Module - 5

Nanotechnology

A glass which is not breakable,

a mobile which is long-lasting battery,

a clothes which never catch the dust, smell free, wrinkle free.

Automobiles will be more fuel efficient stronger and lighter.

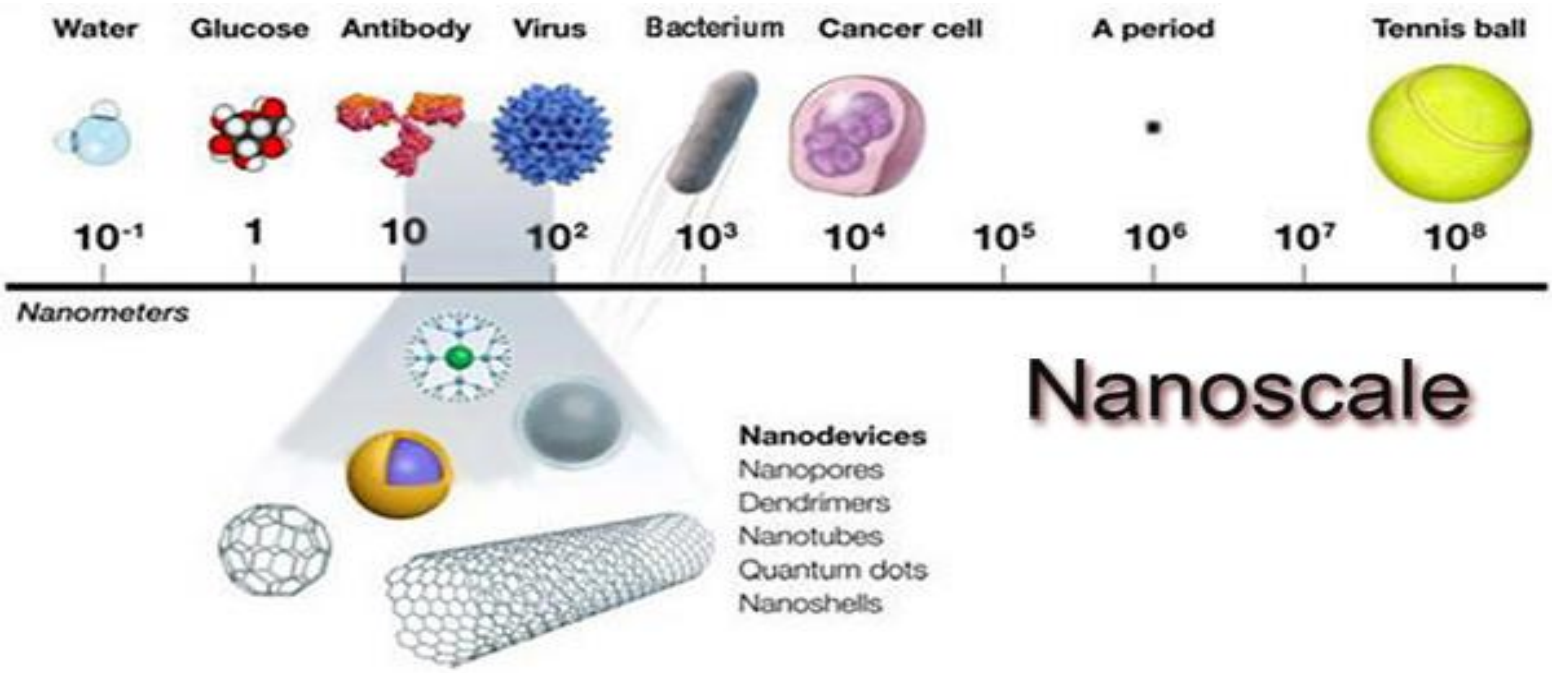
Such unbelievable things can happens in nanotechnology

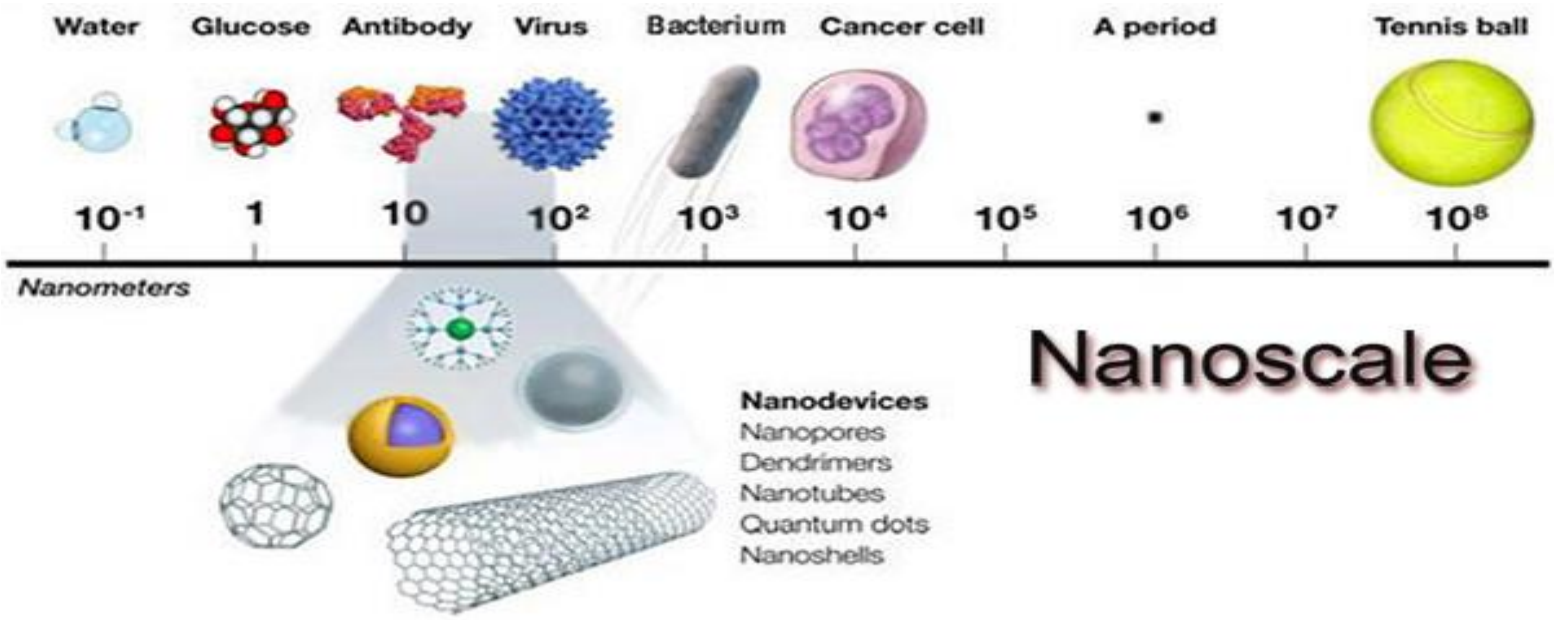
Let us understand what is nanotechnology

First we will understand what is Nano?

