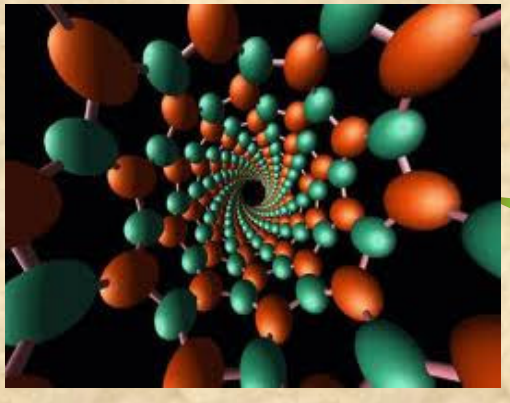
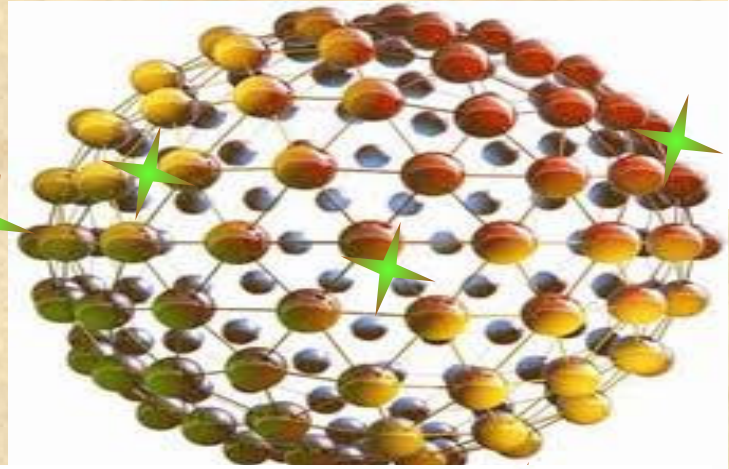
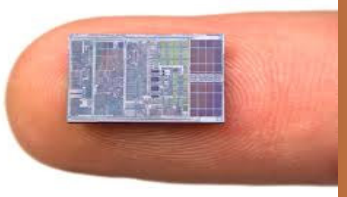
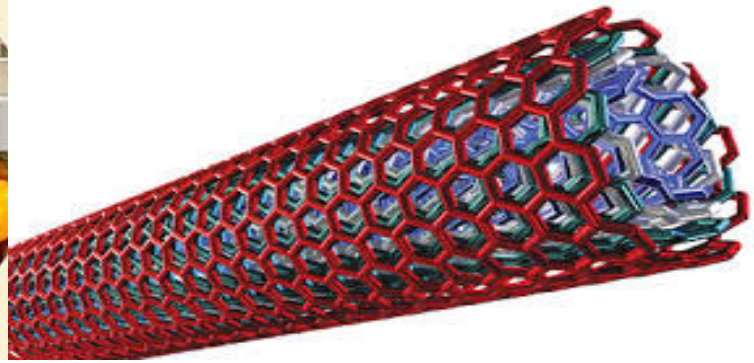
nano materials

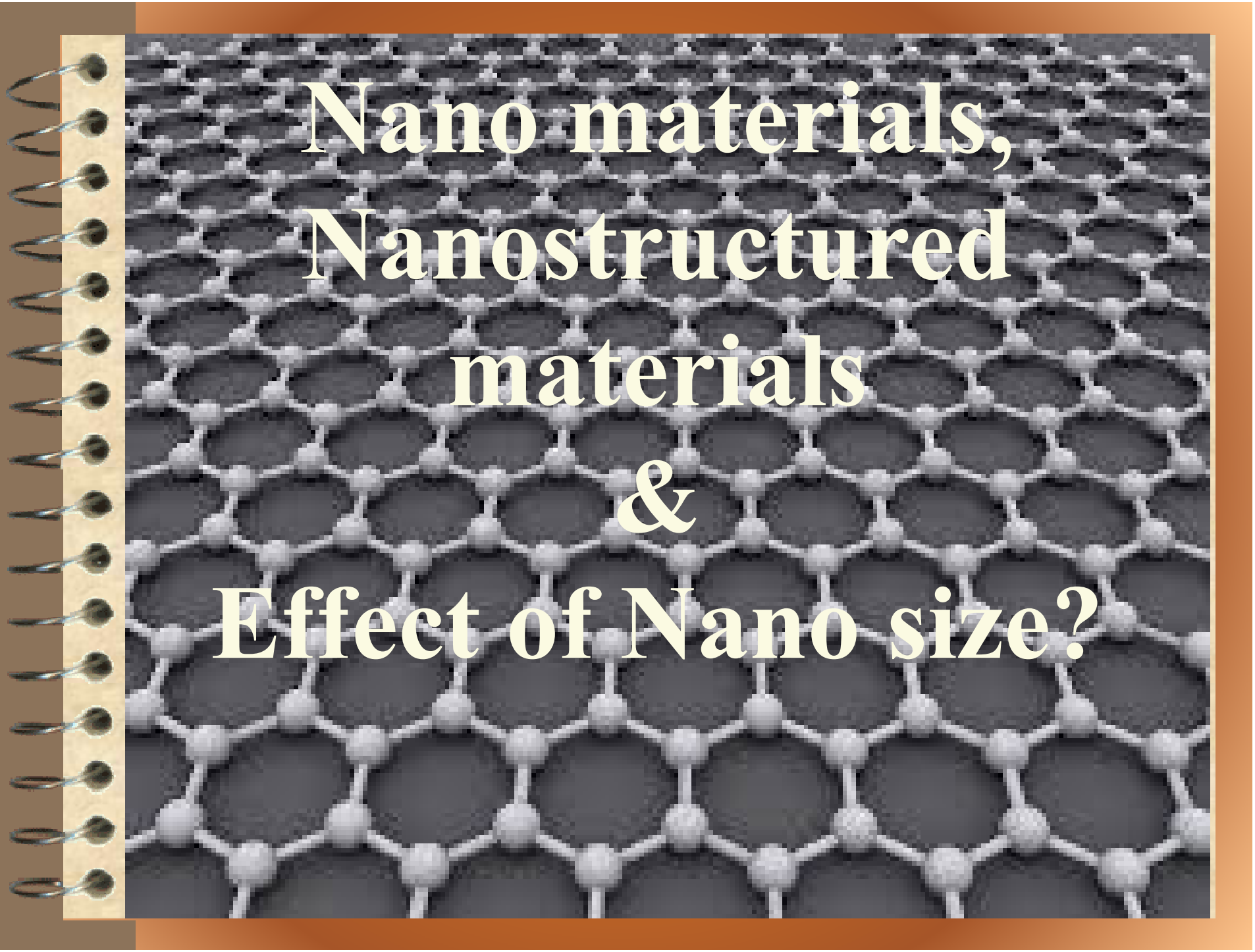
BY V. M. DESAI










Nano materials,
Nanostructured
materials
&
Effect of Nano size?

Nano materials

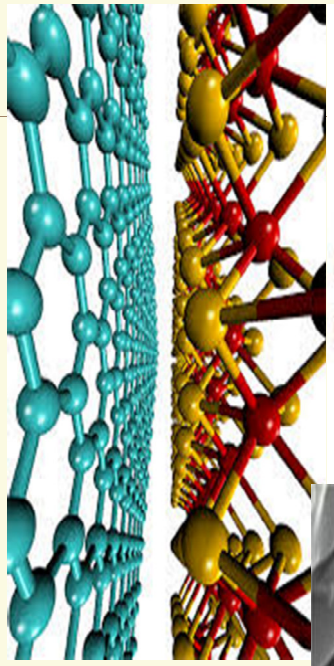
The term nano materials is used to describe the preparation and applications of materials in **nanometer (10^{-9} m) scale range**.

