

UNIT II . Chemistry of Nanomaterials

Method of synthesis of nanomaterials

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

- Top-Down approach
- Bottom-up approach.

Differences between Top-Down and Bottom approach methods of synthesis.

Top Down approach

1. In top-down approach refers to slicing or successive cutting of a bulk material to get nano sized particle
2. In Top-down Techniques the starting material is solid state
3. Physical methods involved in Top-Down approach are
 - Mechanical methods:
 - cutting, etching, grinding
 - ball milling
 - Lithographic techniques
 - Photo lithography
 - Electron Beam lithography.

Bottom-up approach

1. Bottom-up approach refers to building what we want by assembling it from building blocks (such as atoms and molecules).
2. All the Bottom up techniques the starting material is either gaseous state or liquid state of matter.
3. In this case both Physical and chemical techniques are used. Which are following
 - Physical techniques:-
 - Physical Vapour Deposition (PVD).
Involves condensation of vapour phase species.
 - Evaporation (Thermal, e-beam)
 - Sputtering
 - Plasma Arcing.
 - Laser ablation

Top-Down approach

4. Top-down refers to the traditional workshop or microfabrication method where tools are used to cut, mill and shape materials into the desired shape and order.

5. Advantages

- Large scale production: deposition over a large substrate is possible
- Chemical purification is not required.

Disadvantages

Yields

- broad size distribution (10-1000 nm)
- Varied particle shapes or geometry.
- control over deposition parameters is difficult to achieve.
- impurities: stress, defects, and imperfections get introduced.
- Expensive technique

Bottom-Up approach

Chemical technique

- CVD: Deposition of vapour phase of reaction species

- PECVD (RF-PECVD, MPECVD)

• Self-assembled Monolayers:

Electrolytic deposition, sol-gel method, Microemulsion route, pyrolysis.

4. Bottom-up refers to methods where devices 'create themselves' by self assembly. Chemical synthesis is good example.

5. Advantages

- Ultra-fine nanoparticles, nanoshells, nanotubes can be prepared.
- Deposition parameters can be controlled.
- Narrow size distribution is possible (1-20 nm)
- Cheaper technique

Disadvantages

- Large scale production is difficult.
- Chemical purification of nanoparticles is required.

Q: How to synthesize nanoparticles?

- The key to make nanoparticles is how to control and stop the reaction to make nano-size products because the properties of nanoparticles depend on their size and morphology.
- Bottom-up should broadly speaking be able to produce devices much cheaper than the top-down methods, but getting control over the methods is difficult when things become larger and more bulky than what is normally made by chemical synthesis - of course nature has had time to evolve and optimize self-assembly processes that can do wonders.