Session 16: Modern Physics I

- Dual nature of matter: De Broglie's Hypothesis
- Davisson Germer Experimental Setup
- Ni Crystallographic planes
- Validation through X-Ray Diffraction

Calculate de Broglie wavelength of a tennis ball, m = 0.1 Kg, v = 10 m/s

$\lambda = \frac{h}{p}$

A). 10^{-20} m B). 10^{-30} m

C). $6.6X10^{-34}$ m D). 3 nm

$$\lambda = \frac{6.62 \times 10^{-34}}{0.1 \times 10}$$

$$= 6.6 \times 10^{-34}\ m$$

Calculate de Broglie wavelength of an electron, m = $9.1X10^{-31}$ Kg, v = 10^6 m/s

A). 10 Å B). 10^{-9} m

C). $6.6X10^{-10}$ m D). 7.27 Å

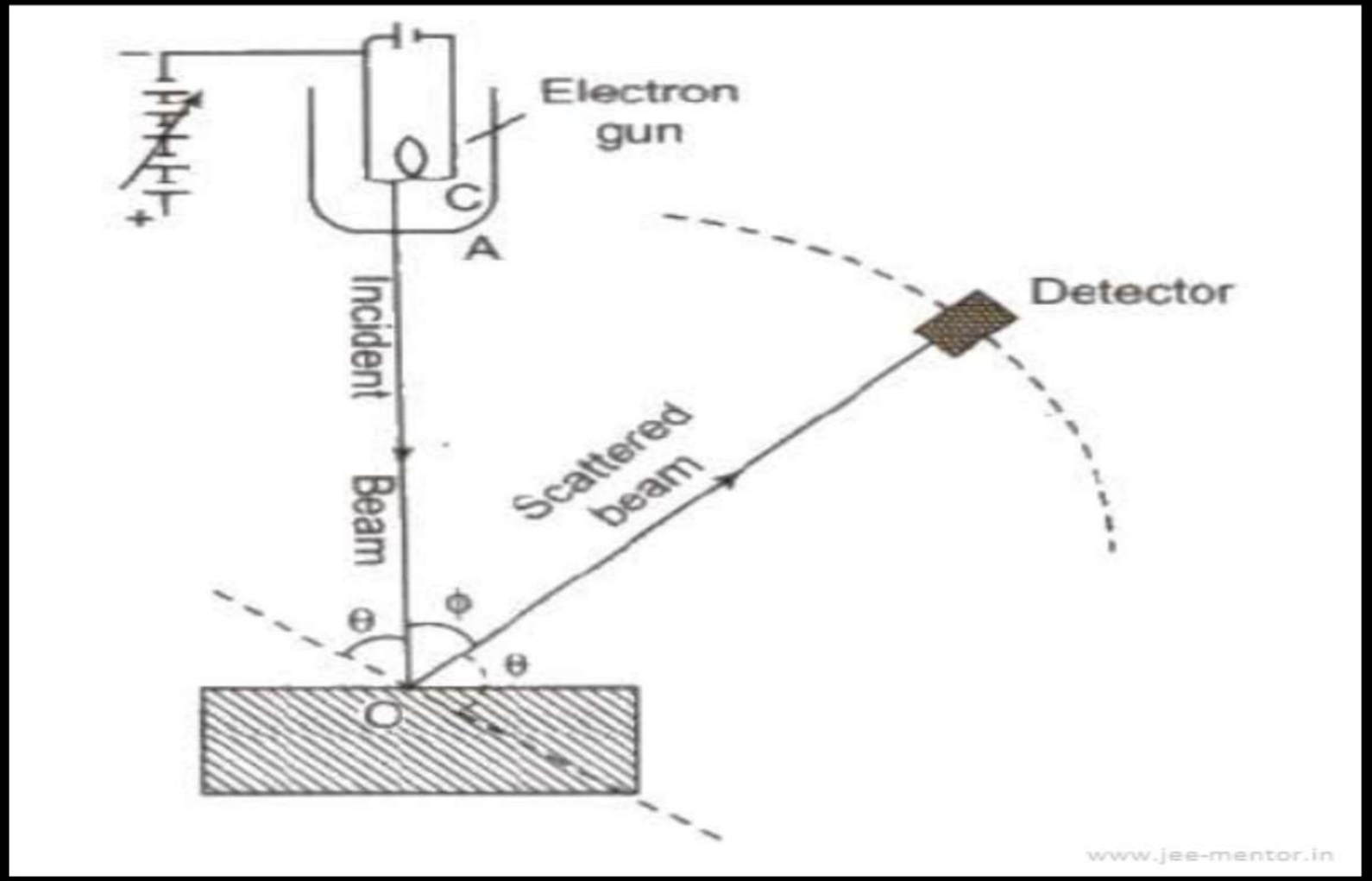
$$\lambda_{e^-} = \frac{h}{p}$$

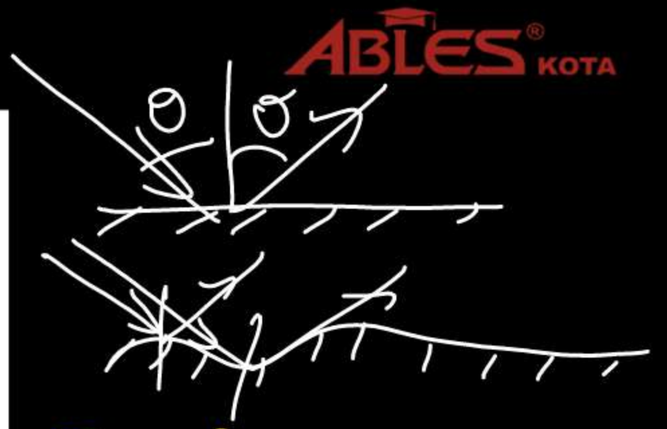
$$= \frac{6.62 \times 10^{-34}}{9.1 \times 10^{-31} \times 10^{6}}$$

