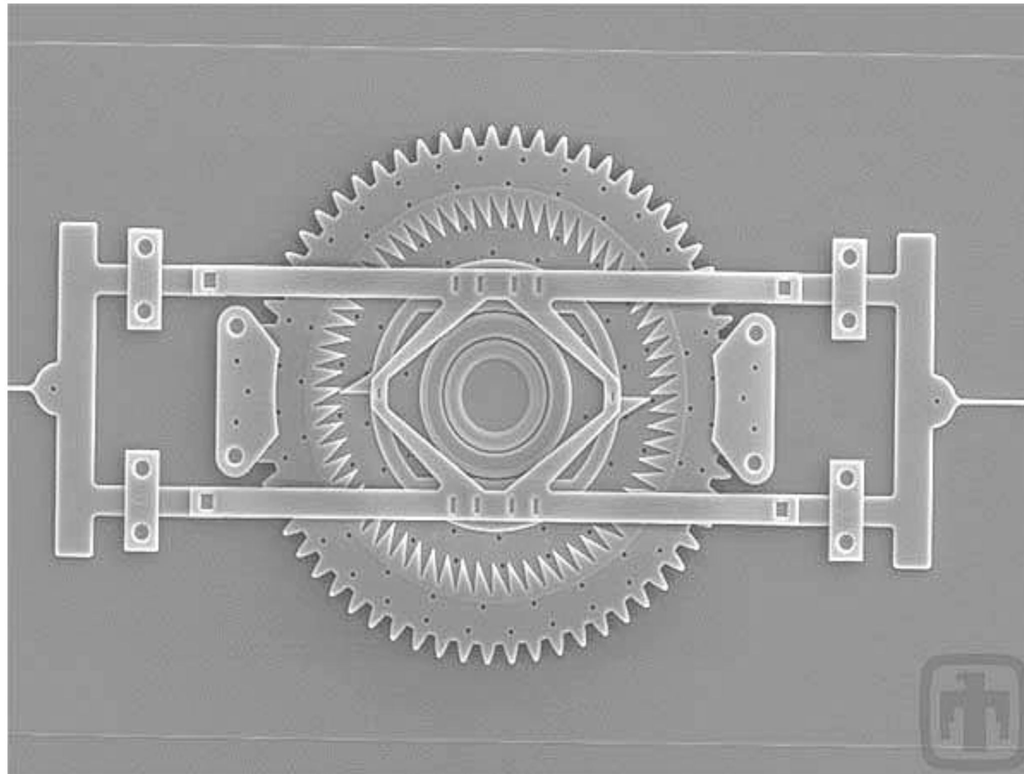
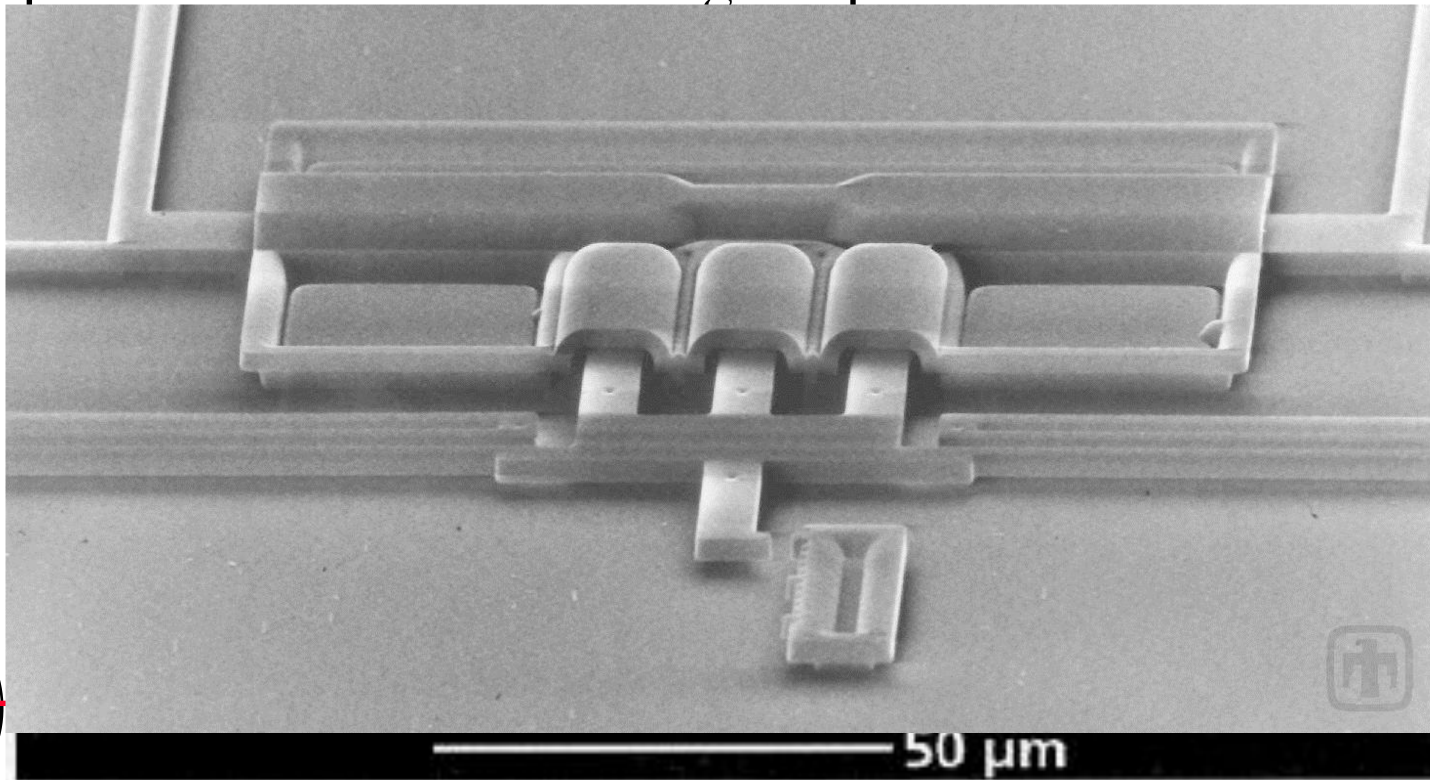
INDEXING MOTOR



