MICRO-523: Optical Detectors

Week Five: Photodiodes – Exercises

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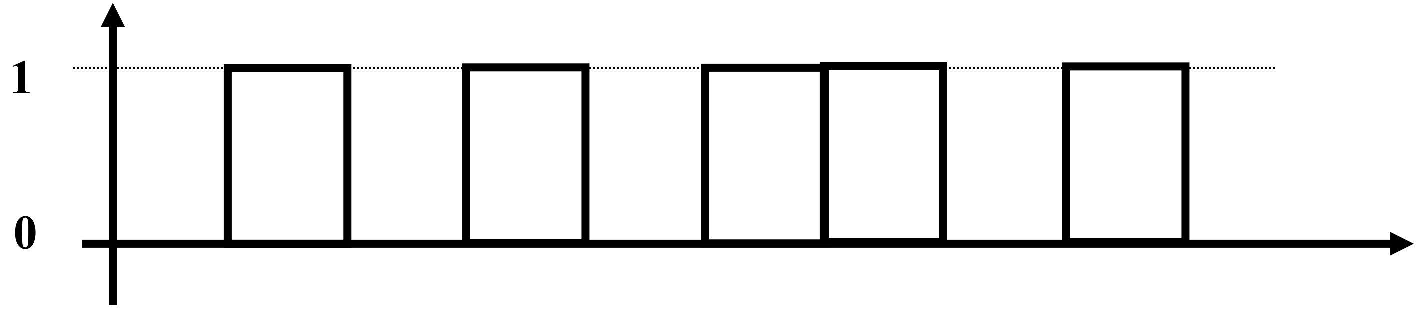
Outline

Exercise 5.1: High-speed photodiodes and BER

- On-off keying system: bits “0“ and “1“

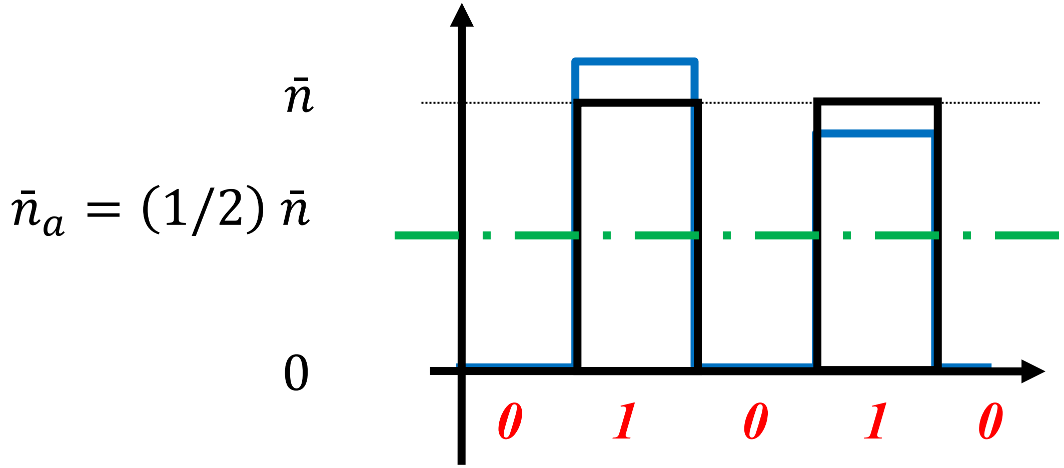


- BER: probability of error per bit
- If p_0 =probability of mistaking a “ 0“ for a “ 1“
  & p_1 =probability of mistaking a “1” for a “0”, then

$$BER = p_0 /2 + p_1/2$$ *(BER definition)*

Exercise 5.1: High-speed photodiodes and BER

Ideal = limited by the optical signal shot noise



- If an average of $\bar{n}$ photons is transmitted by a laser diode, the probability of detecting n photons is given by:

$$p(n) = \bar{n}^n \frac{\exp(-\bar{n})}{n!}$$

→ How many photons per "1" bit are needed to guarantee a BER of 10^{-9}?

