

## Introduction to ECE 658

## Of Microsensors and MEMS....

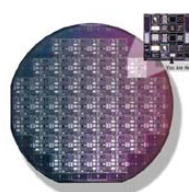
## The Si revolution...



First Transistor  
Bell Labs (1947)



Si integrated circuits  
Texas Instruments (~1960)

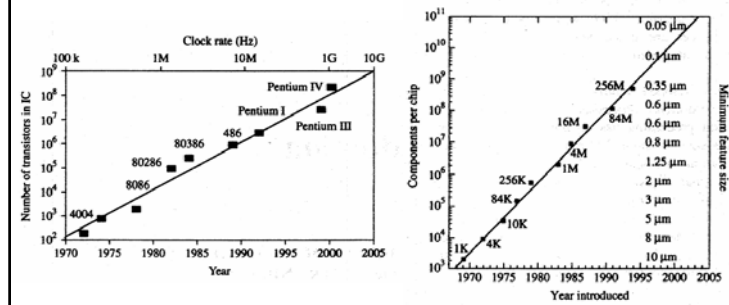


Modern ICs

More ? Check out:

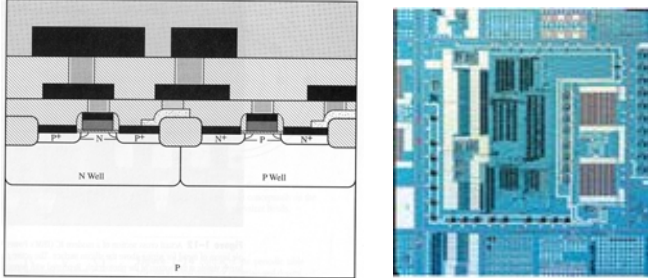
<http://www.pbs.org/transistor/background1/events/miraclemo.html>  
<http://www.ti.com/corp/docs/company/history/firstic.shtml>

## Moore's Law in Silicon Devices



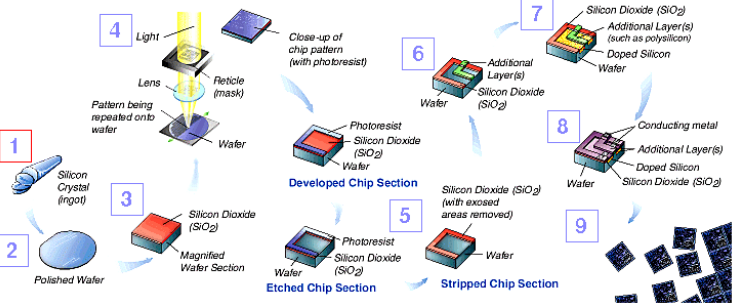
Computing power doubles every 18 months

### The Need of Micropatterning



The batch fabrication of microstructures requires a low-cost, high throughput surface patterning technology

### Integrated Circuit Manufacturing

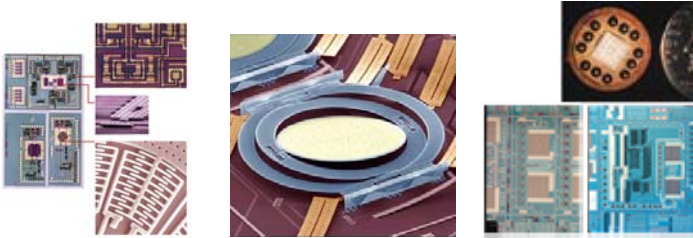


Source: <http://www.cae.wisc.edu/~chauhan/nanolith2.shtml>

### Meanwhile...the Need for Cheap Sensing



### MEMS and Integrated Microsystems

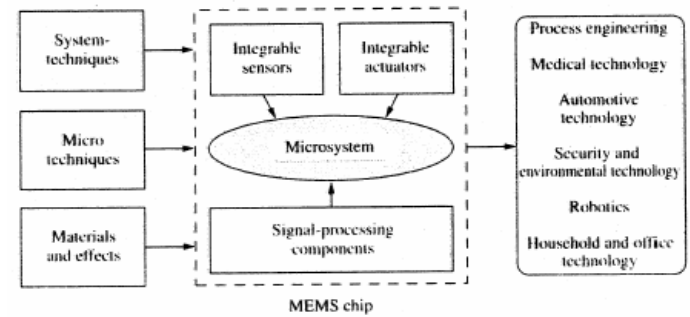


Sandia Integrated Accelerometers      Lucent Optomechanical Systems      Sandia Integrated Sensors