This is an indexing motor. There are two teeth that engage the gears teeth this is designed to make one step at a time. One of the indexing (inside) teeth are meshed with the gear at all times
http://mems.sandia.gov/gallery/images_indexing_motors.html

SANDIA STEAM ENGINE

The above device is a single-piston steam engine fabricated by Sandia National Labs. A small amount of water is heated as a current passes through the device. The water vaporizes and pushes on the piston. After the current is removed, the capillary forces inside the cylinder pull the piston back down to its original position.

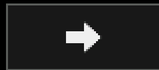


MIRROR

http://www.bacteria-world.com/mems-mirror.htm

MEMS Mirror

Optical Window and Lens
www.yoptics.com
Germanium, Silicon, MgF2, CaF2, Sapphire Window and Lens



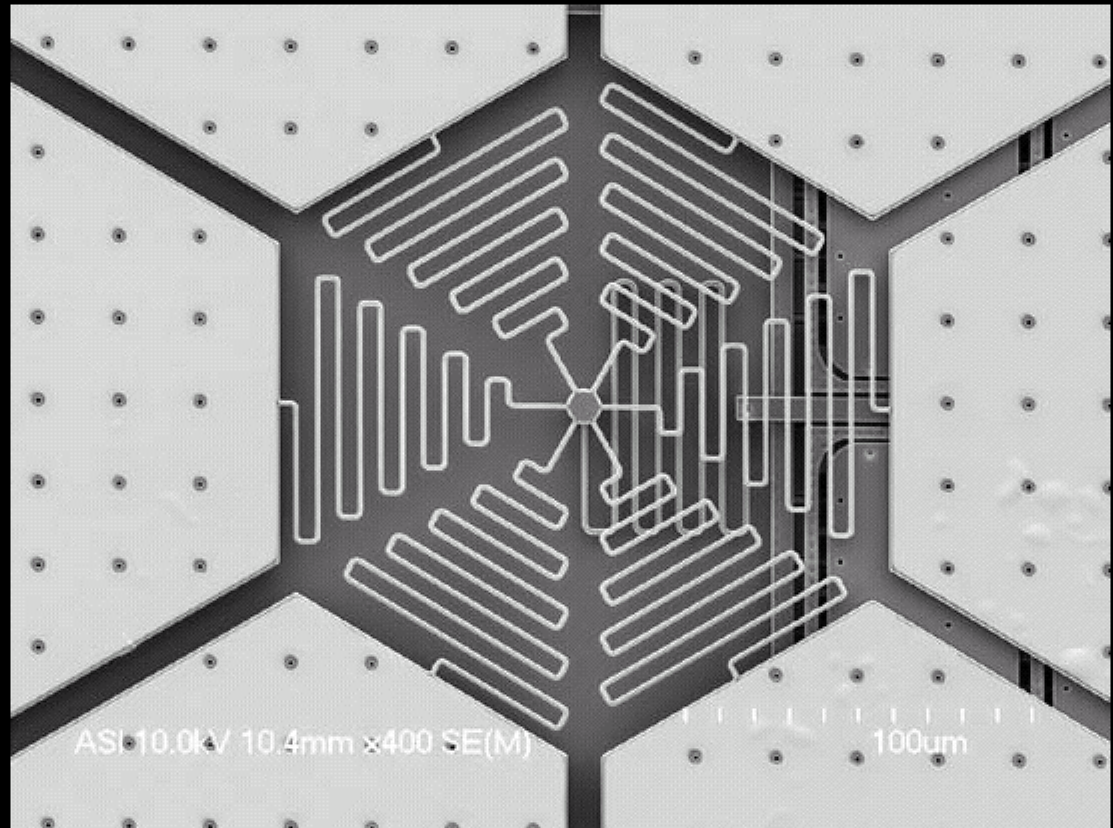
AdChoices

This Site:

- Home
- Bacteria Pictures
- Biofilms
- Blood Cells
- Links
- Contact Us

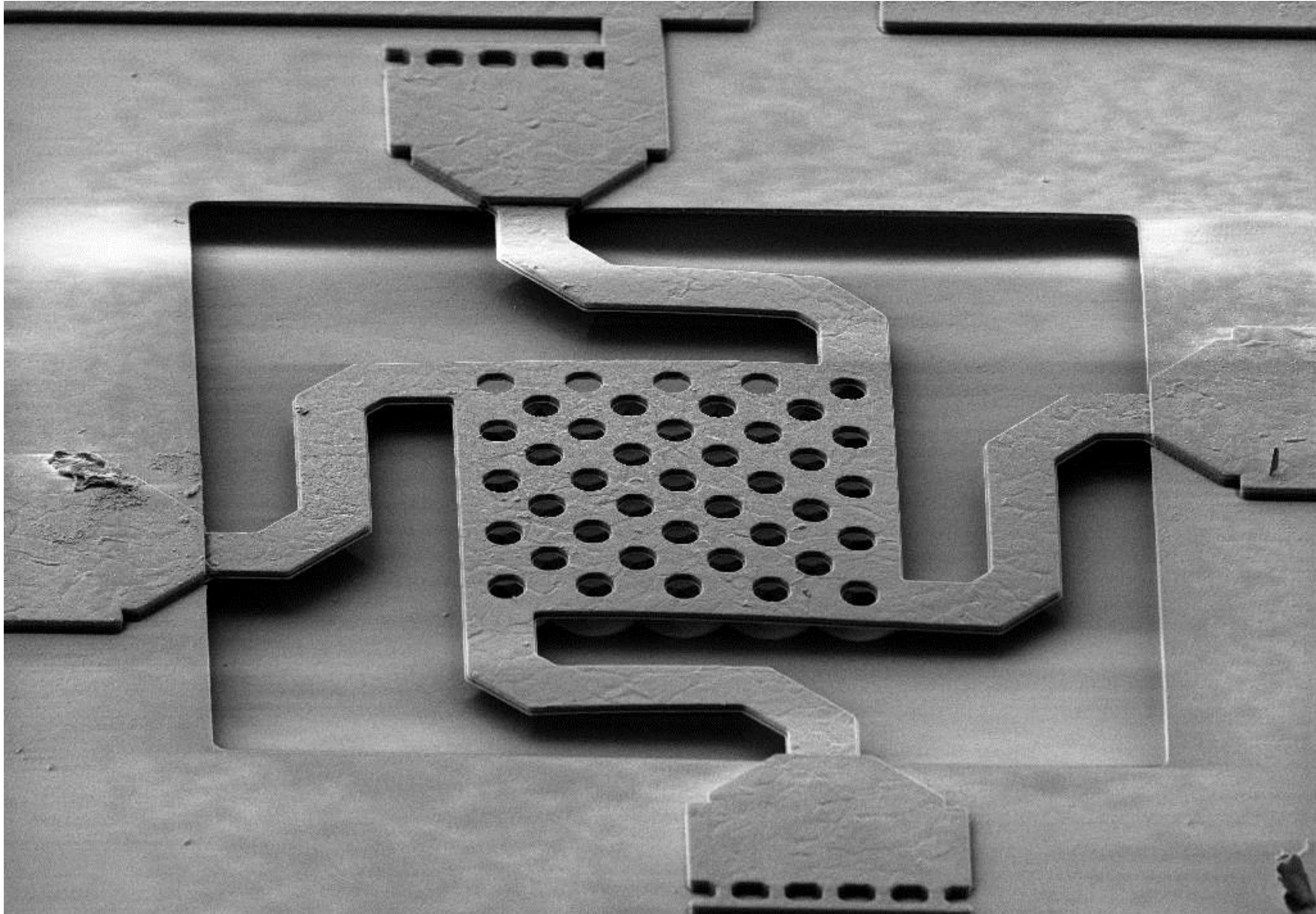
AdChoices

MEMS Fabrication
www.roguevalleymi...
Quality MEMS

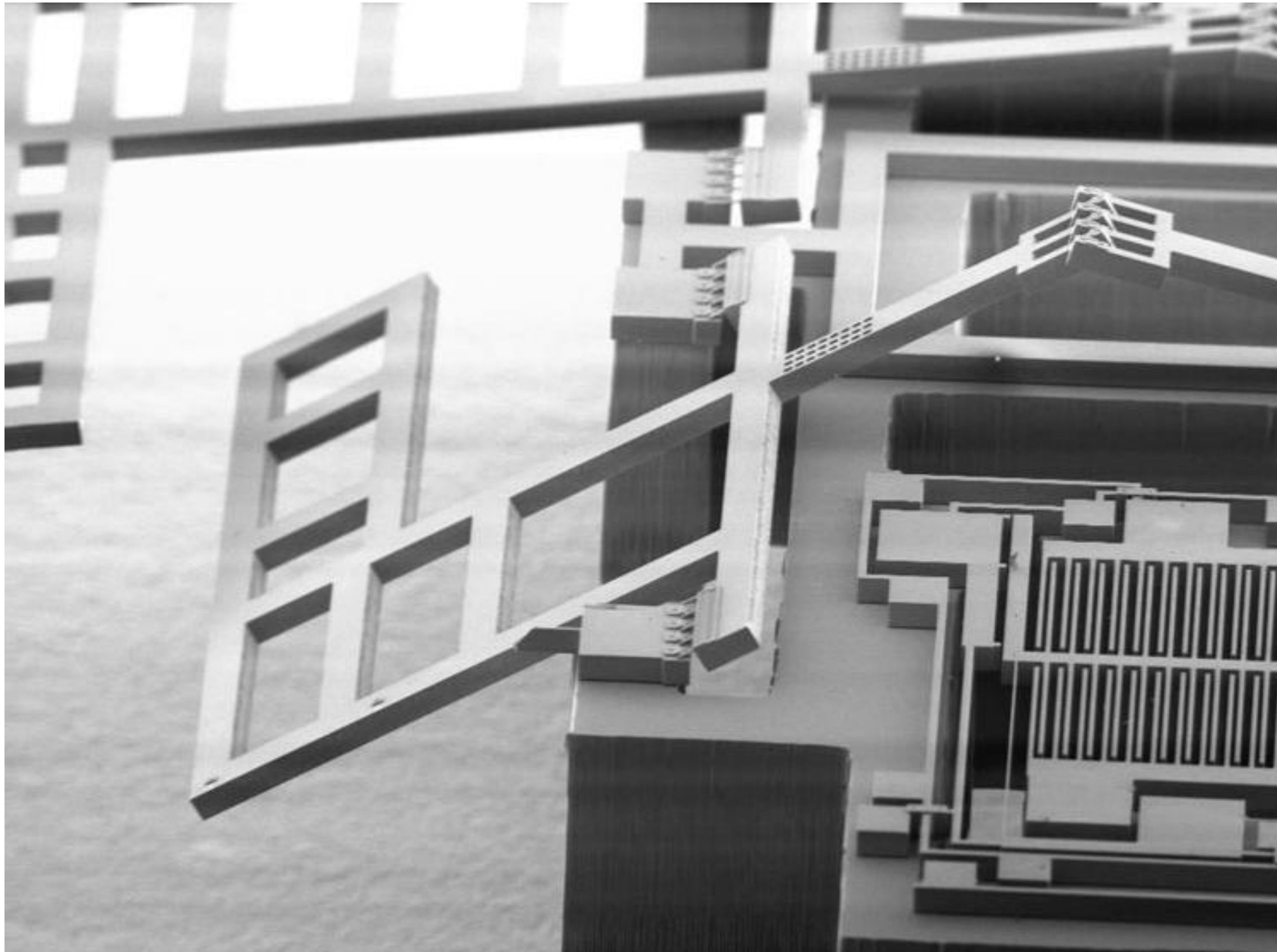


MEMS Mirror

SUSPENDED PLATFORM



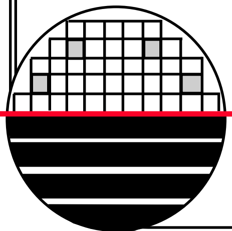
