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SCHOLAR NO : 214104010 SECTION : E

EXAM NAME : MID - SEM SUBJECT CODE : PHY-102

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1. The Michelson's interferometer produces interference fringes by splitting a beam of light so that one beam strikes a fixed mirror and the other a movable mirror. When reflected beams are bought back together, an interference pattern produces.

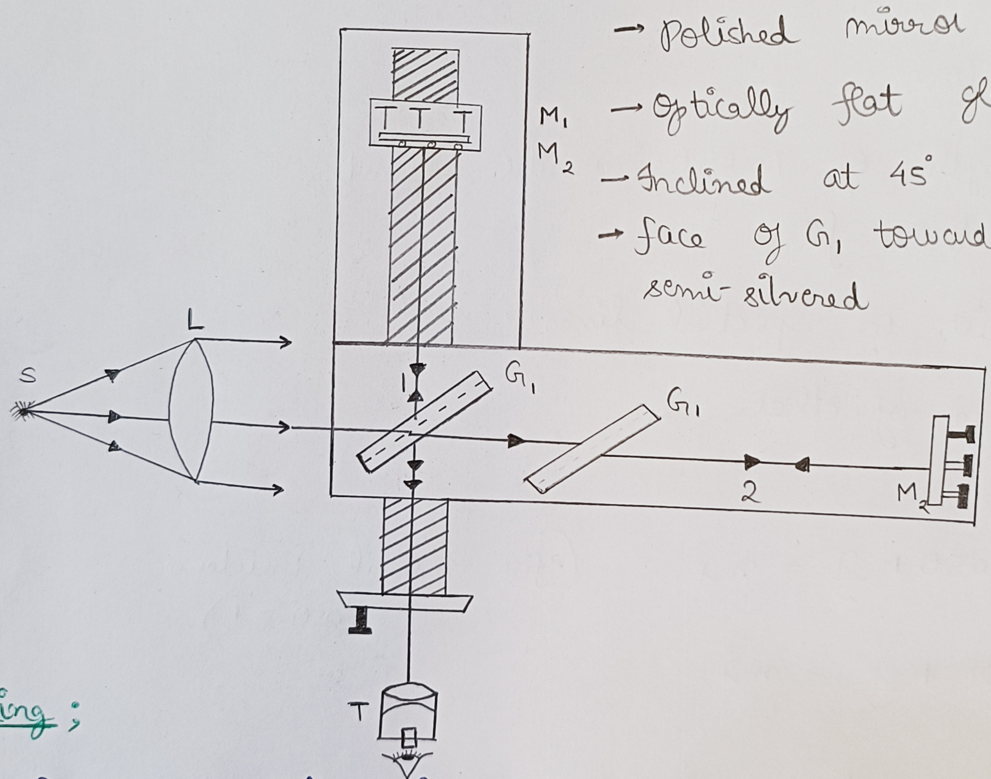
→ S - monochromatic light source

→ Polished mirror M_1 & M_2

→ Optically flat glass G_1 & G_2

→ Inclined at 45°

→ face of G_1 towards G_2 is semi-silvered



Working ;

Light from a monochromatic source S after being rendered parallel by a collimating lens L falls on the semi-silvered glass plate G_1. It is divided into two parts, one being reflected from the semi-silvered glass plate G_1 to rise (1) which travel towards mirror M_1 and other being

transmitted giving rise to ray which travels towards (2)
M_2. The two rays fall normally on mirrors M_1 & M_2 respectively and are reflected back along their original paths. The reflected rays meet at semi-silvered and enter telescope T. The two rays entering the telescope are originally derived from the single beam, hence they are in a position to produce interference fringes in the field of view of telescope.

Applications

- Wavelength of monochromatic light
- μ of thin film
- Resolution of spectral lines
- Presence of ether

$$2t\cos\theta + \frac{\lambda}{2} = n\lambda$$ (for normal incidence $\cos\theta = 1$)

$$2t + \frac{\lambda}{2} = n\lambda$$

If M_1 is moved $\frac{\lambda}{2}$ from M_2, then path difference of λ will be and $(n+1)^{th}$ bright spot appears on n^{th} bright spot

$$\frac{N\lambda}{2} = x_2 - x_1$$

$$\boxed{\lambda = \frac{2(x_2 - x_1)}{N}}$$

2. **ROLL NO : 21EO63** (3)

- **Given** : $a = 0.19$ mm , $b = 0.41$ mm , $\lambda = 6500 \mathring{A}$

  $f = 63$ cm

The direction of 1^{st} minima

$$\boxed{(a+b)\sin\theta_1 = (2n+1)\frac{\lambda}{2}}$$

For 1^{st} secondary minima , $n = 0$

$$\sin\theta_1 = \frac{\lambda}{2(a+b)}$$

For small θ_1

$$\theta_1 = \frac{\lambda}{2(a+b)}$$

If f is focal length of less and x_1 is position of 1^{st} minima from centre ,

$$\boxed{\theta_1 = \frac{x_1}{f} = \frac{\lambda}{2(a+b)}}$$

$$x_1 = \frac{\lambda f}{2(a+b)} = \frac{6500 \times 10^{-8} \times 63}{2 \times 0.06} = 341.25 \times 10^{-4} \text{ cm}$$

