TYPES OF NANOMATERIALS

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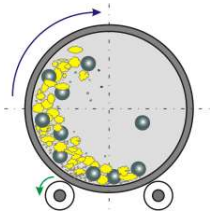
Methods of preparing nanomaterials

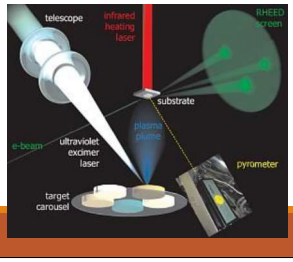
Physical and Chemical methods

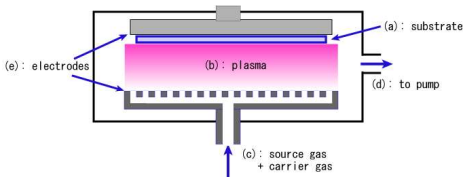
Physical Method -
Grind materials Using ball milling



Evaporate materials to gas phase and solidify

Laser





Chemical methods (most powerful)

React a metal salt with an alcohol or
some other reducing agent

Metal compound along with a reagent
in a boiling solvent (sealed vessel)

Under this condition,
many kinds of nano-particles are formed

Hydrothermal and solvothermal methods

Water used as a boiling solvent - Hydrothermal

Organic boiling solvent like a hydrocarbon - solvothermal

For example, if we take a metal acetate and heat in a boiling hydrocarbon, we get metal or metal oxide nanoparticles

Today we have reached a level where can make nanomaterial of any compound in any shape we desired

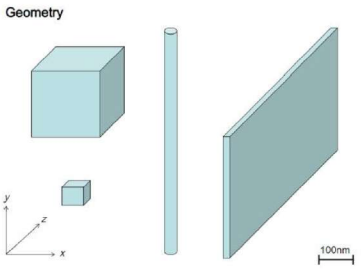
Nanostructured materials

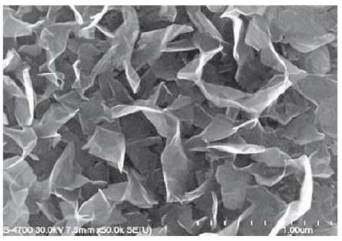
- **3D: Bulk material**
- **2D: Quantum well, Thin films**
- **1D: Quantum wires, nanowires**
- **0D: Quantum dots**

Quantum Confinement

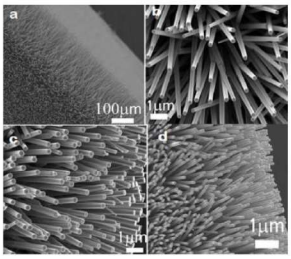
Quantum Confinement is the spatial confinement of electron-hole pairs (excitons) in one or more dimensions within a material.

1D confinement: Quantum Wells
2D confinement: Quantum Wire
3D confinement: Quantum Dot

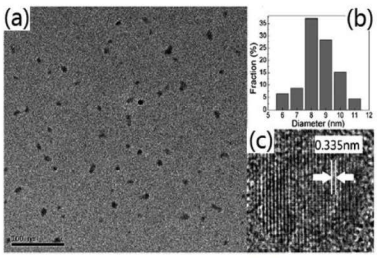




2D-Graphene Nanosheet



1D- ZnO Nanowire



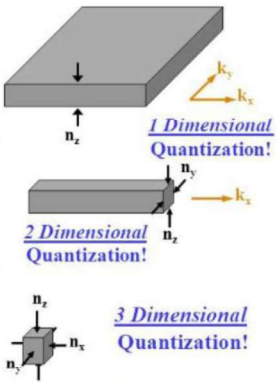
0D- Carbon quantum dots

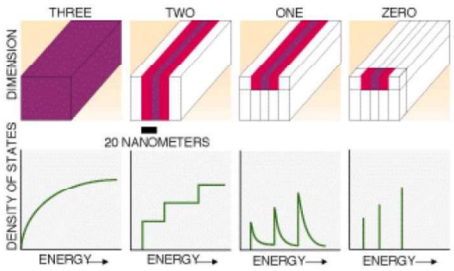
Quantum Confinement in Nanostructures: Overview

Electrons *Confined in 1 Direction*:
Quantum Wells (thin films):
⇒ **Electrons** can easily move in
2 Dimensions!

Electrons *Confined in 2 Directions*:
Quantum Wires:
⇒ **Electrons** can easily move in
1 Dimension!

Electrons *Confined in 3 Directions*:
Quantum Dots:
⇒ **Electrons** can easily move in
0 Dimensions!





- Density of states (dn/dE) is a function of dimensionality.
- Discreteness increases for lower dimensions of particles.

