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Nanotechnology

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.

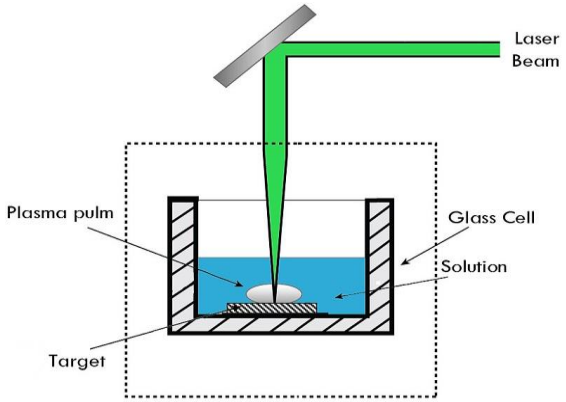
- Require energy for nanoparticles generation it may be (thermal, electrical or mechanical energy).

- Top- down methods involves 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 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.

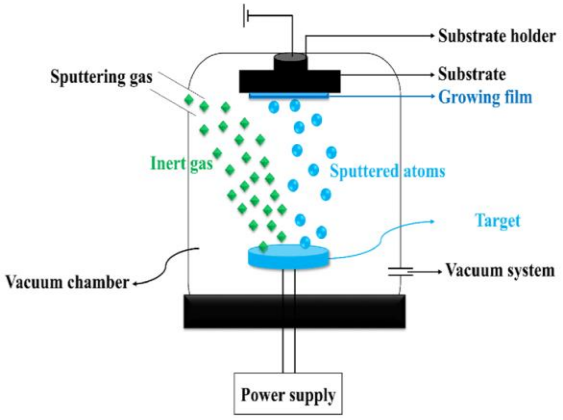
- These interactions may be Van der Waals forces, hydrogen bonding, or ionic interactions. Bottom-up synthesis is also called chemical synthesis, self-assembly and positional assembly.

- 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 de-posited on thin film.

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



Molecular manufacturing

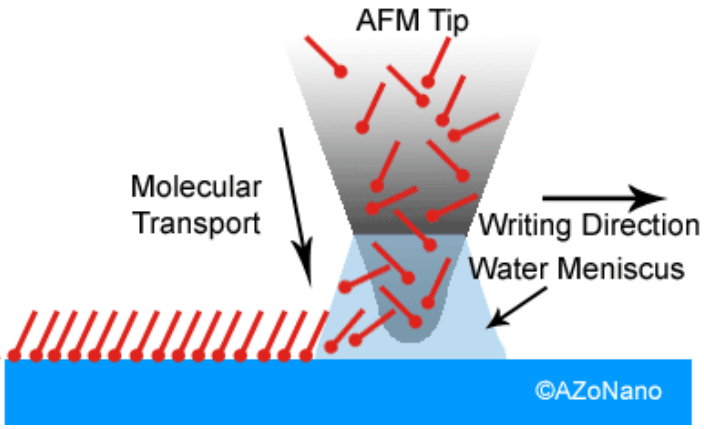
• This method constructs things atom by atom.

• 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 passivized 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

rapidly.

than the depositing ones (e.g., sand grains). ((**Colloid = Non filtered easily or non-settled**

- 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.