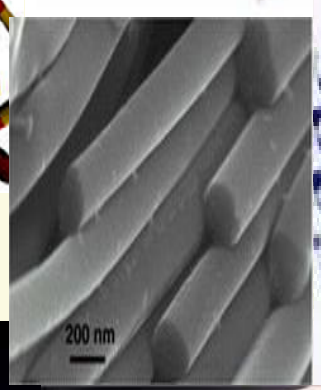
Nano science and nanotechnology are emerging areas with technological importance in

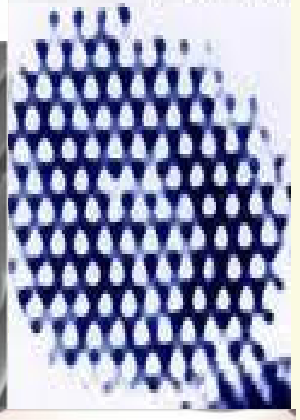
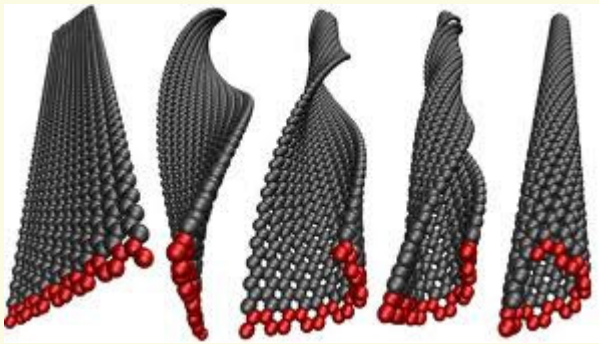
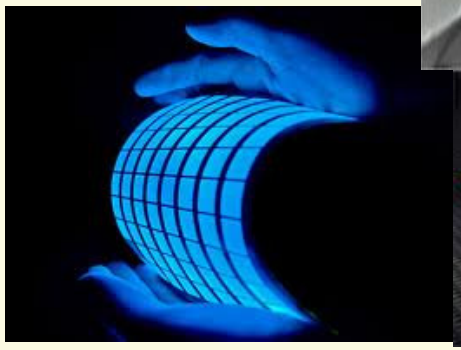
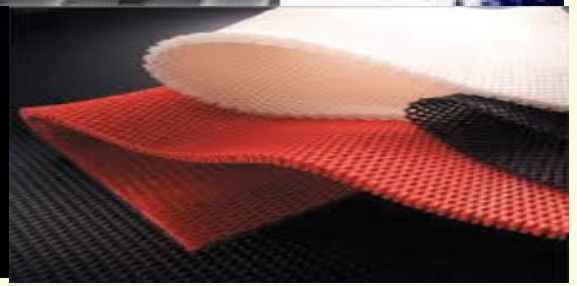
a) **Physical sciences**
b) **Engineering**
c) **Biological and medical fields**

Nanostructured Materials

- Nanoparticles
- Nanowires
- Nanotubes
- Nanorods
- Nanoporous materials



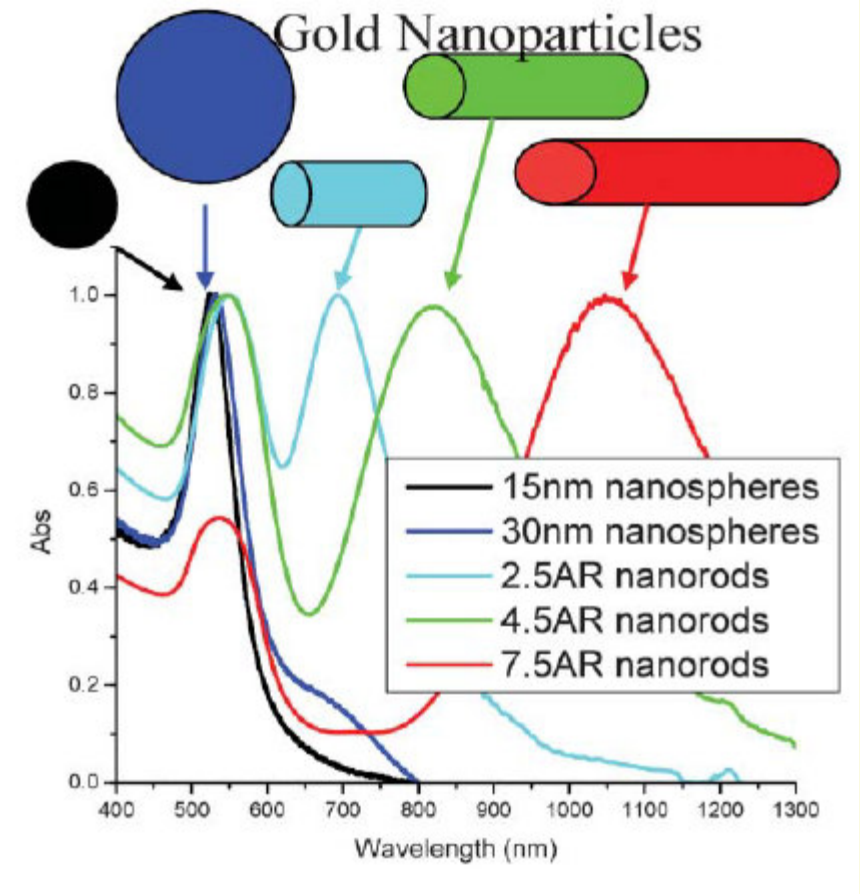
Effect of Nano size

- Increase the surface area
- Change in surface energy
- Change in the electronic properties
- Change in optical band gap
- Change in electrical conductivity
- Higher and specific catalytic activity

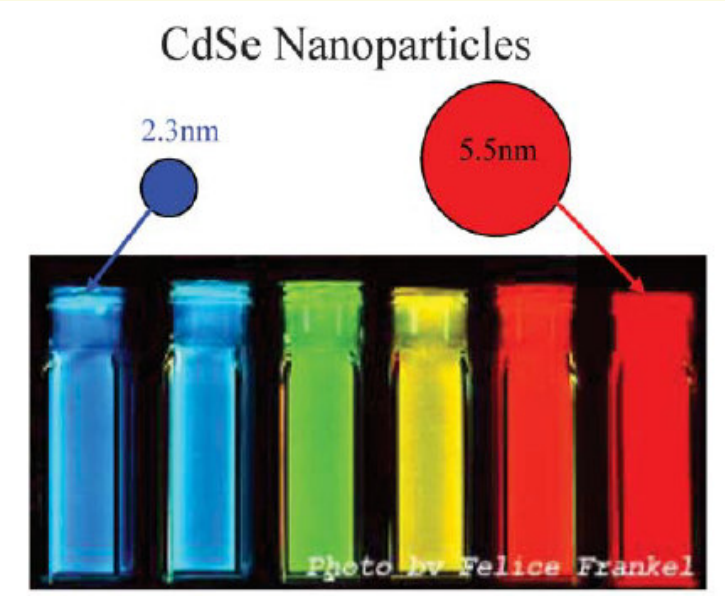
Bulk and Nano scale

Bulk (eg. Gold)	Nano (eg. Gold)
1. **Lustrous**–Shiny surface when polished. 2. **Yellow colour** when in a mass 3. **Malleable**–Can be hammered, bent or rolled→any desired shape. 4. **Ductile**–Can be drawn out into wires 5. **Heat & electricity conductor** 6. **High densities** 7. **High melting point** (1080^{o}C) 8. Tough with high tensile strength 9. **Inert**-unaffected by air and most reagents	1. Vary in appearance depending on size & shape of cluster. 2. Are **never gold in colour!**. 3. Size & Shape of the nanoparticles determines the color. 4. Are **found in a range of colours**. 5. Are very **good catalysts.** 6. Are **not "metals" but are semiconductors.** 7. **Melts at relatively low** temperature (~940^{o} C). 8. <u>For example;</u> Gold particles in glass: 25 nm — Red reflected 50 nm — Green reflected (Unexpected visible properties & they are small enough to scatter visible light rather than absorb)

