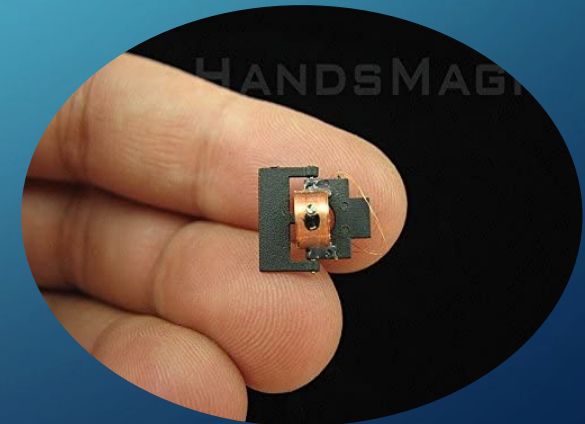
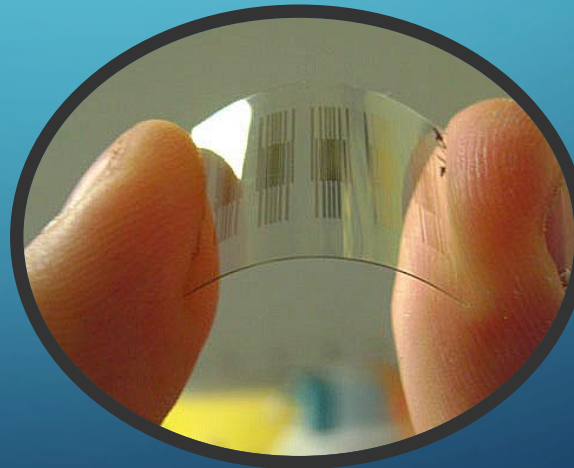
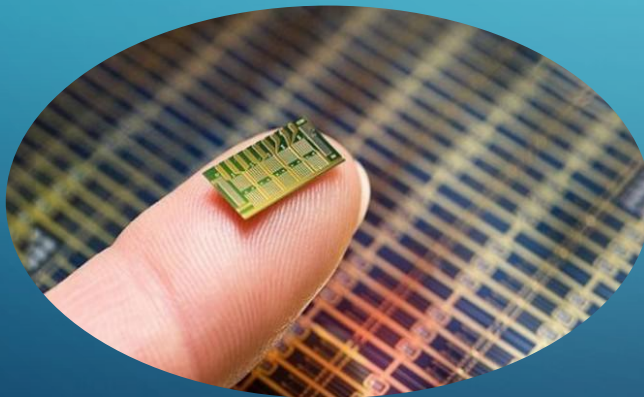


**18NTO301T - APPLICATIONS OF NANOTECHNOLOGY**

**MODULE-III**

# NANOSENSORS AND ACTUATORS



**DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY**  
**SRM INSTITUTE OF SCIENCE AND TECHNOLOGY**

# ELECTRONIC CIRCUIT

## CHIPS

- ~~Very~~-large-scale integration (VLSI) is the process of creating an integrated circuit (IC) by combining thousands of transistors into a single chip.
- VLSI began in the 1970s when complex semiconductor and communication technologies were being developed.
- The microprocessor is a VLSI device.
- Before the introduction of VLSI technology most ICs had a limited set of functions they could perform.
- An electronic circuit might consist of a CPU, ROM, RAM and other glue logic. VLSI lets IC designers add all of these into one chip.

# INTEGRATED CIRCUIT CLASSIFICATION

| Name | Signification                 | Year | Number of Transistors | Number of Logic Gates |
|------|-------------------------------|------|-----------------------|-----------------------|
| SSI  | small-scale integration       | 1964 | 1 to 10               | 1 to 12               |
| MSI  | medium-scale integration      | 1968 | 10 to 500             | 13 to 99              |
| LSI  | large-scale integration       | 1971 | 500 to 20,000         | 100 to 9,999          |
| VLSI | very large-scale integration  | 1980 | 20,000 to 1,000,000   | 10,000 to 99,999      |
| ULSI | ultra-large-scale integration | 1984 | 1,000,000 and more    | 100,000 and more      |

