Sumedh

- **Topics**

i) DOS in 2D, 1D, 0D system
ii) low dimension system
iii) Fullerenes
iv) Graphene
v) CNT
vi) Fabrication – PVD
CVD
vii) Characterisation - Powder X-ray
viii) Electron micro – SEM
TEM
AFM
ix) Hetero Junc

- **Fullerenes**

- New allotrope of carbon discovered in 1985
- It is arranged in a closed shell and named buckminister fullerene
- Various forms of fullerene are C_{60}, C_{70}, C_{76}, C_{84}, Most abundant one is C_{60} have 32 facus (12 penta & 20 hexagons
- C_{60} is chemically stable & resembles a soccer ball
- C_{60} can be stretched in rods & tubes as they are superconducting & serve as lubricants
- Various species are Alkali doped F, Exo F, Endo F
- App : i) Hydrogen storage
ii) Sensors
iii) Alloy hardning / strengthning agents

- **Graphene**
  - Another allotrope of carbon discovered in 1910
  - Two-dim building block of carbon based material in a honey-comb lattice
  - It is million times thinner than paper, stronger than diamond & good elec cond than copper
  - **props :** i) Can absorb / deabsorb various atoms & molecules
    ii) perfect thermal conduction, thermal conductivity is isotrophic
    iii) Edge of graphene is more reactive that surface
    iv) Good Tensile strength.
  - **Apps :** i) used to detect single molecule gas
    ii) ultra capacitors
    iii) as reinforcement in polymer nanocomposites

- **CNT (Carbon Nano tubes)**
  - CNT are sheets of graphene rolled in cylindrical form and constructed from covalent C-C bonds in form of hexagonal rings
  - Two type, if one graphene layer rolled is called single walled CNT & multi layer is called multiwalled CNT
  - Based on geometry there are 3-types :

    Armchair : Here C-C bonds are ⊥ to tube axis

    zig zag : C-C bonds are ⊥ to tube axis

Chiral : C-C bonds inclined to tube-axis

- **Props :** i) Electrical : based on the diameter they are either metallic / semiconducting

  ii) Chemical : Highly resistant to chem rxns & directly related to pi-orbital Mismatch

  iii) Mechanical : They have a high tensile strength, can recover frm severe metal distortions.

  iv) Thermal : Have high thermal cond, it inc with dec. in diameter.

- **Synthesis :** i) laser ablation : high powered laser beam put on Carbon target, plasma fume created as SWCNT formed

  ii) Arc-discharge : CNT are synthesized by using a low volt power supply to strike an elec arc b/w two carbon electrodes

  iii) Chem Vapour deposition : Carbon in gas phase used and CNT formed as a substrate

- **Apps :** i) ∵ Hydrogen is a combustion product in H_2O, CNT used to store Hydro

  ii) FET is a 3 terminal switching device made frm SWCNT

  iii) SWCNT used as miniature sensors

  iv) Compusite materials made as CNT have a $Y = 1TPa$

- **CVD (Carbon Vapour deposition)**

Decomposition of solid material gas phase.

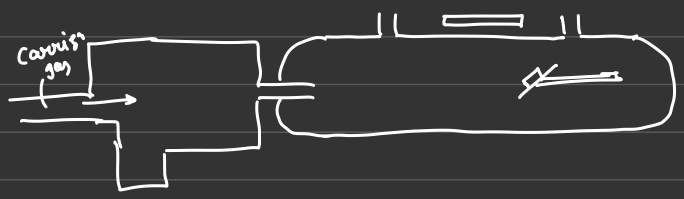
- **Working principle:** Chem rxn of gas source at a heated substrate to yield a fully dense deposit. Thermodyamics & kinetics lead to deposition. Can be controlled by Temp & conc

Metal deposit^n : Metal Halide (gas) → metal (solid) + by product (gas)

Ceramic " : " → $O_2/C_2/N_2/B_2$ (gas) + ceramic + byprod

- **Steps:** i) A predefined mixture of gases (inert gas) are introduced in a reactant chamber
  ii) The gases move to the substrate
  iii) They are adsorbed and chem rxn take place
  iv) A nano particle film is formed on the surface
  v) The by-prods are removed from the chamber from the carrier gas

- **Chem rxns:** i) Homo : take place in gas phase, form low density films
  ii) Hetero : rxn take place at the substrate, good quality films formed