The term "**Nano**" comes from ancient Greek and **means** "dwarf"

Nano means very small (near to size of molecules)





A particles between the range of 1nm to 100 nm is called Nano-particles or Nano world

What is nanometer?

A nanometer is defined as one billionth of a meter.

$\frac{1}{1000000000}$ meter = 1 X 10^{-9} meter

$\frac{1\ meter}{1Billionth\ (\ Arab)}$ meter = 1 nm

1 nm is like sise of football

suppose size of eath is 1 meter

What is Nano Science?

It means gaining knowledge through observations and experiment is called Nano science.

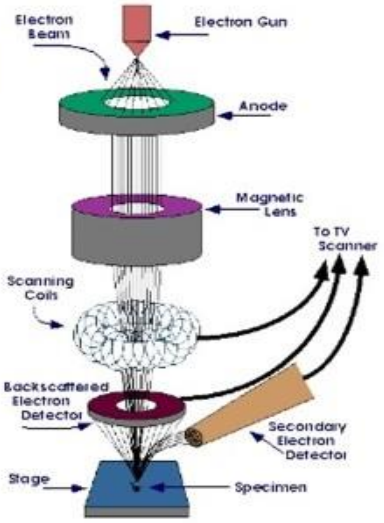
What is Nanotechnology?

A practical application of Nano Science for various purposes is called Nano technology

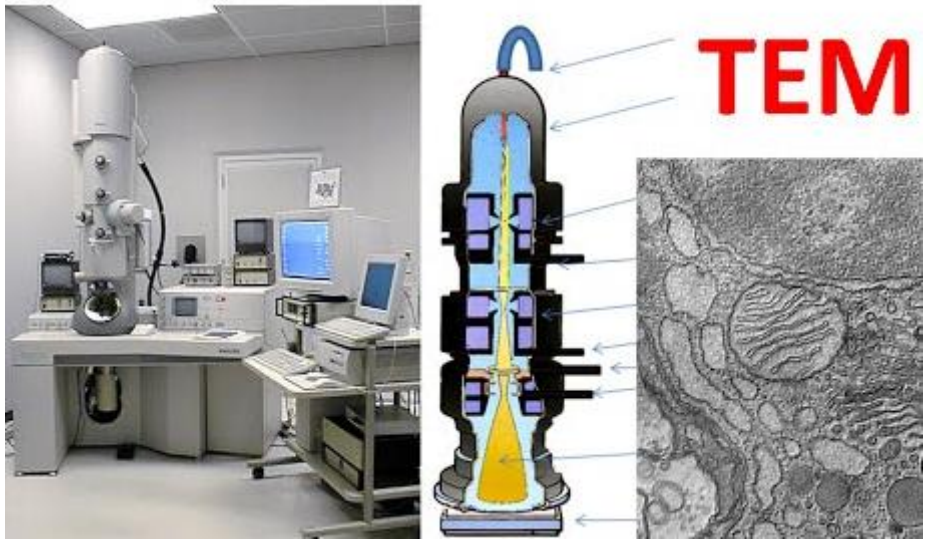
Nanomaterial's and properties of nanomaterial's.

To see these particles we have to use

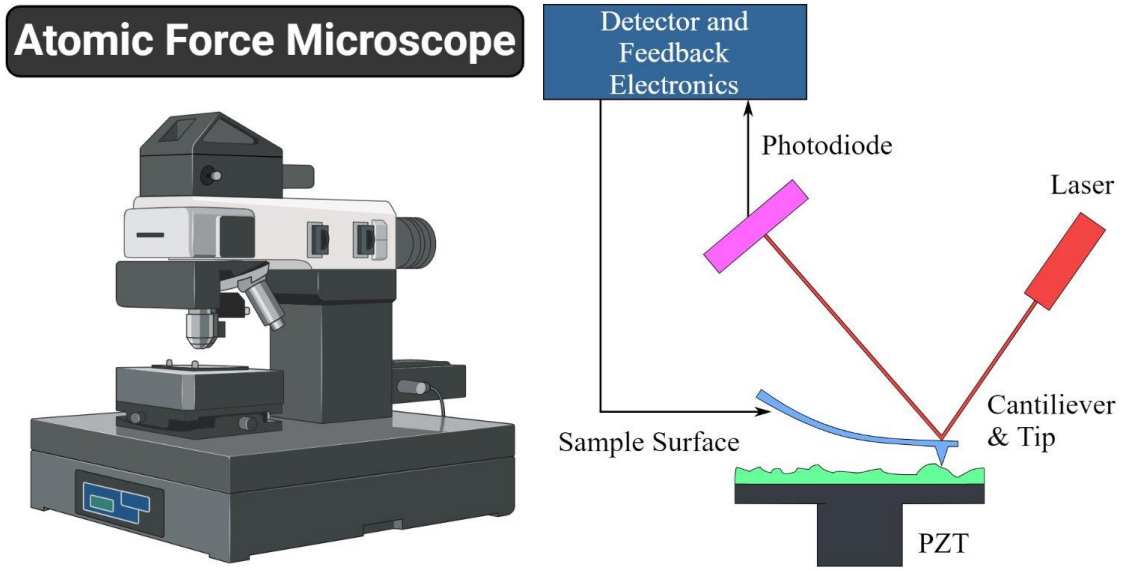
SEM (scanning electron microscope)