# SENSOR

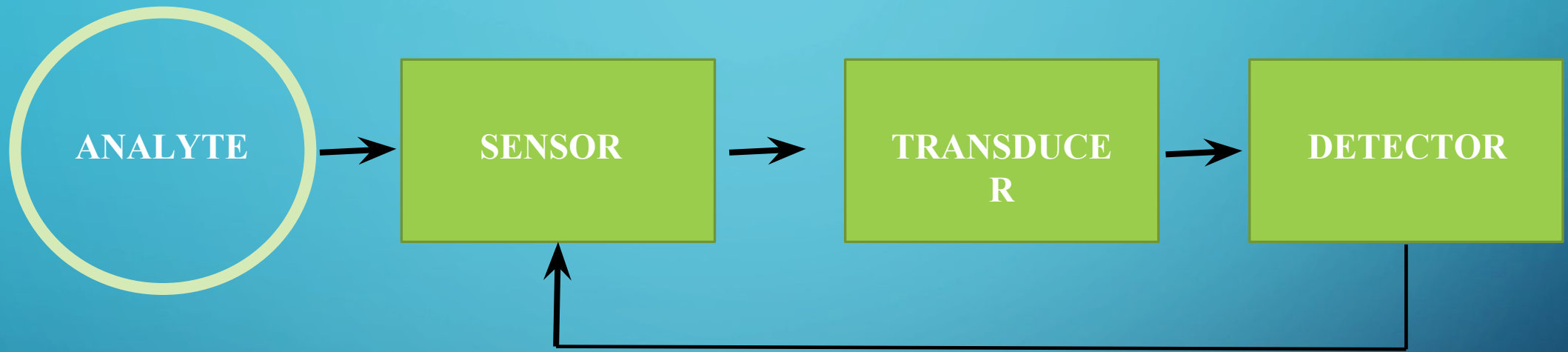
- A sensor is an instrument that responds to a physical stimulus (such as heat, light, sound, pressure, magnetism, or motion)
- It collects and measures data regarding some property of a phenomenon, object, or material
- Sensors are an important part to any measurement and automation application
- The sensor is responsible for converting some type of physical phenomenon into a quantity measurable by a data acquisition (DAQ) system