## What are MEMS...

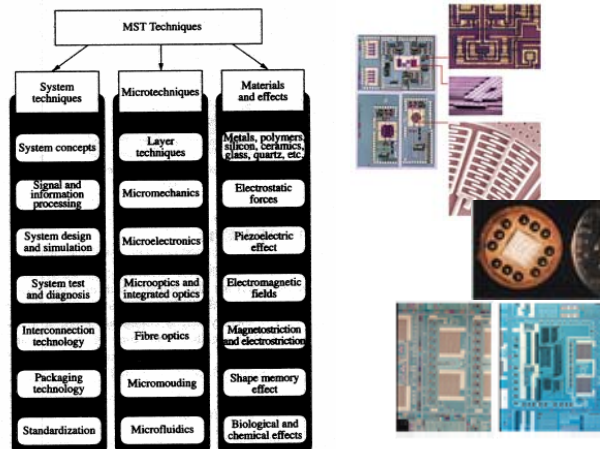
- **Microelectromechanical Systems**
  - Small in some relevant sense
  - Can include electrical and mechanical elements in their interactions
  - Systems: not just core technology, but also packaging, electronics, calibration
  
- **More generally, MEMS include other type of devices**
  - Fluidic systems, bioMEMS, etc
  - A common element: the usage of micromachining techniques

## Microsensors and MEMS



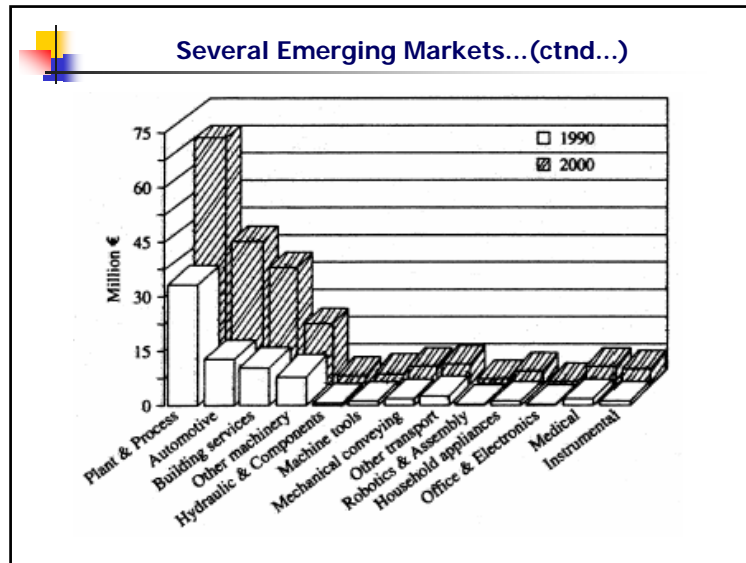
The merging of surface machining technologies to microsensor research and development has enabled a new class of integrated microsystems loosely referred to as "MEMS"

## Enabling Science and Technologies

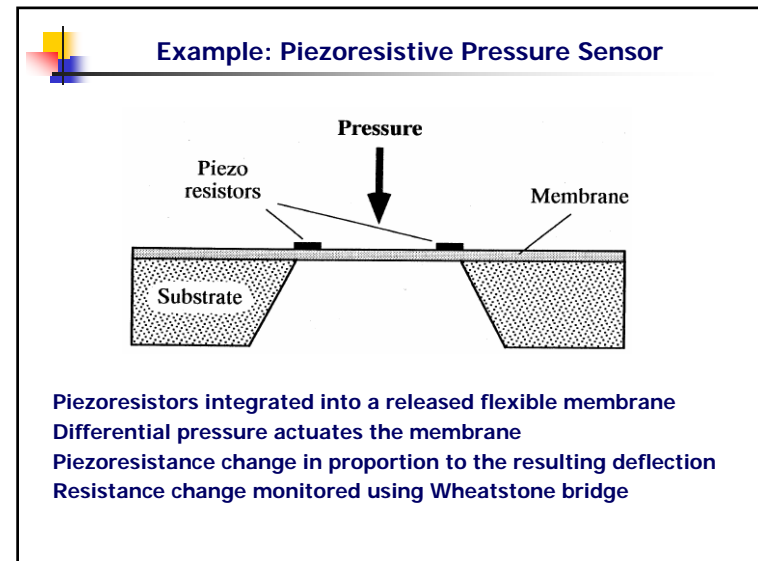
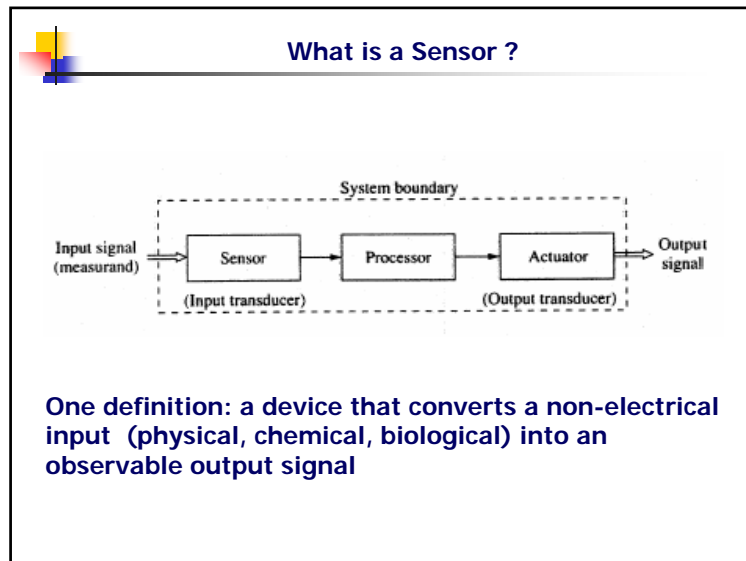


