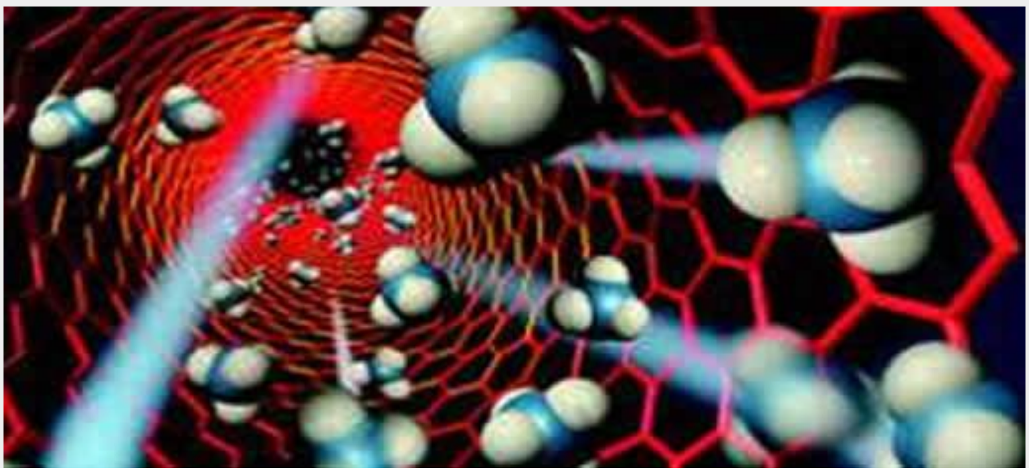
Nanotechnology

Particle Technology



Course Content

- ***Introduction to the subject***
- ***Characterization of Solid Particle***
- ***Measurement of Particle size***
- ***Size Reduction***
- ***Crystal Structure***
- ***Separation of Particles***
- ***Synthesis of Nanomaterials***

- ***Techniques and Testing Machines of Nanomaterial.***
- ***Application.***

Introduction:

Particle technology is a term used to refer to the science and technology related to the handling and processing of particles and powders. Particle technology is also often described as powder technology, particle science and powder science. • Particles are commonly referred to as bulk solids, particulate solids and granular solids. • Today particle technology includes the study of liquid drops, emulsions and bubbles as well as solid particles. • This course is however limited only to solid particles. • The discipline of particle technology now includes topics as diverse as the formation of aerosols to the design of bucket elevators, crystallization to pneumatics transport, slurry filtration to silo design. Particulate materials, powders or bulk solids are used widely in all areas of the process industries, for example in the food processing, pharmaceutical, biotechnology, oil, chemical, mineral processing, metallurgical, detergent, power generation, pint, plastics cosmetics industries and cosmetics.

The three most important characteristics of an individual particle are:

1- Particle Composition.
2- Particle Size.
3- Particle Shape.

Measurement of particle size

A wide range of measuring techniques is available both for single particles and for systems of particles

Particle size distribution

Most particulate systems of practical interest consist of particles of a wide range of sizes and it is necessary to be able to give a quantitative indication of the mean size and of the spread of sizes. The results of a size analysis can most conveniently be represented by means of a *cumulative mass fraction curve*, in which the proportion of particles *(x)* smaller than a certain size *(d)* is plotted against that size *(d)*. In most practical determinations of particle size, the size analysis will be obtained as a series of steps, each step representing the proportion of particles lying within a certain small range of size. From these results a cumulative size distribution can be built up and this can then be approximated by a smooth curve provided that the size intervals are sufficiently small. A typical curve for size distribution on a cumulative basis is shown in Figure 1.5. This curve rises from zero to unity over the range from the smallest to the largest particle size present. The distribution of particle sizes can be seen more readily by plotting a *size frequency curve*, such as that shown in Figure 1.6, in which the slope *(*d*x*/d*d)* of the cumulative.