HINDGES



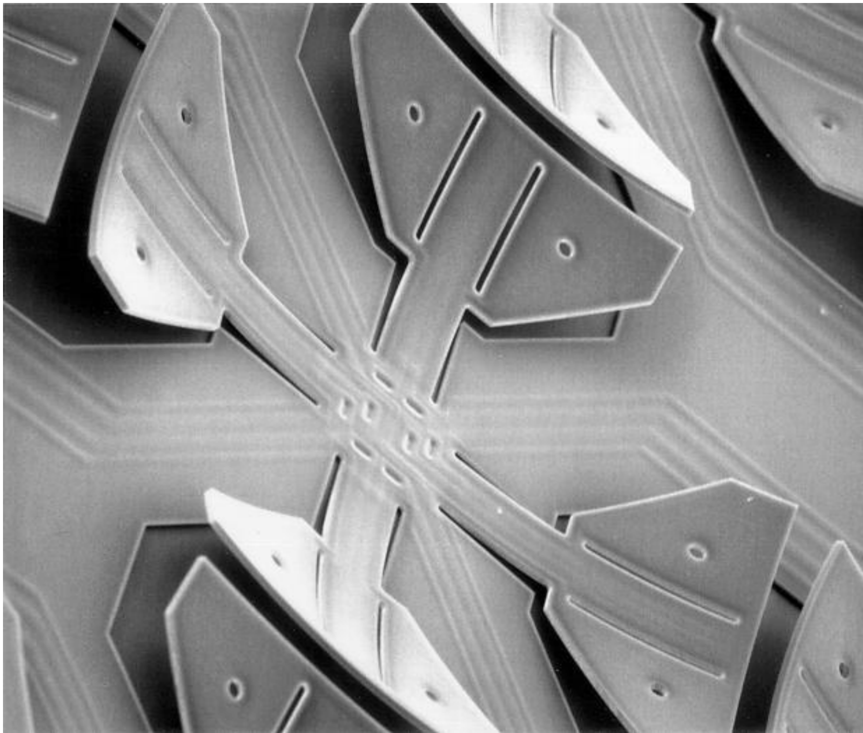
http://coe.berkeley.edu/labnotes/0903/pister.html

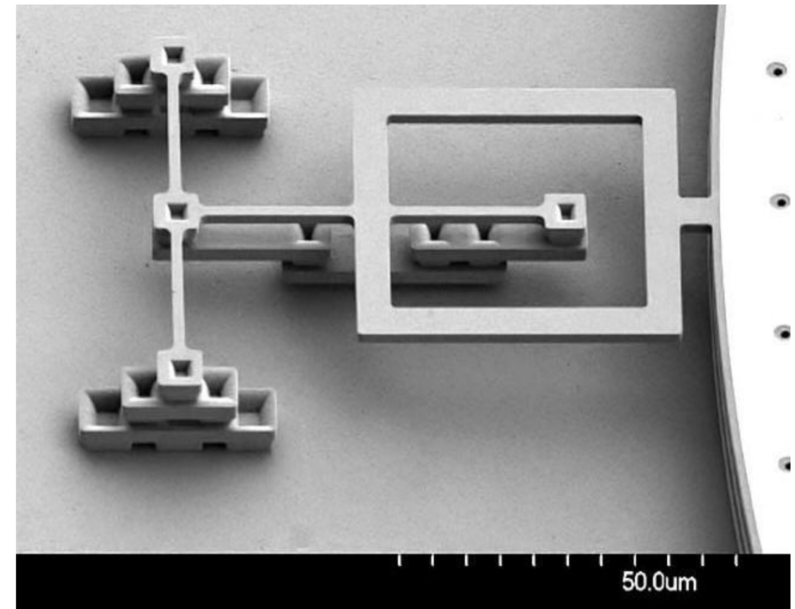
ELECTROTHERMAL ACTUATORS

1mm
Act1
y
x
z
Mirror
Act3
Act2
Frame
Single-Crystal
Silicon (SCS)
A'
Act4
Substrate
A