## Several Emerging Markets...

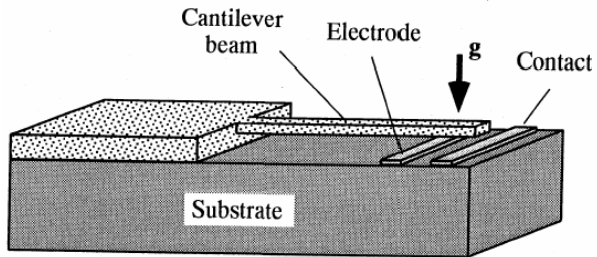
- **Automotive**
  - Pressure sensors, airbag sensors, acceleration sensors
  
- **Medical**
  - Drug discovery, genetics, pressure measurements, monitoring
  
- **Chemical**
  - Analysis systems, reactors
  
- **Optics**
  - Moveable mirrors, displays, fiber positioning
  
- **Fluidic systems**
  - InkJet printing



## Elements and Classification of Microsensors

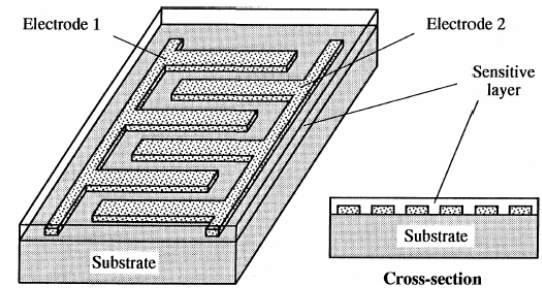


### Example: Capacitive Cantilever Microsensor



Consists of released cantilevers acting as one capacitor electrode and a contact strip acting as other electrode  
 Sawtooth voltage applied to gradually increase electrostatic force until cantilever makes contact with strip  
 Acceleration affects the voltage required to make the contact

### Example: Interdigital Transducer Sensor



Interdigital electrodes monitor the capacitive response of a sensing layer  
 For example, the electrical properties SnO<sub>2</sub> greatly varies as it interacts with certain compounds

### Classification of Microsensors

Form of signal	Measurands
Thermal	Temperature, heat, heat flow, entropy, heat capacity etc.
Radiation	Gamma rays, X-rays, ultra-violet, visible and infrared light, micro-waves, radio waves etc.
Mechanical	Displacement, velocity, acceleration, force, pressure, mass flow, acoustic wavelength and amplitude etc.
Magnetic	Magnetic field, flux, magnetic moment, magnetisation, magnetic permeability etc.
Chemical	Humidity, pH level and ions, gas concentration, toxic and flammable materials, concentration of vapours and odours, pollutants etc.
Biological	Sugars, proteins, hormones, antigens etc.

### Objectives of Class



### A. Micromechanical Devices

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- Review of Microfabrication Techniques
- Introduction to Lumped Modeling
- Overview of Elasticity in Solids
- Analysis of Micromechanical Structures
- Review of Case Studies of Micromechanical Devices



### B. Microfluidic Systems

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- Introduction to Fluid Dynamics
- Case Study: PCR-on-a-chip



### C. Other Sensors (time permitting)

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- Magnetic Microsensors
- Thermal Microsensors
- Biochemical Sensors
- Surface Acoustic Wave Sensors



### Evaluation

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- 5-6 Homework Assignments (30 %)
- 1 Partial Exam (Feb 13th) (35 %)
- 1 Final Exam (35 %)



### Important Policies

- Homework expected to be independent. Plagiarism and carbon copies will not be tolerated.
- Lateness policy on homework: 20 % + 0.3 % per hour.
- Lateness due to illness or other major event should be noted to Dr. Evoy before deadline. A medical or other note will then be expected.