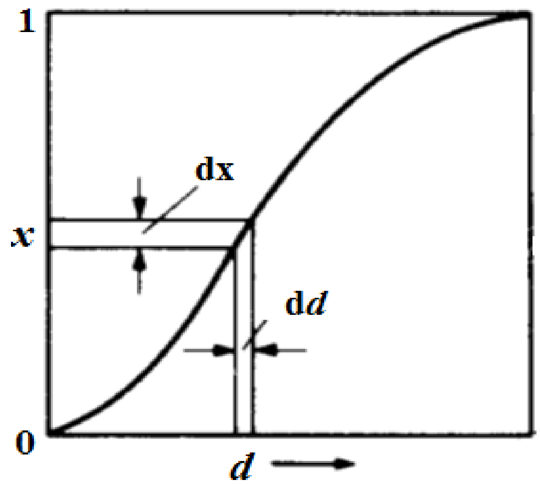


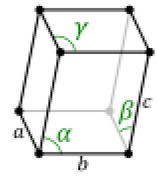
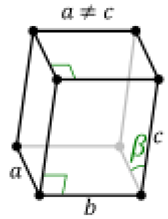
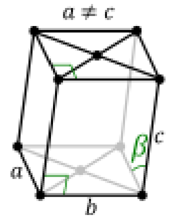
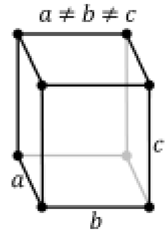
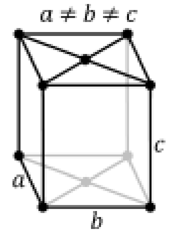
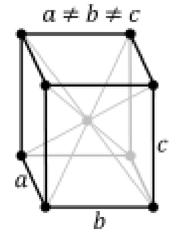
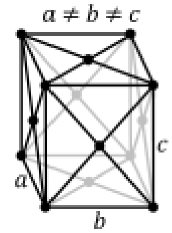
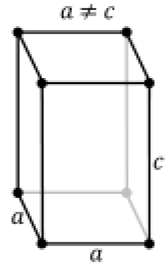
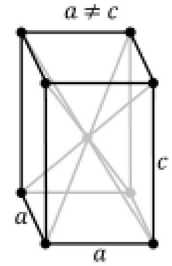
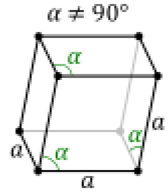
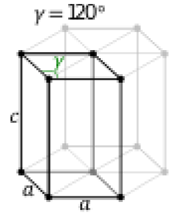
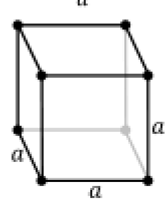
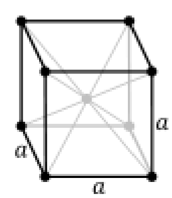
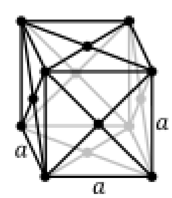
Figure 1.5. Size distribution curve-cumulative basis.

1.2.4. Mean particle size

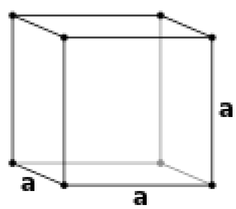
The expression of the particle size of a powder in terms of a single linear dimension is often required. For coarse particles, BOND *(*9, 10*)* has somewhat arbitrarily chosen the size of the opening through which 80 per cent of the material will pass. This size *d*80 is a useful rough comparative measure for the size of material which has been through a crusher. A mean size will describe only one particular characteristic of the powder and it is important to decide what that characteristic is before the mean is calculated. Thus, it may be desirable to define the size of particle such that it's mass or its surface or its length is the mean value for all the particles in the system. In the following discussion it is assumed that each of the particles has the same shape.

Crystal material or crystalline solid is a solid material whose constituents are arranged in a highly ordered microscopic structure, forming a crystal lattice.

Unit cell: It is smallest group of atoms which by repetition in three dimensions built up the crystal.

