ME 517: Micro- and Nanoscale Processes

Lecture: Introduction

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Unifying themes in ME/CHE517

- Continuum breakdown
  - In each physical process studied, where does the atomic nature of matter become important?
- Pairwise atomic interaction potential
  - For many of the processes we will start with how atoms interact and go up as well as down
- Atomic force microscopy will be used as a prototypical nanotech system in which MEMS tools are necessary to study nanoscales

Micro/Nano Classes at Purdue

- Wereley:
  - ME517 Micro/nano Physical Processes
  - ME697W small-scale fluid mechanics
- Tim Fisher: ME597F Micro/nano Energy Transfer Processes
- Ziaie/Savran: ECE595B MEMS and Micro-Integrated Systems
- David Janes: ECE557 Microfabrication
- Ivansivec/Raman: AFM course(s)
- Birck staff: SEM course

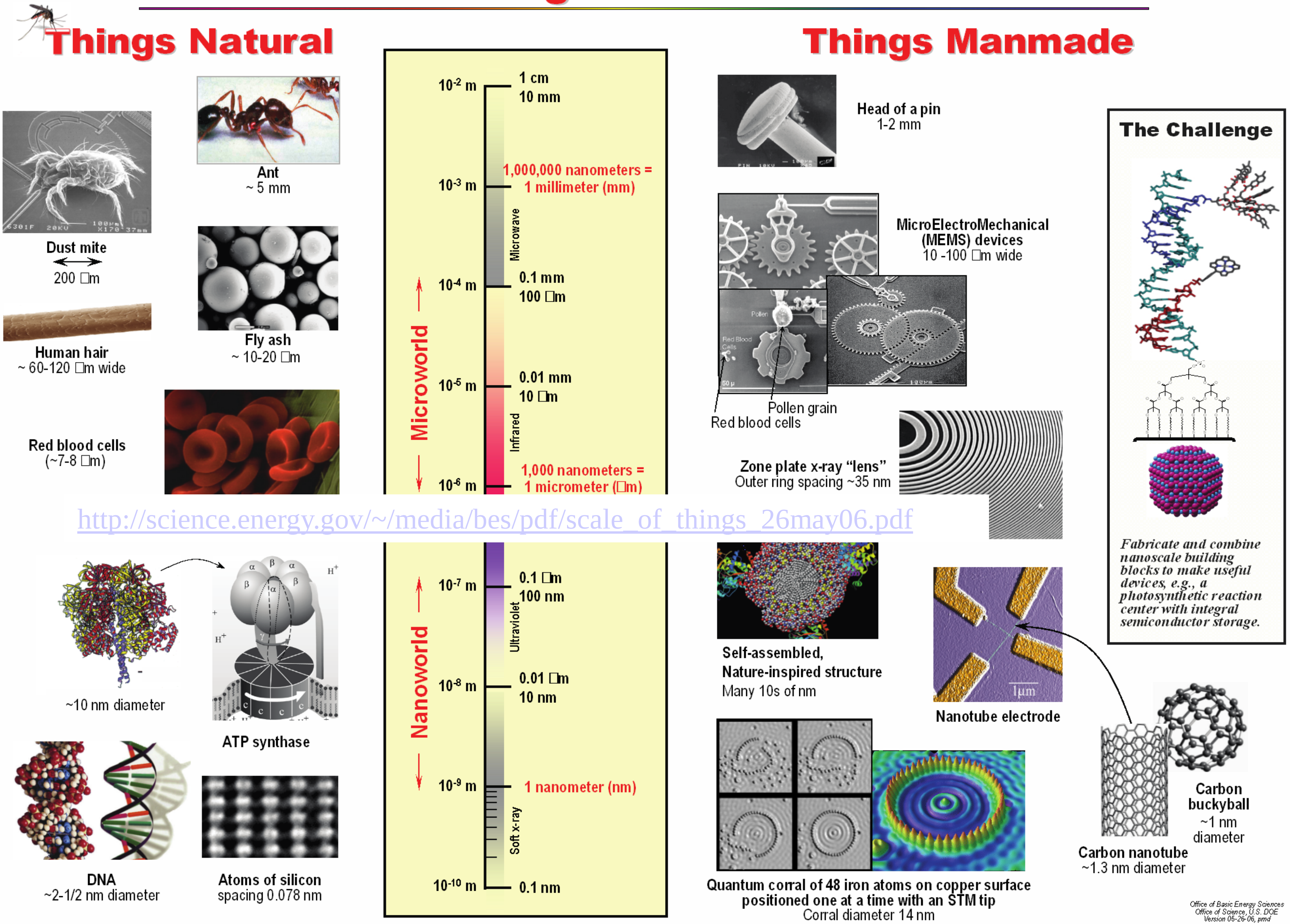
The *Big* Picture: Dictionary Definitions

