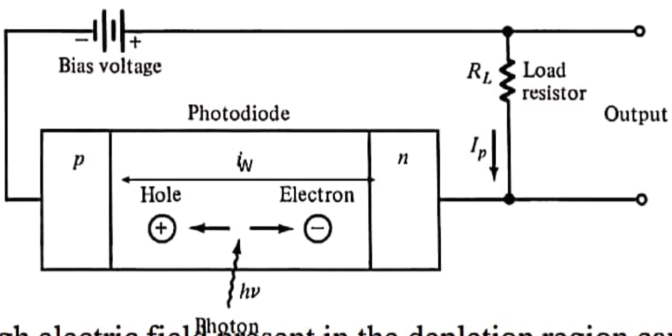
Unit-IV
FIBER OPTICAL RECEIVERS

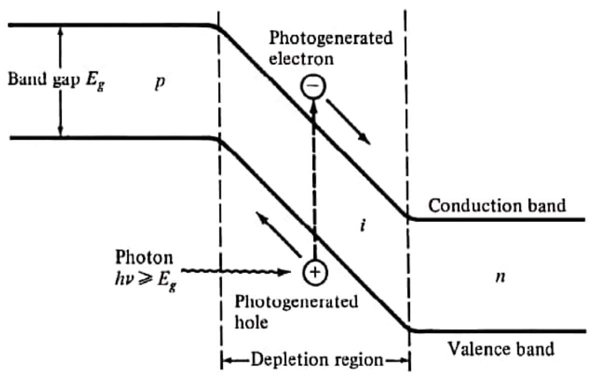
- PIN and APD diodes
- Photo detector noise, SNR, Detector Response time
- Avalanche multiplication Noise – Comparison of Photo detectors
- Fundamental Receiver Operation – pre-amplifiers
- Error Sources – Receiver Configuration – Probability of Error – The Quantum Limit

PIN Photodetector



The high electric field present in the depletion region causes photo-generated carriers to separate and be collected across the reverse –biased junction. This give rise to a current Flow in an external circuit, known as **photocurrent**.

Energy-Band diagram for a *pin* photodiode



Photocurrent

- Optical power absorbed, $P(x)$ in the depletion region can be written in terms of incident optical power, P_0 :

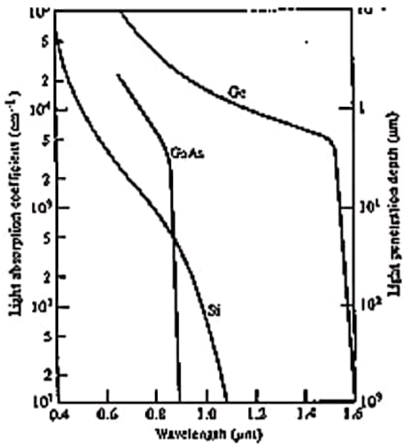
$$P(x) = P_0(1 - e^{-\alpha_s(\lambda)x}) \quad [6\text{-}1]$$

- Absorption coefficient $\alpha_s(\lambda)$ strongly depends on wavelength. The upper wavelength cutoff for any semiconductor can be determined by its energy gap as follows:

$$\lambda_c(\mu\text{m}) = \frac{1.24}{E_g\,(\text{eV})} \quad [6\text{-}2]$$

- Taking entrance face reflectivity into consideration, the absorbed power in the width of depletion region, w, becomes: $(1-R_f)P(w) = P_0(1-e^{-\alpha_s(\lambda)w})(1-R_f)$

Optical Absorption Coefficient



Responsivity

- The primary photocurrent resulting from absorption is:

$$I_p = \frac{q}{h\nu} P_0(1 - e^{-\alpha_s(\lambda)w})(1 - R_f) \quad [6\text{-}3]$$

- Quantum Efficiency:

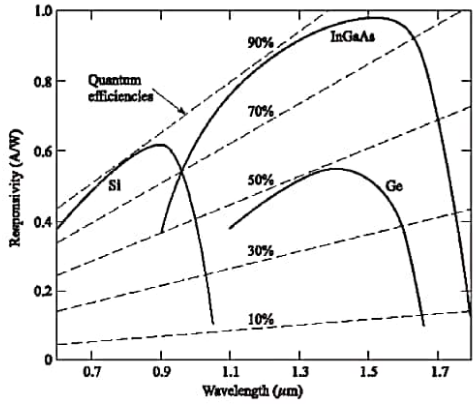
$$\eta = \frac{\#\text{ of electron - hole photogenerated pairs}}{\#\text{ of incident photons}}$$

$$\eta = \frac{I_P / q}{P_0 / h\nu} \quad [6\text{-}4]$$

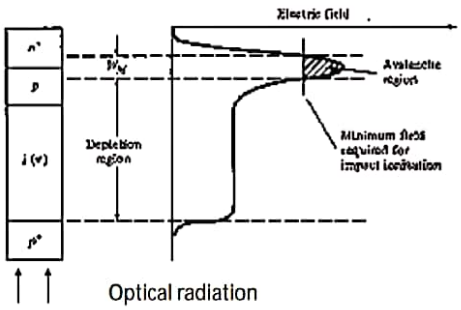
- Responsivity:

$$\Re = \frac{I_P}{P_0} = \frac{\eta q}{h\nu} \quad [\text{A/W}] \quad [6\text{-}5]$$

Responsivity vs. wavelength



Avalanche Photodiode (APD)



Reach-Through APD structure (RAPD) showing the electric fields in depletion region and multiplication region.

APDs internally multiply the primary photocurrent before it enters to following circuitry.
In order to carrier multiplication take place, the photogenerated carriers must traverse along a high field region. In this region, photogenerated electrons and holes gain enough energy to ionize bound electrons in VB upon colliding with them. This multiplication is known as **impact ionization**. The newly created carriers in the presence of high electric field result in more ionization called **avalanche effect**.