TEM (transmission electron microscopy)

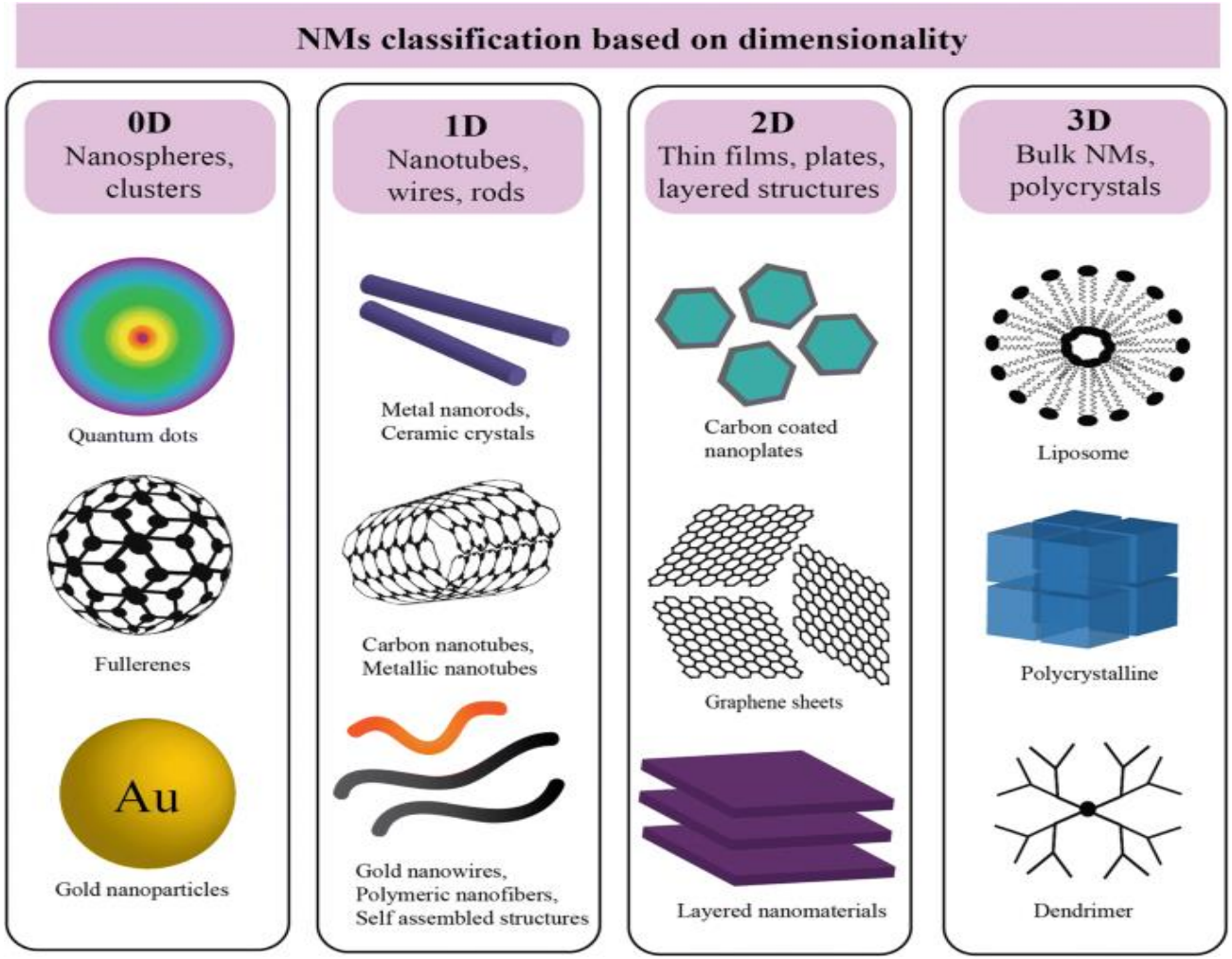


AFM (atomic force microscopy)



Classification of Nanomaterial

1. Zero dimensional
2. One dimensional
3. Two dimensional
4. Three dimensional



1. Zero dimensional

Material wherein all the dimensions (like length, width and height) are within Nano scale is called zero dimensions.

2. One dimensional

Material wherein any two dimensions are within Nano scale and one dimension is out of scale is called one dimension.

3. Two dimensional

Material wherein any one dimension is within Nano scale and others two dimensions are out of scale is called two dimensions.

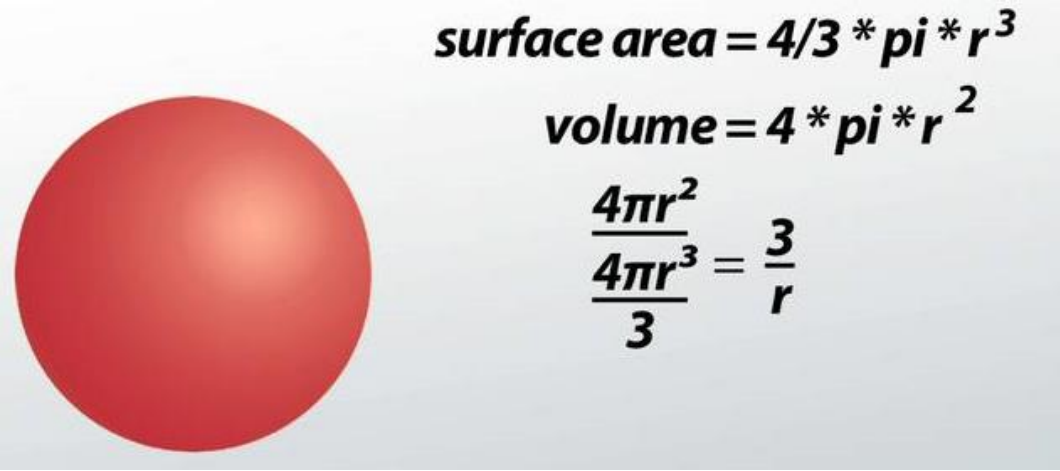
4. Three dimensional

Material wherein all dimensions are out of Nano scale is called three dimensions.