- Main Entry: micro-
  - Etymology: International Scientific Vocabulary, from Greek *mikros* meaning small
  - one millionth (10^{-6}) part of <*micro*meter>
- Main Entry: nano-
  - Etymology: International Scientific Vocabulary, from Greek *nanos* meaning dwarf
  - one billionth (10^{-9}) part of <*nano*meter>
- We will see that these scales are important indicators in determining when systems behave differently from macroscopic expectations

What is Nanotechnology?

- Called many different things:
  - Nanoscale Science and Engineering, Nanotechnology, Molecular Nanotechnology, …
- According to the *National Nanotechnology Initiative*, Nanotech is "research and technology development at the atomic, molecular or macromolecular levels, in the length scale of approximately 1 - 100 nanometer range, to provide a fundamental understanding of phenomena and materials at the nanoscale and to create and use structures, devices and systems that have novel properties and functions because of their small and/or intermediate size. ***The novel and differentiating properties and functions are developed at a critical length scale of matter typically under 100 nm.***

The Scale of Things – Nanometers and More



What is MEMS?

Methodology

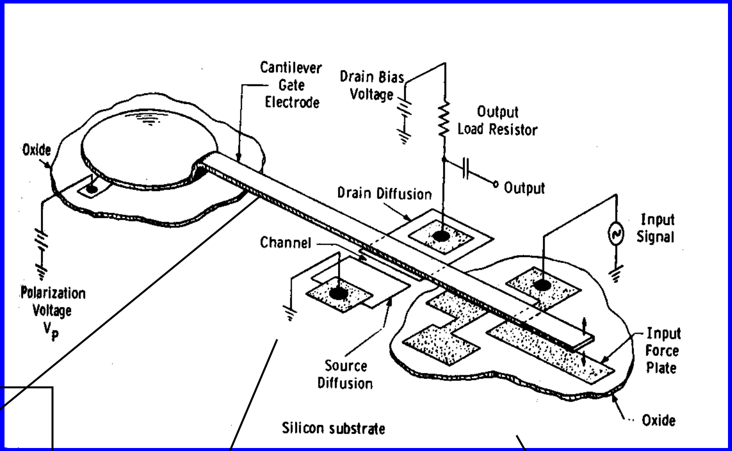
"MEMS is a way of making things" (DARPA). These things merge the functions of sensing and actuation with computation and communication to locally control physical properties at the microscale, yet cause effects at much grander scale.

MEMS is an enabling technology for many nanotech processes

When did MEMS Start?

'The Resonant Gate Transistor', H.C. Nathanson, W.E. Newall, R.A. Wickstrom, J.R. Davis, IEEE Transactions on Electron Devices, 3, 117-133, 1967.
Westinghouse Research Labs

Application: integrated tuning device - capacity of high Q.