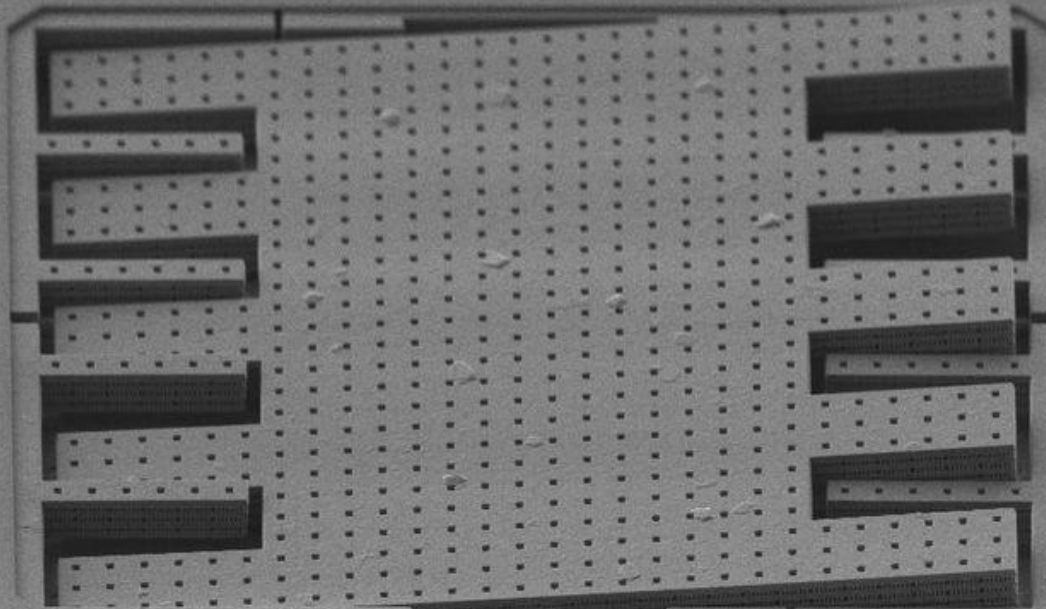


INTERESTING STRUCTURES



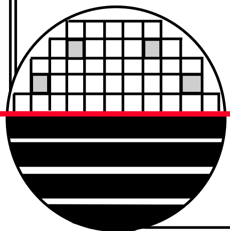


INTERESTING STRUCTURES

