Bulk Versus Nano

Atoms/ Molecules (1) ⇓ Quantum Chemistry → Nanoscale particles $125 - 70 \times 10^3$ 1 - 10 nm → condensed matter 6×10^6 ~~∞~~ N° Atoms ⇓ solid state physics 100 - ∞ Diameter (nm)

For nanoscale regime, neither quantum science nor solid state classical physics hold any significance.

Why do we need nanoscale?

→ high fraction of atoms at or near the surface

→ liquid surfaces behave as an elastic film.

→ higher vapor pressure over smaller droplets - faster evaporation.

~~Kelvin~~ Kelvin effect

→ Large particles grow at the expense of smaller particles

⇒ Ostwald Ripening

Adsorption ⇒ impurities tend to stick to the surfaces.

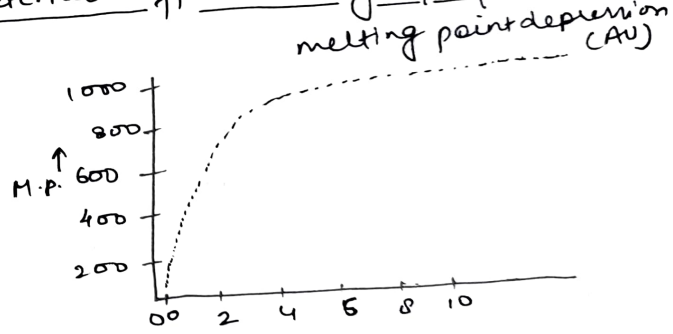
- Surface charge ⇒ Adsorption of ions can leave the nanoparticles electrically charged

Nanoparticles & nanocrystals

⇒ Utility of approaching nanoscale

- surface-to-volume : The presence of high proportion of surface and near surface atoms can greatly affect structural & chemical properties.

- Reducing the dimensions of a material affects many properties :-
  - → melting point
  - → chemical reactivity
  - → optical properties
  - → Electrical properties
  - → Magnetic properties



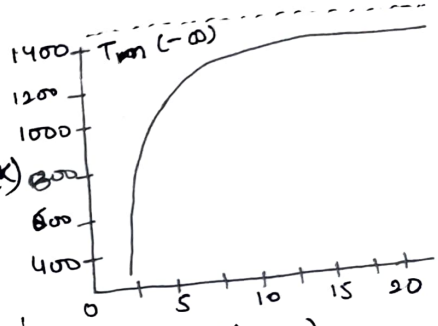
Size-dependence of material properties

Melting points :- when the mean thermal displacement (δ) of the atoms becomes larger than some fraction of the interatomic distance, the material melts.

Surface atoms have lower ~~concentration~~ coordination and higher displacement ($d\bar{s}$) a factor of 2-4 compared to bulk (dV)

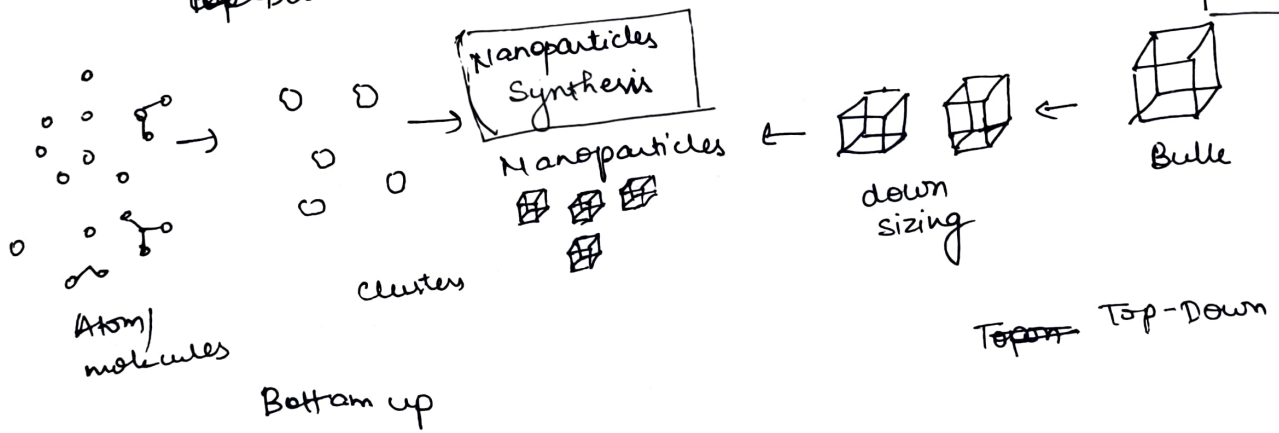
The melting point is only constant as long as surface effect can be neglected.

When the surface/volume ratio increases the mean δ increases; the melting point decreases.



size dependence of the melting point of gold particles. T_m is melting point of bulk gold

~~Top-Bottom~~



Top - Down synthesis

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Breaking down of bulk

⇓

Mechanical Attrition
Lithography
Etching
Micro - machining
MEMS

Bottom UP

Self Assembly
liquid phase
Chemical vapor deposition
combustion
Hydrothermal treatment

Preparative methods

1) ceramic / solid - state synthesis
2) Mechanochemical synthesis
3) sol - Gel methods
4) Precursor - based Approaches.
5) solvo - hydrothermal methods
6) Electrospinning
7) chemical vapor deposition (CVD)
8) Molecular Beam Epitaxy (MBE)
9) Atomic layer deposition (ALD)
10) physical vapor deposition (PVD)
11) Additive Manufacturing (3D Printing)