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Nanotechnology

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Lab. 2: Nanomaterials synthesis

In general nanoparticles can be synthesized by two approaches, "top-down" approach and the "bottom-up" approach.

A. Top-down methods

- Starting material has been **broken down** into nano-sized materials through energy applied on the bulk material which causing reduction in size.

- Require energy for nanoparticles generation it may be (**thermal**, **electrical** or **mechanical energy**).

● Top- down methods involve **chemical** and **physical** techniques like (sputtering, electro-explosion, high energy milling, vapour phase deposition, laser ablation, thermal methods and arc discharge.

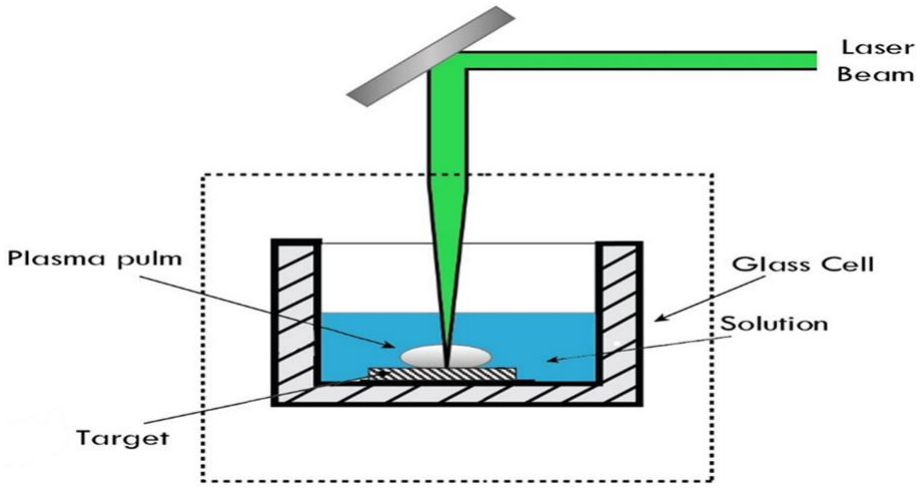
– Laser ablation method

- Laser ablation (LA) is a process by which tiny materials are removed from bulk material samples.

- It is an effective method to synthesize nanoparticles by interactions of high energy laser beam with solids.

- No contamination occurs by laser ablation method.

- Without needing chemical reagents or mechanical contact.



B. Bottom-up methods

-This technique employs buildup (**construction**) of nanomaterials from bottom.

-Assembling **atom-by-atom** or **molecule-by-molecule** through a set of **physical or chemical interactions** among these units.

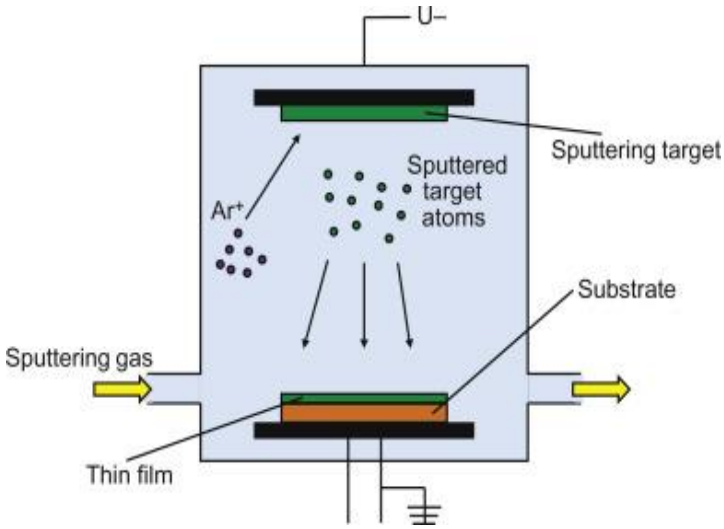
-These interactions may be **Van der Waals forces**, **hydrogen bonding**, or **ionic interactions**. Bottom-up synthesis is also called chemical synthesis, self-assembly and positional assembly.

● Bottom-up can be classified into **chemical** and **physical** techniques like (chemical precipitation method, sol-gel method, solution combustion method, Physical vapor deposition, chemical reduction, electrostatic self-assembly and plasma-enhanced chemical deposition.