Exercise 5.2: PIN Heterostructure Photodiode

$In_{1-x}Ga_xAs_yP_{1-y}$ system on an InP substrate

a) To grow a monocrystal, we have to preserve the lattice of the InP substrate. This involves satisfying the following relationship:

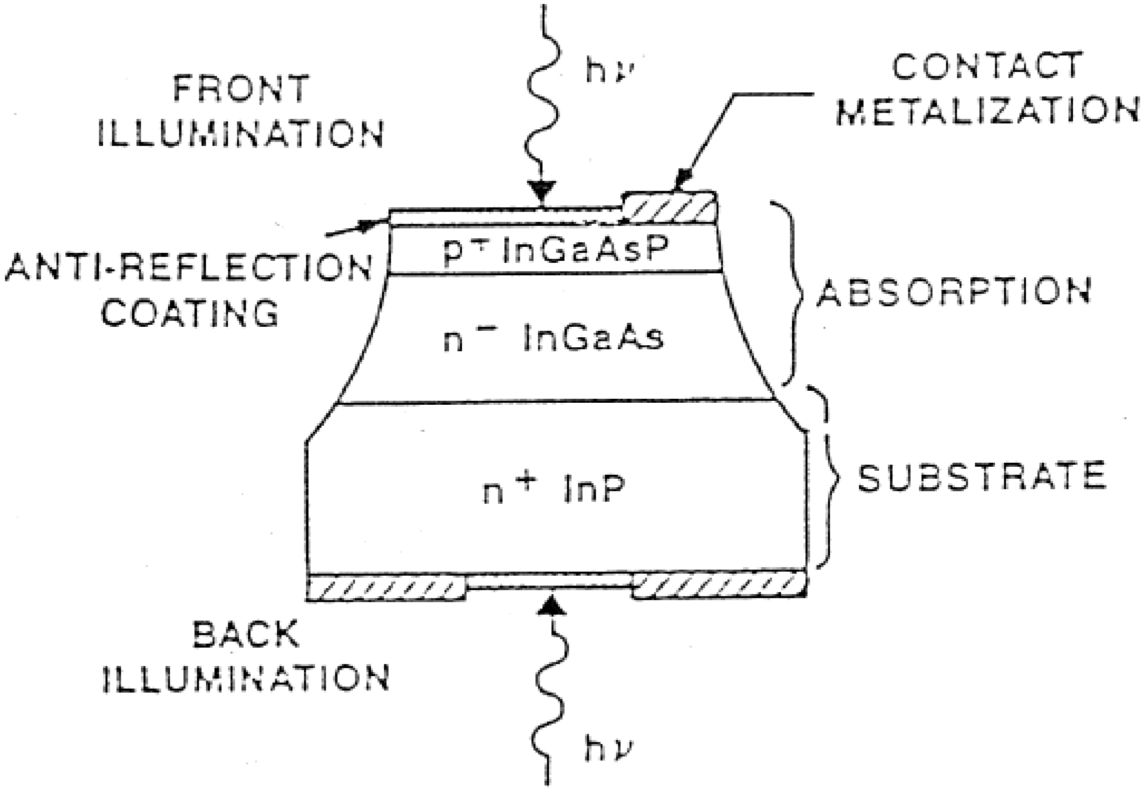
$$x = \frac{0.4562 \cdot y}{1 - 0.031 \cdot y}$$

b) In this case ("lattice matched to InP") the gap can be changed according to:

$$E_g(y) = 1.35 - 0.72 \cdot y + 0.12 \cdot y^2 \quad [eV]$$

Exercise 5.2: PIN Heterostructure Photodiode

Consider the PIN photodiode depicted below:



Exercise 5.2: PIN Heterostructure Photodiode

This type of photodiode was designed for optical telecommunications and has to work at wavelengths between 1.50 μm and 1.60 μm. Its diameter is 10 μm, corresponding to that of a single mode fiber optic cable.

A) Considering a superficial layer with the following composition: $In_{1-x}Ga_xAs_yP_{1-y}$, with y=0.84.
   Sketch the quantum efficiency for front and back illumination. What is the main difference?

B) Estimate the width W of the intrinsic InGaAs region to optimize the bandwidth using a load resistance of $R_L = 50\ \Omega$.
   (use $\varepsilon = 12$ and $v_{sat} = 10^5$ m/s)
   Does the diode have to be polarized, and if so, why?