



Nanotechnology

Lecture 5

Nano-Material Fabrication Methods

Al-Mustaqbal University Department of Medical Physics

4nd stage

Second Course

Dr. Forat Alsultany

Msc. Ali Jaafar Obeid

2025- 2026

Classification of nano-materials fabrication

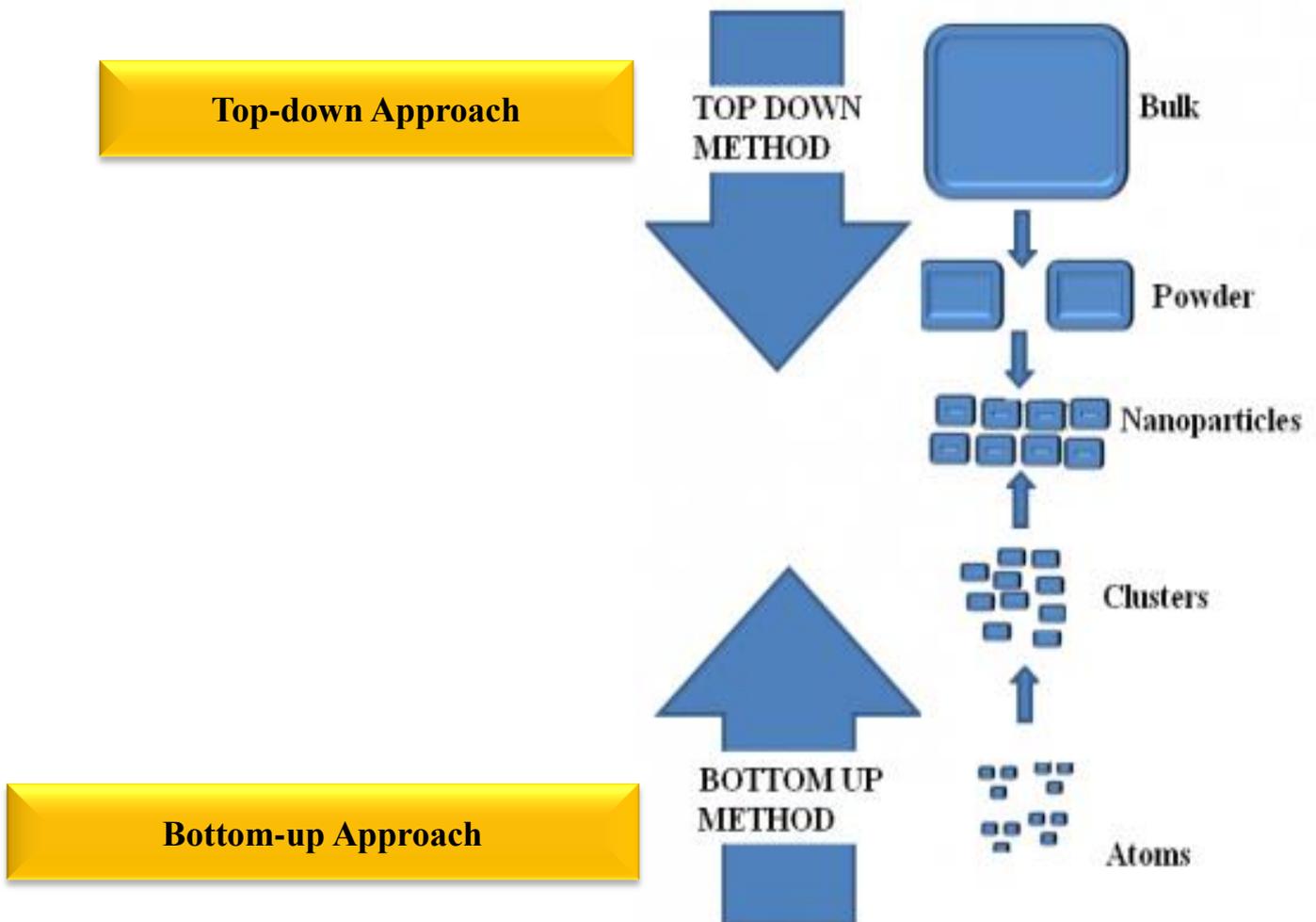
- ❑ Fabricating materials at the nanoscale is basically a choice between two approaches or two classification :

Building up from atoms or carving down from bulk materials.

