If one of length, width & height are on nano-scale then the material is nano-material.

When we go from micro to nano, a material's properties are affected.

Iron is tough & Ductile → It bends instead of breaking

Brittleness ∝ No. of C-atoms.

Every Iron ore has some C-atoms present.

Toughness:

- The impact absorbtion ability of a material till it's fraction point.

Important considerations:

- Iron is abundantly available from earth's crust (4%)
- Iron is quite machinable due to it's ductility & glass is NOT as it is brittle
- Iron is quite weldable due to it's high resistance to heat.
- Susceptibility to corrosion & brittle under certain conditions

Nano-technology:

A branch of science dealing with designing, producing & using devices & systems by manipulating atoms on nano-scale.

Tyndall effect:

Dispersion light ∝ size of particle

Material science in bottles:

Glass — cold for long time
— Too heavy to transport

Tin — Too small

Plastic — Perfect

Properties to consider while making materials:

- Durability
- How it would react in an environment
- feasibility
- Environmental impacts

How material would respond when subjected to:

1) Mechnical forces:

- Materials may deform OR resist compression depending on their properties.
- They may elongate or break under tension.

2) Electrical forces

→ To varying degrees

- Materials may conduct, semi-conduct OR insulate

3) Magnetic forces

- Materials can be magnetized & exhibit susceptibility to magnetic field on varying degrees.

4) Optical forces:

- Materials interact with light leading to effects like reflection, refraction etc.

5) Temperature gradient:

- Materials contract or expand on heating & cooling.

6) Chemical (Corrosion) Environments:

- Materials may corrode depending on environment.
- Chemical reactivity of different materials.

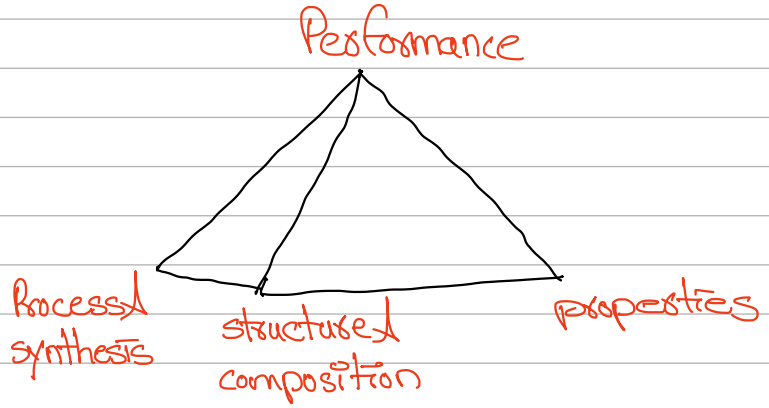
Material & their properties:

1) Electrical → conductor, semi-conductor, insulator
2) Magnetic → Dia-magnetic, para magnetic
3) Radio activity
4) Thermal → conductor, insulator
5) Biological → self replicating
6) Mechanical → strong, tough, hard
7) chemical → reactivity, corrosive
8) Optical → LCD, night vision camera, optical fibres
9) Cost → most important

Optical performance of Al_2O_3

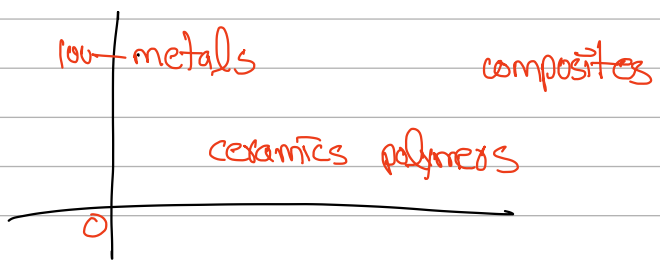
- Single crystal has no grain boundary that's why it is transparent.
- Poly-crystalline has some grain boundaries that's why it is little opaque.
- Poly crystalline with poses

Four components of the discipline of material science & Engineering



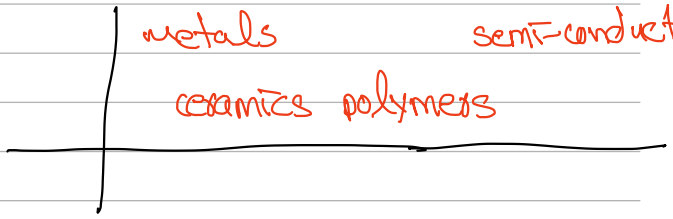
Toughness of materials:

1) Metals
2) Composites
3) polymers
4) Ceramics



Reactivity of materials:

1) Metals
2) Semi-conductors
3) polymers
4) Ceramics



Why are they conductors OR insulators?