# NANOSENSOR

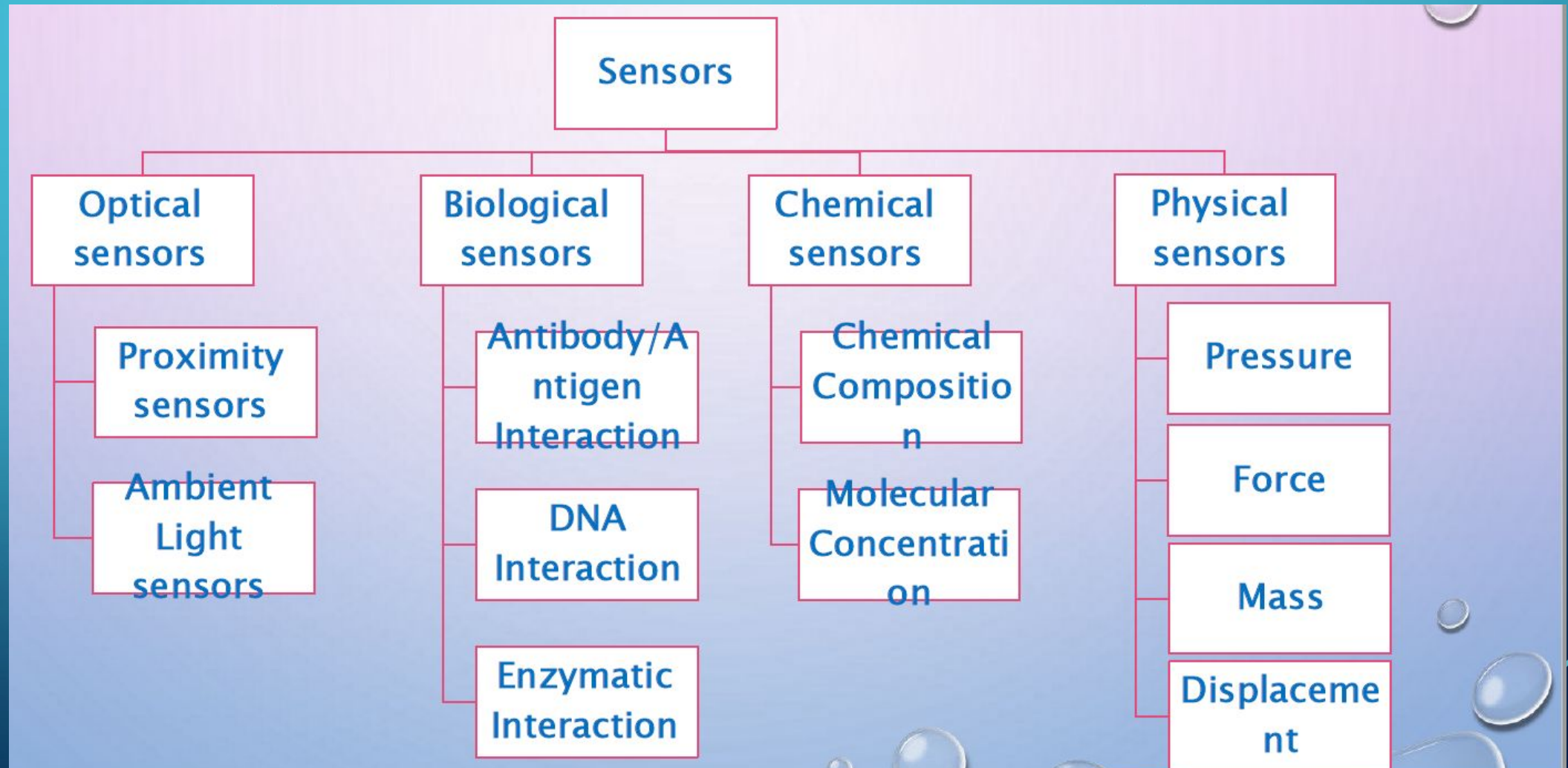
- Nanosensor: an extremely small device capable of detecting and responding to physical stimuli with dimensions on the order of one billionth of a meter
- Physical Stimuli: biological and chemical substances, displacement, motion, force, mass, acoustic, thermal, and electromagnetic
- Particles that are smaller than the characteristic lengths associated with the specific phenomena often display new chemistry and new physics that lead to new properties that depend on size