Crystal family	Lattice system	Symmetry	14 Bravais Lattices			
			Primitive	Base-centered	Body-centered	Face-centered
triclinic		C_i				
monoclinic		C_{2h}	$\beta \neq 90°$ $a \neq c$ 	$\beta \neq 90°$ $a \neq c$ 		
orthorhombic		D_{2h}	$a \neq b \neq c$ 	$a \neq b \neq c$ 	$a \neq b \neq c$ 	$a \neq b \neq c$ 
tetragonal		D_{4h}	$a \neq c$ 		$a \neq c$ 	
hexagonal	rhombohedral	D_{3d}	$\alpha \neq 90°$ 			
	hexagonal	D_{6h}	$\gamma = 120°$ 			
cubic		O_h				

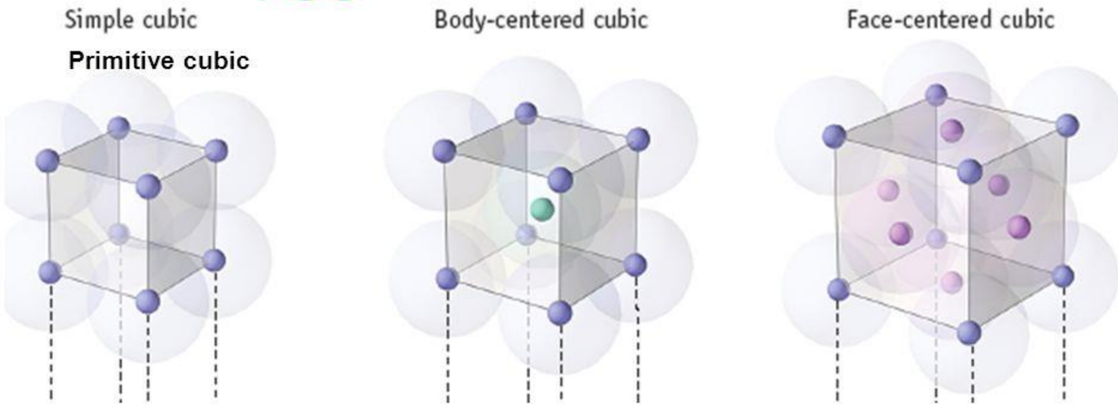
Crystal structure is a description of the ordered arrangement of atoms, ions or molecules in a crystalline material.[3] Ordered structures occur from the intrinsic nature of the constituent particles to form symmetric patterns that repeat along the principal directions of three-dimensional space in matter. The smallest group of particles in the material that constitutes the repeating pattern is the crystal structure of a material (the arrangement of atoms within a given type of crystal) can be described in terms of its unit cell. The unit cell is a small box containing one or more atoms arranged in 3 dimensions. The unit cells stacked in three-dimensional space describes the bulk arrangement of atoms of the crystal. The unit cell is represented in terms of its lattice parameters, which are the lengths of the cell edges (*a*, *b* and *c*) and the angles between them (alpha, beta and gamma), while the positions of the atoms inside the unit cell are described by the set of atomic positions (x_i, y_i, z_i) measured from a lattice point. Commonly, atomic positions are represented in terms of fractional coordinates, relative to the unit cell lengths.

- 

  Simple cubic (SCC)

Number of Atoms per Unit Cell

Unit Cell Type	Net Number Atoms
SC (Primitive Cubic)	1
BCC	2
FCC	4

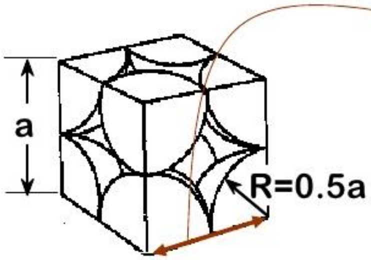


Here's the better way to tell about packing.

