NANOTECHNOLOGY

Q1. What are nano materials and what is nanotechnology?

We know all materials are composed of atoms with different sizes. If we take a material in which the atoms do not move away from each other and with size in the range of 1 to 100 nano meters, these materials are called nano materials.

The technology emerged out of this is called Nanotechnology. Using these highly so latest technology nano materials can be formed from metals, ceramics polymers and even from liquids.

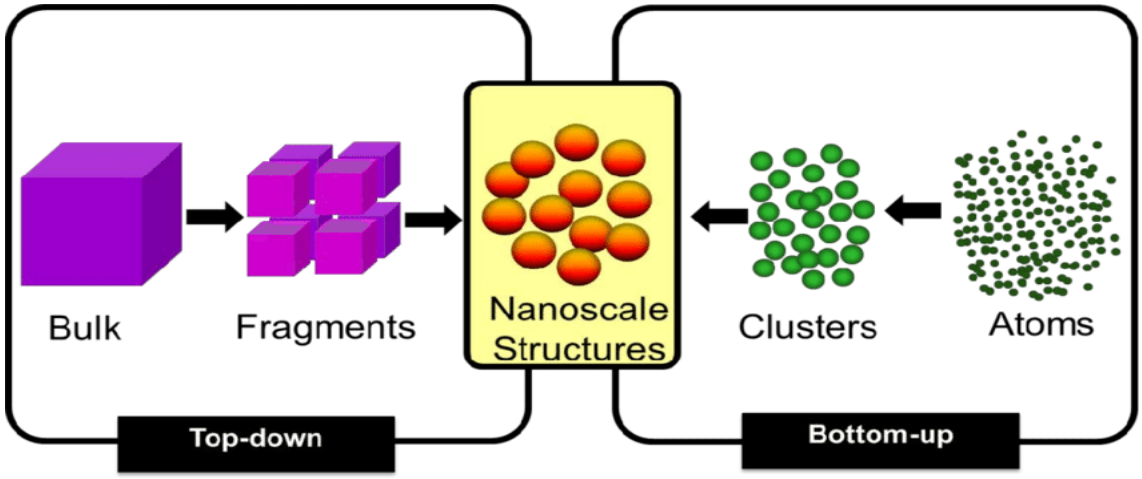
Q2. What are two approaches in nanotechnology

(M.U. Dec. 2015, 16, 17; May 2015, 19) (5 m)

There are two approaches for synthesis of nano materials and the fabrication of nano structures.

(I) Bottom up approach:
In this nanomaterials are made by building atom by atom or molecule by molecule.

(II) Top down approach:
In this a bulk material is broken or reduced in size or pattern. The techniques developed under this are modified or improved one what we have in use to fabricate micro-processors, micro-electro-mechanical system.

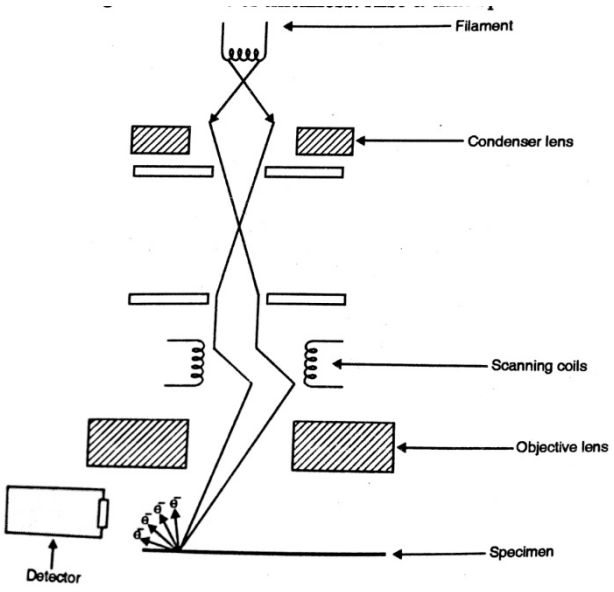


image@https://www.researchgate.net/figure/Top-down-and-bottom-up-synthesis-of-nanofabrication_fig1_277574475

Q3. Write a short note on Scanning Electron Microscope (SEM)

(M.U. May 2013, 14, 17 ;Nov 2018;Dec 2013, 14, 16, 19)(5m)

- SEM is used to obtain images of surface of thickness. Also a thin specimen can be studied. Construction of TEM includes an arrangement that makes it possible for an electron beam to scan the specimen similar to that we have in TV picture tube.
- Here electron beam is obtained from electron gun and it is made to pass through condenser lens. Next stage is of scanning coil which is used to focus the electron beam on a small spot on specimen surface and also to scan the surface like electron beam scans in TV picture tube.



- Image formation in SEM is due to two main combining aspects.
  - Scattering of electron beam is because of atoms on the surface of the specimen and these atoms have different scattering power.
  - Topographical variations of the surface.