- When the size of the structure is decreased, surface to volume ratio increases considerably and the surface phenomena predominate over the chemistry and physics in the bulk
- The reduction in the size of the sensing part and/or the transducer in a sensor is important in order to better miniaturise the devices
- Science of nano materials deals with new phenomena, and new sensor devices are being built that take advantage of these phenomena
- Sensitivity can increase due to better conduction properties, the limits of detection can be lower, very small quantities of samples can be analysed, direct detection is possible without using labels, and some reagents can be eliminated.



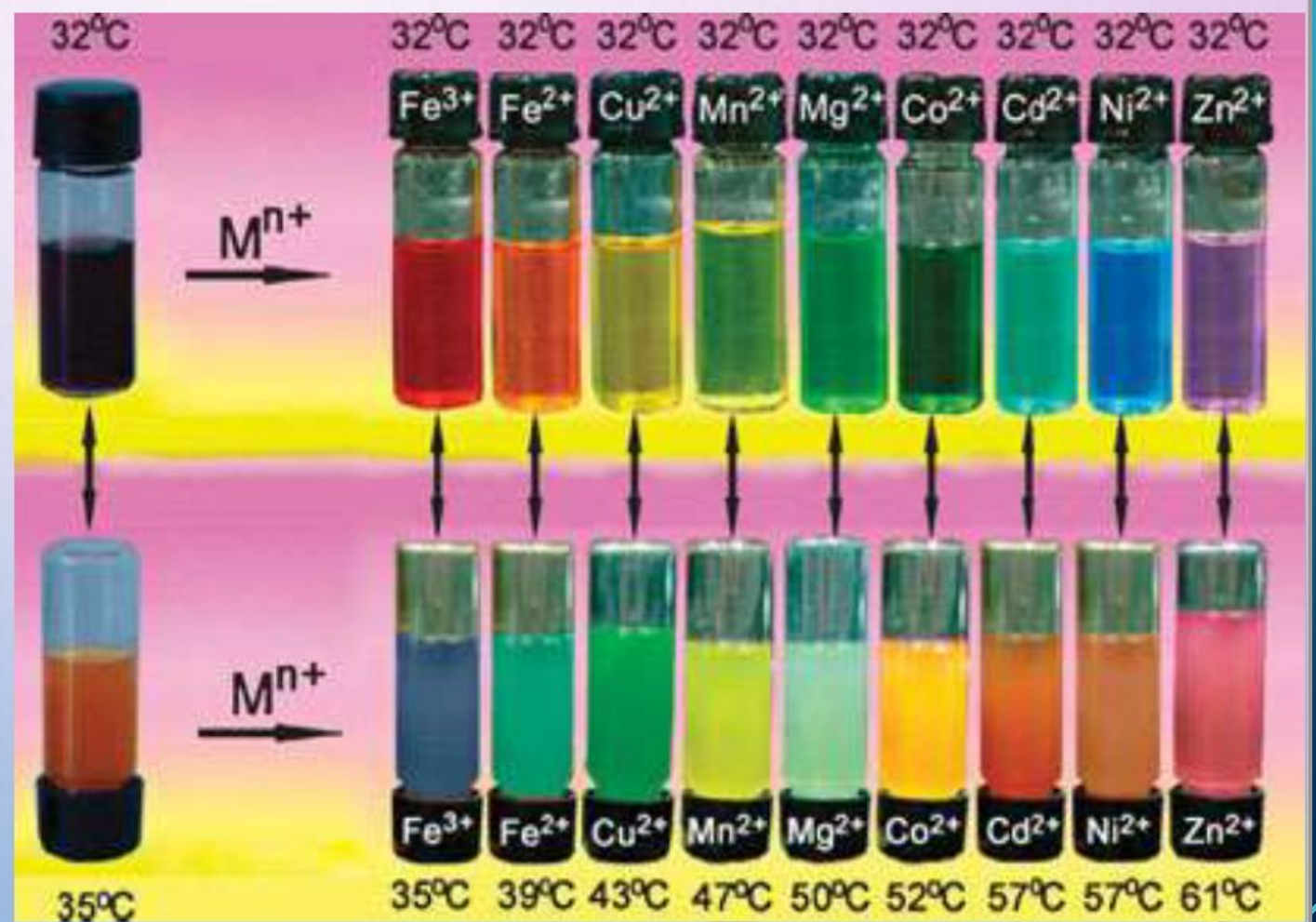
Current nanosensors device: Nanostructured materials  
- e.g. porous silicon Nanoparticles Nanoprobes  
Nanowire nanosensors Nanosystems – Cantilevers,  
NEMS, mostly theoretical