Properties of Nanomaterial's

A Nanoparticle of material show different properties compared to large particles of the same size.

The reasons for different properties in nanomaterial than their bulk materials are



From this surface area to volume ratio is 3/r
Its show that lesser the size of the particles more is the surface area to volume ratio

Quantum effect

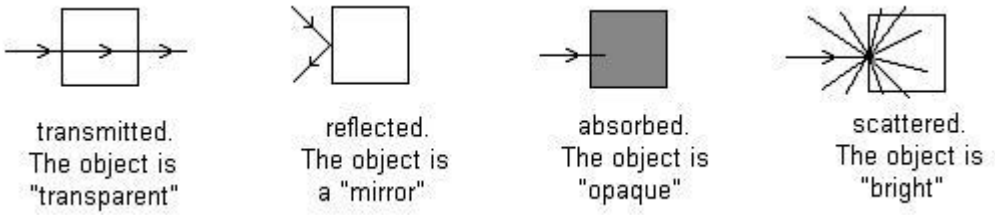
Due to less size it reduced imperfection

Let's study the properties of Nanomaterial's

1. **Optical properties**
2. **Electrical properties**
3. **Magnetic properties**
4. **Structural properties**
5. **Mechanical properties**

1. Optical properties

When light falls on material it can be scattered or absorbed.



The scattering and absorption varies greatly depending upon the particles size of materials.

At size of < 20 nm absorption occurs while at the size of > 200nm scattering take place.

It show that depending upon the size of particles the amount of scattering and absorption of light can be achieved

Eg.

Gold Nano sphere of 100nm size appears orange

Gold Nano sphere of 50 nm size will appears green.

2. Electrical properties

Size of materials plays very important role in electrical properties. Reduction in size will increase crystal perfection (I.e. reduction of defects) which results in reduction of resistivity and hence conductivity increases.

3. Magnetic properties

These are dependent on size.

Small particles are more magnetic than bulk materials.

Nonmagnetic solids are found to be magnetic in nano range.

METAL	BULK	CLUSTER(nano)
Na,K	paramagnetic	Ferromagnetic
Fe,Co,Ni	Ferromagnetic	Superparamagnetic
Gd,Tb	Ferromagnetic	Rotors/superparamagnetic
Cr	Antiferromagnetic	Frustered paramagnetic
Rh	paramagnetic	Ferromagnetic

5. Structural properties

Reducing the particle size, the surface to volume ratio increase. Which influence the chemical and physical properties of bulk material.

Eg. Melting point and solubility

6. Mechanical properties

The mechanical properties of nanomaterial's increase with decrease in size, because smaller the size, lesser is the probability of finding imperfections such as dislocations and vacancies

Strength of materials improves significantly as the particle size decrease due to perfect defect free surface.

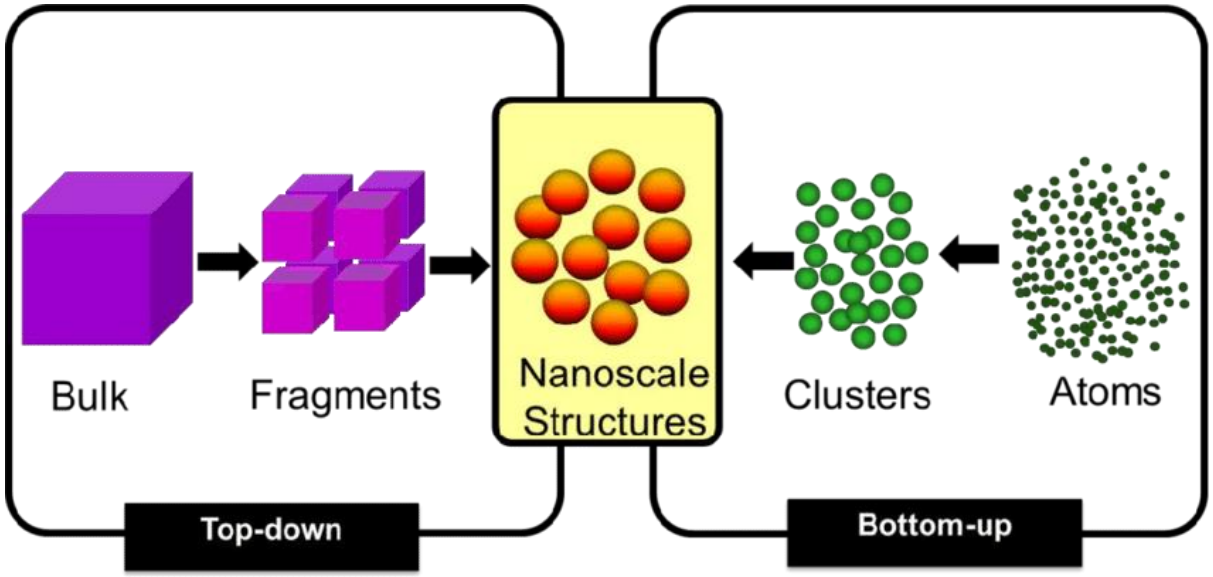
Hardness and strength of material also increase as particle size is decreased.

Elastic modulus and toughness of material also increase as particle size is decreased.

Let us discus the preparation of Nanomaterial's

There are two ways

Top down **Bottom up**



Top -Down	Bottom-up
In this technique the bulk material are breaking down to the size of nanoparticles.	In this technique there is building of nanomaterial's from the atomic scale
This process is used only for hard and brittle materials.	This process is used for gas, liquid and solid as well.
The nanomaterial's prepared by this process may be contaminated by milling tools and atmosphere.	In this method there are less chance of contaminations
E.g. ball milling	E.g. sol-gel method

Method of synthesize Nanomaterial's:

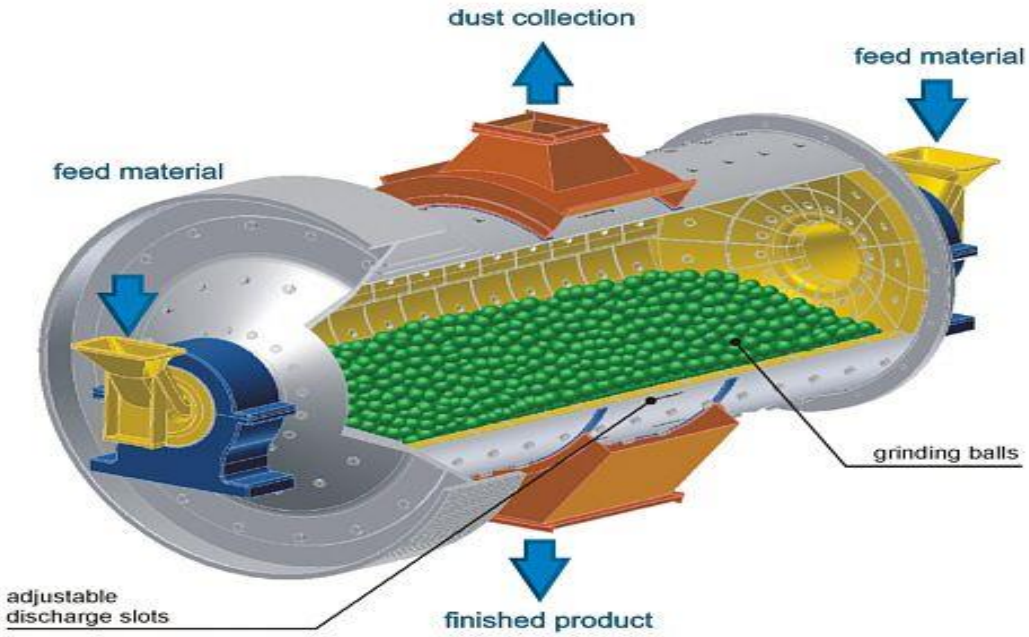
Ball milling method

It is Top down method

Ball mill is a type of grinder used for grind of bulk materials.

Principle

It works on the principle of impact and attrition (collision)



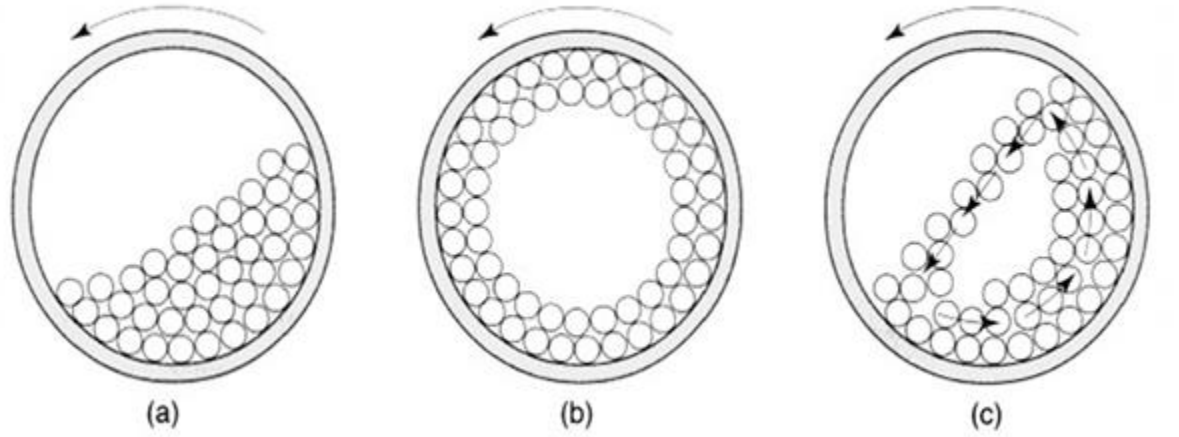
Construction

Cylinder- it consist of hollow cylinder which rotate continuously

Metal balls- it consists different size spherical metal balls made by stainless steel.

at very low speed

at correct speed



at very high speed

Working

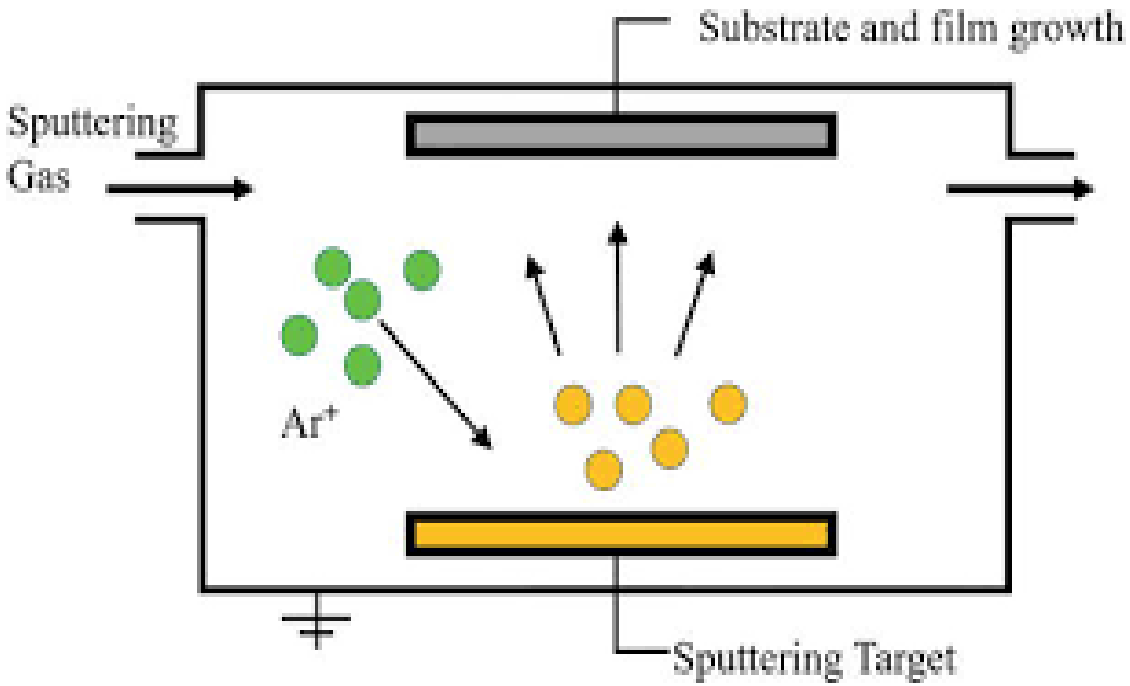
Material whose nanoparticles to be prepared are filled in the cylinder up to 60% of the total volume.

