



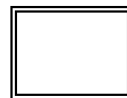
Princess Sumaya
University
for Technology

King Abdullah II School of Engineering

EE 23551
Optical Communications

Quiz #2
Sunday 2/8/2026

Name:.....



Q.1) Explain in details how the photodetector shown in Figure Q.1 works and how one should design a high sensitive detector that works at the required operating wavelengths.

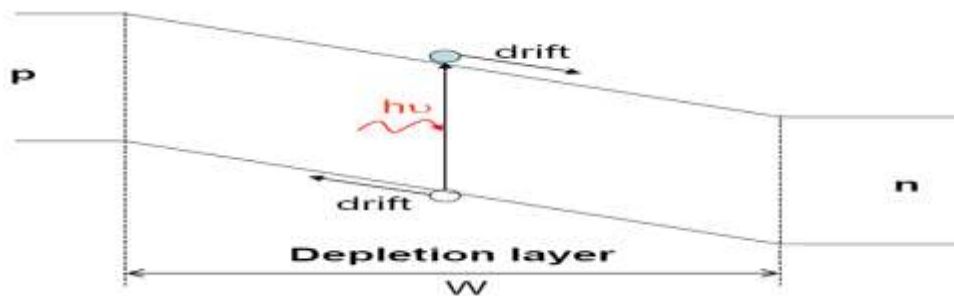
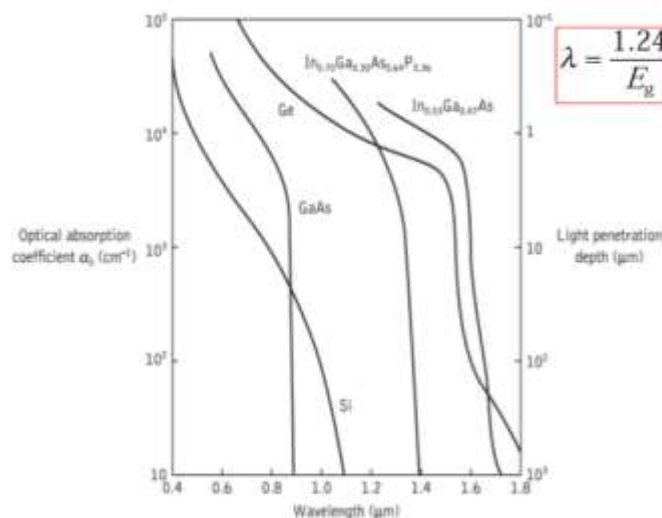


Figure Q.1 PN Junction.

Hint:

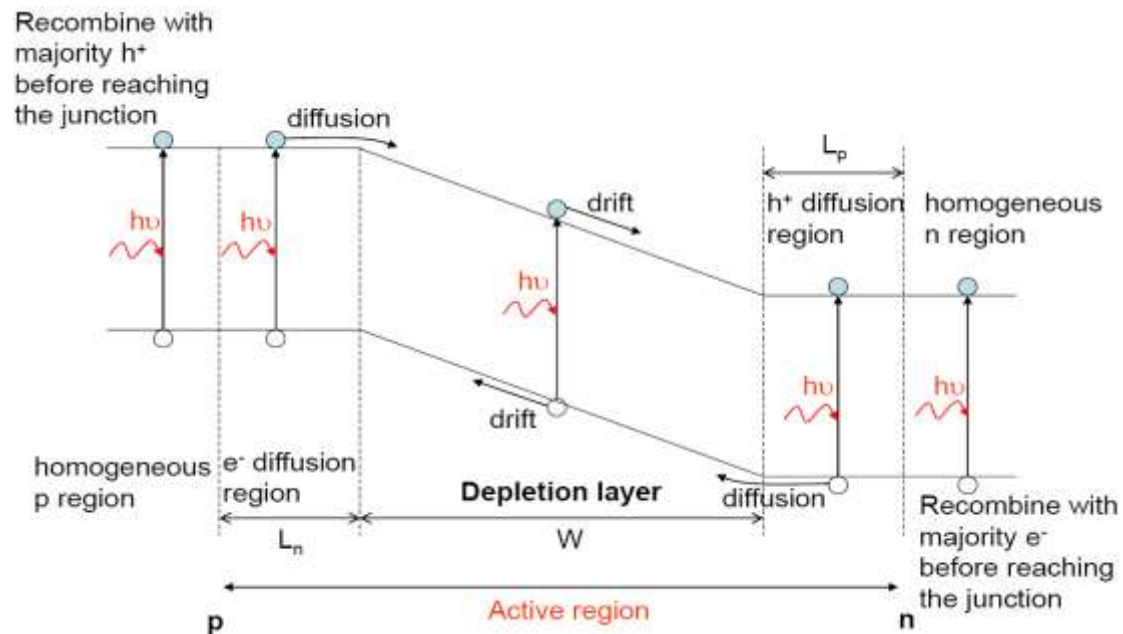


$$\lambda = \frac{1.24}{E_g}$$

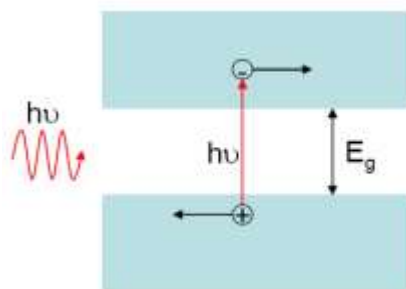
Table 8.1 Bandgaps for some semiconductor photodiode materials at 300 K

	Bandgap (eV) at 300 K	
	Indirect	Direct
Si	1.14	4.10
Ge	0.67	0.81
GaAs	-	1.43
InAs	-	0.35
InP	-	1.35
GeSi	-	0.73
In _{0.53} Ga _{0.47} As	-	0.75
In _{0.53} Ga _{0.47} As	-	1.15
GaAs _{1-x} Si _x	-	1.15

Solution: [6-Points]



- Most modern photodetectors operate on the basis of the *internal photoelectric effect* – the photoexcited electrons and holes remain within the material, increasing the electrical conductivity of the material
- *Electron-hole photogeneration* in a semiconductor



- absorbed photons *generate* free electron-hole pairs
- *Transport* of the free electrons and holes upon an electric field results in a *current*

- The *semiconductor photodiode detector* is a p-n junction structure that is based on the internal photoeffect.
- The photoresponse of a photodiode results from the *photogeneration of electron-hole pairs through band-to-band optical absorption*.
=> The *threshold* photon energy of a semiconductor photodiode is the bandgap energy E_g of its active region.
- The *photogenerated* electrons and holes in the *depletion layer* are subjected to the local electric field within that layer. The electron/hole carriers *drift* in opposite directions. This *transport* process induces an electric current in the external circuit.
- Here, we will focus on semiconductor *homojunctions*.
- ***In the depletion layer***, the internal electric field sweeps the photogenerated electron to the n side and the photogenerated hole to the p side.
=> a *drift current* that flows in the *reverse* direction from the n side (cathode) to the p side (anode).
- Within one of the ***diffusion regions*** at the edges of the depletion layer, the photogenerated *minority* carrier (*hole in the n side and electron in the p side*) can reach the depletion layer by *diffusion* and then be swept to the other side by the internal field.
=> a *diffusion current* that also flows in the *reverse* direction.
- In the p or n ***homogeneous region***, *essentially no current is generated* because there is essentially no internal field to separate the charges and a minority carrier generated in a homogeneous region *cannot diffuse to the depletion layer before recombining with a majority carrier*.