$$= \frac{6.62}{9.1} \times 10^{31-34-6}$$

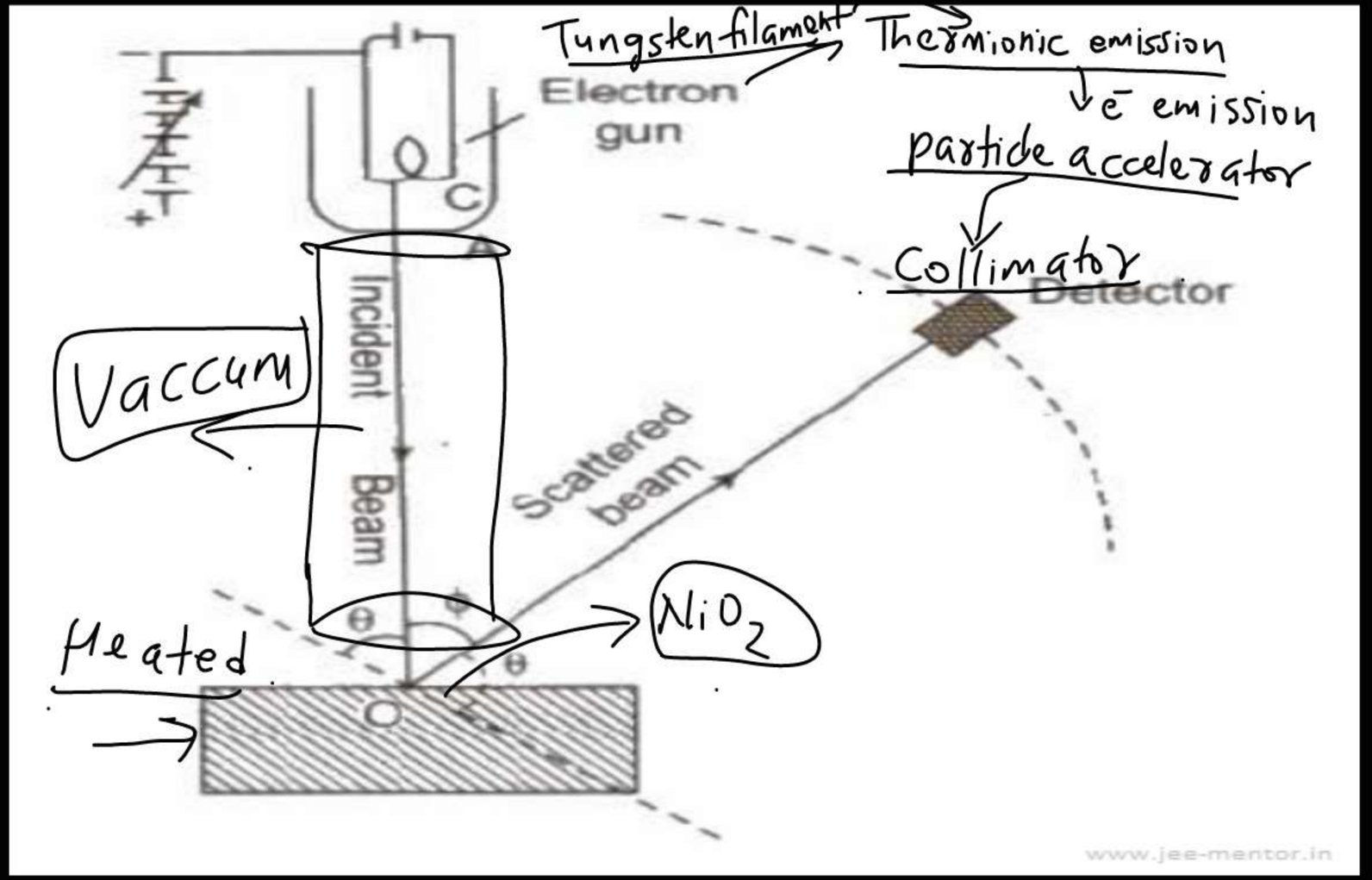
$$= 0.727 \times 10^{-9}$$