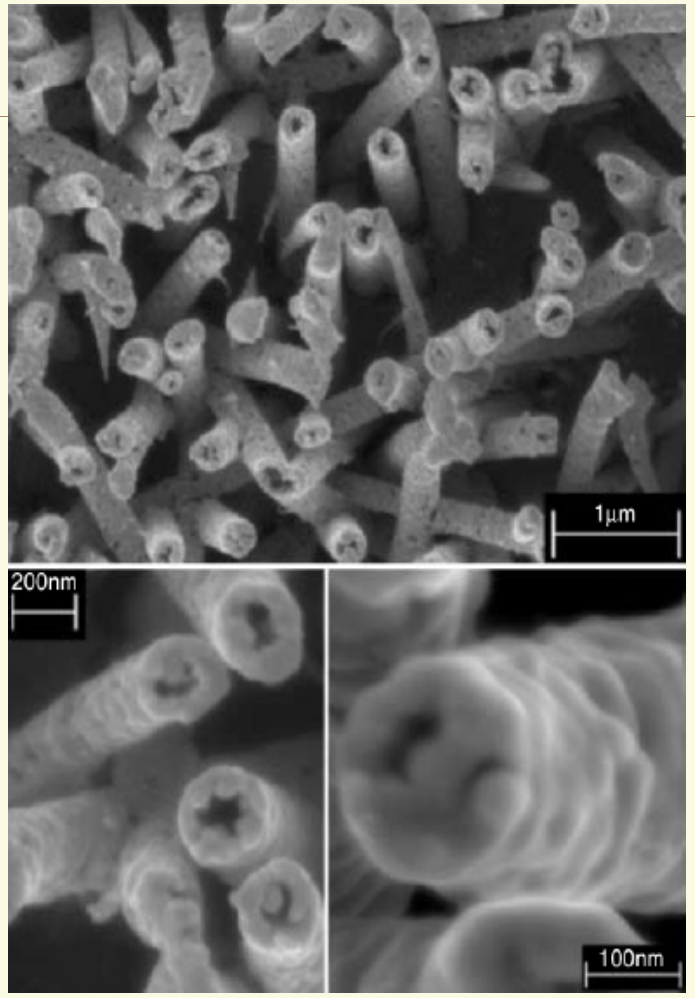
Optical properties of Gold NPs



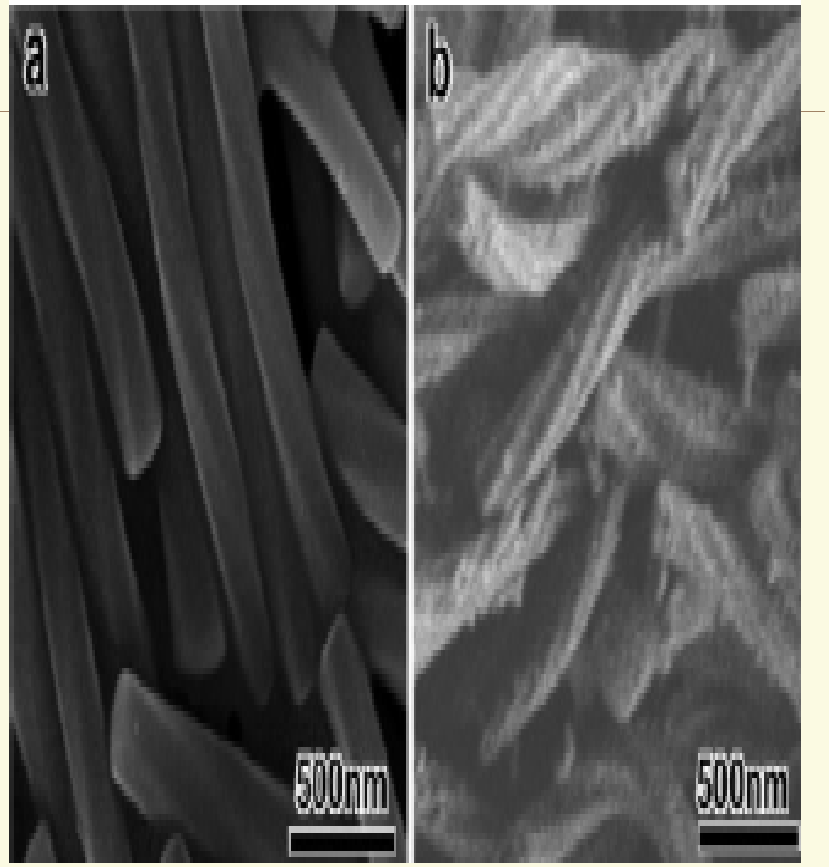
Size, shape, change the optical properties of nano sized gold



Nanotubes



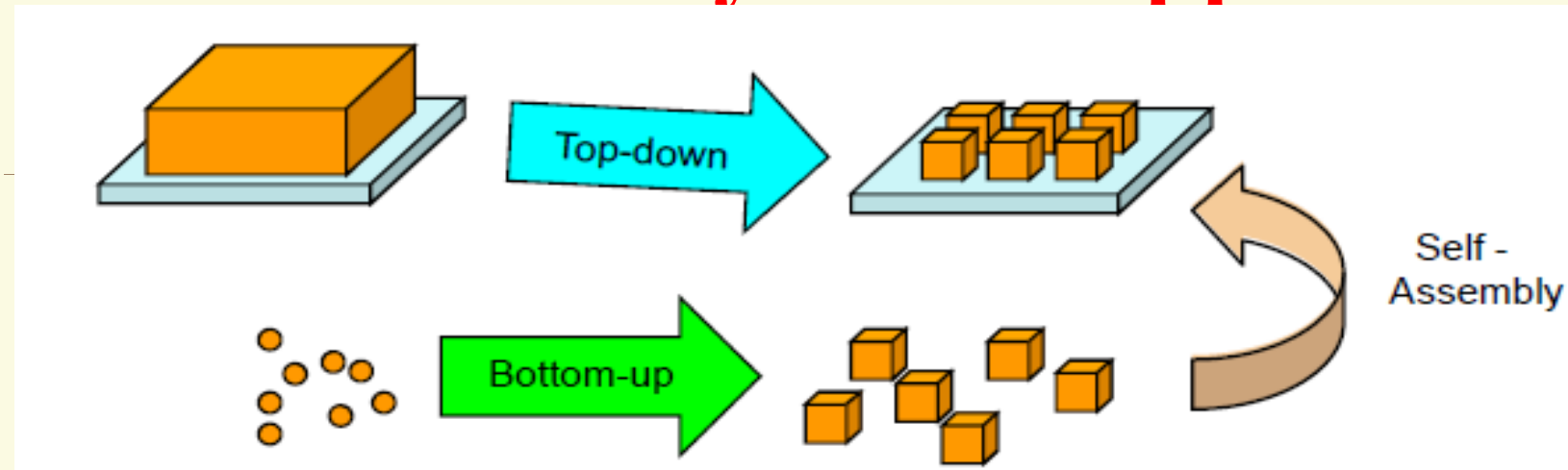
Au - Nanotubes



SiO_2 - Nanotubes

Nanomaterials Synthesis Approach

Nanomaterials synthesis approach



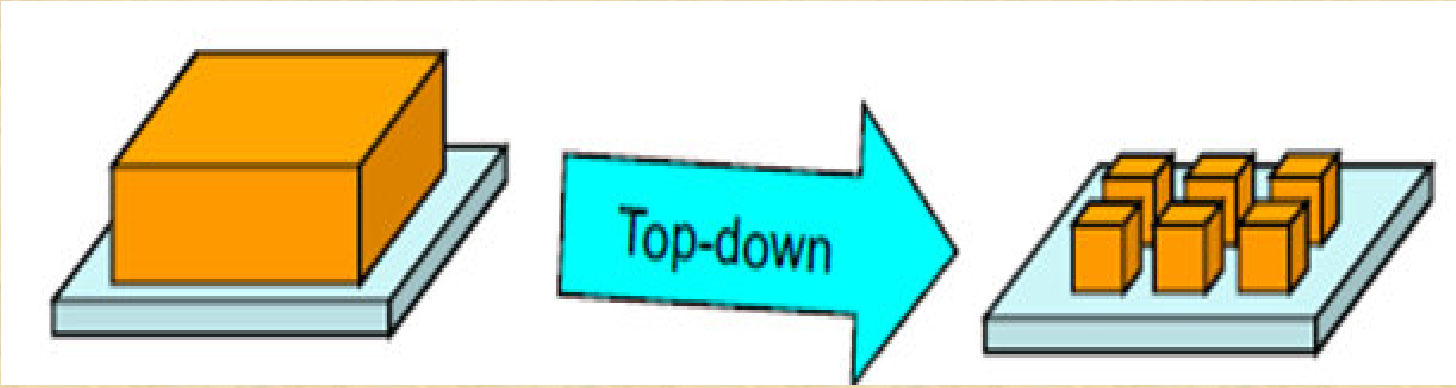
There are **two broad approaches** for the preparation of nano materials. They are