ATOMIC PACKING FACTOR (APF)

$$APF = \frac{\text{Volume of atoms* in unit cell}}{\text{Volume of unit cell}}$$

*assume hard spheres



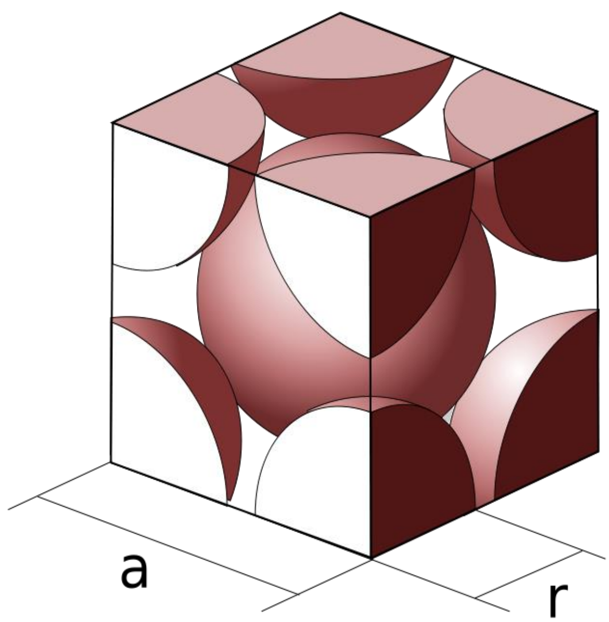
Close-packed direction:
a= 2R

atoms/unit cell: 1; volume/atom: $\frac{4}{3}\pi(0.5a)^3$; volume/unit cell: a^3

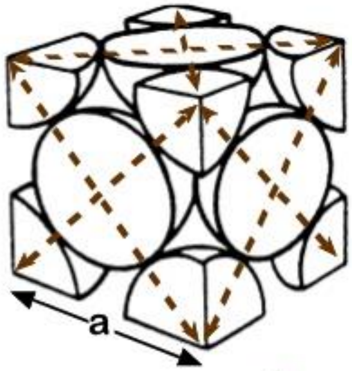
$$APF = \frac{1 \; \frac{4}{3}\pi(0.5a)^3}{a^3} = 0.52$$

There are 8 of 1/8 atoms.

1 atom/unit cell



ATOMIC PACKING FACTOR: FCC



Close-packed directions:

length = 4R

$= \sqrt{2}\, a$

Unit cell contains = 4 atoms/unitcell

$$APF = \frac{N_{atoms} * V_{atom}}{V_{crystal}}$$

$$APF = \frac{4 \cdot \frac{4}{3}\pi(\sqrt{2}a/4)^3}{a^3}$$

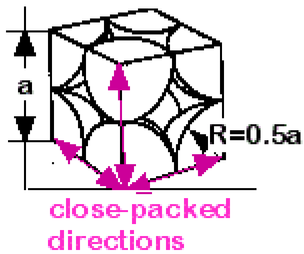
atoms / unit cell → 4

volume / atom → $\frac{4}{3}\pi(\sqrt{2}a/4)^3$

volume / unit cell → a^3

- ***APF for a body-centered cubic structure = $\pi/(3\sqrt{2})$ = 0.74***

APF FOR SIMPLE CUBIC



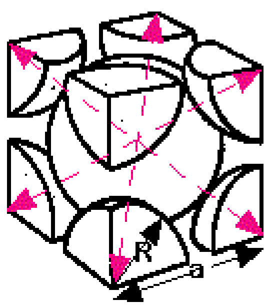
contains 8 x 1/8 =
1atom/unit cell

APF = 0.52 for simple cubic

$$APF = \frac{\overbrace{1}^{\text{atom/unit cell}} \cdot \overbrace{\frac{4}{3}\pi(0.5a)^3}^{\text{volume/atom}}}{\underbrace{a^3}_{\text{volume/unit cell}}}$$

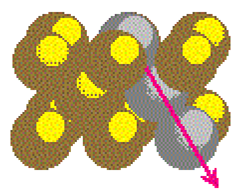
APF FOR BCC / BODY CENTERED CUBIC

1 unit cell



close-packed directions:
length = 4R = $\sqrt{3}a$

Coordination Number = 8



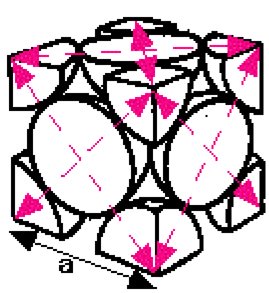
One of 4 close-packed directions

contains 1 + 8 x 1/8 = 2atoms/unit cell

$$APF = \frac{\overbrace{2}^{\text{atoms/unit cell}} \cdot \overbrace{\frac{4}{3}\pi(\sqrt{3}a/4)^3}^{\text{volume/atom}}}{\underbrace{a^3}_{\text{volume/unit cell}}}$$