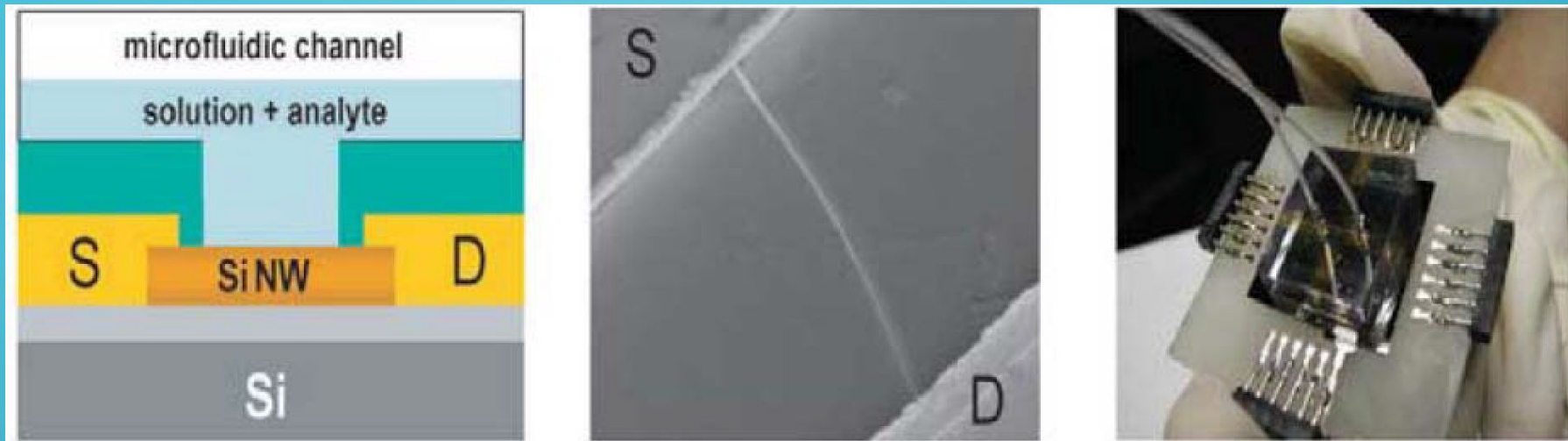
# Types of Nanosensors



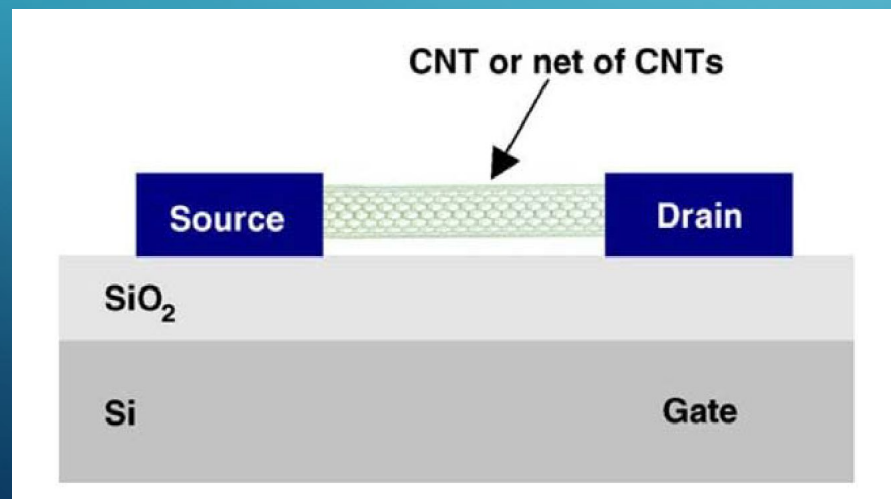


- ✓ A polymer Nanosensor developed by Chinese scientists responds to both metal ions and temperature.
- ✓ The copolymer solution can be used with a variety of metal ions which each give a different colour and allows to create a nanoarray which is capable of simultaneously conveying nine colour signals.

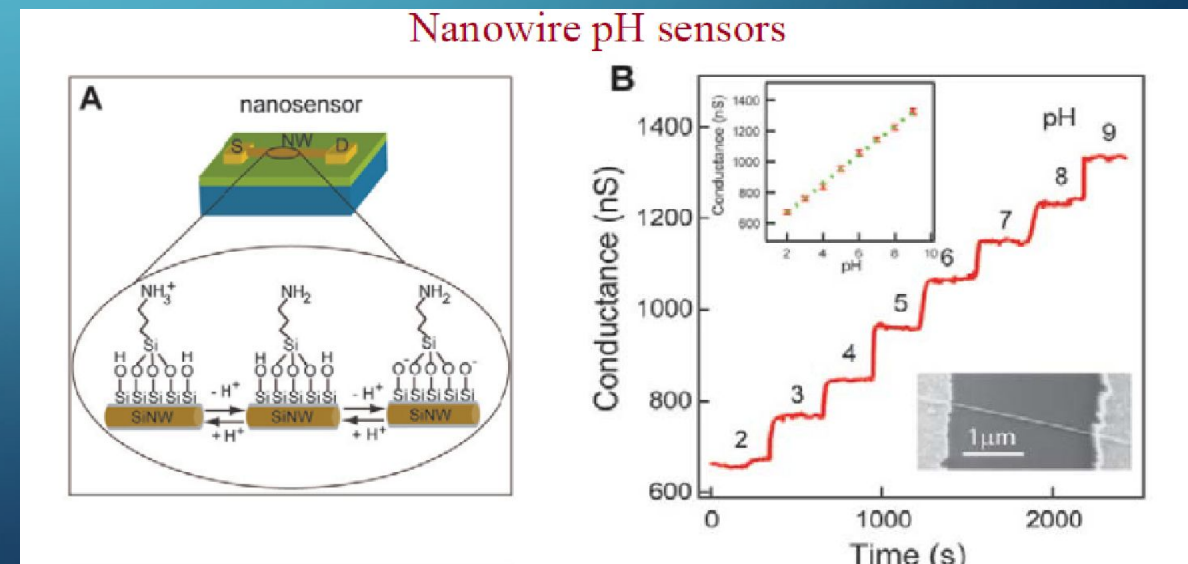




Cross-sectional diagram and scanning electron microscopy image of a single Si nanowire sensor device, and a photograph of a prototype nanowire sensor biochip with integrated microfluidic sample delivery