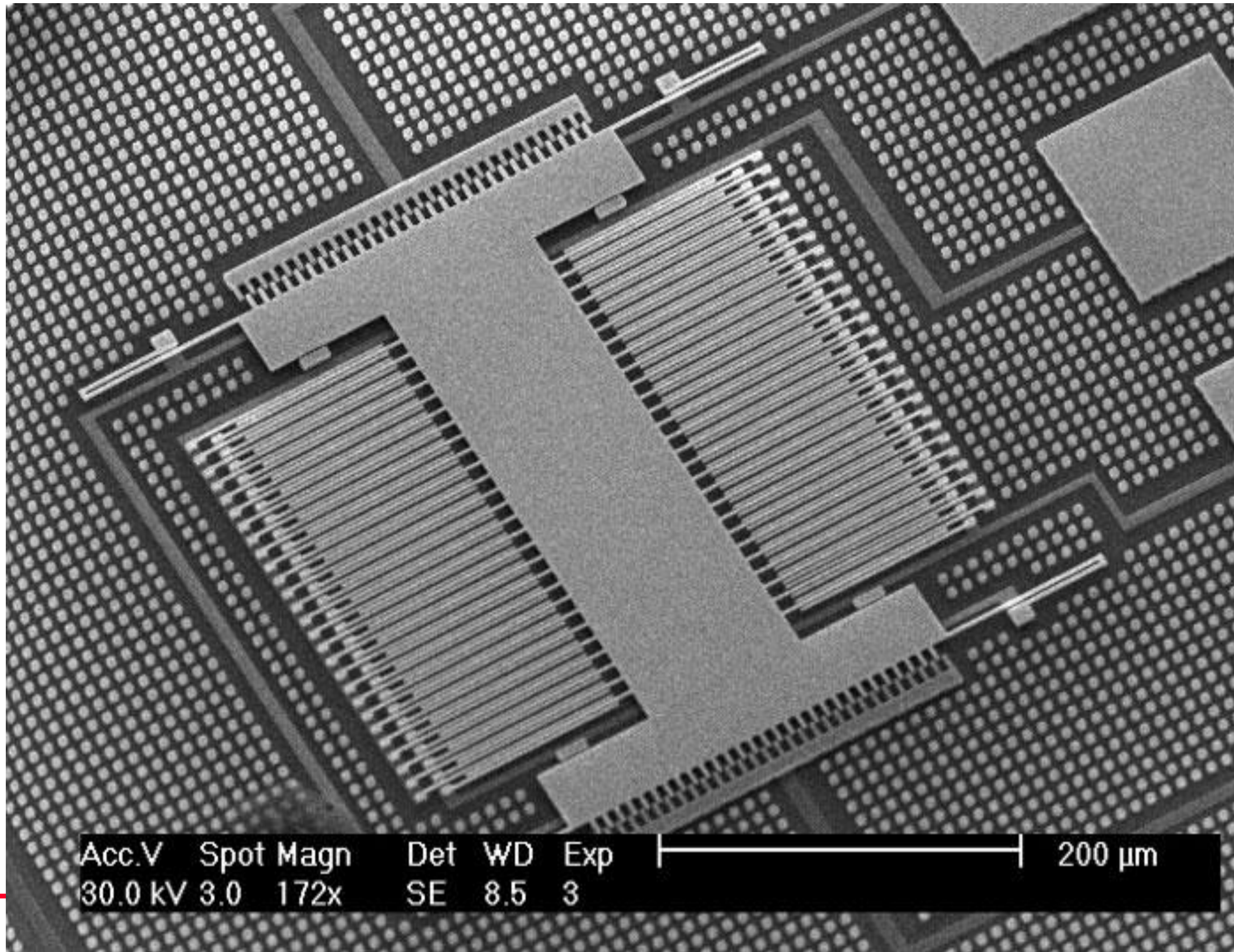


INTERESTING STRUCTURES

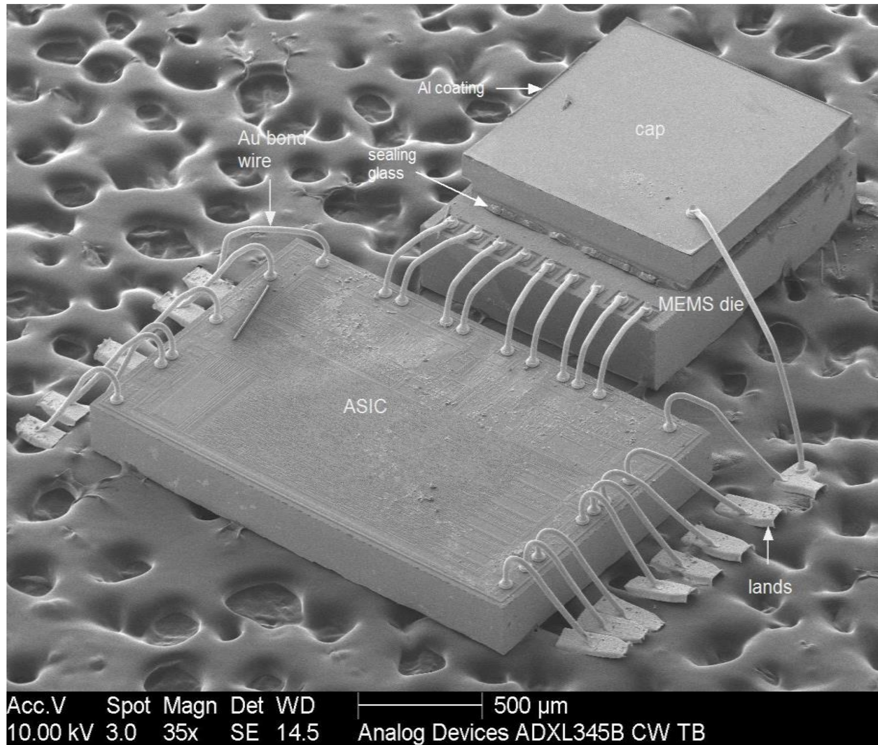
x135 200μm 3.00kV 4mm
#------- 19.03.2010 SDCSP1
1024 x 1024 V9.TIF

