Unit 5: NANOTECHNOLOGY

Q5.1. What are nano materials and what is nanotechnology?

We know all materials are composed of atoms with different sizes. Any material having very closely packed atoms within the size range of 1 to 100 nanometres are called nanomaterials.

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

Q5.2. What are two approaches in nanotechnology?

(M.U. Dec. 2015, 16, 17; May 2015, 19) [5 marks]

There are two methods for the production of nanomaterials: as shown in *Figure 5.2.1*.

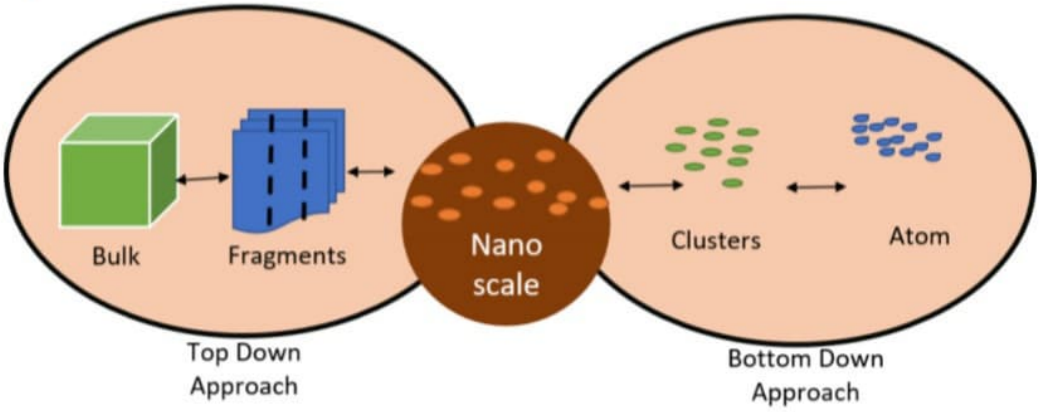

Figure 5.2.1: Techniques of Nano synthesis

(I) Bottom-up approach:
In these nanomaterials are made by building atom by atom or molecule by molecule.
These approaches include:
1)chemical synthesis
2)self-assembly
3)positional assembly

(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.

Q5.3. Write a short note on Scanning Electron Microscope (SEM)?

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

- 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 tubes.
- Here as shown in *Figure 5.3.1* electron beam is obtained from electron gun and it is made to pass through a condenser lens. Next stage is the 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 tubes.

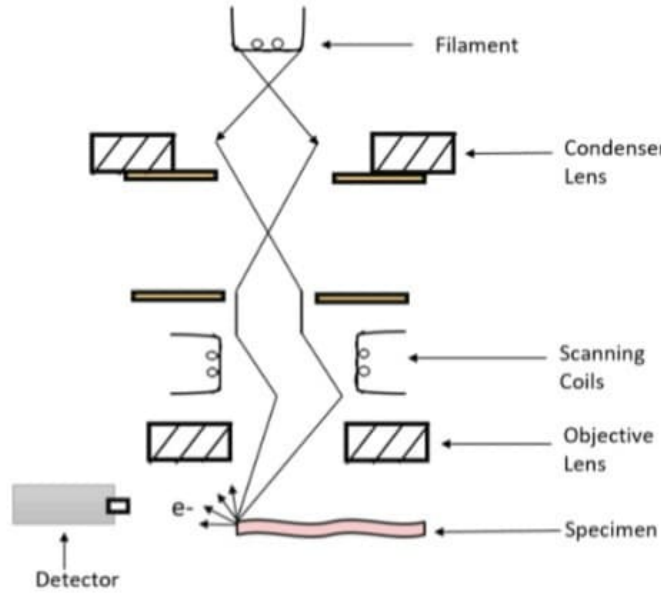

Figure 5.3.1: Scanning Electron Microscope

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

Q5.4. Write a short note on Atomic Force Microscope?

(M.U. Dec. 2012, 16, 17; May 2015, 16, 19) [5 marks]

Atomic Force Microscope or the AFM is a scanning microscope used as an imaging device. It works on the basic principle of recording the scattering of electromagnetic radiation i.e. when the laser beams are scattered off of the surface of the sample material, the readings are recorded by the microscope. These readings are detailed to the atomic level and the three dimensional images produced have atomic resolution.