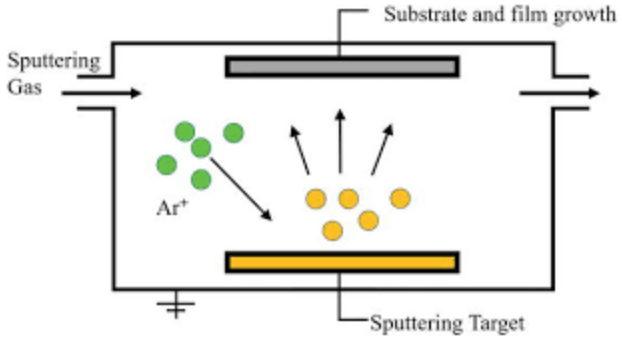
Metal balls are filled into the cylinder up to 30 to 40 % for suitable time

In this method the speed of cylinder is very important it should not be very low or very high. It should be rotated at correct speed.

Sputtering method

Sputtering is the **process** whereby atoms are ejected from a target or source material that is to be deposited on a substrate





Sputtering involves ejection of atoms from a target (i.e. source) and get deposit onto a substrate.

This method is carried out in vacuum or in an inert gas (argon gas).

Argon atoms being positive get attracted towards the target (which is kept at negative potential) and hit the target with very high velocity and remove the target atoms.

An ejected atom carries a large amount of K.E. due to large amount of potential difference is applied between substrate and target and get deposit on the substrate

The deposition of atoms on substrate forms very thin films which can be controlled by varying potential difference , gas pressure and time of sputtering process.

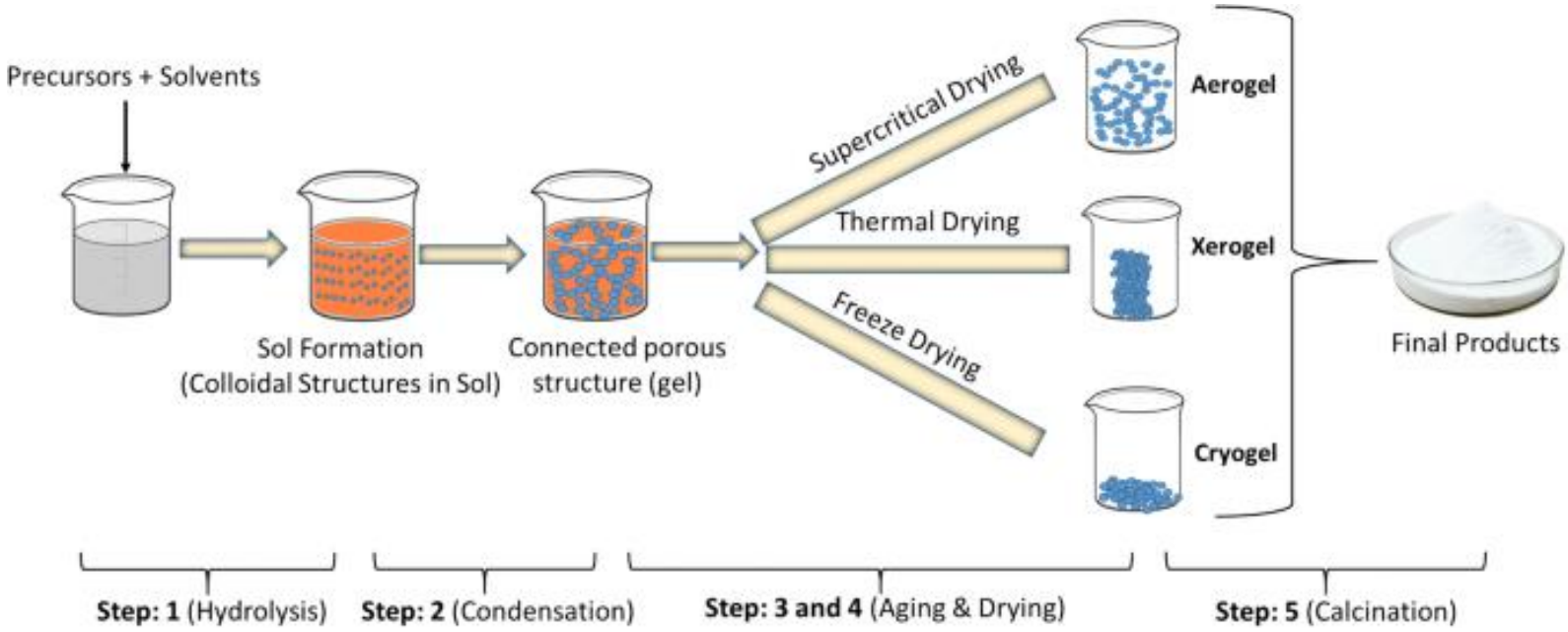
Sol- Gel method

Sol-Gel Technologies for nanomateials fabrication

Sol

Gel

The sol-gel method is the bottom-up approach technique for preparation of Nano particles



Preparation of sol

When solid particles are dispersed in liquid is called sol (sol means solution)

When liquid and solid particles are diffused in each other it becomes gel.