  Actually, the aspects mentioned above are also responsible for the contrast which is essential for image formation.
- During the scanning of atoms by electron beam, the scattered electrons intensities are measured by detector and then displayed on the screen. If the scattering is high at a particular point during the scanning, the corresponding point on the viewing screen will be bright and for low scattering, the corresponding point on the screen will be dark. This develops required contrast for a clear image of the specimen.
- Specimen as small as 50A° size may be clearly resolved by SEM.

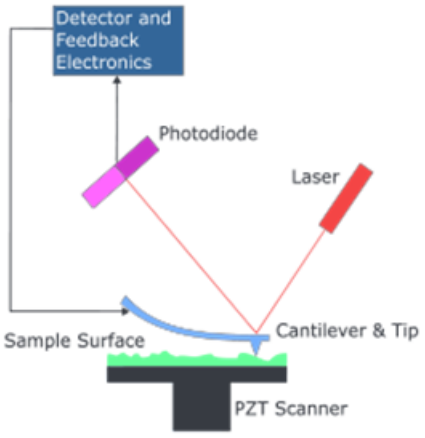
Q4. Write a short note on Atomic Force Microscope

(M.U. Dec. 2012, 16, 17; May 2015, 16, 19) (5 m)

Atomic Force Microscopy (AFM) is arguably the most versatile and powerful microscopy technology for studying samples at nano-scale. It is versatile because an atomic force microscope can not only image in three-dimensional topography, but it also provides various types of surface measurements to the needs of scientists and engineers. It is powerful because an AFM can generate images at atomic resolution with angstrom scale resolution height information, with minimum sample preparation.

1) Surface Sensing - An AFM uses a cantilever with a very sharp tip to scan over a sample surface. As the tip approaches the surface, the close-range, attractive force between the surface and the tip cause the cantilever to deflect towards the surface. However, as the cantilever is brought even closer to the surface, such that the tip makes contact with it, increasingly repulsive force takes over and causes the cantilever to deflect away from the surface.

2) Detection Method - A laser beam is used to detect cantilever deflections towards or away from the surface. By reflecting an incident beam off the flat top of the cantilever, any cantilever deflection will cause slight changes in the direction of the reflected beam. A position-sensitive photo diode (PSPD) can be used to track these changes. Thus, if an AFM tip passes over a raised surface feature, the resulting cantilever deflection (and the subsequent change in direction of reflected beam) is recorded by the PSPD.



image@https://en.wikipedia.org/wiki/Atomic_force_microscopy

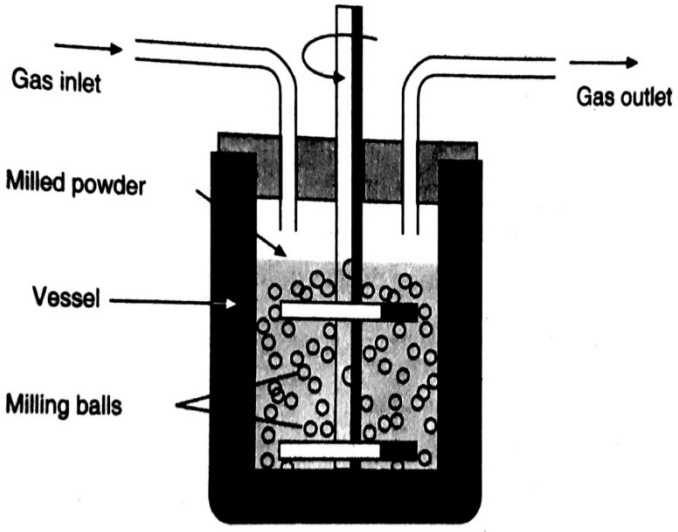
3) Imaging An AFM images the topography of a sample surface by scanning the cantilever over a region of interest. The raised and lowered features on the sample surface influence the deflection of the cantilever, which is monitored by the PSPD. By using a feedback loop to Control the height of the tip above. The surface—thus maintaining constant Laser position—the AFM can generate accurate topographic map of the surface features.

Q5. Explain the Ball Milling method of nanoparticle synthesis

(M.U. May 2013, 14, 17, 18; Nov. 2018; Dec. 2013, 14, 16, 19) (5 m)

It is a process where a powder mixture placed in the ball mill is subjected to high energy collision from the balls. Planetary ball mill is most frequently used system for mechanical alloying since only a very small amount of powder is required. In simple language, a ball mill consists of a hollow cylindrical shell rotating about its axis.

The axis of the shell may be either horizontally or at a small angle to the horizontal. It is partially filled with balls which makes grinding media and made up of steel, stainless steel or ceramic.