1.Top down approach: Breaking of bulk material

2.Bottom-up approach: Build up of material Atom→molecule→cluster

1)Top down approach:

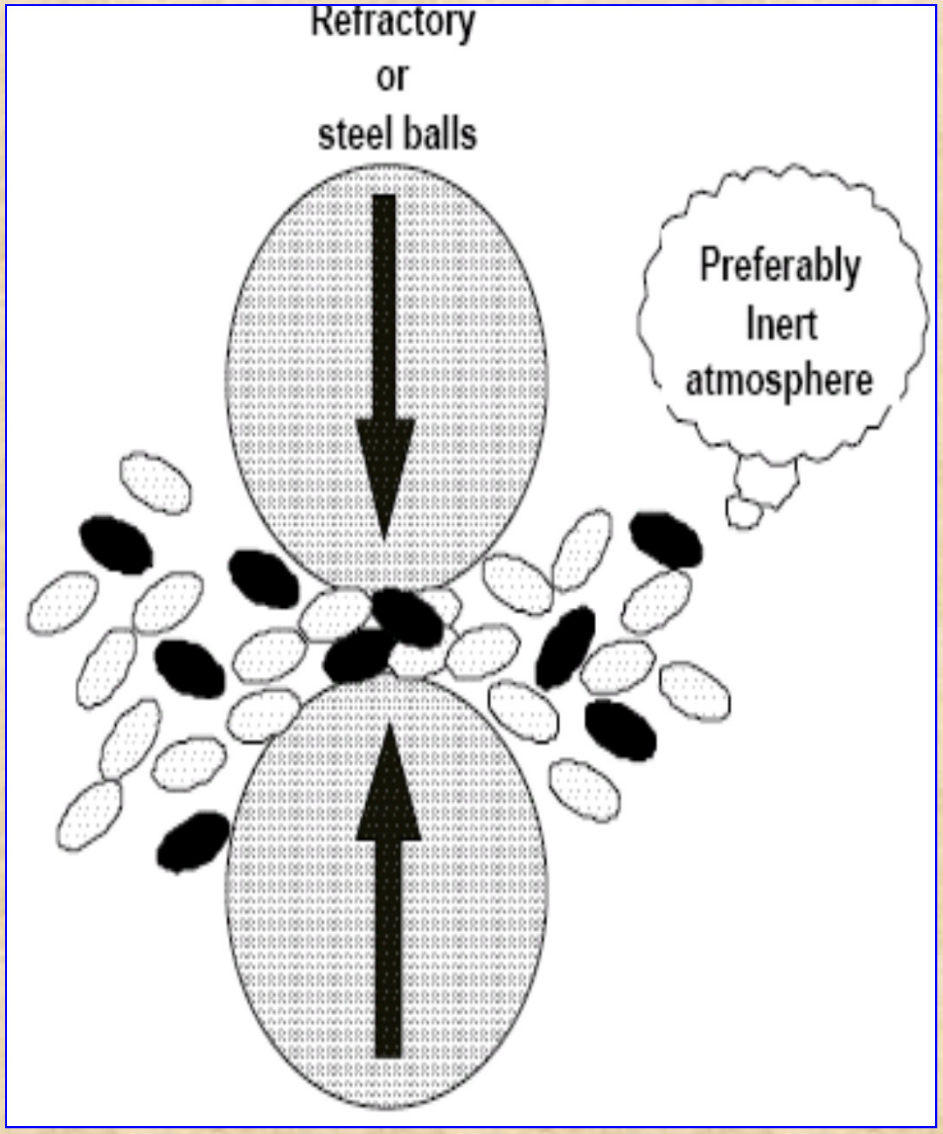
It involves mostly **mechanical and electromechanical methods for cutting down the bulk materials** to give **colloid sized particles** which are **stabilized by protecting agents.**



Example: Ball Milling Method

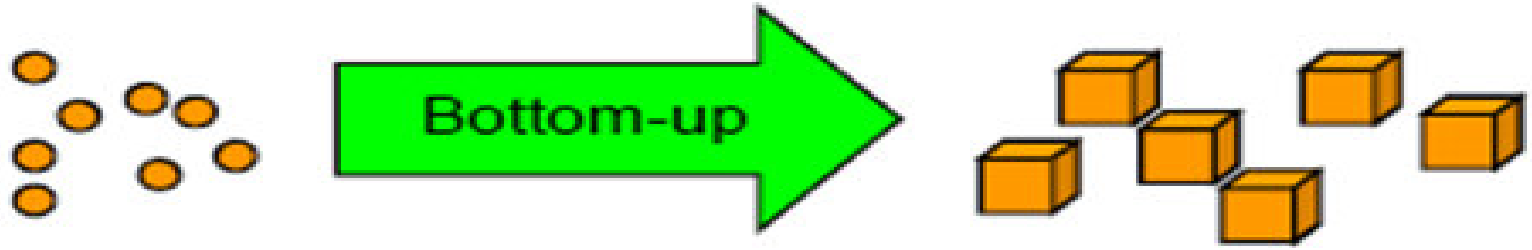
Ball milling method (Top down approach):

Schematic representation of the principle of mechanical ball milling method .



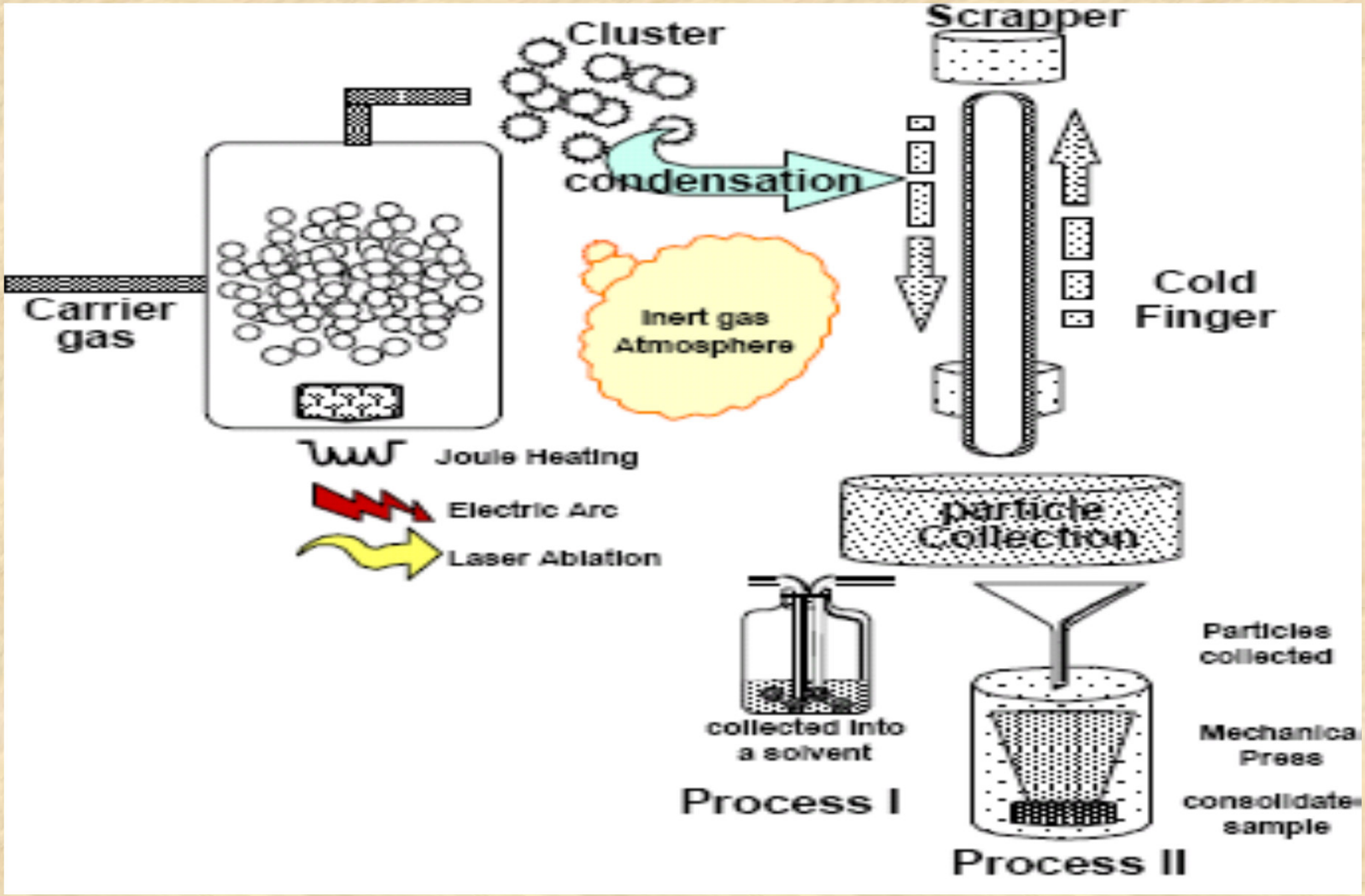
2) Bottom-up approach:

It involves mostly **wet chemical methods** such as **chemical reduction of metal salts, electrochemical methods, controlled decomposition of metal stable organometallic compounds.** This make use of self-assembly and self–organization capabilities of molecules to **build nano materials.**



Example: CVC, CVD, GPC, Sol-gel synthesis etc.

Schematic representation of GPC



Schematic representation of CVC

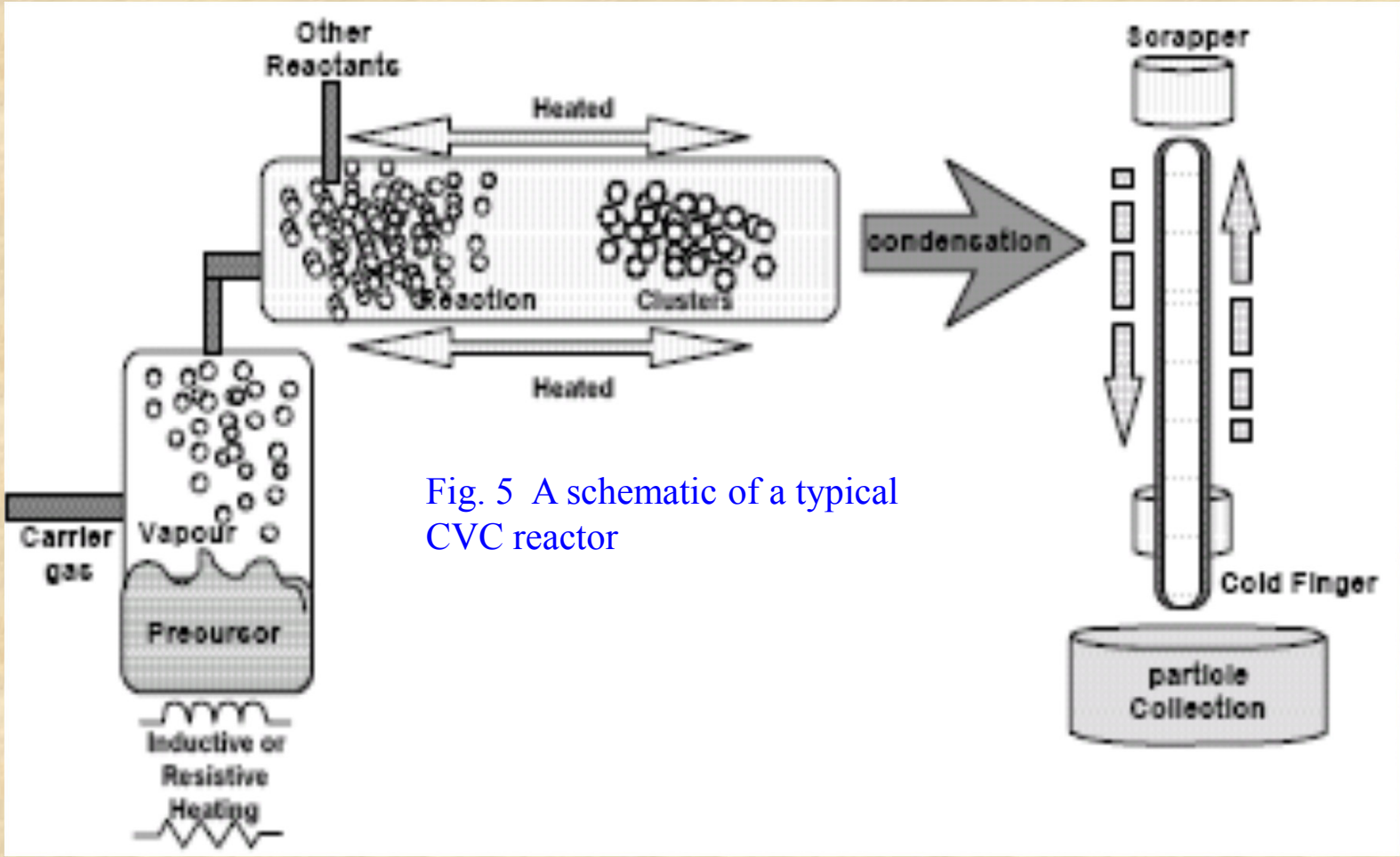
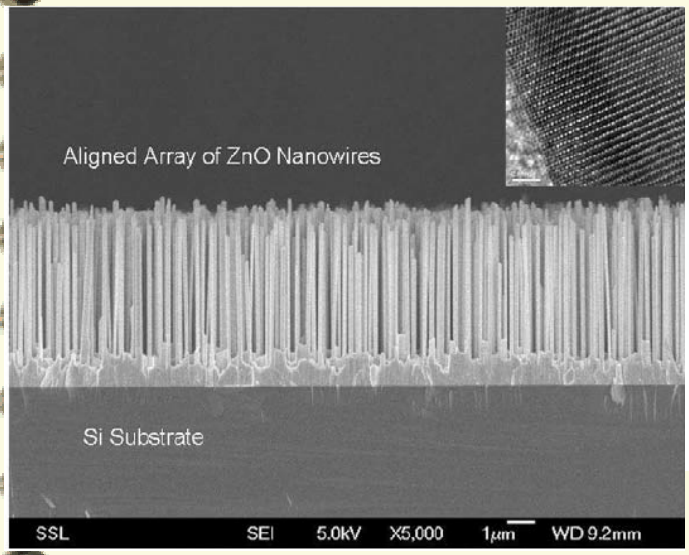
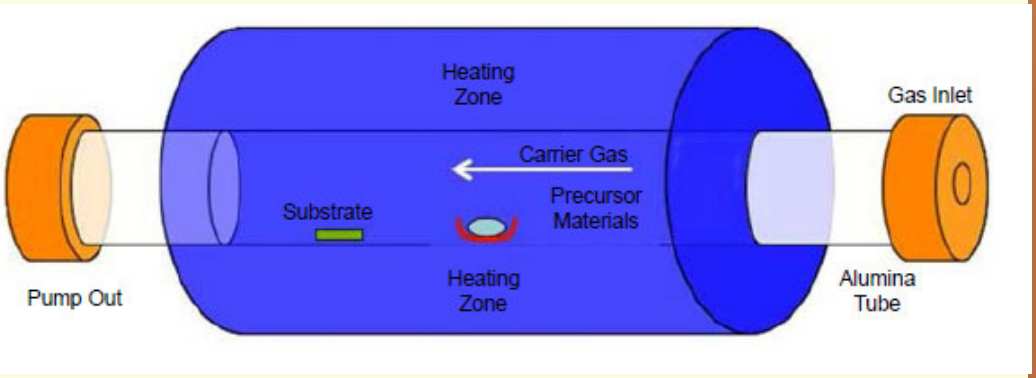