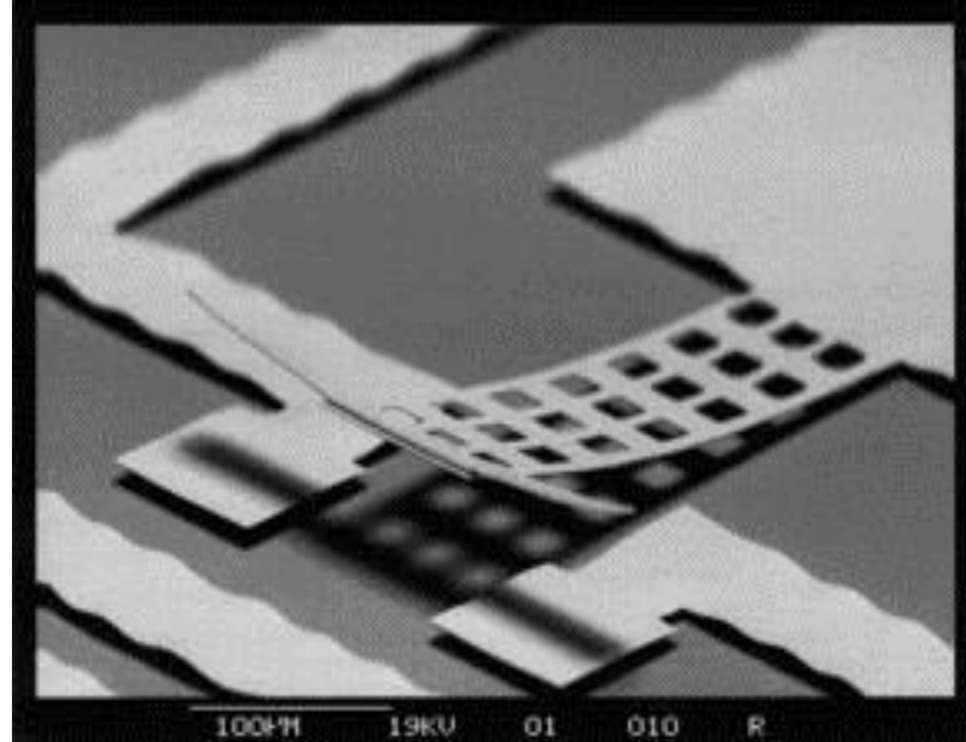


INTERESTING STRUCTURES



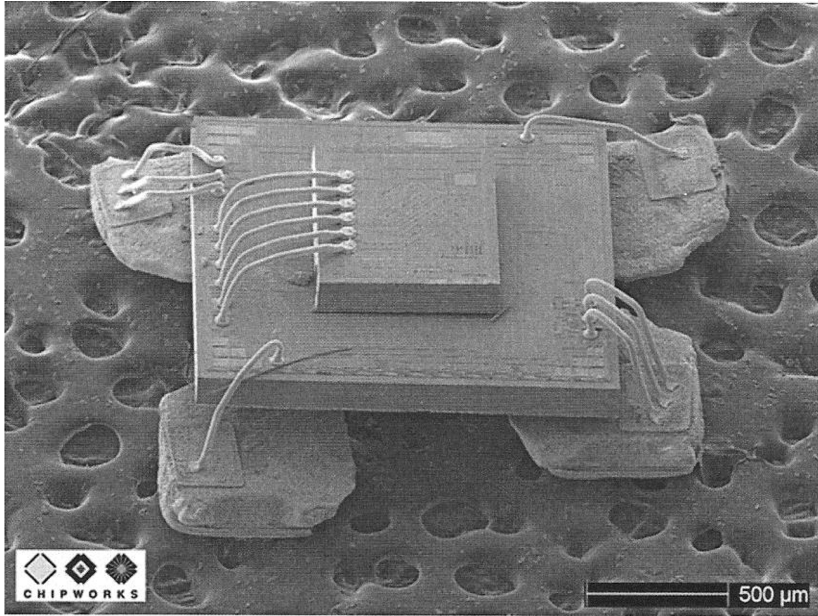
MULTI CHIP IN SINGLE PACKAGE & MEMS SWITCH



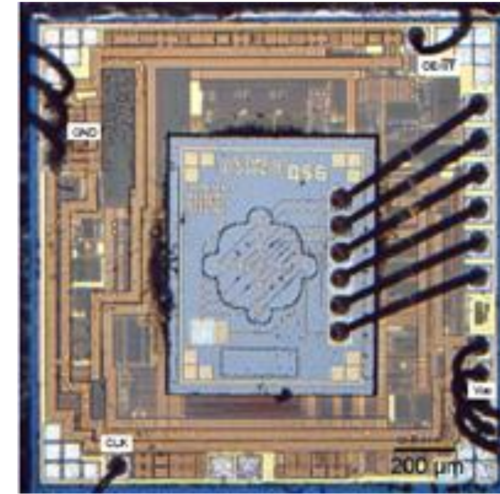


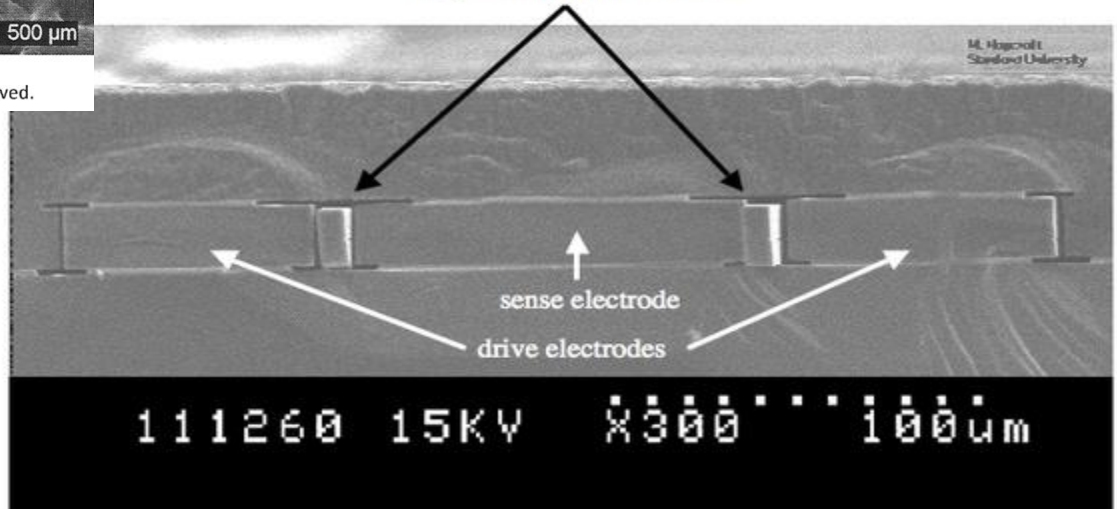
3-axis accelerometer

SiTime Oscillator



Above is a picture of the SiTime SI8002AC package with its outer protective casing removed.





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REFERENCES

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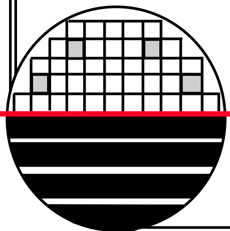
2. Silicon Sensors and Microstructures, Janusz Brysek, Kurt Petersen, Joseph Mallon, Lee Christel, Farzad Pourahmadi, 1990 Nova Sensor, 1055 Mission Court, Fremont, CA 94539, (415)490-9100
3. http://www.mdl.sandia.gov
4. http://www-mtl.mit.edu/semisubway.html
5. Joel%20SEM%20guide.pdf



HOMEWORK – MEM SEMS

1. Go online and find a high quality SEM picture of a MEMS device. (other than the ones in this presentation)
2. Write a brief description of the device.
3. Email an electronic copy to Dr. Fuller