– Physical vapor deposition (PVD) method

-The material is **evaporated** from the reservoir and deposited on thin film.

- Deposition is typically very slow (several seconds to achieve 1 nm film thickness).



Molecular manufacturing

• This method constructs things atom by atom.

• A more specific formulation focused on carbon-based, diamond like structure.

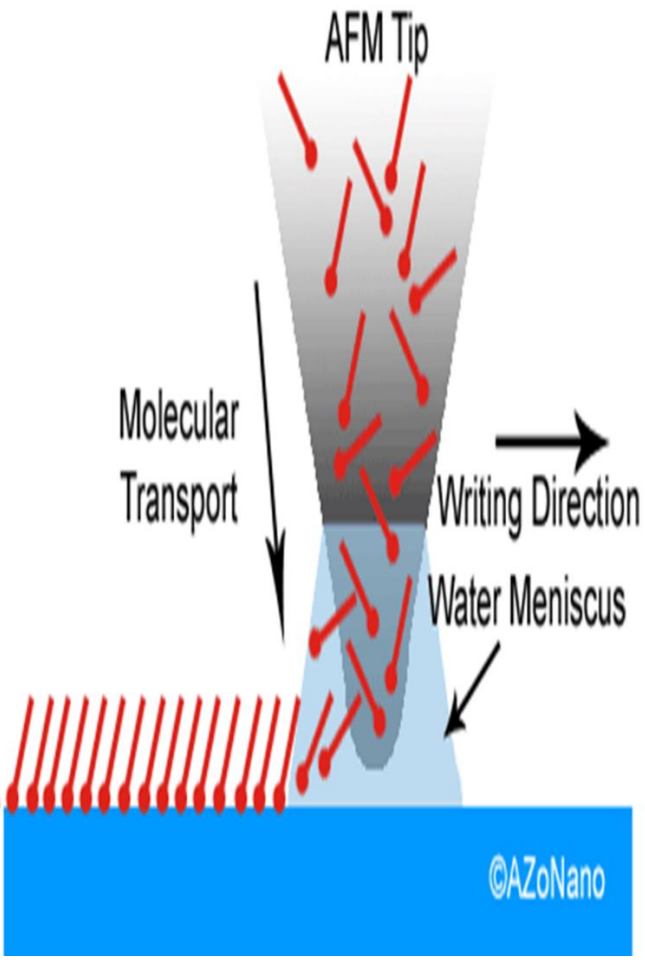
• An appropriately functionalized molecular tool driven by mechanical forces (such as the tip of a scanning probe microscope) abstracts hydrogen from passivated surfaces to for radicals , where other atoms can be added.

• At present, atom-by-atom assembly is very slow and laborious.

• High throughput can only be achieved by massive parallelization, which in turn is only feasible if the required tools can make themselves.

►Significant **acceleration** of the process could take place if "nanoblocks**"** **(pre-** assembled units that may comprise dozens or more atoms) are **manipulated.**

- A related technique, called **Dip-pen nanolithography (DPN),** is a way of picking up solutions of molecules (ink) and allowing it to be transferred to the substratum by capillary action.
- Although **not atomically precise** manufacturing, it **allows** features of the order of **100 nm** to be written.



Random addition of particles to a surface

- Particle deposition is the spontaneous attachment of particles to surfaces.
- The particles in question are normally **colloidal particles**, while the surfaces involved may be planar, curved, or may represent particles much larger in size than the depositing ones (e.g., sand grains). ((Colloid = Non filtered easily or non-settled rapidly))
- Deposition processes may be triggered by appropriate hydrodynamic flow conditions and favorable particle-surface interactions.

- Depositing particles may just form a monolayer which further inhibits additional particle deposition, and thereby one refers to *surface blocking*.
- Initially attached particles may also serve as seeds for further particle deposition, which leads to the formation of thicker particle deposits, and this process is termed as *surface ripening*.

Biological fabrication

• Reproducibility is translated somewhat differently by living processes.

• Although the basic building blocks (e.g., proteins) of living organisms are identical, organisms are not identical in the way that very large scale integrated circuits.

• **For example**, the **magnetic protein ferritin**, which is constituted from an iron oxide core surrounded by protein, could in principle be made on a large scale by low-cost biotechnological manufacturing routes for use in magnetic memory devices.

