Ministry of Higher Education & Scientific Research
University of Technology
Laser & Optoelectronic Eng. Department
Branch: Optoelectronic Engineering
Class: 3rd Year
Subject: Infrared technologh

Final Examination
Time: Three Hours
Date: 1 / 6 / 2016
Examiner: Dr. Suad M. Kadhim
Code: OPE 3306
Academic Year 2015-2016

Attempt Five questions only

Q1) a) Give the Planck radiation law in terms of power per unit area per unit wavelength interval.

b) Calculate the wavelength of the peak radiation emitted by an object at 200°C. (12 marks)

Q2) a) Define: Emissivity, Irradiance, Radiant flux, Threshold frequency.

b) The photoelectric threshold wavelength of a tungsten surface is 272nm. Calculate the maximum kinetic energy of the electrons ejected from this tungsten surface by ultraviolet radiation of frequency 1.45×10^{15} Hz. (12 marks)

Q3) A germanium rod of (10*10*10 mm) with resistance 120Ω. Calculate the density of majority and minority carriers,then calculate the conductivity caused by the minority carriers. Knowing that the rod is p-type and $\mu_h = 0.19\ m^2/V.s$, $ni = 2.5*10^{19}\ atom/m^3$, $\mu_e = 0.39\ m^2/V.s$. (12 marks)

Q4) Explain a typical of an infrared system and state the function of each element. (12 marks)

Q5) a) Several sources are available for use in infrared system. What are the sources of infrared,and explain two of them.

b) There are two important ways of describing the amount of radiant energy collected by an optical system. State that. (12 marks)

Q6) a) Explain the Golay pneumatic detector.

b) Practically all optical systems deploy optical filters to optimize their performance. List these optical filters. (12 marks)

Constants

$q=1.6*10^{-19}C$ $h=6.63*10^{-34}$ J.s mass of electron$=9.1*10^{-31}$kg

Good luck

"Infrared technology"

3rd years

Solution

Q1/a

$$M(\lambda) = \frac{C_1}{\lambda^5} \frac{1}{e^{c_2/\lambda T} - 1}$$

b/ $\lambda_{max} = \frac{2.898 \text{ mm.K}}{T}$

$$= \frac{2.898 \text{ mm.K}}{(200+273) \text{ K}} = \frac{2.898 \text{ mm.K}}{473 \text{ K}}$$

$$= 6126 \text{ nm}$$

Q2/a)

① Emissivity: Is a function of wavelength, temperature, body material and surface conditions of the radiating body.

$$\varepsilon(\lambda, T) = \frac{M(\lambda, T)_{source}}{M(\lambda, T)_{blackbody}}$$

2- Irradiance : It is the radiant flux incident on a surface of unit area. The unit in which it is measured $w.cm^{-2}$ are the same as those used for radiant emittance. $H = \frac{J}{d^2}$

3- Radiant flux :- It is the measure of the time rate of transfer of radiant energy and is given in watt.

4- Threshold frequency :- It is a minimum frequncy, when the frequncy of ~~incident~~ light incident is less than from threshold frequney no photoelectrons at all were emitted from surface.

b/

$$E = hf - \phi = hf - \frac{hc}{\lambda_0}$$

$$= h\left[1.45 * 10^{15} Hz - \frac{3 * 10^8}{272 * 10^{-9}}\right]$$

$$= 2.3 * 10^{-19} J$$

Q3/

① $\sigma = \frac{1}{R} \cdot \frac{L}{A}$

$= \frac{10 * 10^{-3}}{120 * 10 * 10 * 10^{-6}} = 0.83 \, (\Omega \cdot m)^{-1}$

$P = \frac{\sigma}{q \mu_h} = \frac{0.83}{1.6 * 10^{-19} * 0.19} = 2.7 * 10^{19} / m^3$

② $n = \frac{n_i^2}{P} = \frac{(2.5 * 10^{19})^2}{2.7 * 10^{19}} = 2.3 * 10^{19} / m^3$

$\sigma = n e \mu_n = 2.3 * 10^{19} * 1.6 * 10^{-19} * 0.39$

$= 1.4 \, (\Omega \cdot m)^{-1}$

Q4/

1- The target:- Is the object of interset, usually the real reson for the existance of the system, its assumed that the target radiates energy somwhere in the infrared portion of the spectrum.

2- Attenuating atmosphere:- If the radiation from the target passes through any portion of the earth's atmosphere, it will be attenuated because the atmosphere is not perfactly transparent.

3-Optical receiver:- The optical receiver which is closely anlagous to aradar antenna, collects some of the radiation from the target and delivers it to an optical modulation.

4-Optical modulation:- It is coded with information concerning the direction to the target or information to assist in the differentiation of the target from unwanted details in the background.

5-The detector:- which coverts the information into an electrical signal.

Q5/a

1- The Nernst Glower
2- Glowbar Lamp
3- Tungsten filament Lamp
4- Garbon Arc Lamp
5- The Laser

Garbon Arc Lamp:-
A- Low-intensity arc Lamps
B- flame arc Lamp
C- High-intensity arc Lamps

b/ Radiant energy :- This term is used to describe the entire amount of energy radiant from asource in given time interval.
It is also describes the energy received by an accumulative or integration type of detectors, such as the photographic plate.

Q6/a

Golay Pneumatic detector:-

These detectors are in fact rather complex instruments that were first described by Golay in 1977. The responsivity of this dectectors is specified as $(1.5 - 3*10^{6}\ V/w)$. The maximum input is specified as $2.3*10^{-6}$ w and NEP as $7*10^{-11}$ w. This value is lower than NEP of the ideal thermal detector.

b/ 1- Band-Pass filters (BPFs)

2- Low-Pass Filters (LPFs) and High-Pass Filters (HPFs)

3- Add-Drop Filters

4- IR Absorbing Filters

5- Dielectric Heat Rejection Filters (DHRFs)

6- Dielectric Hot-Mirror Filters (DHMFs)

7- Tunable filters :-

A- Fiber optic Tunable filters (FOTFs)

B- Tunable Filters for Military and commerical Applications.