$$= 7.27 \times 10^{-10}$$

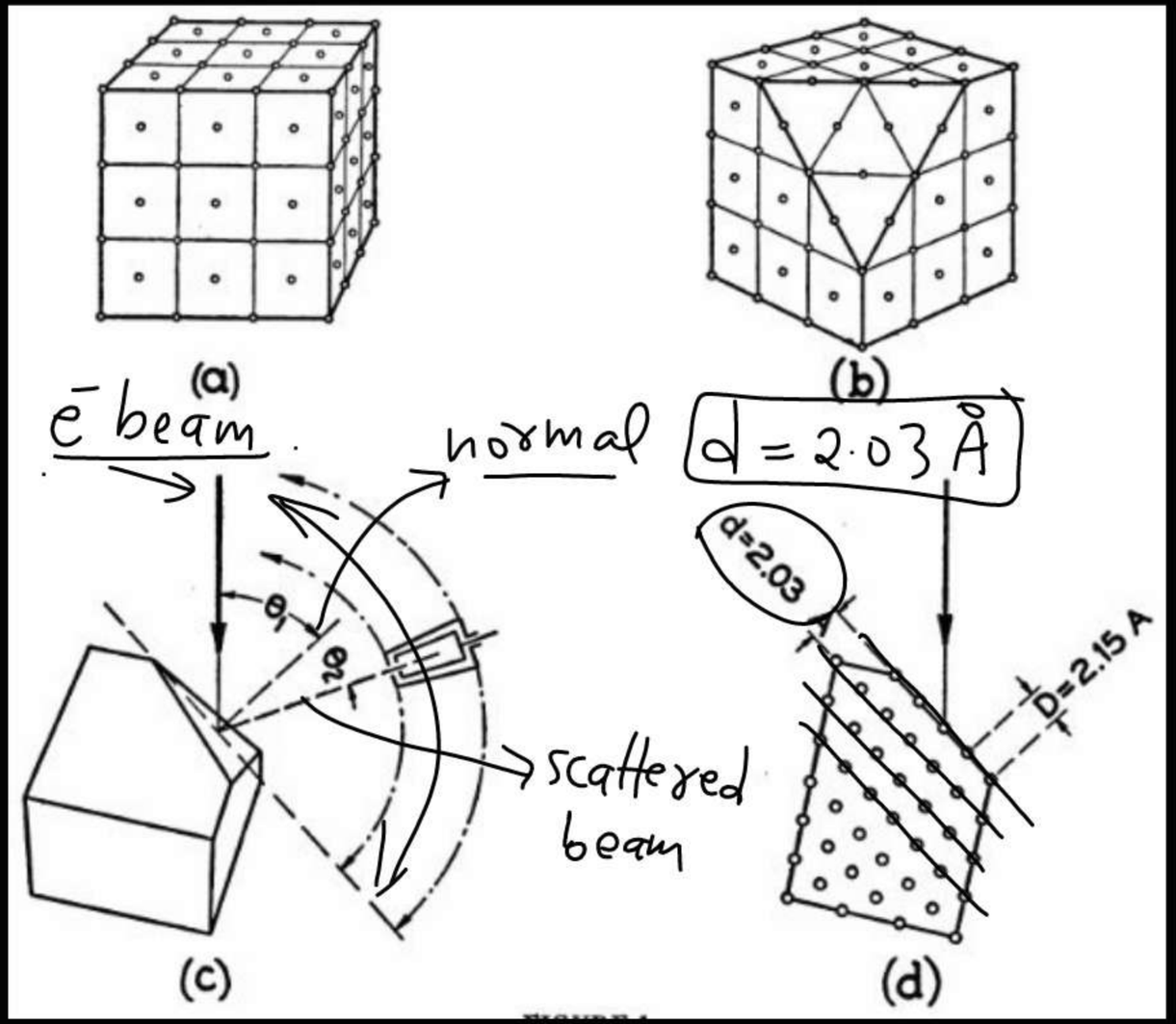




Davisson Germer Experiment



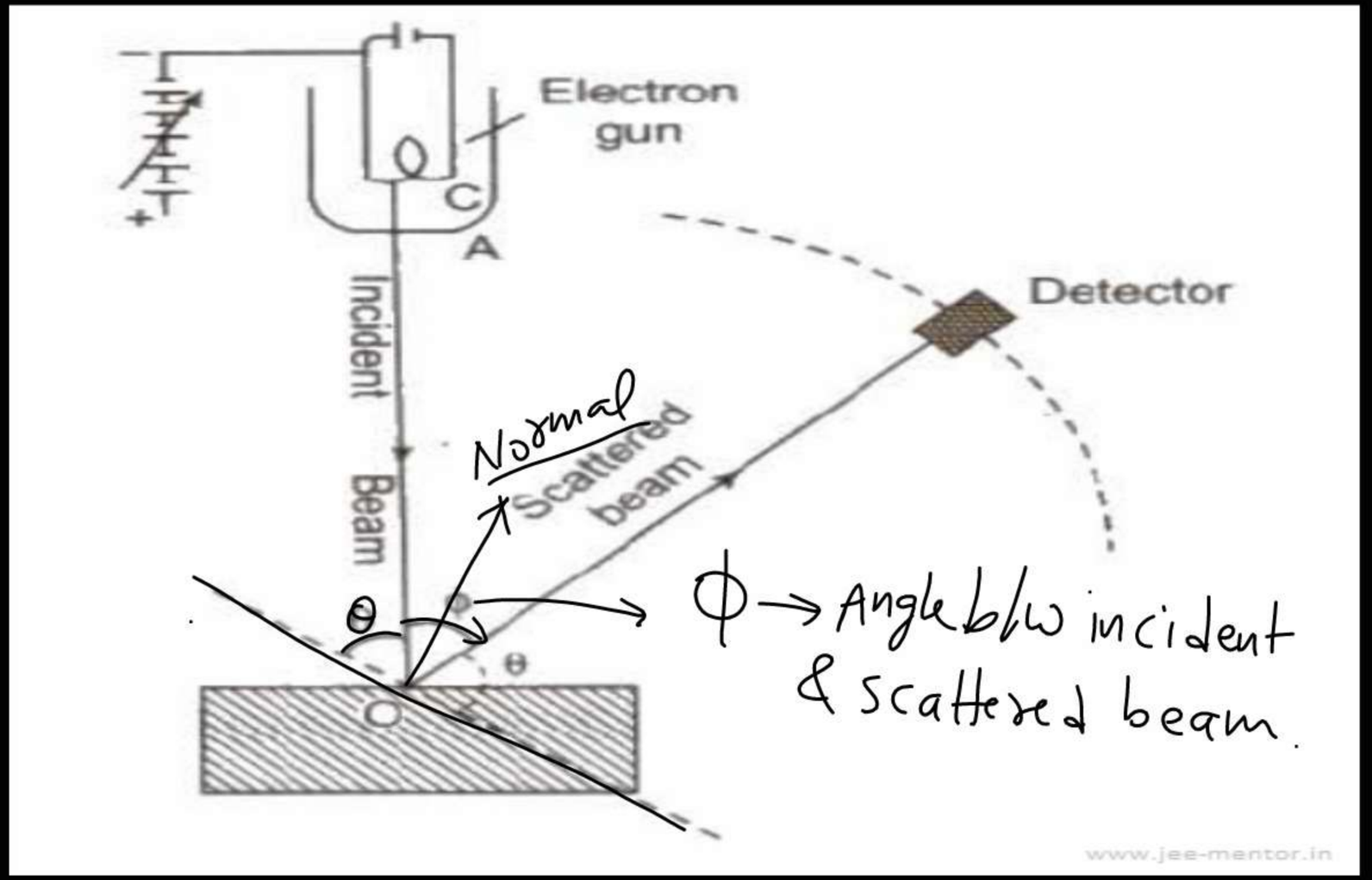
Davisson Germer Experiment



FCC Ni Crystal, (111) plane with hexagonal symmetry

d → interplanar dist.