Position of 1^{st} maxima

$$(a+b)\sin\theta = n\lambda \quad (\theta \text{ is direction of } 1^{st} \text{ max})$$

$$\theta_2 = \frac{n\lambda}{a+b} \quad (\text{here } n=1)$$

$$= \frac{\lambda}{a+b}$$

$$\frac{x_2}{f} = \frac{\lambda}{a+b} \quad (\text{where } x_2 \text{ is position of } 1^{st} \text{ maxima})$$

$$x_2 = \frac{\lambda f}{a+b} = \frac{6500 \times 10^{-8} \times 63}{0.06} = 682.5 \times 10^{-3} \text{ cm}$$

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3. In a pure semiconductor the electrons in the Conduction band cluster very close to the bottom edge of the band and we assume that e^- are located right at bottom edge of conduction band. Similarly, we assume that holes are at top edge of valence band.

* The electron concentration in conduction band is given by;

$$n = N_C \, e^{-(E_C - E_F)/KT}$$

* The hole concentration in valence bond is given by;

$$p = N_V \, e^{-(E_F - E_V)/KT}$$

* In an intrinsic semiconductor, the electron and hole concentrations are equal so $n = p$

* $$N_C \, e^{-(E_C - E_F)/KT} = N_V \, e^{-(E_F - E_V)/KT}$$

taking log;

$$\frac{-(E_C - E_F)}{KT} = \ln\left(\frac{N_V}{N_C}\right) - \left(\frac{E_F - E_C}{KT}\right)$$

$$-E_C + E_F = KT \ln\left(\frac{N_V}{N_C}\right) - E_F + E_V$$

$$2E_F = (E_C + E_V) + KT \ln\left(\frac{N_V}{N_C}\right)$$

$$E_F = \frac{E_C + E_V}{2} + \frac{1}{2} KT \ln\left(\frac{N_V}{N_C}\right)$$

but $N_C = 2\left(\frac{2\pi m_e KT}{h^2}\right)^{3/2}$ & $N_V = 2\left(\frac{2\pi m_h KT}{h^2}\right)^{3/2}$

$$\frac{N_V}{N_C} = \left(\frac{m_h}{m_e}\right)^{3/2}$$

$$\ln\left(\frac{N_V}{N_C}\right) = \frac{3}{2} \ln\left(\frac{m_h}{m_e}\right)$$

$$E_F = \frac{E_C + E_V}{2} - \frac{3}{4} KT \ln\left(\frac{m_e}{m_h}\right)$$

if effective mass of free e^- is assumed to be equal to effective mass of hole i.e.,

$$m_h = m_e$$

$$\ln\left(\frac{m_h}{m_e}\right) = 0$$

$$E_F = \frac{E_C + E_V}{2}$$

To make meaning of above equation more explicit,
we write

$$E_F = \frac{E_C - E_F}{2} + E_V$$

$$E_F = \frac{E_g}{2} + E_V$$

If we denote the top of valence band E_V as zero level, $E_V = 0$

then $E_F = \frac{E_g}{2}$

The above result shows that in an intrinsic semiconductor Fermi level lies in the middle of forbidden gap.

4. (a) Hall Effect

If a metal or a semiconductor carrying a current I is placed in a transverse magnetic field B, a potential difference. V_H is produced in a direction normal to both the magnetic field and current direction.

Determining the carrier sign

We know that, with direction of magnetic field and current the sign of hall voltage will be negative when direction of B & I are kept same.
∴ knowing sign of hall voltage, type of semiconductor and hence sign of majority carrier can be determined.

(b) The relation b/w current amplification factor α and β of a transistor.

$$\boxed{\alpha = \frac{I_C}{I_E} = \frac{I_C}{I_B + I_C}} \quad (\because I_E = I_B + I_C)$$

$$\frac{1}{\alpha} = \frac{I_B + I_C}{I_C} = 1 + \frac{I_B}{I_C}$$

$$\frac{1}{\alpha} - 1 = \frac{1}{\beta} \qquad \therefore \boxed{\beta = \frac{\alpha}{1-\alpha}}$$

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5. Probablity of occupation $f(E) = 0.75$

Temperature $(T) = 300\,K$

$$\boxed{f(E) = \frac{1}{1 + e^{\frac{E - E_f}{KT}}}}$$

$$0.75 = \frac{1}{1 + e^{\frac{E - E_f}{KT}}}$$

$$e^{\frac{E-E_f}{KT}} = \frac{1}{3}$$

$$\frac{E-E_f}{KT} = \log_e\left(\frac{1}{3}\right)$$

$$E = E_f + KT \log_e\left(\frac{1}{3}\right)$$

$$= 3.13 + (8.61 \times 10^{-5})(300)(-1.09)$$

$$= 3.13 - 0.0283$$

$$E = 3.101\ eV$$