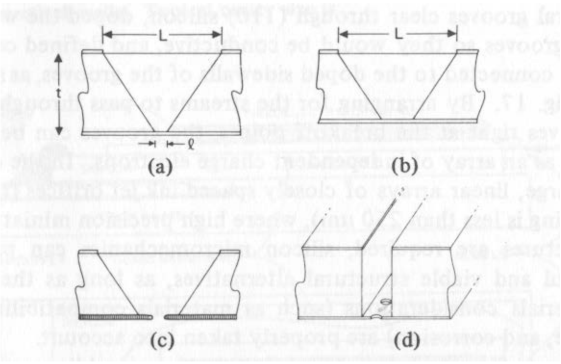


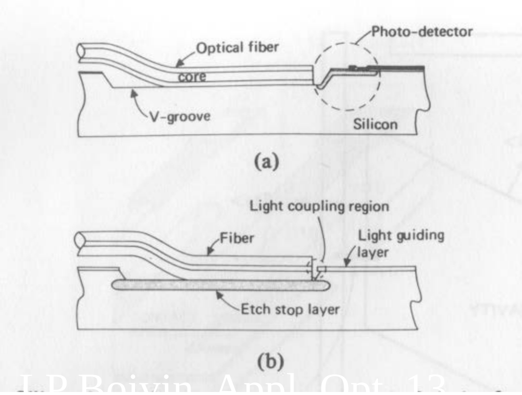
Mechanical resistor with desired Q.

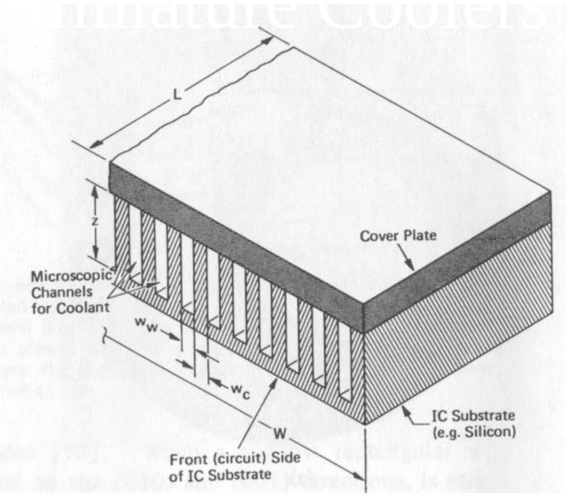
Output transistor to sense
the motion of the mech. resonator and generate signal.

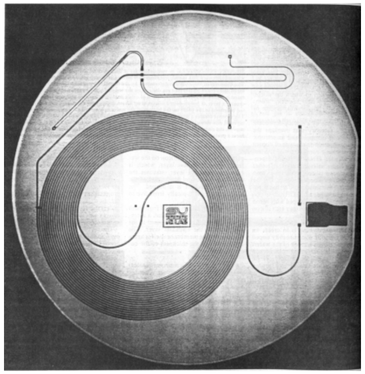
Input transistor to convert the input electrical signal Into a mechanical force (electrostatic).

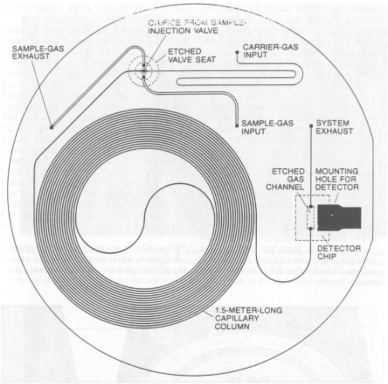
What was MEMS circa 1982?









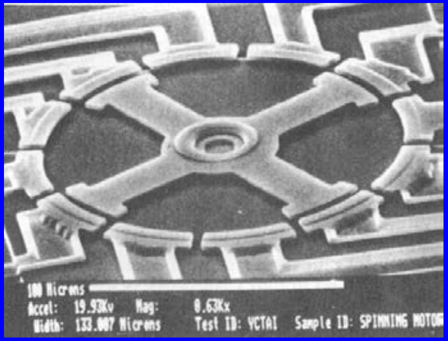


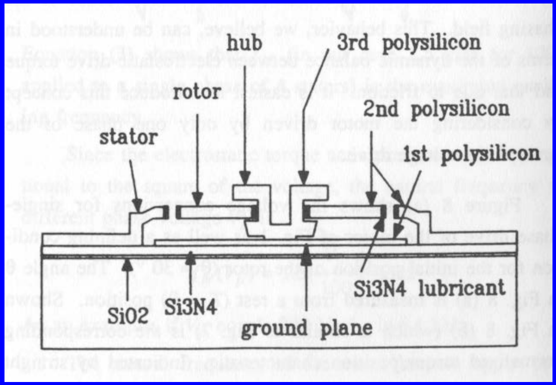
What was MEMS circa 90s?