- The AFM consists of a sharp tip probe which is attached to a cantilever on the top. The tip of the probe is about 1 nm in radius and the length of the cantilever is about 10 nm . The surface of the cantilever is highly reflective.
- A laser beam is passed through an optical fibre to be made incident on the surface of the cantilever. As the probe moves around the surface of the sample it experiences different kinds of forces.
- This in turn makes the cantilever undergo deflection. These deflections are recorded with the help of photo detectors.
    - Depending upon the material the forces could be electrostatic, mechanical, magnetic or even Van Der Waals forces.
- The readings from the photo detectors are then processed and used to create three dimensional images of the topography of the sample.
- The resolution of the image is in nanometers.

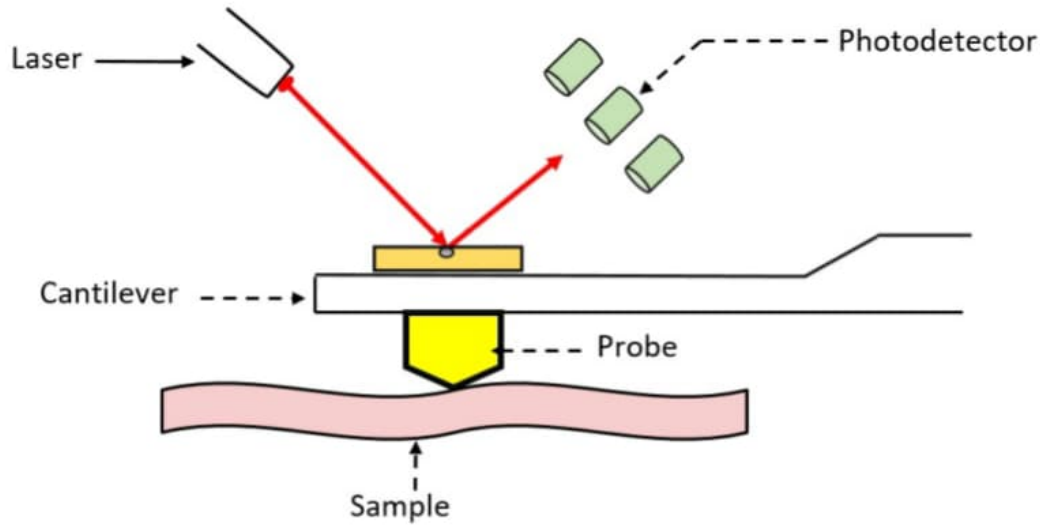

Figure 5.4.1: Atomic Force Microscope

Q5.5. Explain the Ball Milling method of nanoparticle synthesis?
(M.U. May 2013, 14, 17, 18; Nov. 2018; Dec. 2013, 14, 16, 19) [5 marks]

- Ball Milling method is a physical/mechanical process of creating nanoparticles.
- In this method small hard steel balls are used to make nanoparticles.
- These balls are kept in a container along with the powdered form of the material.
- These containers are made to rotate about their own axis while revolving around in a circular motion.
- This creates centrifugal and centripetal forces which cause the steel balls to collide with the powdered material continuously and create nanoparticles.
- The size of the steel balls are inversely proportional to the size of the nanoparticles they create.
- This method is generally used to create nanoparticles of metals and alloys.