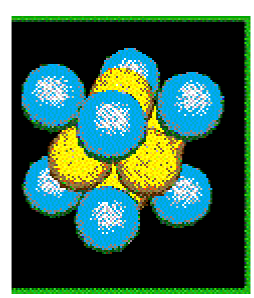
APF =0.68 for BCC

Face-Centered Cubic Structure (FCC)



close-packed directions:
length = 4R = $\sqrt{2}a$

Coordination Number = 12



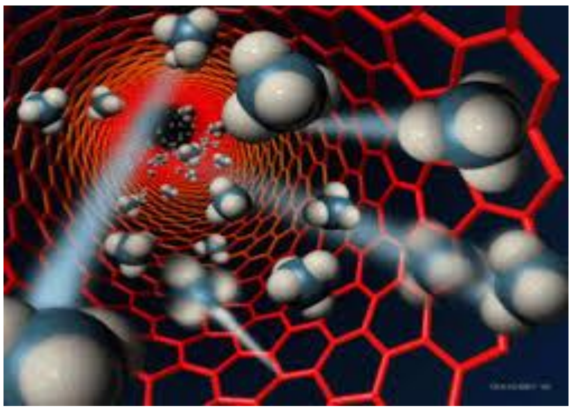
Courtesy of Materials Science: A Multimedia Approach, by John C. Russ

contains 6 x 1/2 + 8 x 1/8 = 4atoms/unit cell

$$APF = \frac{\overbrace{4}^{\text{atoms/unit cell}} \cdot \overbrace{\frac{4}{3}\pi(\sqrt{2}a/4)^3}^{\text{volume/atom}}}{\underbrace{a^3}_{\text{volume/unit cell}}}$$

APF =0.74 for FCC

What is Nanotechnology?

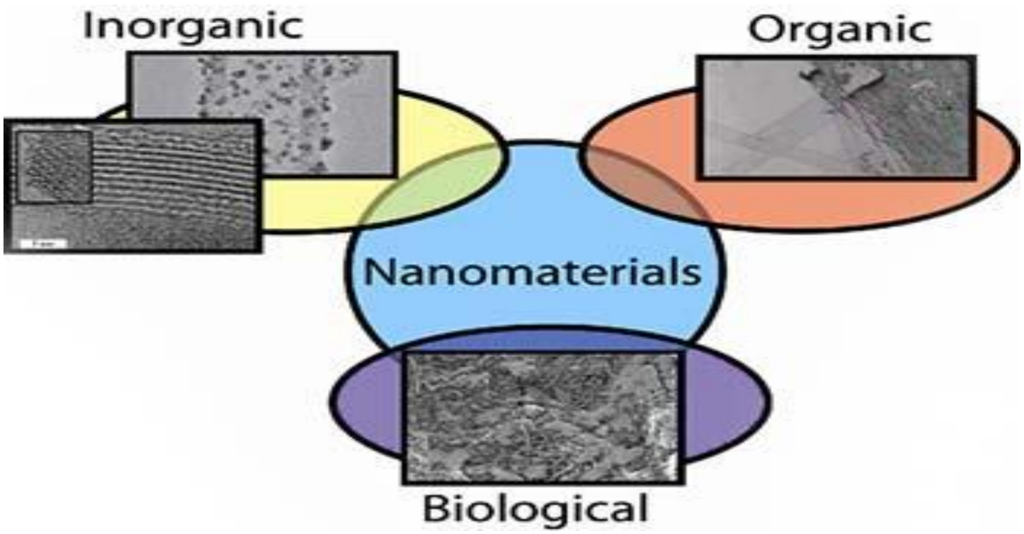
Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers.

Nanoscience and nanotechnology are the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering.

Nanomaterials: Materials which are made of grains that are about 100 nm in diameter and contain less than few ten thousands of atoms.