Fig. 5 A schematic of a typical CVC reactor

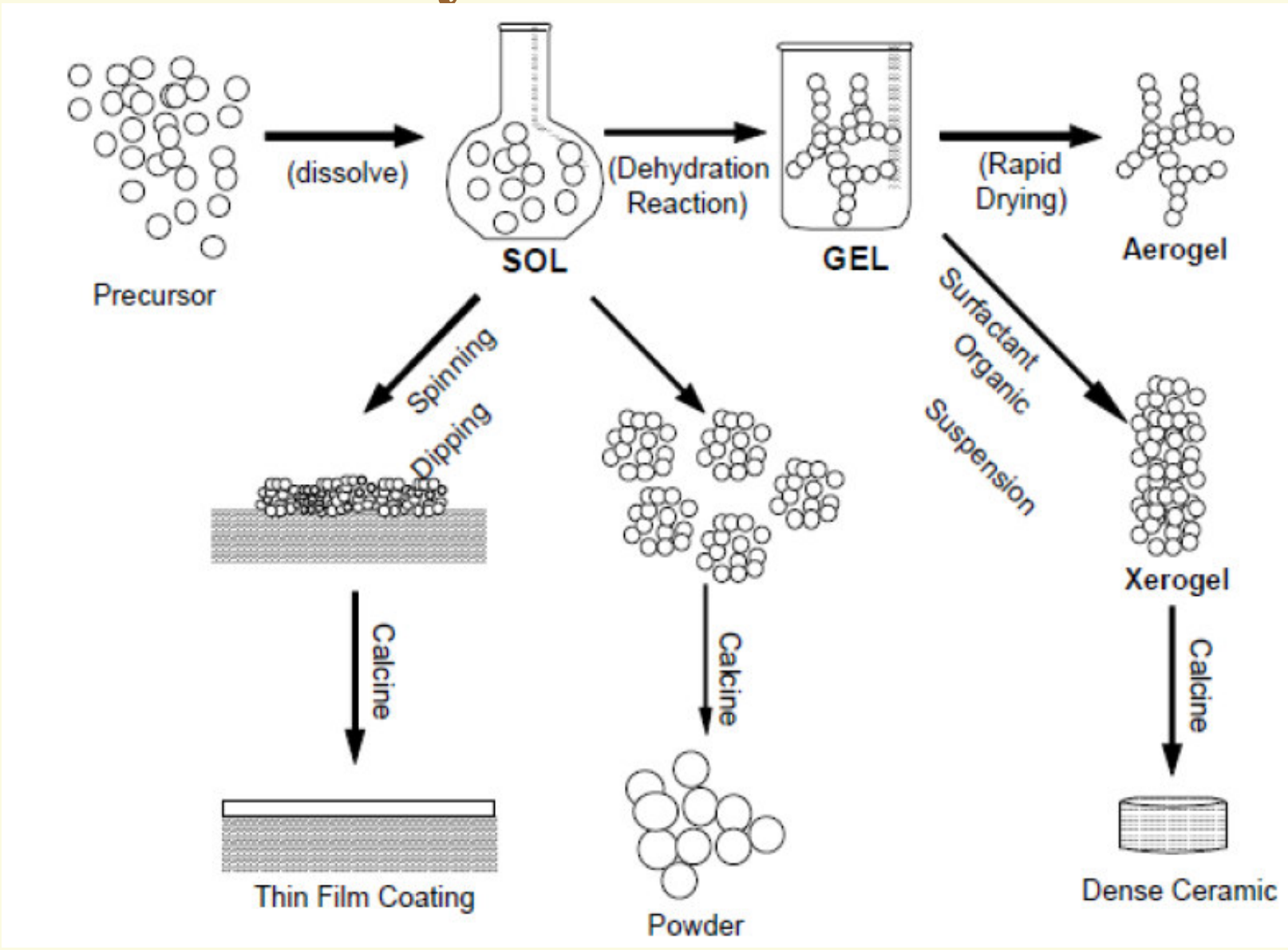
Preparation by CVD





Tubular furnace for synthesis of nanomaterials, nanowires by Chemical vapour deposition

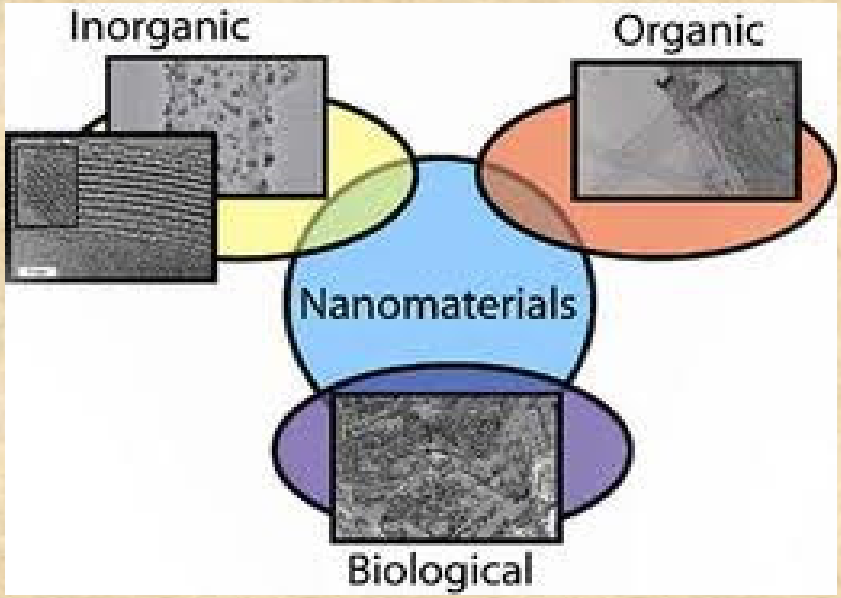
Sol – Gel synthesis



Nano materials Preparation

Physical Methods

1) Ball Milling Method
2) Laser Ablation Method
3) Gas Condensation Processing (GPC)



Chemical Methods

1) Sol-Gel Synthesis
2) Chemical Vapour Condensation (**CVC**)
3) Chemical Vapour Deposition (**CVD**)
4) Catalytic Chemical Vapour Deposition (**CCVD**)
5) Template assisted **CVD**
6) **Electrochemical** method
7) **Precipitation** method
8) Solution phase method (using Stabilizing Ligands)

Synthetic methods for the preparation of nano particles and nano crystals:

(1) Precipitation methods:

(2) Thermolysis of organometallic compounds.

(3) Hydrothermal or solvothermal synthesis.

(4) Vapor phase reactions

(5) Sonochemical reduction.

Nano tubes and nano wires can be prepared by

(1) Nano wire growth in vapor phase:

- (a) Vapor-liquid-solid growth
- (b) Oxide-assisted growth
- (c) Cabo thermal processes.

(2) Solution based methods:

- (a) Template-based synthesis
- (b) Solution-liquid-solid process
- (c) Solvothermal synthesis.

Applications of Nanomaterials:

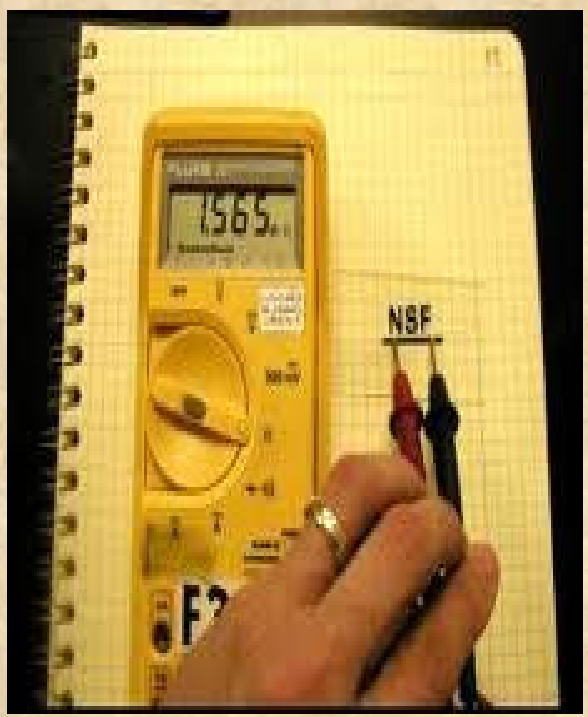
1) In Cosmetics:

Nano sized titanium oxide and zinc oxide are used in sunscreen creams, lotions and other cosmetics. These Nanoparticles become transparent and retain ability to absorb UV radiation.