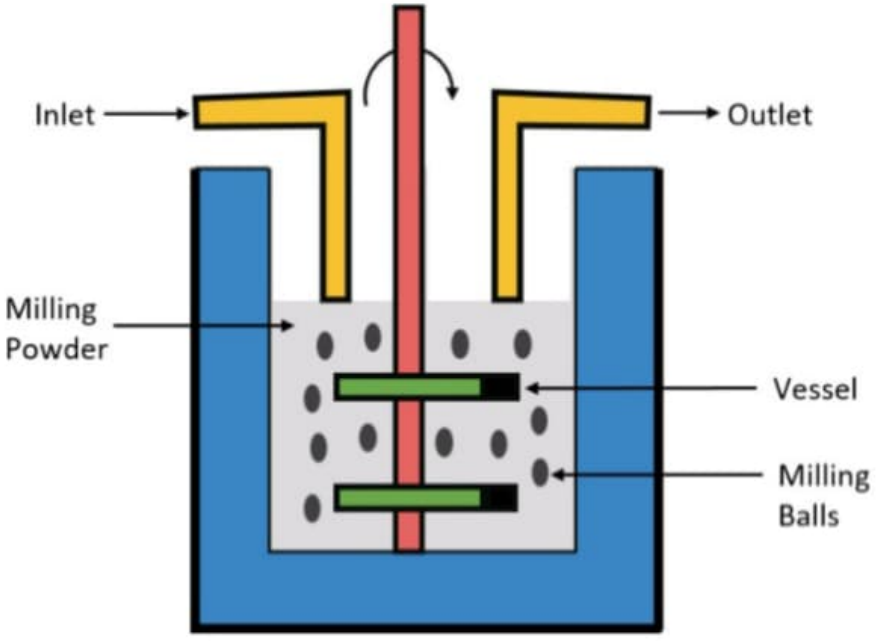

Figure 5.5.1: Ball Milling

Q5.6. Explain the Sputtering method of nanoparticle synthesis?

(M.U. May 2019) [5 mark]

Sputtering is a process in which the target material is subjected to high energy particles. This causes the material to vaporise and the nanoparticles of this material is collected in the collecting rod.

A typical arrangement of thin film deposition using sputtering is shown in the 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.

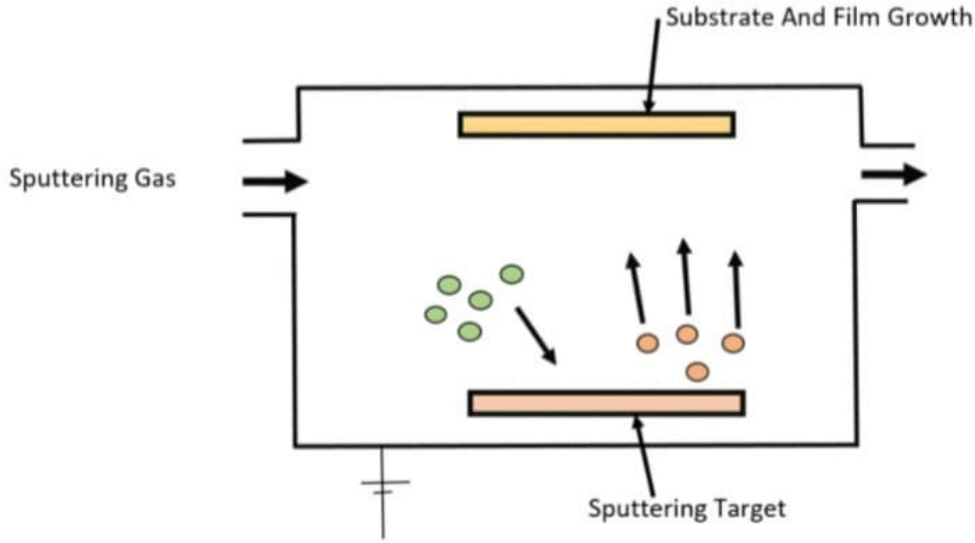

Figure 5.6.1: Sputtering

Q5.7. Explain the Vapour Deposition method of nanoparticle synthesis?

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

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.