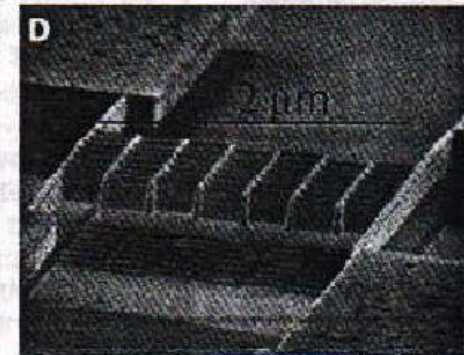
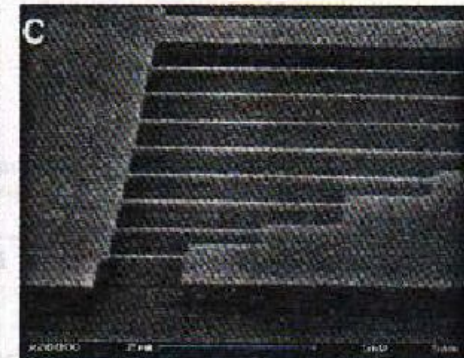
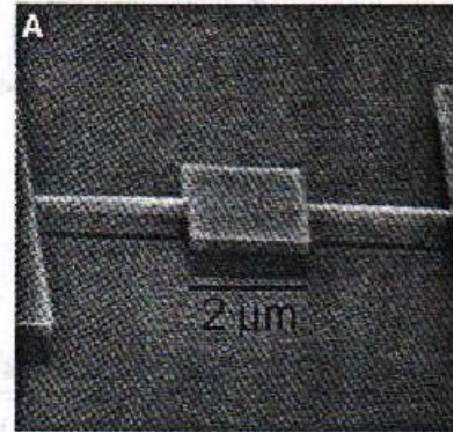
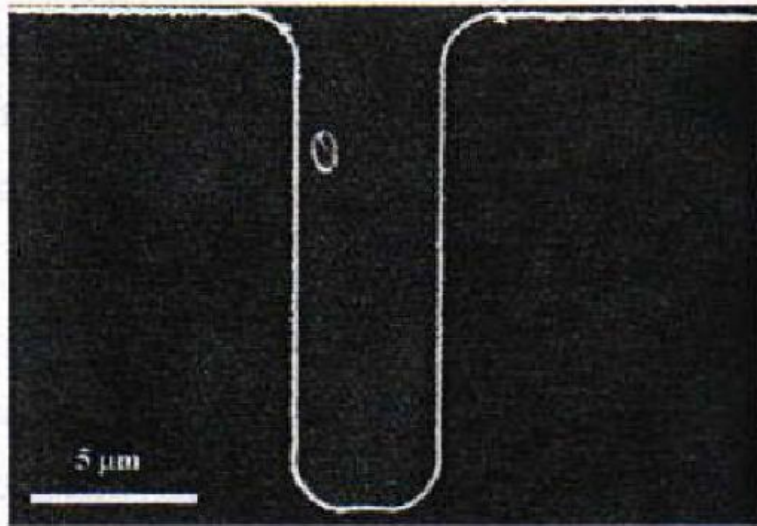
Schematic structure of a Carbon Nanotube-FET





- ✦ Nanodevices - Nano Electro Mechanical Systems (NEMS)

- ✦ NEMS oscillators (resonant sensors) used to detect
  - ✦ Magnetic forces of a single spin
  - ✦ Biomechanical forces
  - ✦ Adsorbed mass



# ACTUATORS

HARDWARE DEVICES THAT CONVERT A CONTROLLER COMMAND SIGNAL INTO A CHANGE IN A PHYSICAL PARAMETER

- The change is usually mechanical (ex. Position or Velocity)
- An actuator is also a transducer because it changes one type of physical quantity into some alternative form
- An actuator is usually activated by a low-level command signal, so an amplifier may be required to provide sufficient power to drive the actuator