D → Interatomic dist (in the same plane)



Davisson Germer Experiment

Particle Nature

↓

Newtonian mechanics

$F = ma$.

when size of particles becomes small, $< 10^{-6}$ m → Newtonian mech. fails.

Wave Nature

DeBroglie said that small particles can exhibit wave nature & it can be observable for some cases.

p, λ

$p = h/\lambda$

$\lambda_{particle} = h/p$

$$\lambda_{particle} = \frac{h}{p}$$

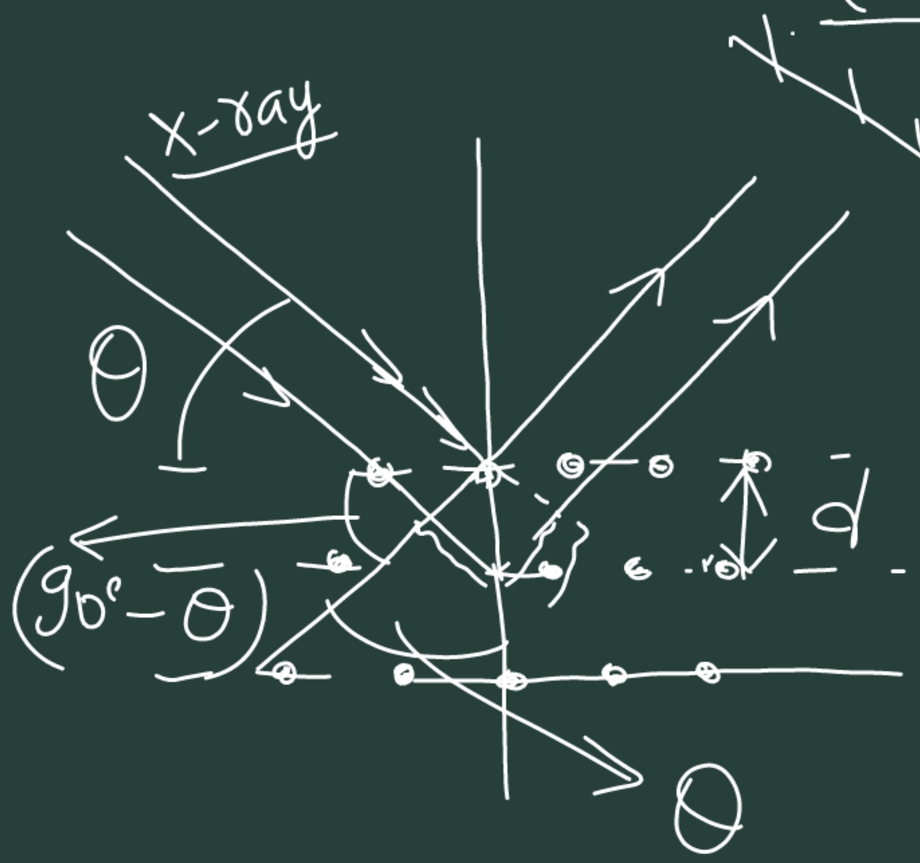
$$\boxed{p = m_{particle} v_{particle}}$$

for eg. e^- → material particle.
- → $m_e = 9.1 \times 10^{-31}$ kg.
- → speed/momentum

Davisson Germer Experiment

1. For e^- beam to show diffraction, they should strike @ regular (smooth surface).
2. Smoothest surface can be offered by crystallographic structure of solids.
3. The e^- from electron gun are passed thru a vaccum chamber (to avoid any other collision).
4. Inspite of vaccum chamber, due to some air, NiO_2 formed.
5. D&G → heated Ni metal surface which rendered a pure crystal structure.

X-ray diffraction (Bragg)



$2d\sin\theta \rightarrow$ path diff.

$$2d\sin\theta = n\lambda \qquad n \in I$$

Bragg's law

$$d = \frac{\lambda}{2\sin\theta}$$