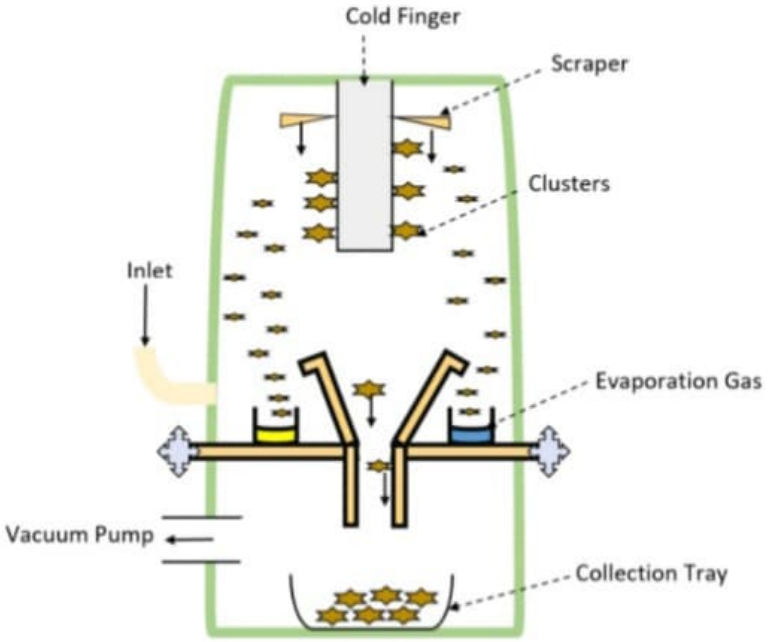

Figure 5.7.1: Vapour Deposition

Q5.8. Explain the SOL- Gel Technique method of nanoparticle synthesis?

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

- Sol-gel method is a chemical process used to synthesize nanoparticles. It is one of the best and efficient methods to synthesize nanoparticles.
- In this method a solution is used with particles suspended in it.
- A powdered form of the material to be synthesized is mixed with chemicals to form the solution or sol. As time passes, long chained polymers are formed in this solution.
- These long chained polymers result in the formation of gel. Only a part of the sol gets converted to gel.
- The sol-gel method with the cavitation effect produces nanoparticles.
- The sol-gel method is a bottom up approach and it can be used to produce nanoparticles of almost any material.

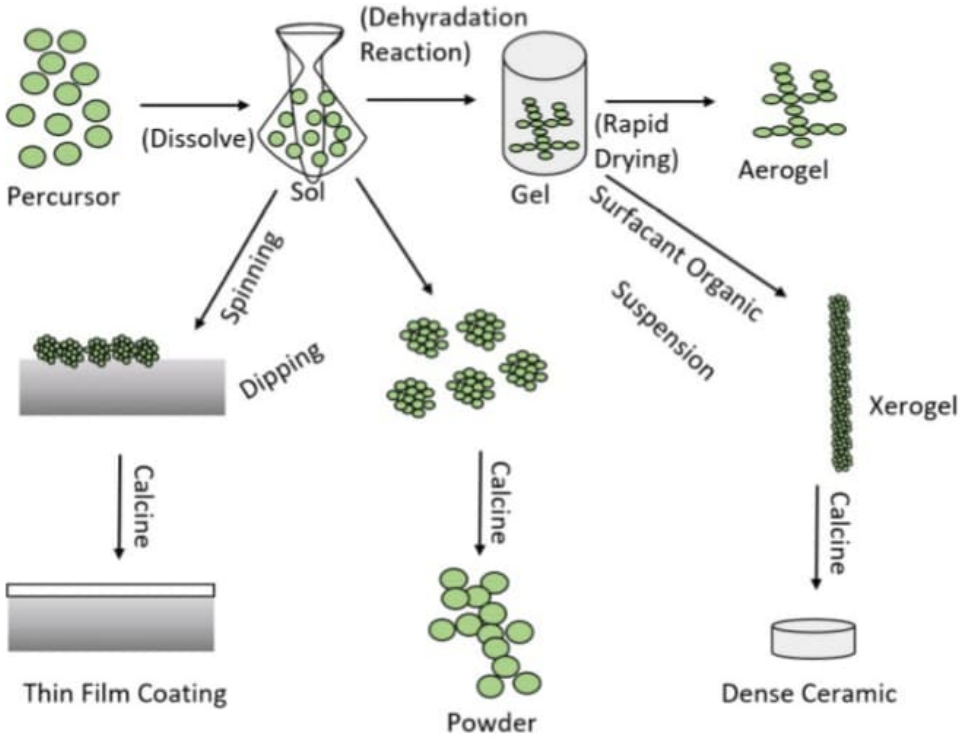

Figure 5.8.1: SOL Gel Technique