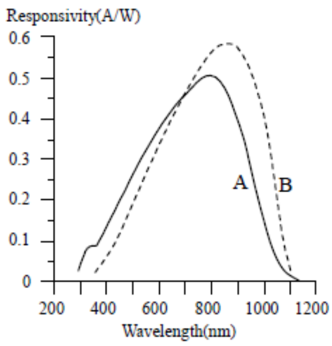
**NTHU Electrical Engineering Department**

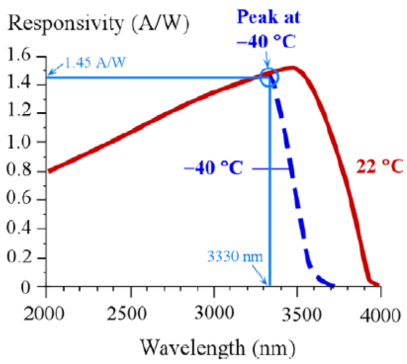
**EE3360 Optoelectronic Devices Spring 2019**

**HW #6**

1. Consider two commercial Si pin photodiodes, type A and type B, both classified as fast pin photodiodes. They have the responsivity curves shown below. Differences in the responsivity are due to the pin device structure. The photosensitive area is 0.125 $mm^2$ (4 mm in diameter). Calculate the photocurrent from each when they are illuminated with blue light of wavelength 700nm and light intensity 1 μW $cm^{-2}$. What is the QE of each device?




2. Figure below shows the responsivity of an InAs pn junction photodiode to use in the infrared. It is normally cooled under normal operation. (a) What is the wavelength and the quantum efficiency at the peak responsivity at -40 degree C? (b) The diode area that is involved in the detection as a diameter of 0.25 mm. What is the intensity of light that corresponds to a photocurrent of 50 nA?




3. (a) Determine the maximum value of the energy gap which a semiconductor, used as a photoconductor, can have if it is to be sensitive to light of wavelength 1550 nm commonly used in optical communication network. (b) A photodetector whose area is $4 \times 10^{-2}$ $cm^2$ is irradiated with light of wavelength 1300nm, whose intensity is 3 mW $cm^{-2}$. Assuming that each photon generates one electron–hole pair, calculate the number of pairs generated per second.

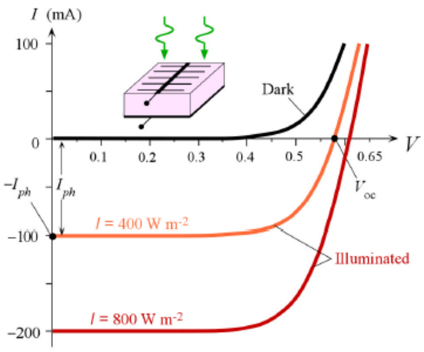
4. A particular photodetection application requires an InGaAs photodetector and needs a bandwidth of 2 GHz. The dark current of the InGaAs pin detector is 6 nA at 30°C. The minimum signal that is to be measured is 5nW at 1550 nm where the responsivity is 0.95 A $W^{-1}$. (a) Calculate the SNR in dB at 30°C. (b) When the detector is cooled to −30°C, the dark current becomes 0.1 nA, and the responsivity is about the same. What is the new SNR? (c) Suppose that we operate the detector over a bandwidth of 20 MHz. What is the new SNR at −30°C?

5. (a) Consider a fast Ge pn junction PD which has a photosensitive area of diameter 0.3 mm. It is reverse biased for photodetection and has a dark current of 0.5 μA. Its peak responsivity is 0.7 A/V at 1.55 μm. The bandwidth of the photodetector and the amplifier circuit together is 100 MHz. Calculate its NEP at the peak

wavelength and find the minimum optical power and hence minimum light intensity that gives a SNR of 1. How would you improve the minimum detectable optical power? (b) Table below shows the characteristics of typical Ge pn junction and InGaAs pin photodiodes in terms responsivity and the current. Fill in the remainder of the columns in the table assuming that there is an ideal, noiseless, preamplifier to detect the photocurrent from the photodiode. Assume a working bandwidth, B, of 1 MHz.

| Photodiode | $R$ at 1.55 μm ($A\ V^{-1}$) | $I_d$ (nA) | $I_{ph}$ for SNR = 1 at $B$ = 1 MHz (nA) | Optical power for SNR = 1 at $B$ = 1 MHz (nW) | NEP W $Hz^{-1/2}$ |
|---|---|---|---|---|---|
| Ge at 25 °C | 0.8 | 400 | | | |
| Ge at –20 °C | 0.8 | 5 | | | |
| InGaAs *pin* | 0.95 | 3 | | | |

6. Consider the I–V characteristics of the solar cell shown below. Suppose that we connect a resistive load of 5 Ω across it. Find the current through and the voltage across the load at 800W $m^{-2}$ and 400 W $m^{-2}$. Please also calculate the filling factor(FF) in each case.




7. A solar cell under illumination of 500 W/$m^2$ has a short circuit current of -16mA and an open circuit output voltage of 0.5V. What are the short circuit current and open circuit voltage when the light intensity is doubled?

8. Find out what types of solar cells are typically used in these applications. Describe the materials and efficiency.

(1)

(2)

(3)

(4)

(5)