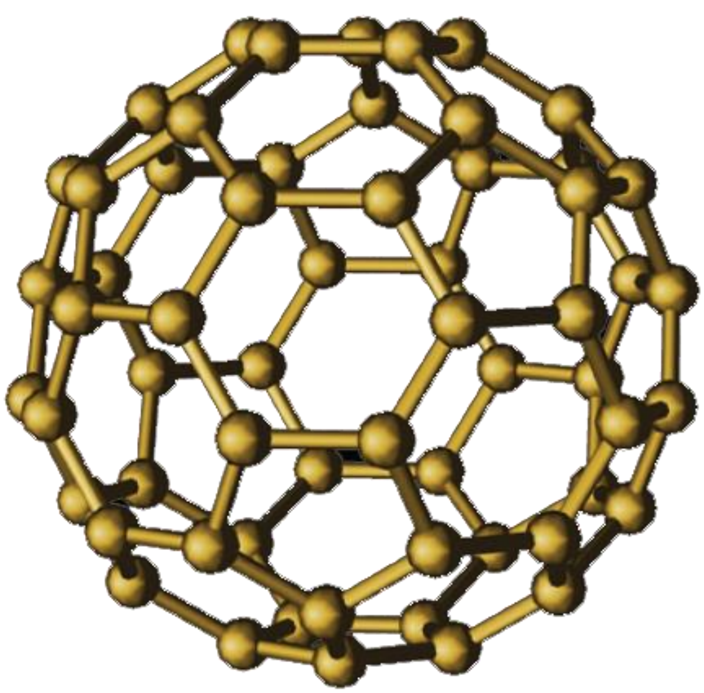
Nano means one billionth (* 10^{-9})

1nm= 10^{-9} m

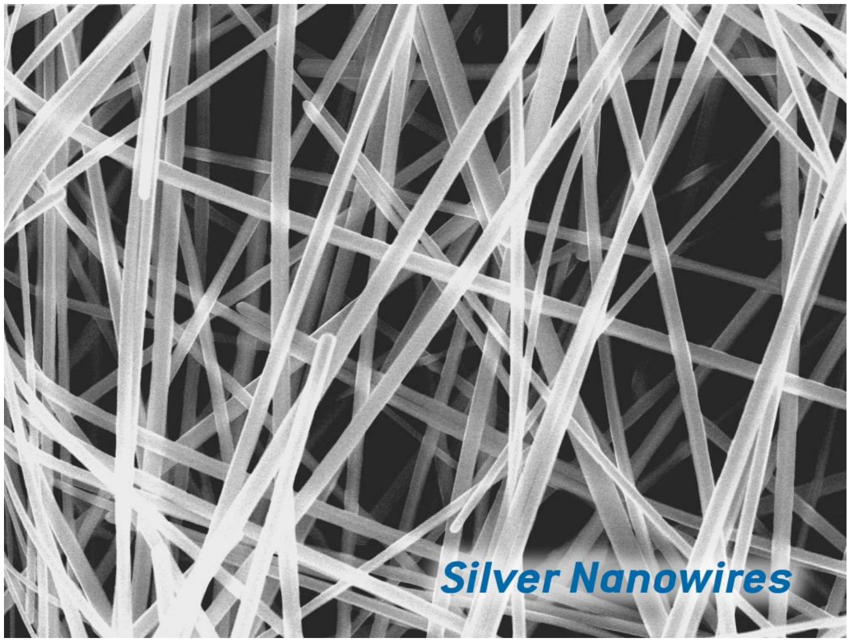


Nano scale of nanomaterials can be in following:

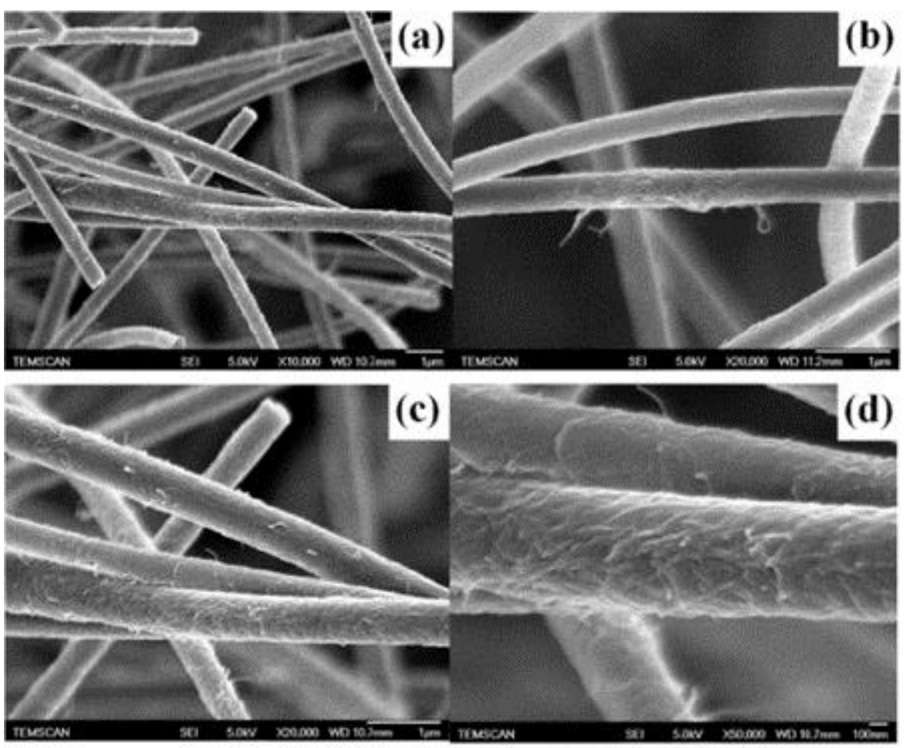
- **Zero dimension**
  Fullerene: A *fullerene* is a molecule of carbon in the form of a hollow sphere.



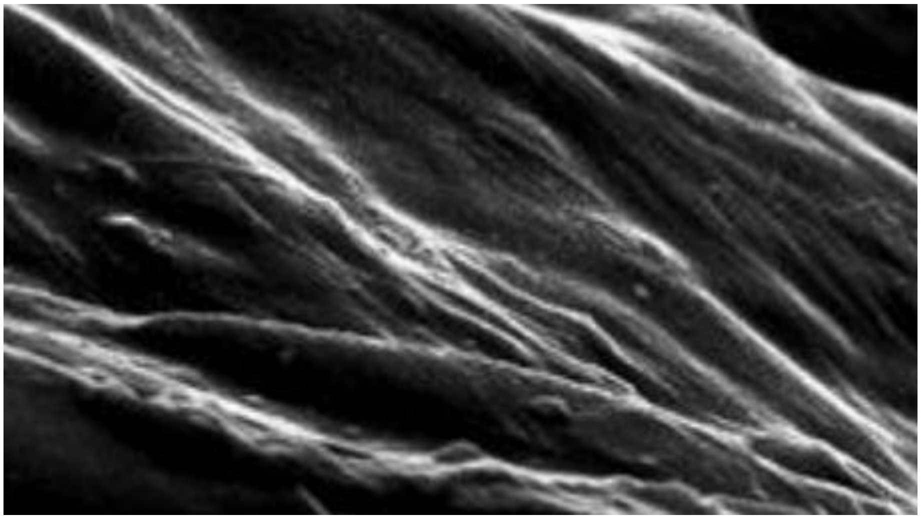
- **One dimension**
  Nano Wires

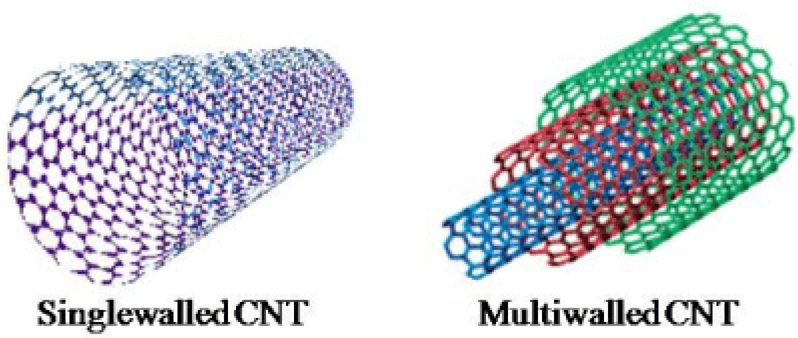


- **Tow dimension**
  Fibers



Nanotubes (CNTs)