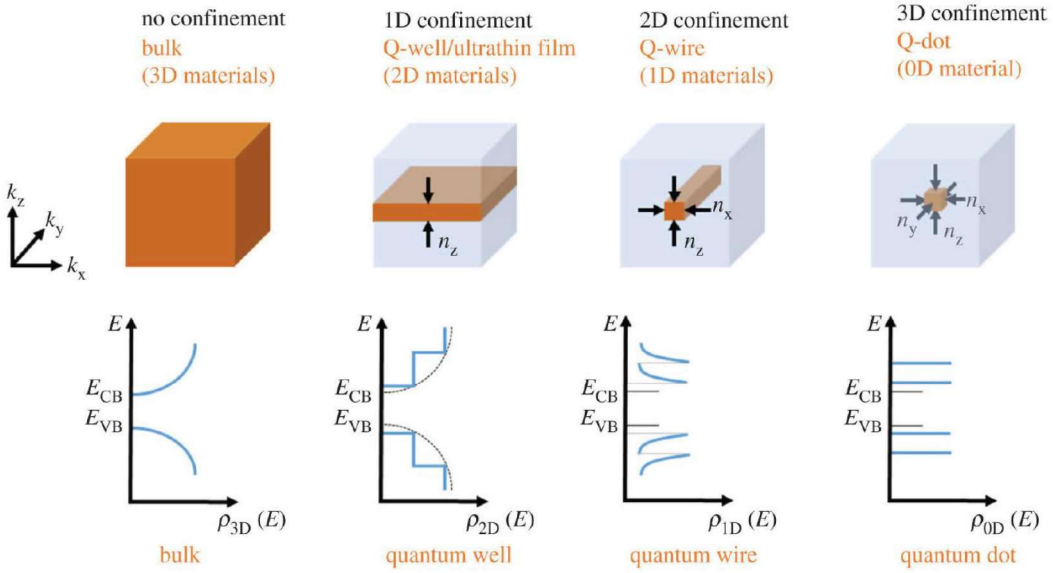
Dimensionality

Zero-dimensional (quantum dots) in which the movement of electrons is confined in all three dimensions.

one-dimensional (quantum wires) in which the electrons can only move freely in the X-direction.

Two-dimensional (quantum wells) in which case the free electron can move in the X-Y plane.

Three dimensional (nanostructured material built of nanoparticles as building blocks) in which the free electron can move in the X, Y and Z directions.



Quantum well

•It is a two-dimensional system

•The electron can move in two directions and restricted in one direction.

Quantum Wire

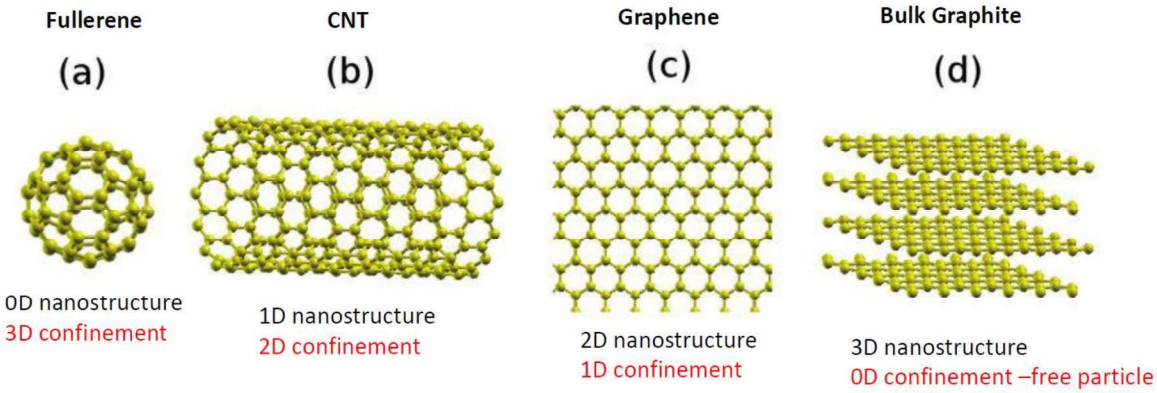
•It is a one-dimensional system

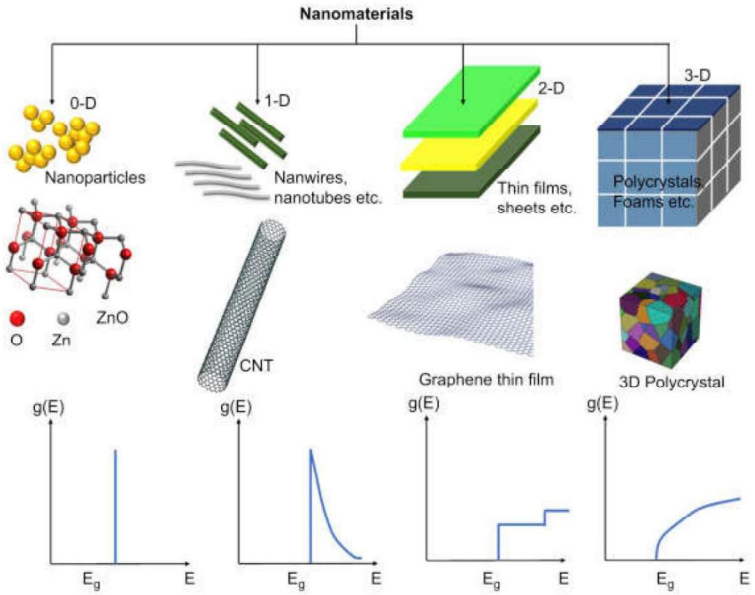
•The electron can move in one direction and restricted in two directions.

Quantum dot

•It is a zero-dimensional system

•The electron movement was restricted in entire three dimensions





Quantum confinement is more prominent in semiconductors because they have an energy gap in their electronic band structure.

Metals do not have a bandgap, so quantum size effects are less prevalent. Quantum confinement is only observed at dimensions below 2 nm.

STRUCTURE	SPATIAL DIMENSION	CONFINEMENT DIMENSION
Bulk	3	0
Surface/ Film (Quantum Well)	2	1
Nanotubes, -wires (Quantum wire)	1	2
Nano-particles, clusters (Quantum dots)	0	3