SIZE DEPENDED PROPERTIES OF NANOMATERIALS

- **Nearly** all the properties of Nanomaterials depend on their size. The reason for which is more reduction in their grain size.
- The properties like hardness, strength, ductility, melting point and densities vary for Nanomaterials as shown in fig 7.1.

Reason for different behaviour of Nanomaterials

1. Nanomaterials possess relatively larger surface area compared to their bulk form. This makes their materials more active and inert for other cases.
2. Nanomaterials are composed of grains and grain boundaries. These grains contain only few atoms within each grains, but large number of atoms present in the grains boundaries. Decrease in grain size will increase the volume fraction of grain boundaries or interfaces. So, the physical and chemical properties of Nanomaterials are significantly altered.
3. The defect configurations affect the properties of Nanomaterials. Generally presence of increased fraction of defects increases the mechanical and chemical properties of Nanomaterials.

Examples:

(a) Nano-crystalline ceramics are tougher and stronger than those with coarse grains.

(b) Nano-sized metals exhibit significant decrease in toughness and increase in yield strength.

(c) A piece of gold is fairly gold colour materials, but gold nano particles are in deep red colour.

(d) Silver foil does not react with dilute hydrochloric acid, but nanoparticles of silver react rapidly with dilute hydrochloric acid, because of the large area to volume ratio.

Melting points

- Nano materials have a significantly lower melting point and appreciable reduced lattice constants.
- This is due to huge fraction of surface atoms in the total amount of atoms.

Optical properties

- Reduction of material dimensions has pronounced effects on the properties.
- Optical properties of nano materials are different from bulk forms.

  The change in optical properties is caused by two factors

  (i) The quantum confinement of electrons within the nano particles increases the energy level spacing.

  Examples: the optical absorption peak of a semiconductor nano-particles shifts to a short wavelength, due to an increase band gap.

  (ii) Surface plasma resonance, which is due to smaller size of nano-particles the the wavelength of incident radiation.

  Examples: the colour of metallic nano-particles may change with their sizes due to surface plasma resonance.

Magnetic properties

- Magnetic properties of Nanomaterials are different from that of bulk materials.
- Ferro-magnetic behaviour of bulk materials disappear, when the particles size is reduced and transfers to super–paramagnetics.
- This is due to huge surface area.

Mechanical properties

- The nano-materials have fewer defects compared to bulk materials, which increases the mechanical strength.
- Mechanical properties of polymeric materials can be increased by the addition of nano-fillers.
- As nano-materials are stronger, harder and more wear resistant and corrosion resistant, they are used in spark plugs.

  Examples:

  Nano – crystalline carbides are much stronger, harder and wear resistant and are used in micro drills.

Electrical properties

- Electrical conductivity decreases with a reduced dimension due to increased surface scattering.

- However, it can be increased, due to better ordering in micro- structure.

  Examples: Polymeric fibers.

- Nanocrystalline materials are used as very good separator plates in batteries, because they can hold more energy than the bulk materials.

  Examples: Nickel – metal hydride batteries made of nanocrystalline nickel and metal hydride, required for less frequent recharging and last much longer.

Chemical properties

- Any heat treatment increases the diffusion of impurities, structural defect and dislocations and can be easily push them to the nearby surface.
- Increased perfection will have increased chemical properties.

Thermal conductivity

- Thermal conductivity of the Nanomaterials lower than the bulk materials because of the energy gap between valance band and conduction band is high.