- **Three dimension**

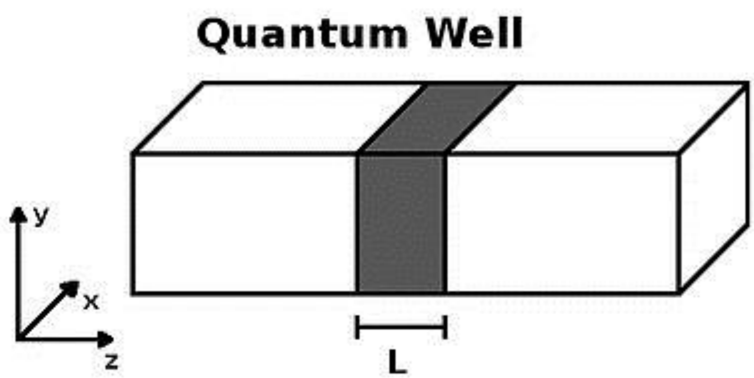
Particles

A nanomaterial can exist in single, fused, aggregated or agglomerated form with spherical, tubular and irregular shapes.

Why nanomaterials have different properties?

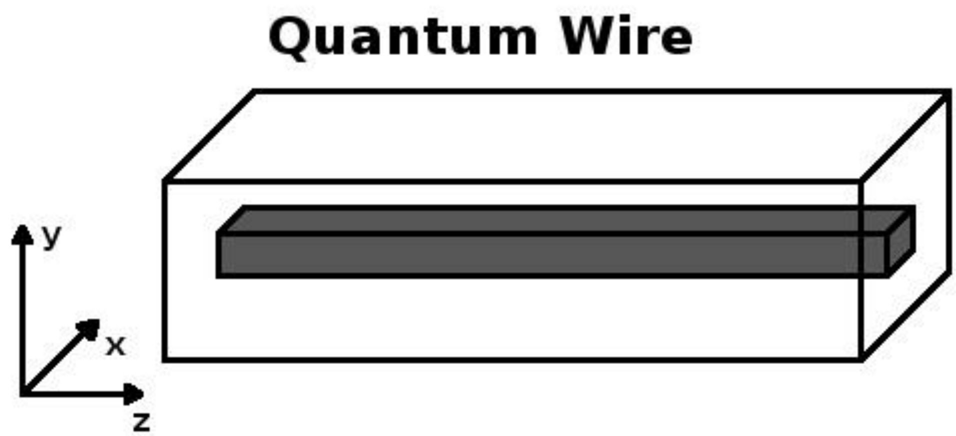
Why nanomaterials have superior chemical reactivity?

Quantum well احدي الابعاد بالنانو



Quantum wire is an electrically conducting **wires** in which **quantum** effects influence the transport properties.

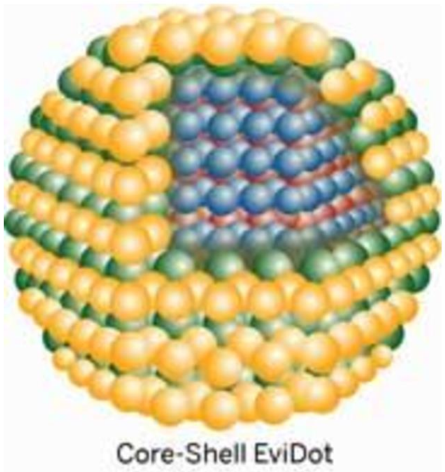
فقط اعطاء المثال على ذالك ذات البعدين بالنانو



Quantum dots (QD) are very small semiconductor particles, only several nanometers in size, so small that their optical and electronic properties.

ثلاثة ابعاد

What is a quantum dot?



- Nanocrystals
- 2-10 nm diameter
- semiconductors

Why the nanomaterials are more interest?