In the world of nanotechnology, these are classified as Top-Down Approach and Bottom-Up Approach.

- ❑ The interesting in the classification and fabrication method of nanomaterials because their properties ability to determined by fabrication method

Classification of nano-materials fabrication



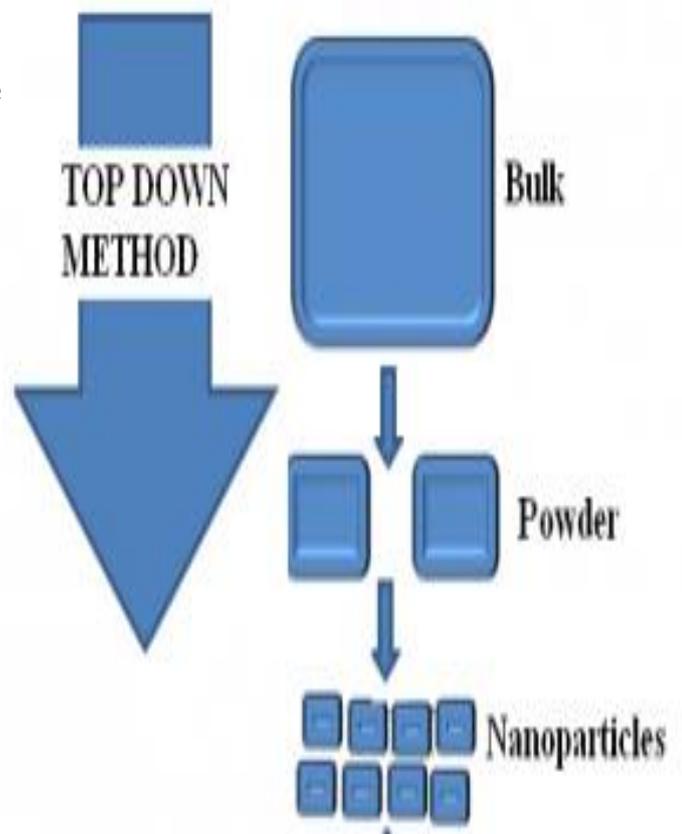
Top-down Approach

In the concepts of nanotechnology and engineering, the **top-down approach** is a fabrication method that starts with a large or bulk piece of material, and then reduce the size of the material to the nanoscale.

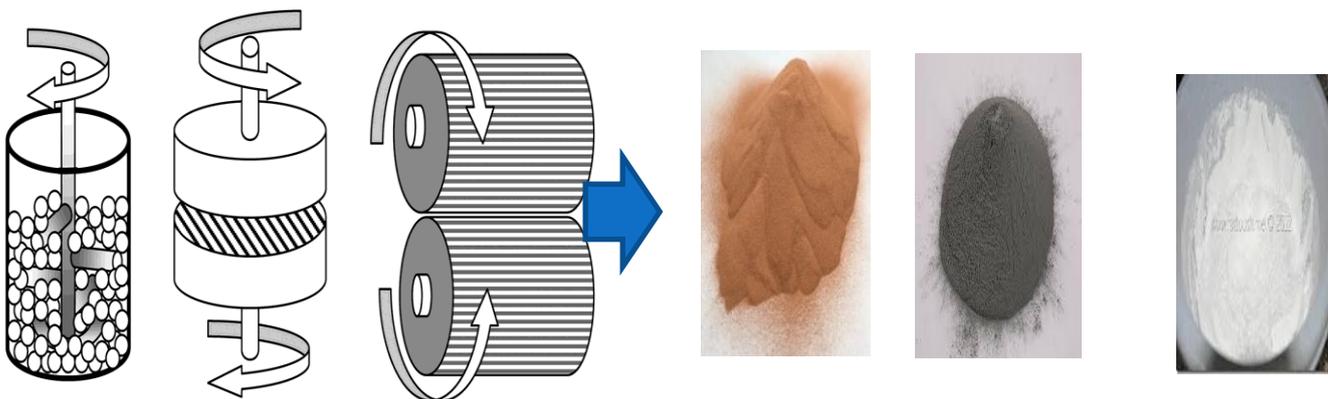
or : It is reduced in size of material from large size to smallest size (nano-size)

Top-down Approach include;

- 1- Mechanical Grinding (Milling)
- 2- Thermal Evaporation
- 3- Laser Ablation



1- Mechanical Grinding (Milling) Method



Mechanical Grinding (Milling) Method

Mechanical grinding is a ‘top down’ method of fabrication of nanomaterials by decomposition of materials, where achieved using high energy mills, vibrators, and electric mixers.

or **Mechanical grinding** is defined as a method used to synthesize nanostructured materials or mixtures of different phases without compositional change, primarily through ball milling. It enables the reduction of particle size to the micrometer scale while achieving crystallite sizes in the nanometer range.

