

Physical properties of nanomaterials

Atoms on a small scale behave like nothing on a large scale

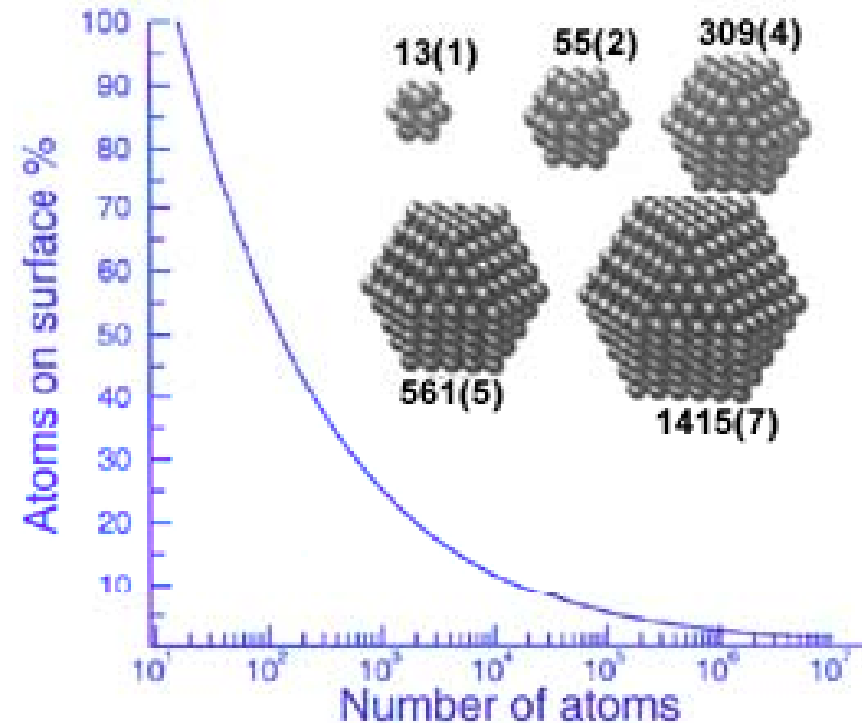
Main feature – size determines the properties of nanomaterials

In macro-scale – properties do not change much with size

In nano-scale – enormous changes

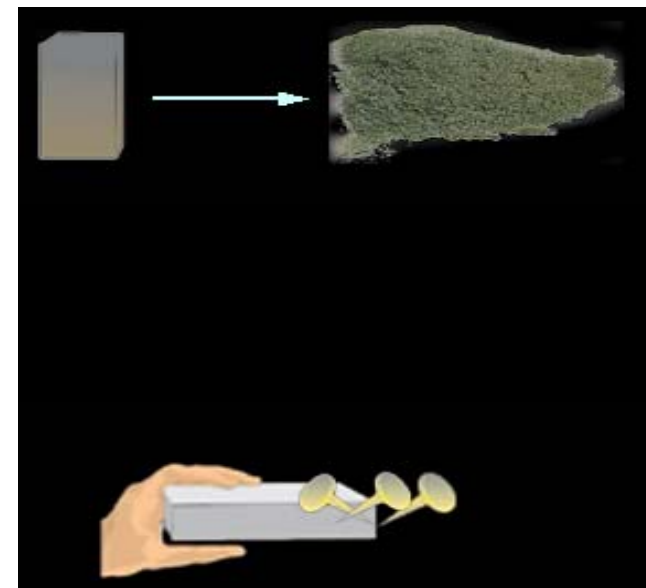
The Surface Area - if you go on reducing the size of a material to a very very small particle, say 1 nm then all the atoms constituting the particle will be on the surface.

-if you increase the size 1 nm to 5 nm, the number of atoms on the surface will decrease.



Changes in properties

1. Magnetic properties of nanostructured materials are distinctively different from that of bulk materials. Ferromagnetism of bulk materials disappears and transfers to superparamagnetism in the nanometer scale due to the huge surface energy.



2. Optical properties of nanomaterials can be significantly different from bulk crystals. E.g. The optical absorption peak of a semiconductor nanoparticle shifts to short wavelength, due to an increased band gap. The colour of metallic nanoparticles may change with their sizes due to surface plasmon resonance.

Bulk gold

shine as a metal;

Chemically not reactive
(make jewel)