# ACTUATORS ARE DEVICES USED TO PRODUCE ACTION OR MOTION

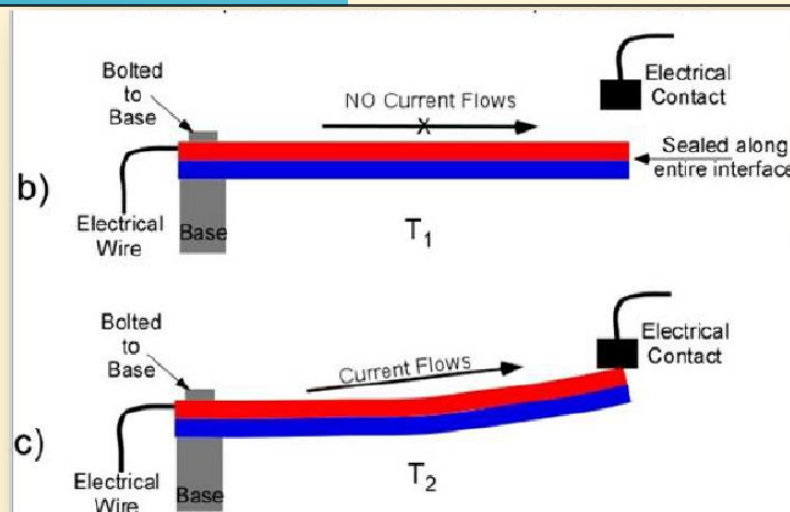
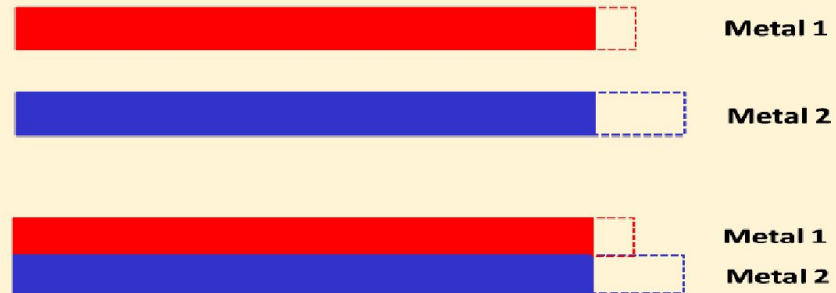
- Input(mainly electrical signal , air, fluids)
- Electrical signal can be low power or high power
- Actuators output can be position or rate i.e Linear Displacement or velocity
- Actuation can be from few microns to few meters

# TYPES OF ACTUATORS

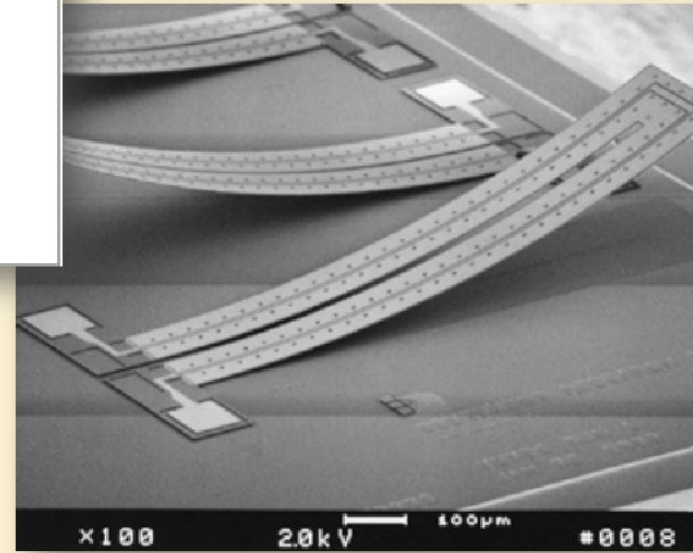
- Manual or mechanical
- Hydraulic/Pneumatic
- Thermal
- Electric

# THERMAL ACTUATORS

- ❖ Converts thermal energy into motion
- ❖ Utilizes an effect called thermal expansion.