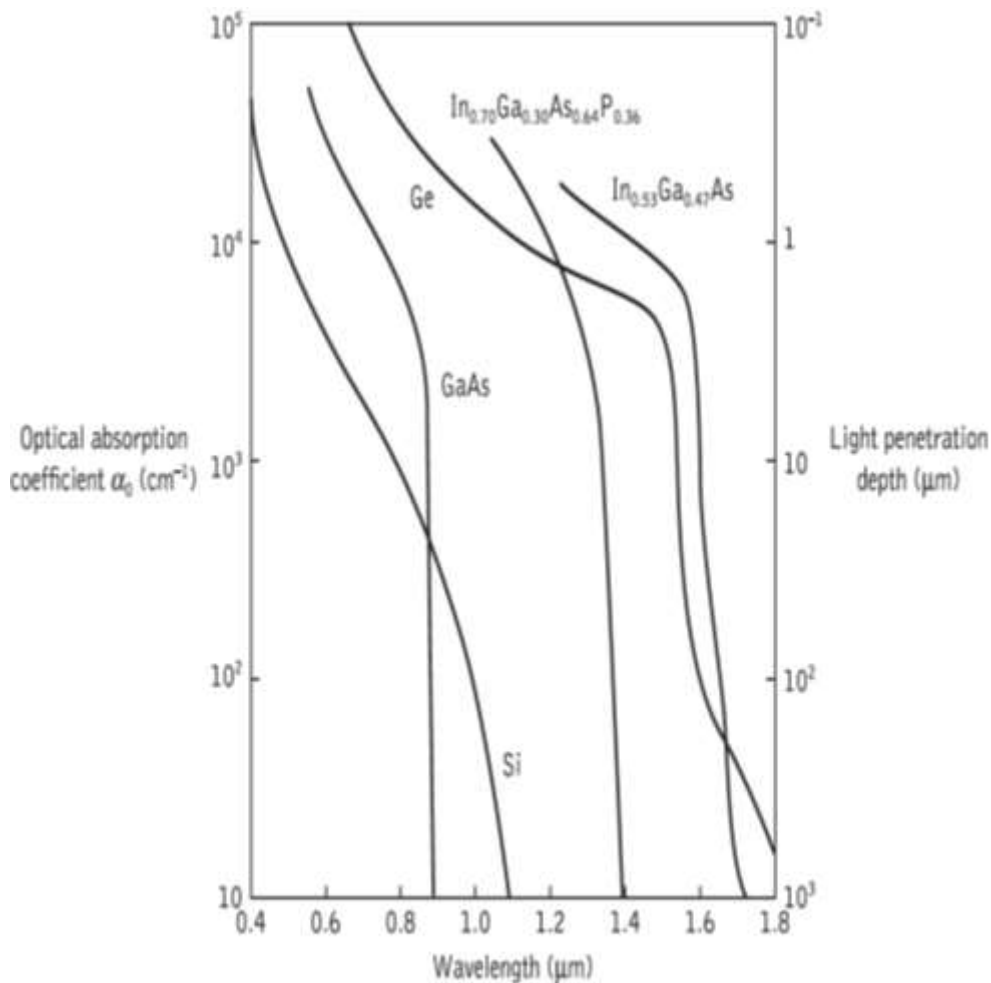


Figure 8.2 Optical absorption curves for some common semiconductor photodiode materials (silicon, germanium, gallium arsenide, indium gallium arsenide and indium gallium arsenide phosphide)

The absorption coefficients of semiconductor materials are strongly dependent on wavelength.

This is illustrated for some common semiconductors in Figure 8.2. It may be observed that there is a variation between the absorption curves for the materials shown and that they are each suitable for different wavelength applications.

This results from their differing bandgaps energies, as shown in Table 8.1. However, it must be noted that the curves depicted in Figure 8.2 also vary with temperature.

Q.2) Explain what is meant by population inversion? Also, explain if it is possible to create that in two-states and three states systems.

Hint:



Solution: [4-Points]

Therefore, we must have a mechanism where $N_2 > N_1$. This is called **POPULATION INVERSION**

Two state no

3 states yes