Properties of mechanical grinding (milling)

- (i) **Simple method.**
- (ii) **Cheap equipment.**
- (iii) **Possibility of making of all types of materials.**
- (iv) **Possibility for increasing the quantities of material.**

Disadvantages (problems) of mechanical grinding (milling)

- (i) **Impurity from milling media and/or atmosphere.**
- (ii) **Product is not uniform in size of nanomaterials .**

2- Thermal Evaporation Method

Thermal evaporation can be defined as follows :

- It is a typical example of ‘**bottom-up**’ method.
- This process begins by **heating the powder to a specific temperature.**



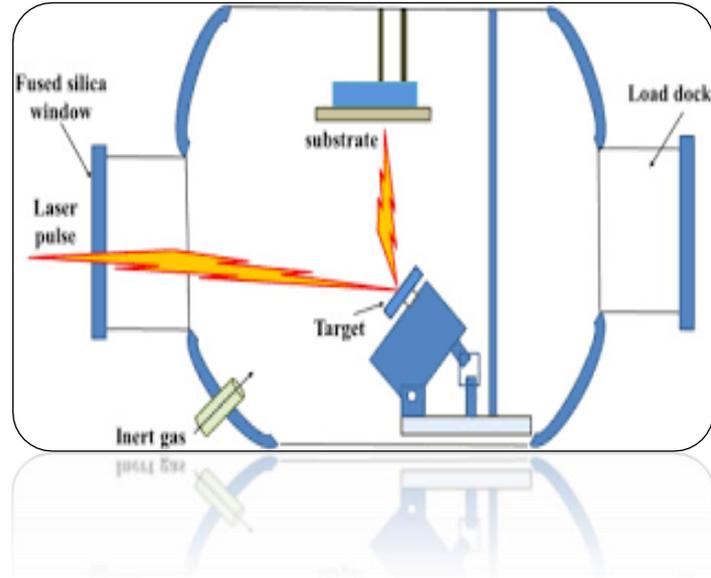
- During the heating process, the atoms of powder will evaporated into an atmosphere inside the tube furnace.
- The vapor of the powder will condense into the substrate with or without the inert carrier gas (e.g. He, Ar) to produce nanomaterials.

Properties of Thermal Evaporation Method

- It is one of the oldest and simplest forms of physical vapor deposition
- High deposition rates
- High efficiency
- Low equipment cost
- High purity nanomaterial films

3- Laser Ablation Method

- Laser ablation method is a "top-down" fabrication method
- This method depend on heating the target using a pulsed laser in the chamber.



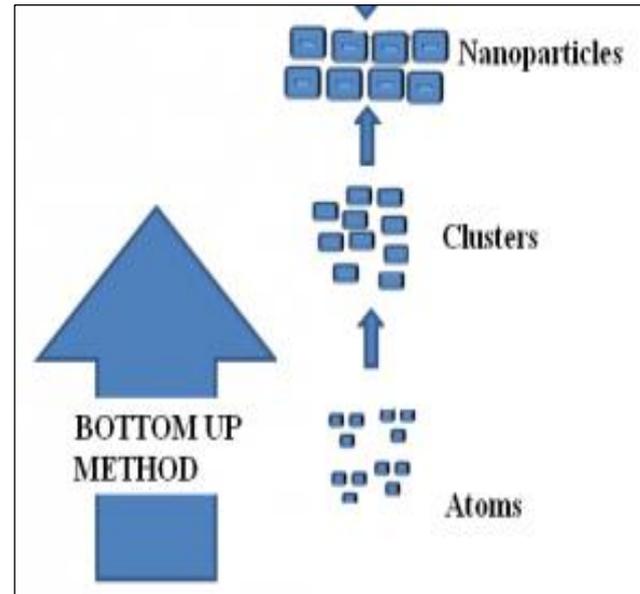
- This method uses a high-energy laser beam to remove particles from the solid surface of a target
- Then condense into clusters of atoms or molecules on a specific substrate to create nanomaterials

Properties of Laser Ablation Method

- High accuracy
- It is simple
- It is rapid
- It works on almost any class of material
- The end product has easily tunable properties.