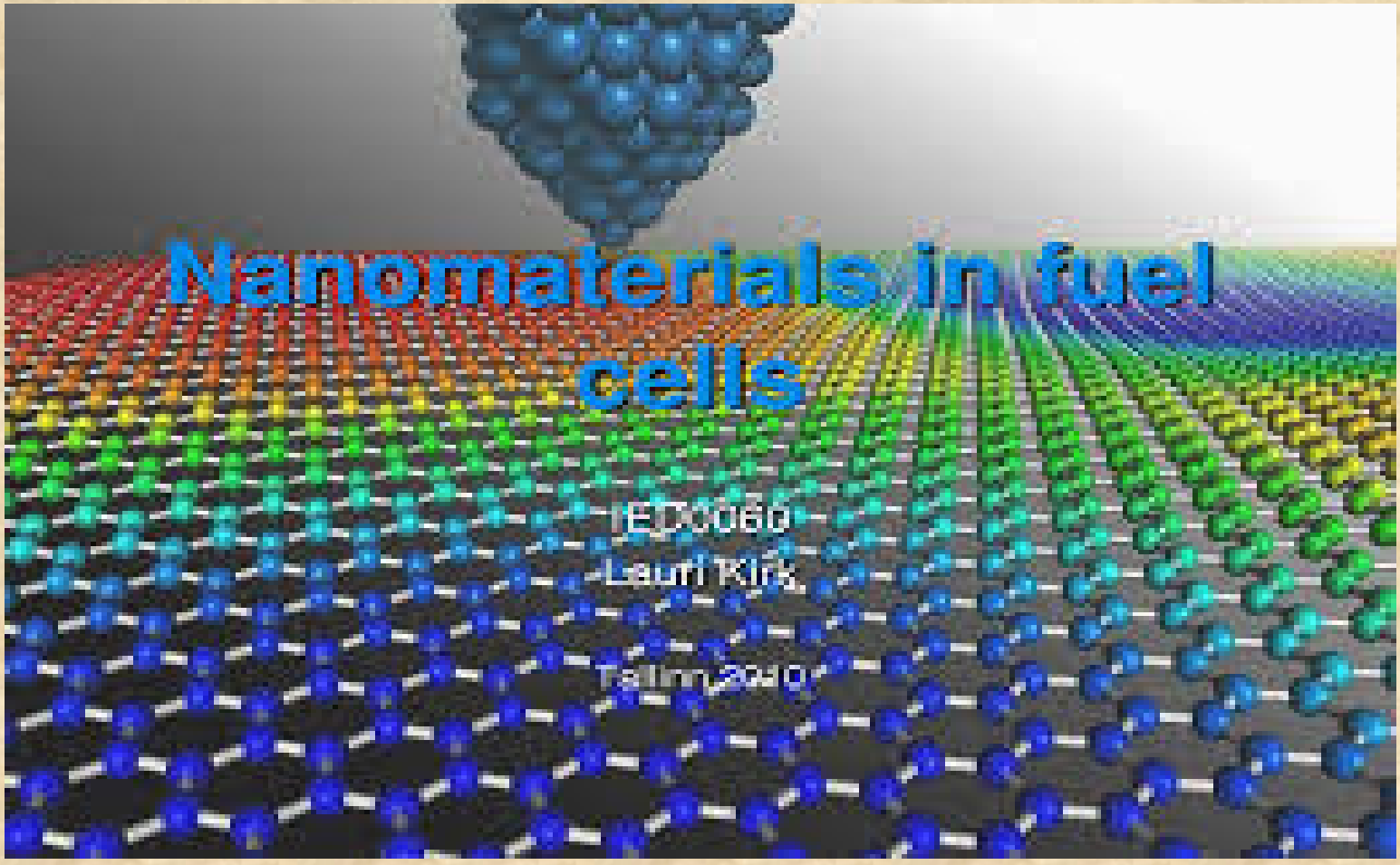
2) In Batteries :

Nanomaterials are investigated as electrode materials in batteries.

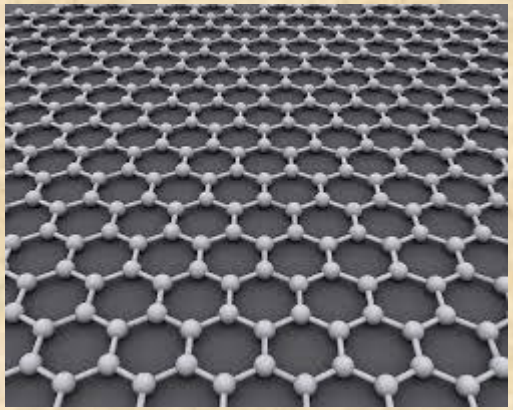
e.g. Nickel-metal hydride batteries requires less frequent recharging and last longer. So, it can be used in portable electronic devices like mobile phones, laptops, computers, remote sensors etc.

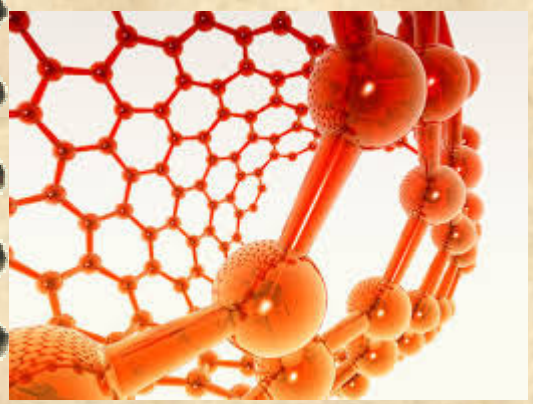


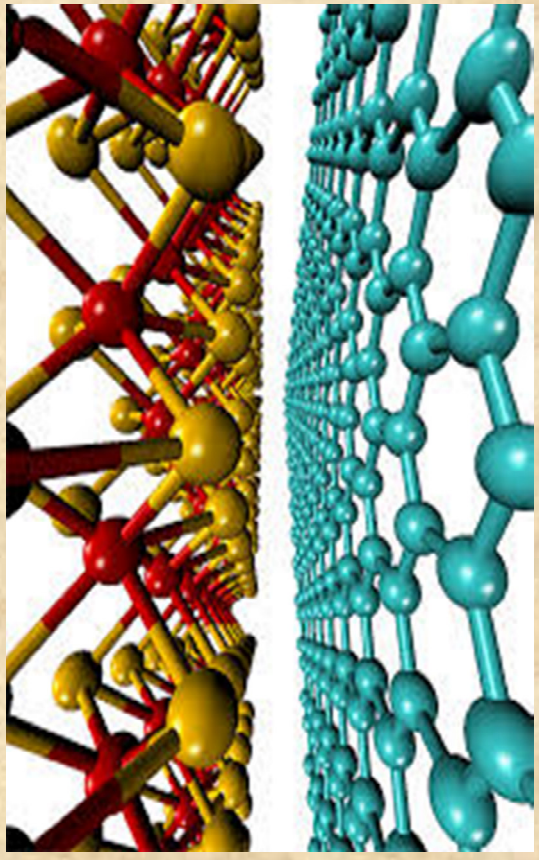
3) In Fuel cells: **Nanotubes also offer enhanced hydrogen storage capability for the use in fuel cells.**