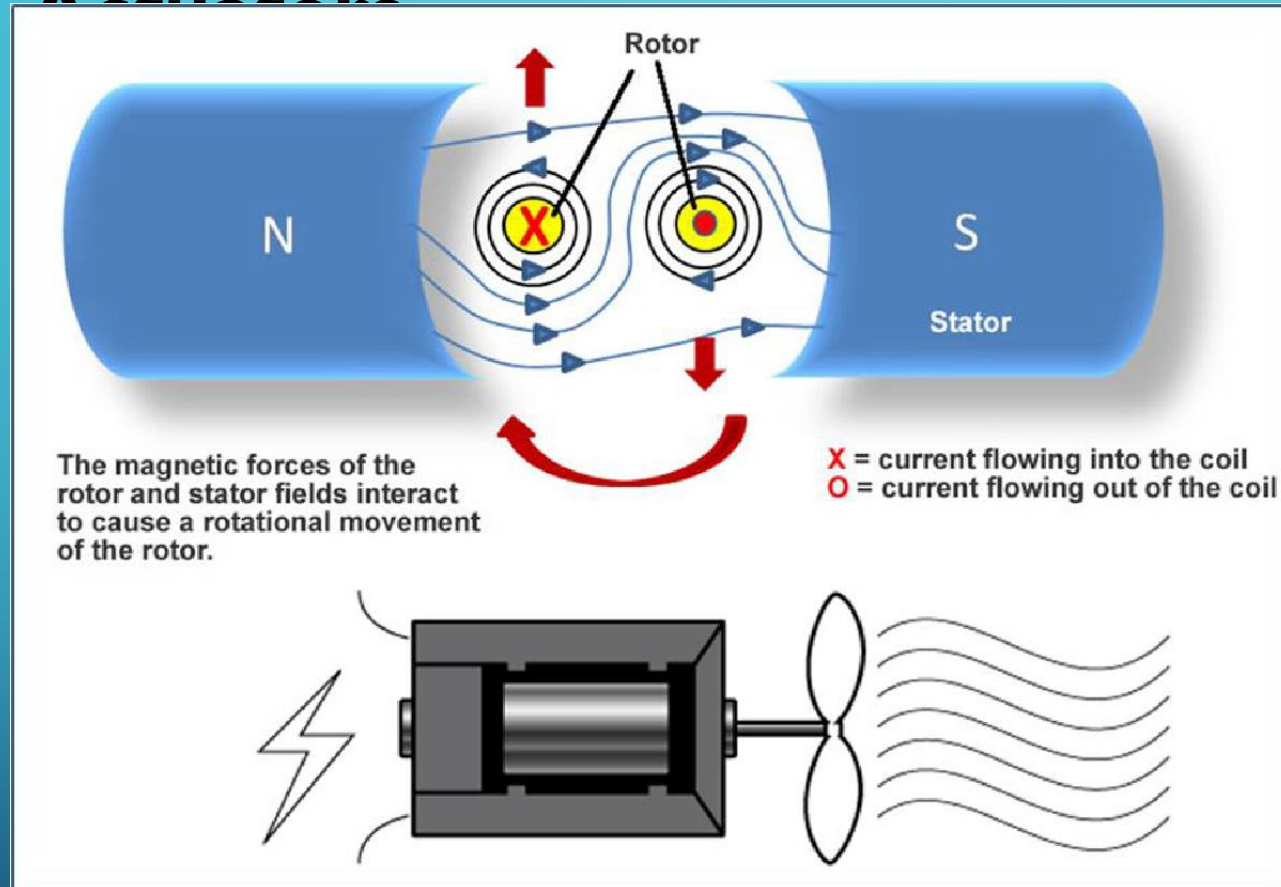


**Vertical Thermal Actuators**  
[Images courtesy of Southwest Research Institute.  
Copyright SwRI.]

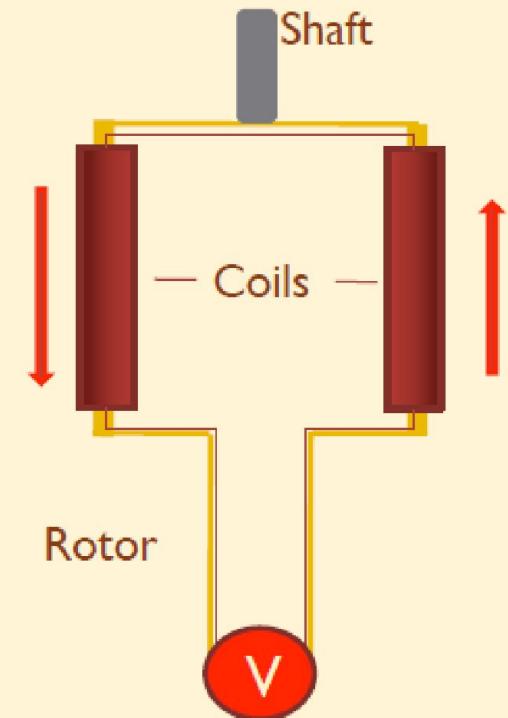


# Electric

## Actuators



## Schematics of an Electric Motor



An electric motor is a transducer and an actuator because it converts an electric current into a large magnetic field which then turns a shaft (mechanical energy).