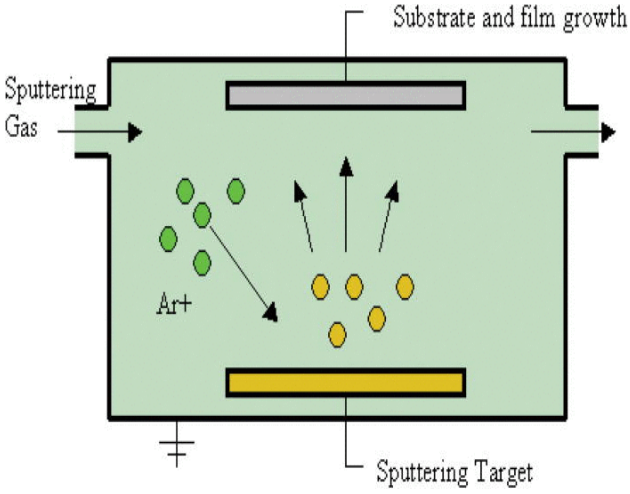


The inner surface of the shell is made up of an abrasion resistant material. When continuously operated, the shell rotates and lifts the balls up and drops them from near the top of the shell which causes the grinding of the particles inside.

Q6. Explain the Sputtering method of nanoparticle synthesis

(M.U. May 2019) (5 m)

Sputtering is a process whereby particles are ejected from a solid target material due to bombarding of target by energetic particles. It is necessary to have kinetic energy of incoming particles much greater than conventional thermal energies.



A typical arrangement of thin film deposition using sputtering is shown in given figure. A sufficiently

large potential difference is maintained between the substrate and the target. Argon gas is introduced into the enclosure at low pressure which can be varied.

The argon atoms get ionized due to the large potential difference. The positive argon ions hit the target with a large velocity and dislodge its atoms. The atoms move towards the substrate and get deposited on it.

The thickness of the film can be controlled by varying the argon gas pressure and the time for which the sputtering process is carried out. Thickness as small as a fraction of a nanometre, i.e., atomic monolayers, have been successfully deposited using this method.

Q7. Explain the Vapour Deposition method of nanoparticle synthesis

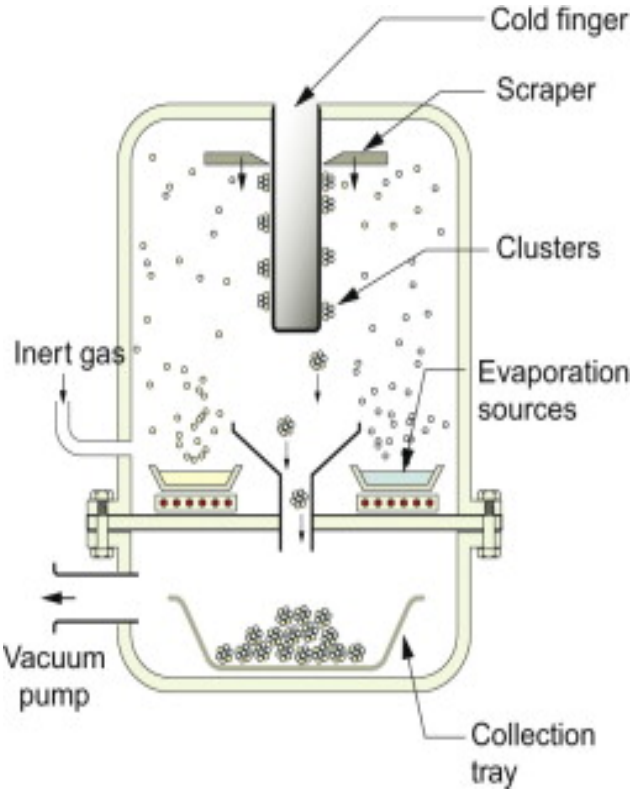
(M.U. May 2013, 14, 17, 18; Nov. 2018; Dec. 2013, 14, 16, 19) (5 m)

The bulk material kept in a crucible is evaporated and the particles formed are blown away by using an inert gas towards the liquid nitrogen cooled cylinder called cold finger.

This assembly is placed in an evacuated chamber.

The evaporated particles get condensed and are collected on the cold finger, which are scraped off and fall into collection tray from the funnel.

The size of particles is controlled by changing the distance between the crucibles and the cold finger and by changing the inert gas pressure.



Q8. Explain the SOL- Gel Technique method of nanoparticle synthesis

(M.U. May 2013, 14, 17, 18; Nov. 2018; Dec. 2013, 14, 16, 19) (5 m)

Nano particles and nano powder is obtained using this technique. In general, sol-gel technique is based on the hydrolysis of liquid Precursors and formation of colloidal solutions.

Out of few more processes, hydro dynamic cavitation is often used; in which nanoparticles can be generated through creation and release of gas bubbles inside the sol get solution.

Here, the sol get solution is taken in a drying chamber and thoroughly mixed by applying enormous pressure, high temperature and further exposing it to cavitational disturbances.

This process creates hydrodynamic bubbles in the sol gel. These bubbles will undergo nucleation, growth and then it quenches to form nano particles.