Actuators

Slide drive actuators

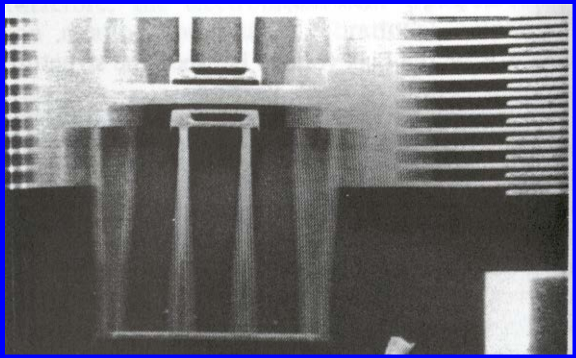
LS Fan, et al, IEEE Inter. Electron. Devices Meeting, 666, 1988

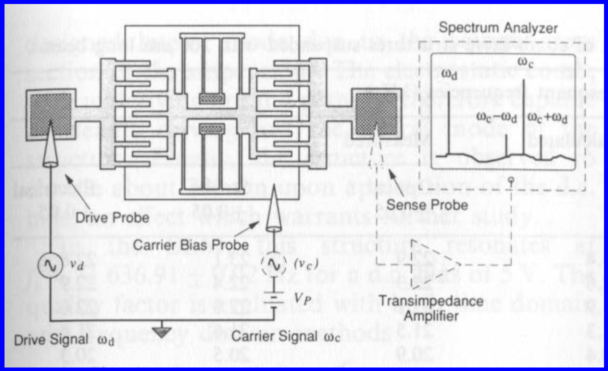




Comb drive actuators

WC Tang, et al, IEEE MEMS, 53, 1989





Electrostatic, Magnetic, Harmonic, Thermal, Shape Memory, Impact and PZT actuators

What is MEMS today?

•Engine and propulsion control.

•Automotive safety, braking, and suspension systems.

•Distributed sensors monitoring structural health.

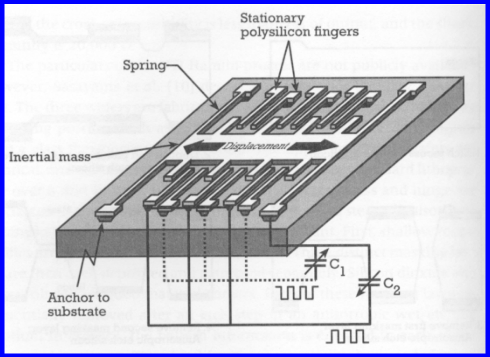
•Distributed control of aerodynamics

•Telecommunication optical fiber components and switches

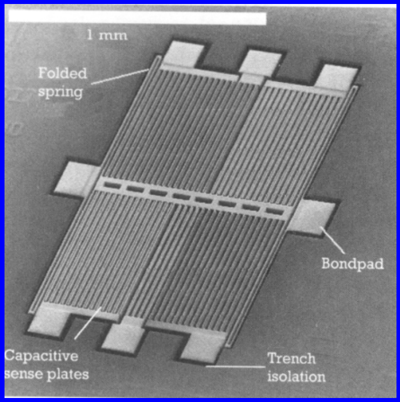
•Electromechanical signal processing.

•Mass data storage systems.