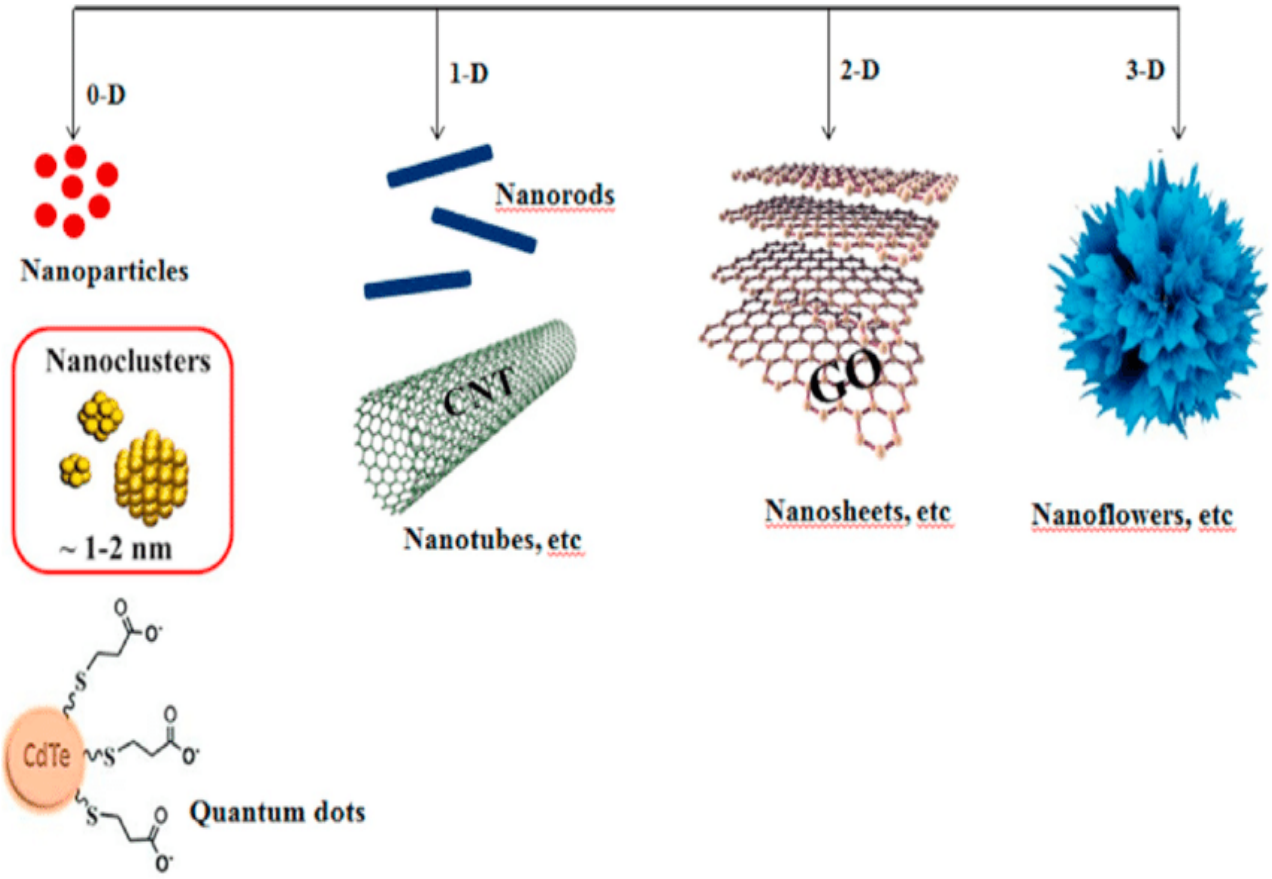
Classification of Nanomaterials

Nanomaterials can be classified dimension wise into following categories.

• **Zero dimension nanomaterials**: all three dimensions are compressed into nanoscale, such as nanoparticles.

• **One dimension nanomaterials**: this group include materials with two dimensions in nanoscale like polymer chains.

• **Two dimensions nanomaterials**: one of their three dimensions is pressed in nanoscale such as thin films.


0-D
1-D
2-D
3-D
Nanoparticles
Nanorods
Nanoclusters
~ 1-2 nm
CNT
GO
Nanotubes, etc
Nanosheets, etc
Nanoflowers, etc
CdTe
Quantum dots