The sol-gel solution is taken for drying process which gives Nano particles

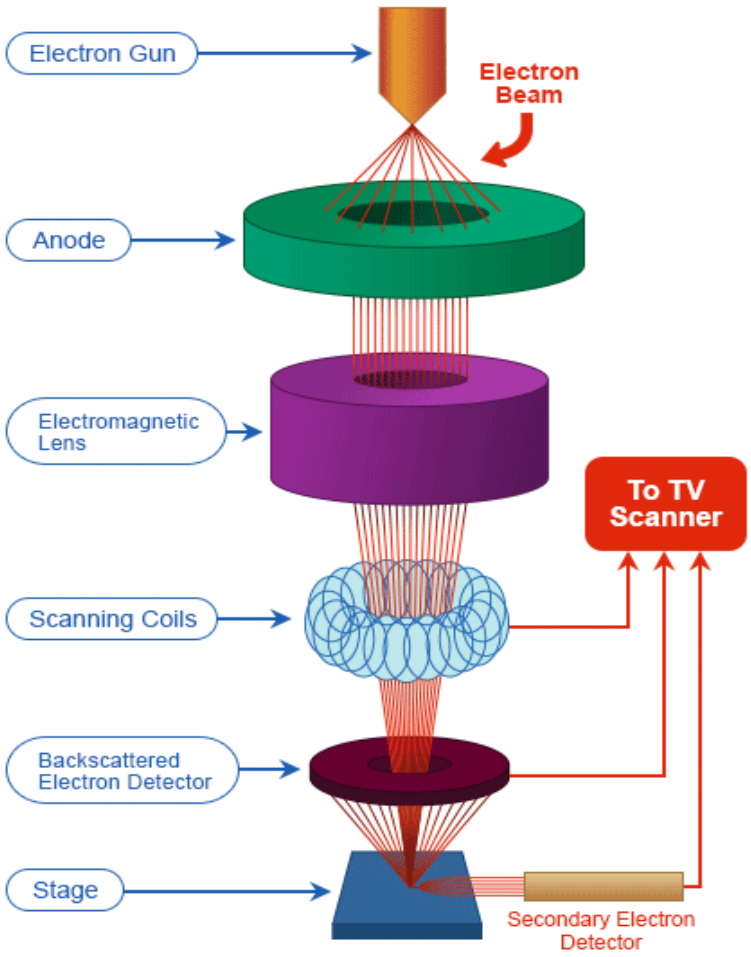
Tools for testing nanoparticles

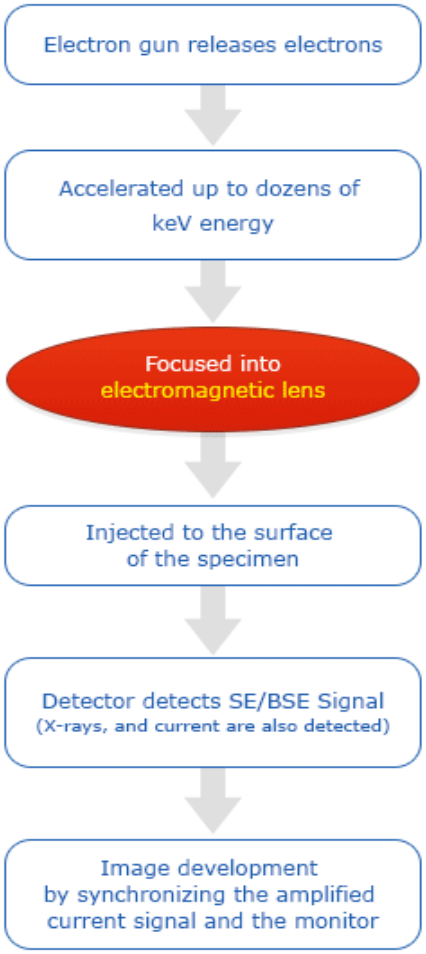
1. scanning electron microscope (SEM)

2. Transmission electron microscopes (TEM)

3. Atomic Force microscopes (AFM)

1. scanning electron microscope (SEM)



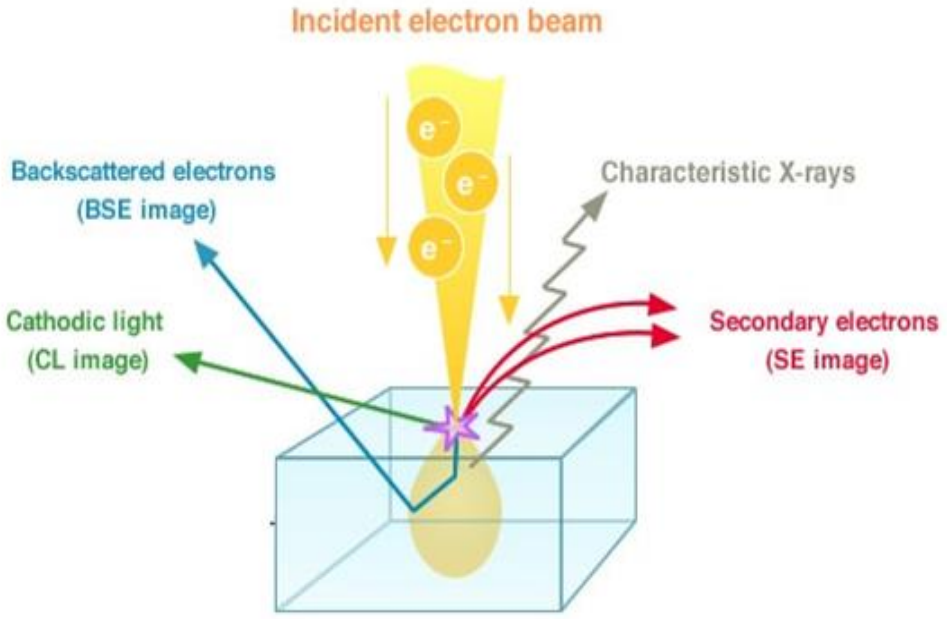


Construction

1 it consisting electron gun for beam of electron

2 electron beams is allowed to pass through magnetic lens and scanning coil for focusing the electron beam.

3 detectors are placed to detect the back scattered electron, secondary electron and x-rays



Principle

In scanning electron microscope, electron which are reflected back from specimen (sample)in the form of

1. secondary electron
2. backscattered electrons and
3. X-rays (photon) are collected and gives the image of the surface of specimen in 3D and black and white

Working

During the scanning, the scattered electron intensities are measured by detector and then displayed on the screen.