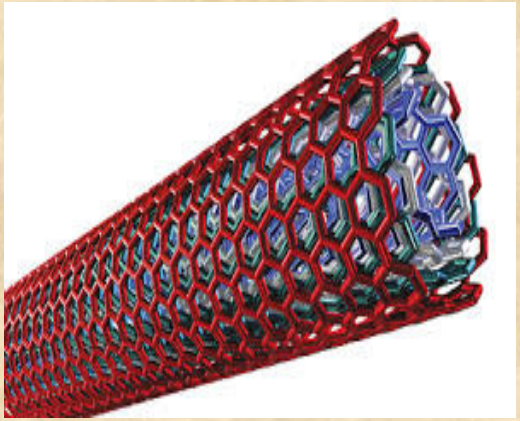


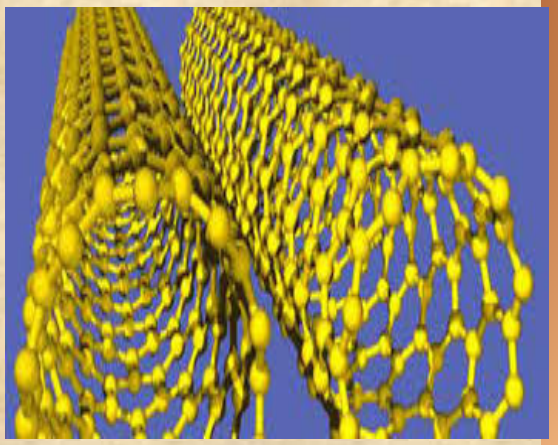
4) In Catalysis: **Nano materials can be used as a catalyst in different synthetic methods because they have large surface area which enhance catalytic activity.**



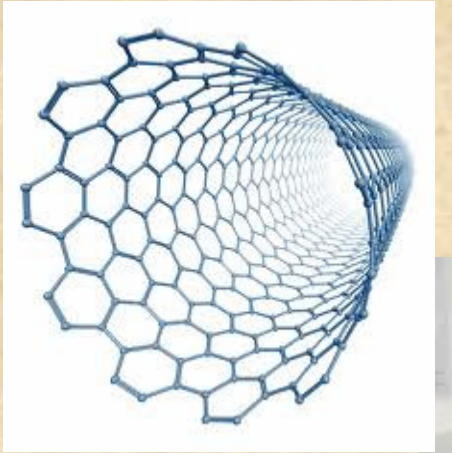








5) As Lubricants: Nanospheres made up of inorganic materials can be used as lubricants by acting as nano sized 'ball bearings'.



6) In Diagnostics : Nanomaterials can be used in diagnostics for detecting or diagnosing diseases like cancer, genetic disorders etc.

7) In composites: The properties of composite materials can be enhanced by incorporating nano particles in it.

e.g. CNTs composites

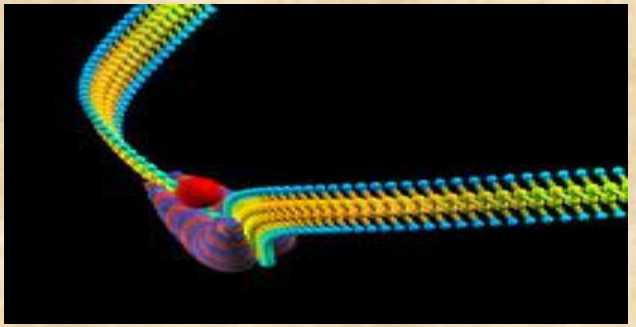
8) In medical implants: Nano particles can be used in medical implants such as orthopedic implants and artificial heart valves.

e.g. For artificial heart valves, nano crystalline silicon carbide is used.

9) In Drug delivery: Nanoporous materials can be used to hold small drug molecules and to transport them to the desired location. Applications include cancer treatment with iron or gold Nanoparticles.

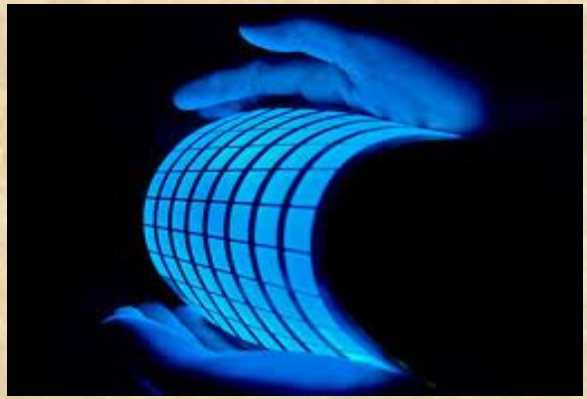
10) Bio or Tissue Engineering:

Nanomaterials can be used to repair or reproduce damaged tissue.



11) Optical Engineering:

Nanomaterials can be used as nanocomposites for sunglasses to have protective, antireflective and scratch resistant surface coatings.



12) Material Engineering : Nanoparticles of tungsten-carbide-cobalt provide a hard coating. This results in a greater resistance to wear in applications such as drill bits, cutting tools and jet engine parts.

13) Textile Engineering : Nanofibers in clothes make waterproof and stain-repellant or wrinkle-free and can be washed less frequently.

14) In Energy Storage: Nano materials finds applications in energy storage and its conversion.

15) In Food Stuffs : Nanomaterials finds applications in the production, processing, safety and packaging of food stuffs.

Other applications of Nanomaterials:

Nanomaterials is used

1) in Nanodevices
2) in **photovoltaic cells.**
3) in **microelectronic devices.**
4) in Nanotransitors,
5) Energy conversion devices
6) in **photo sensors.**
7) As sensors (Sensing chemical, pressure, temperature etc)
8) Nanomedicine
9) **bio-medical appliances.**
10) Magnetic materials
11) Magnetic storage disk materials
12) Thermoelectric materials
13) Piezoelectric materials
14) Nanoelectrodes

Carbon Nanotubes

Carbon Nanotubes (CNTs)/Basics

* Discovered accidently during bulk preparation of C_{60} by the arc method.

*Graphite carbon needles grew on the -ve side carbon electrode (arc method)

*CNT also member of Fullerene structural family.

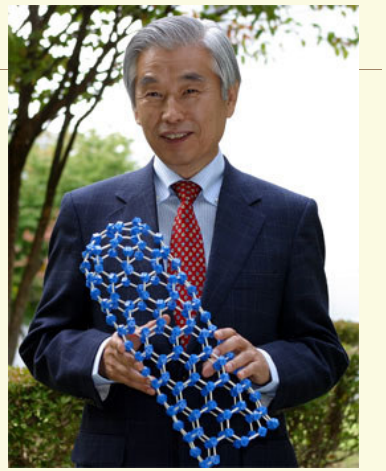
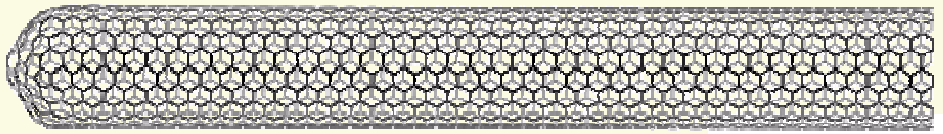
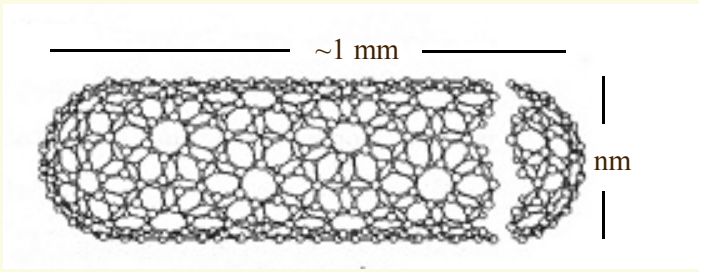


Fig. 6 Prof. Iijuma (Japan) with a CNT model.





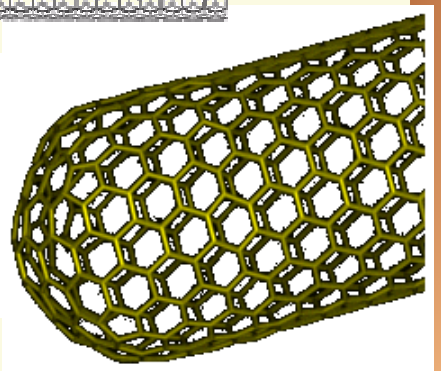


Fig.7 Shape and structure of Carbon nanotube (SWNT).

THANK YOU