Bottom-up Approach

The **bottom-up** is an approach where structures are built by collect atoms, molecules, or clusters on top of each other until the desired (required) shape and size of nanomaterial is achieved .



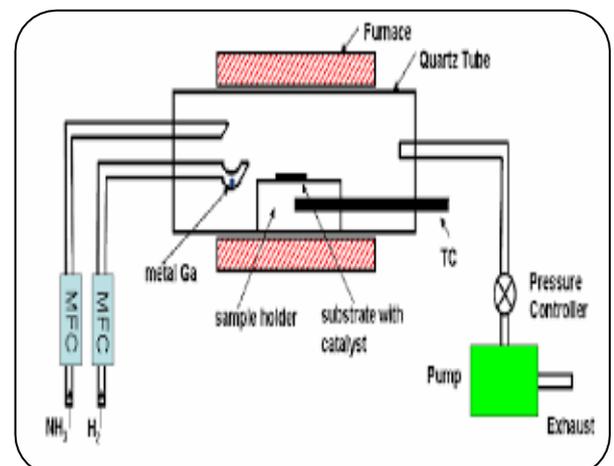
In this process, **physical or chemical forces** (like **Van der Waals forces, hydrogen bonding, or DNA hybridization**) guide the atoms to arrange themselves into organized structures without external human manipulation for every single atom.

Top-down Approach include;

- 1- **Chemical Vapor Deposition (CVD)**
- 2- **Sol-Gel Method**

1- **Chemical Vapor Deposition (CVD)**

Chemical Vapor Deposition (CVD) is a 'bottom-up' method of fabrication of nanomaterials used to produce high-quality, high-performance solid materials, usually under vacuum.



- ✓ If you've ever used a **smartphone** or a **laptop**, you are carrying around products **made with CVD**

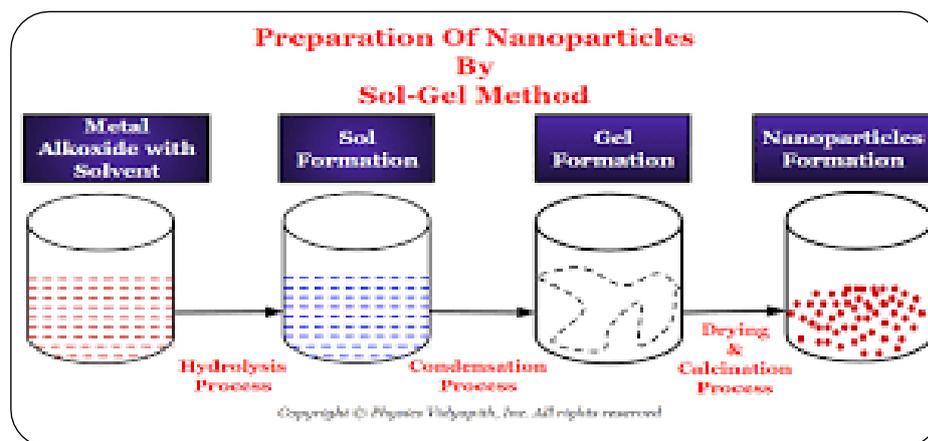
How the Process Works ?

- 1. Transport:** The gases are pumped into a reaction chamber.
- 2. Reaction:** When the gases contact the heated substrate, a chemical reaction occurs.
- 3. Deposition:** This reaction breaks down the gas molecules, leaving a solid layer of the desired material on the surface.

Properties of Chemical Vapor Deposition (CVD)

- **Conformity in the shape and size of nanomaterials films**
- **High Purity**
- **It can deposit a wide range of materials, including silicon, carbon , and metallic thin films.**

2- Sol-Gel Method



Sol-gel processing is a 'bottom-up' method of fabrication of solid materials from small molecules by preparation of a sol, gelation of the sol, and removal of the solvent.

or

The sol-gel process is a chemical synthesis technique used to produce solid materials from small molecules.

Properties of Method

- **Low-Temperature synthesis**
- **High Purity and uniformity**
- **Ability to create complex shapes**
- **High surface area**