OE Devices Hw 06 2019 spring

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1. $\eta_{EQE} = R \times \frac{h\nu}{e} = R \times \frac{hc}{e\lambda} \Rightarrow I_{ph} = R \times P_o = R \times I \times A$

A type: $\eta_{EQE} = 0.45 \times \frac{6.626\times10^{-34}\times3\times10^{8}}{1.6\times10^{-19}\times700\times10^{-9}} = 0.7987$

$I_{ph} = 0.45\,(A/W) \times 1\,(mW/cm^2) \times 0.125\,(mm^2) = 5.625\times10^{-10}\,(A)$

B type: same.

2. (a) $\eta_{EQE} = 1.45 \times \frac{6.626\times10^{-34}\times3\times10^{8}}{1.6\times10^{-19}\times3330\times10^{-9}} = 0.541$

(b) $I \times \pi r^2 \times R = 50\,nA \Rightarrow I = \frac{50\,(nA)}{1.45\,(A/W)\times\pi(0.125\,mm)^2} = 0.702\,(W/m^2)$

3. (a) $E_g = h\nu = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\times3\times10^{8}}{1550\times10^{-9}} = 0.802\,(eV)$

(b) # of photons $= \frac{P}{h\nu} = \frac{4\times10^{-2}\times3\times10^{-3}}{6.626\times10^{-34}\times\frac{3\times10^{8}}{1300\times10^{-9}}} = 7.848\times10^{14}\,(s^{-1})$

4. (a) $SNR = \frac{I_{ph}^2 = (RP_o)^2}{2eI_{dB} + 2eI_{ph}B} = \frac{(0.95\times5\times10^{-9})^2}{2\times1.6\times10^{-19}\times2\times10^{9}(6\times10^{-9} + 0.95\times5\times10^{-9})} = 3.279$

In dB $\Rightarrow$ $SNR = 10\log(3.279) = 5.16\,(dB)$

(b) $SNR = \frac{I_{ph}^2}{2eI_dB + 2eI_{ph}B} = \frac{(0.95\times5\times10^{-9})^2}{2\times1.6\times10^{-19}\times2\times10^{9}(0.1\times10^{-9} + 0.95\times5\times10^{-9})} = 7.269$

In dB $\Rightarrow$ $SNR = 10\log(7.269) = 8.614\,(dB)$

(c) $SNR = \frac{(0.95\times5\times10^{-9})^2}{2\times1.6\times10^{-19}\times20\times10^{6}(0.1\times10^{-9} + 4.5\times10^{-9})} = 766.39$

In dB $\Rightarrow$ $SNR = 10\log(766.39) = 28.84\,(dB)$

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5. (a) $NEP = \frac{P'}{\sqrt{B}} = \frac{1}{R} e\sqrt{B}\left(1+\sqrt{1+\frac{2I_d}{eB}}\right) = 5,737\times10^{-13}\ \left(\frac{W}{\sqrt{Hz}}\right)$

$P' = 5,737\times10^{-9}\ (W)$ $\quad I = 0,08116\ \left(\frac{W}{m^2}\right)$.

(b) $I_{ph} = eB\left(1+\sqrt{1+\frac{2I_d}{eB}}\right)$; $P' = \frac{I_{ph}}{R}$; $NEP = \frac{P'}{\sqrt{B}}$

	R	I_d (nA)	I_{ph} (nA)	$P'(W)$	$NEP\left(\frac{W}{\sqrt{Hz}}\right)$
Ge @ 25°C	0,8	400	0,35793	$4,4741\times10^{-10}$	$4,4741\times10^{-13}$
Ge @ -20°C	0,8	5	0,04016	$5,02\times10^{-11}$	$5,02\times10^{-14}$
InGaAs PIN	0,95	3	0,03114	$3,2783\times10^{-11}$	$3,2783\times10^{-14}$

6. For $400\ W/m^2$, $V = 0,45V$, $I = -90mA$

$FF = \frac{V_{max} I_{max}}{V_{oc} I_{sc}} = \frac{-90\times0,45}{-100\times0,575} = 70,43\%$

For $800\ W/m^2$, $V = 0,55V$, $I = +10mA$

$FF = \frac{-110\times0,55}{-200\times0,605} = 50\%$

7. $I = I_s\left(e^{\frac{eV}{kT}}-1\right) - I_{ph}$ $\quad P_0\times2 \Rightarrow I_{ph}\times2$

$I_{sc} = -I_{ph} = -16mA$ $\quad \Rightarrow I'_{sc} = -32mA$

$V_{oc} = \frac{kT}{e}\ln\left(1+\frac{I_{ph}}{I_{sc}}\right) = 0,5V$ $\quad V'_{oc} = \frac{kT}{e}\ln\left(1+\frac{2I_{ph}}{I_s}\right) = 0,518\ (V)$

assume $2I_{ph} \gg I_s$

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