1) Diamond:

- C-atoms are bonded by covalent bonds.
- They bad conductors of electricity

2) Graphite:

- Hexagonally arranged layers of C-atoms
- Can slide over one another
- Conduct electricity due to presence of delocalized e^-

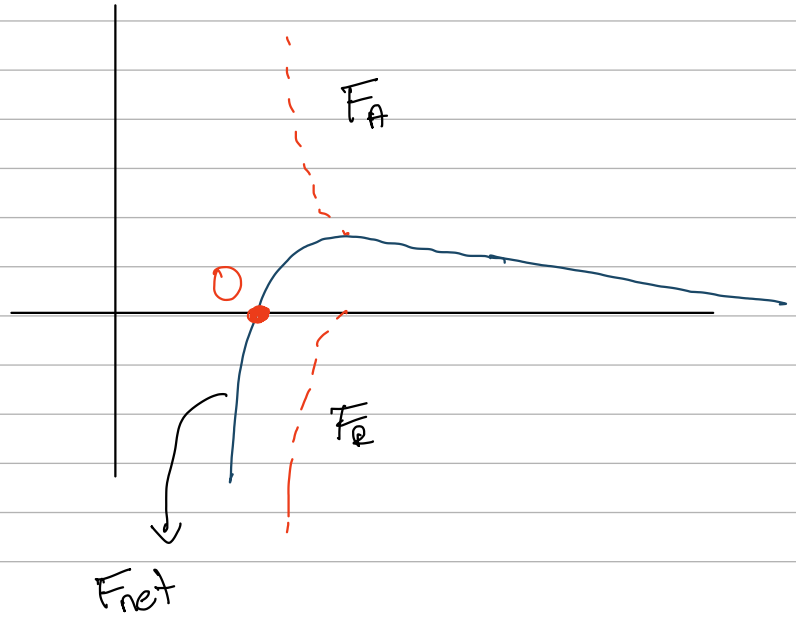
3) Bucky balls:

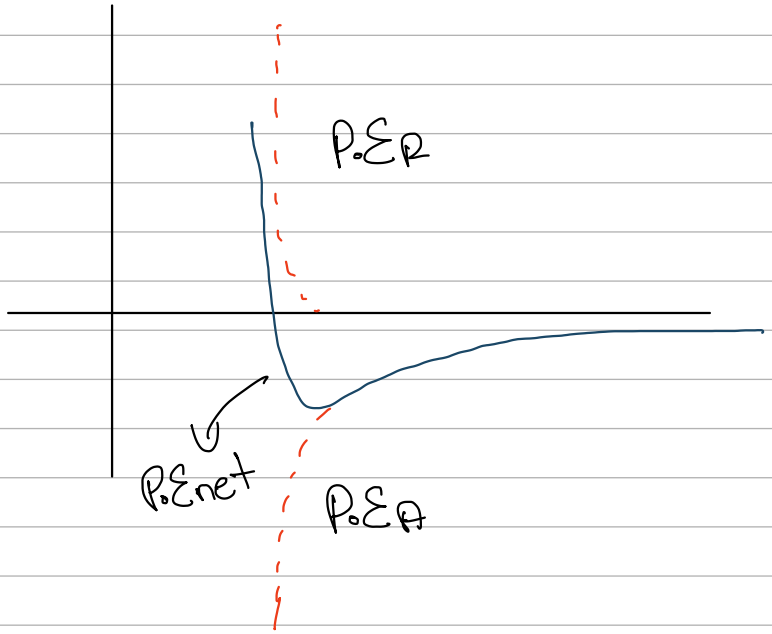
- Cannot conduct electricity as free e^-s are held by van-der waal forces

4) Carbon nano-tubes:

- Excellent conductor of electricity
- similar to graphite

At one point, F_A & F_R are equal. This is equilibrium. F_{net} is F_R.