- **Types:** based on Chem rxn : hot walled CVD
  cold walled CVD

" operation press : Atmospheric press CVD
low press CVD
plasma enhanced CVD

- Adv : i) Controllable thickness
  ii) Coats wide range of metals / ceramics

- Apps : i) Anti-corrosive coating
  ii) prevent adhesion
  iii) chemical implant items
  iv) gas turbine blades

- **PVD (Physical Vapour deposition)**

Vaporisation coating technique. Transfer of material on atomic lvl. Material is taken in solid form

Working : It is carried out in vaccum condit^n to prevent impurities

i) Evaporation : the target material is vapourised by high energy source e^- beam

ii) Transport : The vaporised atoms move to the surface in st. line

iii) Reaction : The atoms react to gas is transport state, the substrate is cold

iv) deposition : The atoms become solid and a film is formed on the surface

- Types : Evaporation dep
  e^- beam PVD dep
  sputter dep
  pulsed laser dep

- Adv : i) improved props
  ii) envo frndly

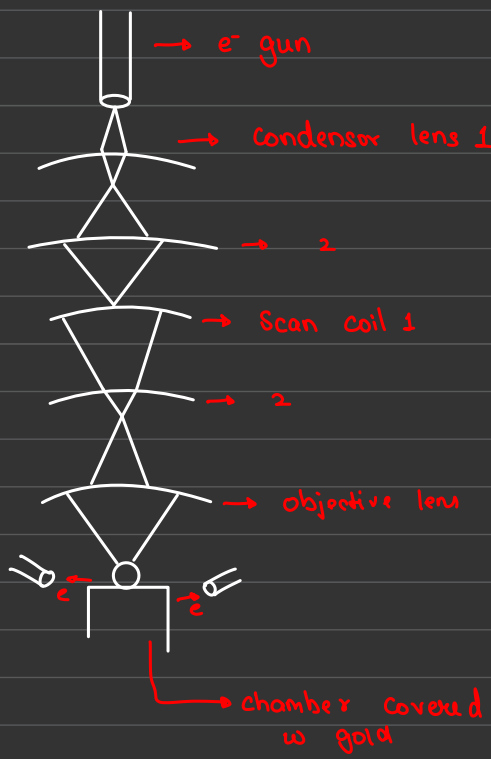
- disadv : i) high capitol lost
  ii) high heat & vaccuum
  iii) needs appropriate cooling system

- Apps : i) aerospace
  ii) automotive
  iii) cutting tools.

• Scanning Electron Microscope (SEM)

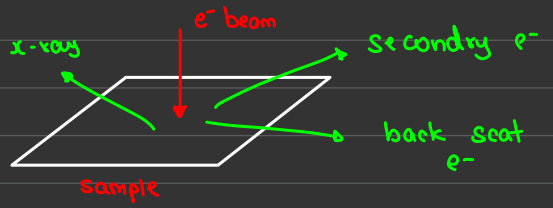
Allows objects to be seen in their natural state without staining. As e^- strikes the object and e^- knock loose e^- that are captured by detectors to form the image

Construction



1) e^- gun produces monochromatic e^-
2) e^- strikes Cond. lens 1 & 2, they control size & brightness
3) e^- beam falls on scan coils 1 & 2, they sweep beam dwelling on points for a period of time
4) They fall on objective lens, the lens focuses the beam onto specimen & e^- interact with specimen
5) The e^- are detected by detector 1 & 2
6) Process is repeated

Specimen interaction



1) Back-Scattered e^-s :-

Incident e^- collides w atom in specimen and scatter backward 180°

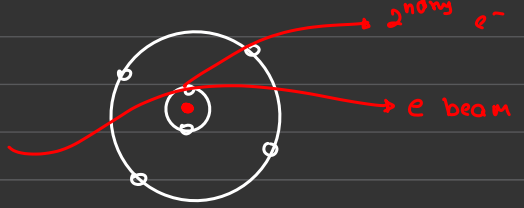
Uses : Due to back scat ;

higher atomic no elem : brighter
lower : not as bright

2) Secondary e^- :-

Incident e^- imparts energy to lower shell e^- making it ionised

These ionised e^- leave atom with small KE are called secondry e^-



Uses : 2nd e^- production is topography related any change in surface depth changes sec e^- collection rate.

3) Auger e^- :- During sec e^- process, inner shell has vacancy cause lower shell e^- was emitted. To the vacancy, higher energy e^- falls to lower energy

These released e^- are auger e^-

Uses : Is e^- enough to give into abt speciment