small particle of gold

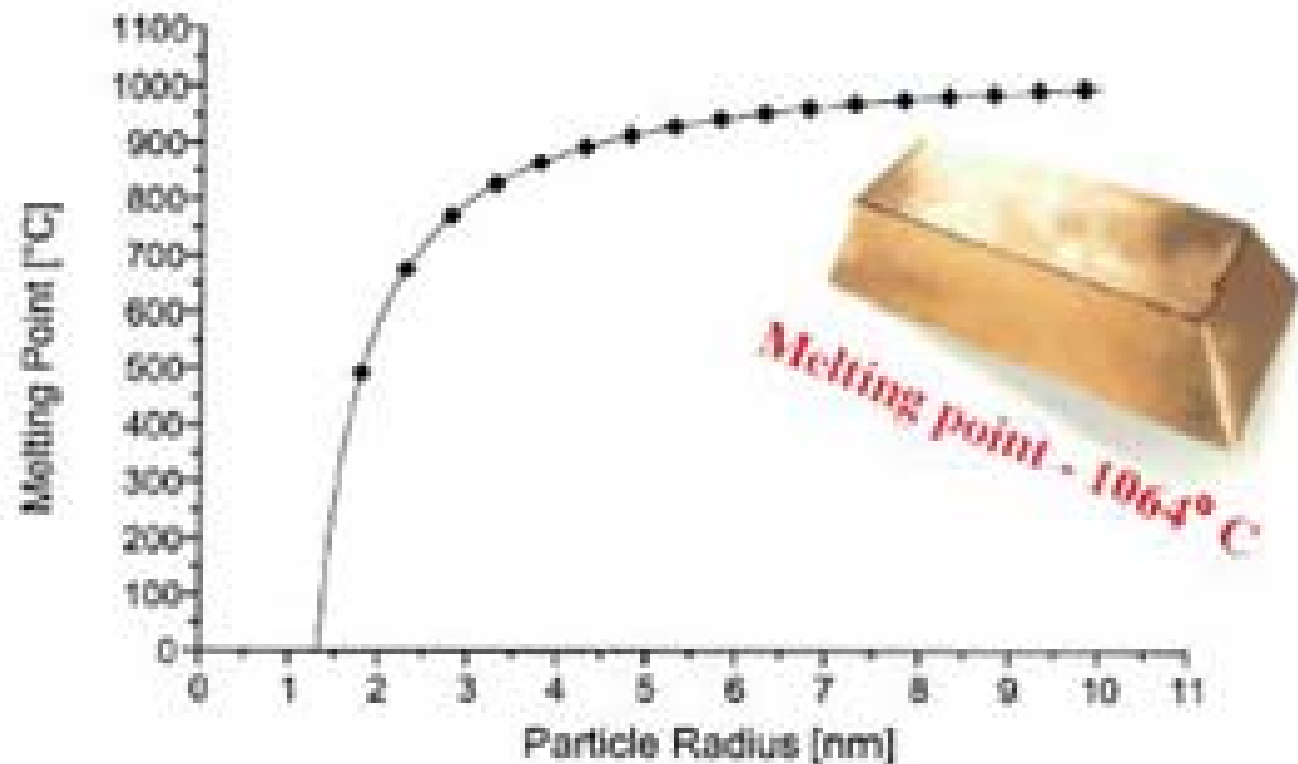
no metallic, don't shine

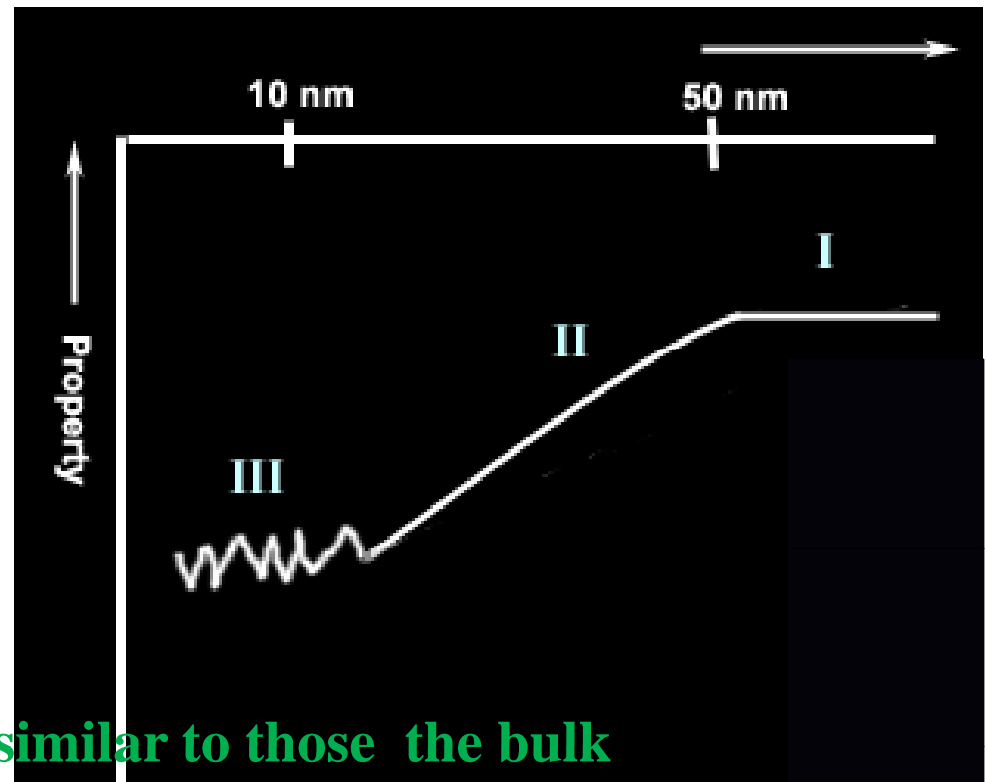
Reactive



Changes in properties

3. Thermal Properties of Nanomaterials may have a significantly lower melting point or phase transition temperature and appreciably reduced lattice constants, due to a huge fraction of surface atoms in the total amount of atoms





In region I (50 nm and above) ,
properties will be similar to those the bulk

II (10 – 50 nm),
their properties vary linearly with size

III (very small),
we get some unusual and new properties

These are due to quantum effects

4.Mechanical properties of nanomaterials may reach the theoretical strength, which are **one or two** orders of magnitude **higher than** that of single crystals in the bulk form. The enhancement in mechanical strength is due to the **reduced probability of defects**.

5.Electrical conductivity decreases with a reduced dimension due to increased surface scattering. However, electrical conductivity of nanomaterials could also be enhanced appreciably, due to the better ordering in microstructure, e.g. polymeric fibrils.

Any heat treatment increases the diffusion of impurities, intrinsic structural defects and dislocations, and one can easily push them to the nearby surface. chemical stability would be enhanced.

Bulk gold does not exhibit catalytic properties

Au nanocrystal is an excellent low temperature catalyst.

- Therefore, if we can control the processes that make a nanoscopic material, then we can control the material's properties.

Characteristics of nanomaterials that distinguish them from bulk materials

- large fraction of surface atoms
- high surface energy
- spatial confinement
- reduced imperfections