Primary bonds:

1) Covalent bonds → sharing of $\bar{e}$ (mutual)

2) Ionic bonds → b/w ions $Na^+ - Cl^-$

3) Metallic bonds → b/w metals

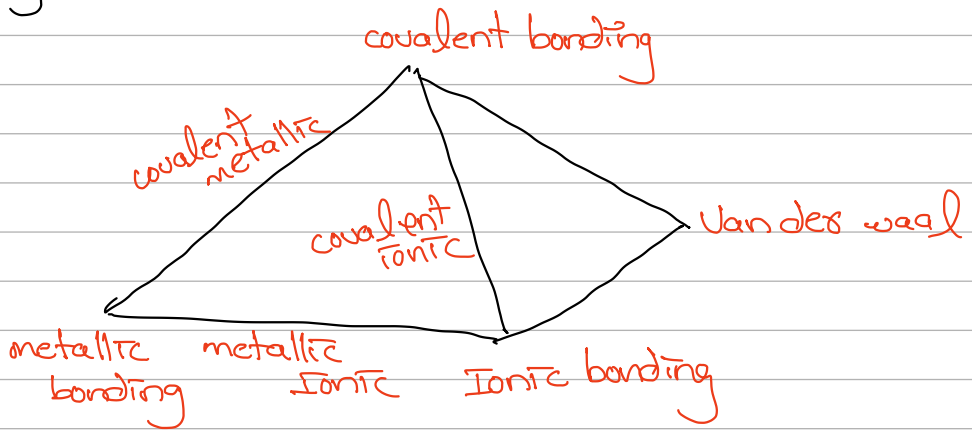
Secondary bonds:

1) Van der waal's forces → Attractive forces due temporary change in dipole moment

2) Dispersion forces → Attractive forces due formation of dipole

3) Partial Covalent bonds → Uneven sharing of $\bar{e}$

4) Hydrogen bonds



The smallest possible unit which repeats to form a crystal is called a unit cell.

Crystalline: Orderly arrangement of atoms (SiO_2 Quartz)

Amorphous: NOT orderly arrangement of atoms (SiO_2 Glass)

Grain boundaries are most active region & helps in melting & also act as hinderance to charge

Materials whose properties are direction dependend are called anisotropic & those whose does not are Isotropic

White Tin (α) $\xrightarrow[\text{cooling}]{13.2^\circ C}$ Gray Tin (β) } Transformation.
BCC FCC

27% Increase in volume.

Piezoelectric material: produce electricity when stress is applied

(a) Carbon Boron Nitrite

(b) hexagonal Boron Nitrite

(c) Wurtzite Boron Nitrite

(d) Rhombus Boron Nitrite

cubic	$a=b=c$	$\alpha=\beta=\gamma=90^\circ$
hexagonal	$a=b\neq c$	$\alpha=\beta=90^\circ, \gamma=120^\circ$
Trigonal	$a=b\neq c$	$\alpha=\beta=\gamma=90^\circ$
Orthorhombic	$a=b\neq c$	$\alpha=\beta=\gamma\neq 90^\circ$
Monoclinic	$a\neq b\neq c$	$\alpha=\gamma=90^\circ\neq\beta$
Triclinic	$a\neq b\neq c$	$\alpha\neq\beta\neq\gamma\neq 90^\circ$

BCC:

Coordination number: 8

Equivalent atoms: 2

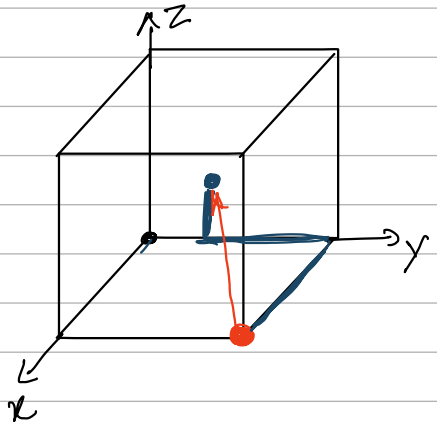
contribution: Corner $\frac{1}{8}$ & Centre 1

FCC:

Coordination number: 12

Equivalent atoms: 4

Contribution: $\frac{1}{2}$ Faces, $\frac{1}{8}$ corner



$\bar{3}$ $\bar{2}$ 1

$\bar{1}$ $\frac{\bar{2}}{3}$ $\frac{1}{3}$

Q 3.33

D2: 1 0 $\frac{1}{2}$

[2 0 1]