Advantages

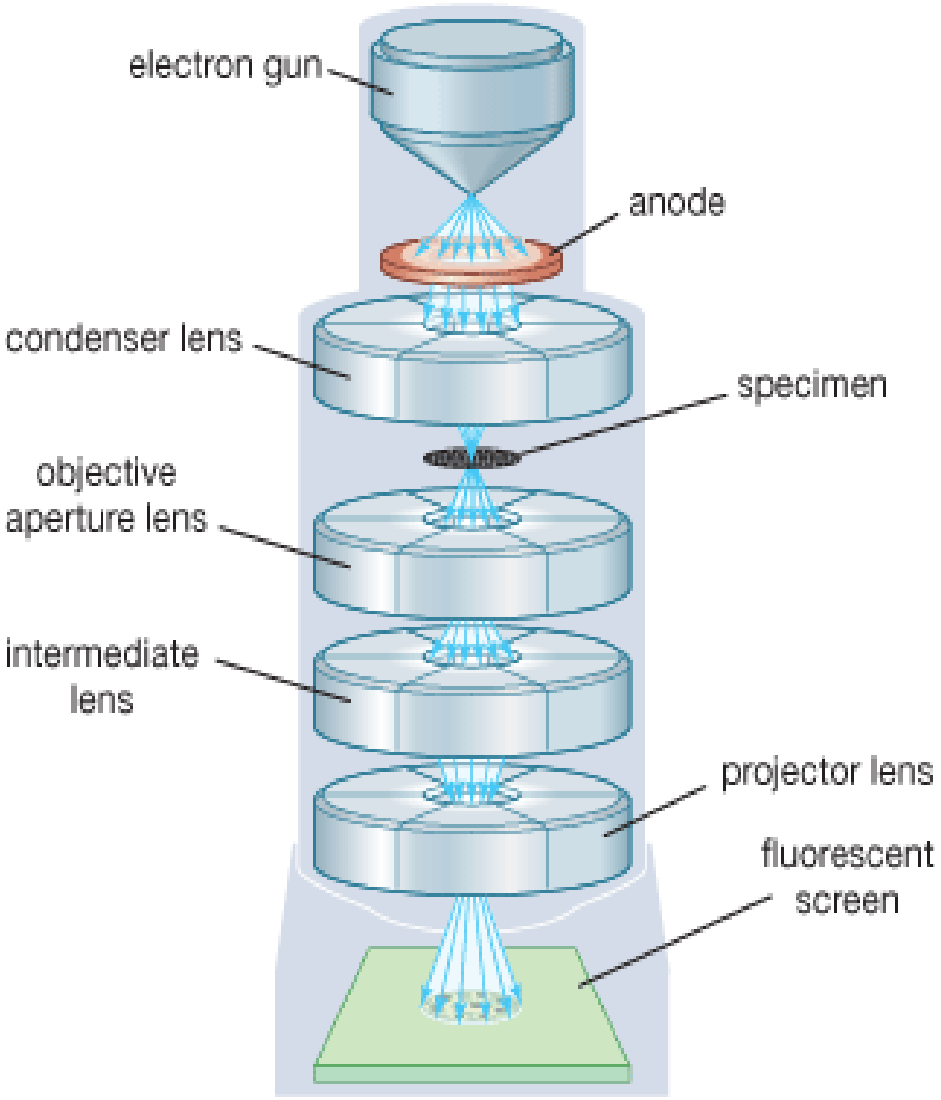
A SEM can produce highly magnified image of resolution between 10 $\dot{A}$ to 100 $\dot{A}$

Disadvantages

1. SEM can produce image of surface only up to few nanometer deep.

2. sample should be conductive otherwise a thin coating of conducting material should be applied

2 Transmission electron microscopes (TEM)



Construction and working

Electron gun

Tungsten filament is used for production of electron beam.

80 to 300 KV accelerating potential voltage is applied to produce electron beam

High voltage is applied for production of electron beam so that it can penetrate the sample.

TEM is operated under vacuum to reduce the any kind of interferences by air.

Anode

It is positively charged and attract the electron from electron beam and accelerate towards condenser lenses

Condenser lenses

They are used to focus the entire electron beam towards the specimen/sample.

Objective lenses

They are used to focus the transmitted beam towards the projector lenses.

Projector lenses

It will magnify the transmitted beams coming from the objective lenses and focused towards the fluorescence screen.

Advantages

1. 3D images is obtained

2. very small amount of specimen is required

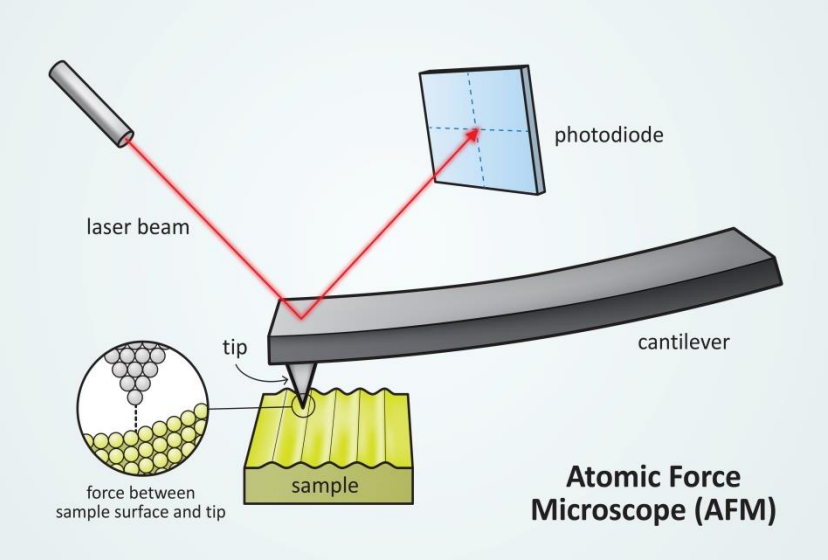
Disadvantages

1. Sample preparation is necessary

2. High vacuums is required

AFM (Atomic Force Microscope)

It is very high resolution type of scanning microscope. It gives 1000 times better images than optical microscope.



Principle:

The principle behind of this microscope technique is that in this method a laser beam is focused on the back of a cantilever that moves up and down on the surface of a specimen and the deflections of the beam are captured by diode

In this method sharp probe moves over the surface of sample at constant distance

The up and down movement of probe as it used to create the image of sample

Advantages

It can be used in air or even within liquid

Sample surface do not required any special treatment

Disadvantages

Scanning speed is low

Tip of cantilever or material can be damaged