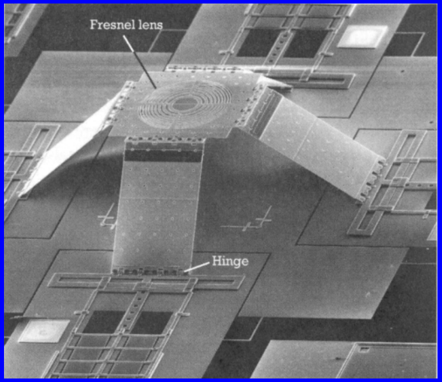
•Biomedical systems



Analog Devices, Inc, Norwood, MA



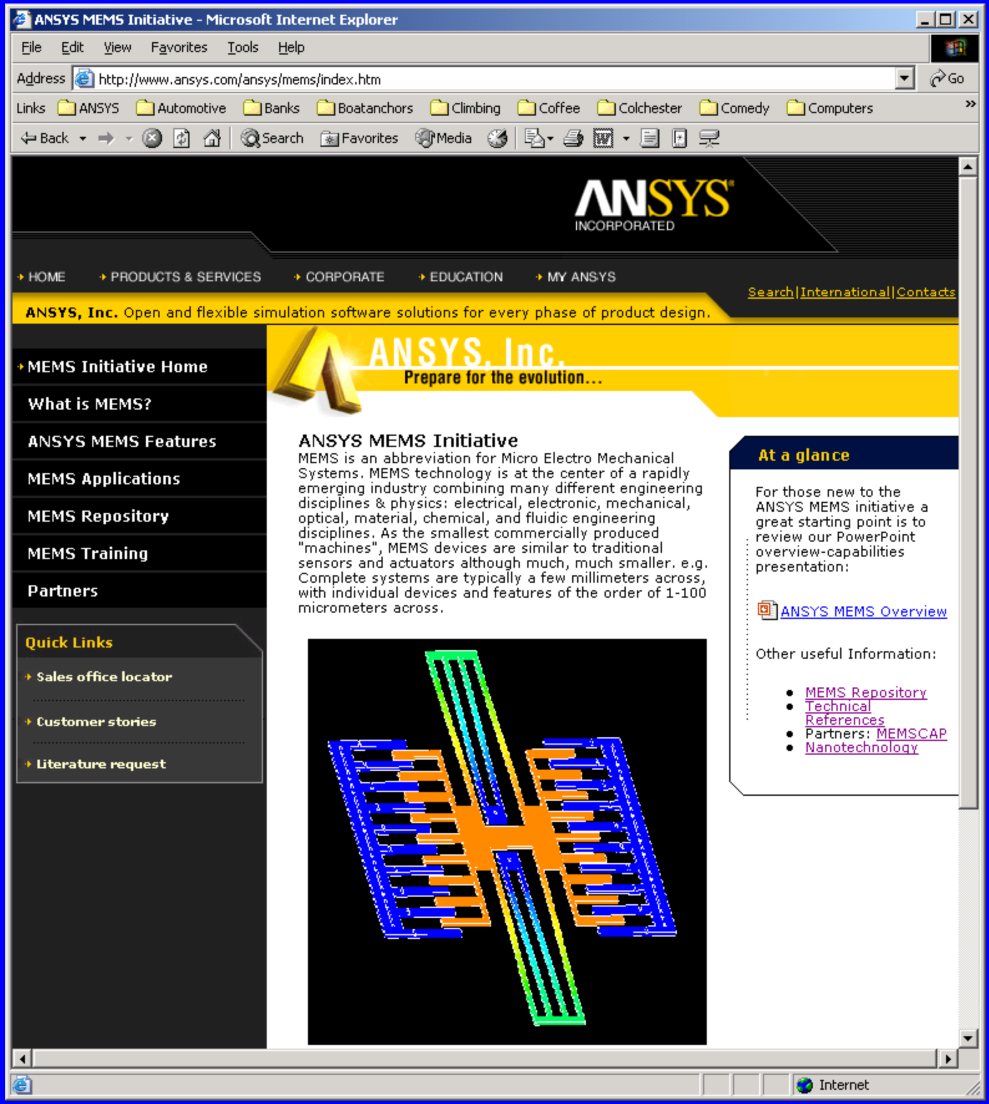
Lucas NovaSensor, Fremont, CA



M.C Wu, Proceedings of the IEEE, 86, 1705, 1998.

The ANSYS multiphysics simulations

www.ansys.com



Assignment for Next Class

1. Log onto the Blackboard website (*and figure out how to use it*).
2. Email me the following information:
   1. Education level and degree(s)
   2. Background in the areas mentioned in the syllabus (other courses, area of research, work experience, etc)
   3. A brief list of your course hopes/expectations
3. Read
   1. Feyman's "Plenty of room at the bottom" http://www.zyvex.com/nanotech/feynman.html
   2. Trimmer's "The Scaling of Micromechanical Devices" http://home.earthlink.net/~trimmerw/mems/Scale.html