MURANG'A UNIVERSITY OF TECHNOLOGY

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF MATHEMATICS AND ACTUARIAL SCIENCE

UNIVERSITY ORDINARY EXAMINATION

2023/2024 ACADEMIC YEAR

SECOND YEAR **SECOND** SEMESTER EXAMINATION FOR BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EES 210: PHYSICAL ELECTRONICS II

DURATION: 2 HOURS

INSTRUCTIONS TO CANDIDATES:

1. Answer Question one and any other two questions.
2. Mobile phones are not allowed in the examination room.
3. You are not allowed to write on this examination question paper.

SECTION A: ANSWER ALL QUESTIONS IN THIS SECTION

QUESTION ONE (30 MARKS)

a) Briefly describe the following terms as applied in quantitates analysis of pn junction diode (2½marks)

   i. Long pn junction
   ii. Low injection current
   iii. Recombination current
   iv. Ambipolar transport

b) State and briefly explain two types of optical losses as a result of spectral mismatch as applied to solar cells. (2marks)

c) The Nobel physics prize of 1905 was won by Einstein for explaining the pholoelectric effect.

   i. Briefly explain the main differences and similarities between photoelectric effect and photovoltail effect. (4marks)
   ii. Explain briefly how if at all photoelectric effect could be used to generate useful energy (2marks)

d) Distinguish between conversion efficiency and external quantum efficiency (EQE) as applied to solar cells. With aid of a suitable diagram, briefly explain how the EQE of alight of varied wavelength incident on its surface (3½marks)

e) Define the term "pinch off" as applied to JFETs and explain its significance in electronic circuit design (2marks)

f) Briefly explain with aid of a well labelled diagram and associate equations the distribution and steady. State concentrations of minority camera in a long pn junction under forward bias (3marks)

g) The V-J characteristics of a pn junction diode are NOT bilateral. Briefly substantiate this fact. (3marks)

h) State and briefly explain two ways of minimizing shading loss in solar cells (2marks)

i) State four advantages of using a perouskite solar cell over the conventional solar cells (2marks)

j) For the silicon pn junction at T=300k with doping concentrator of $Na = 10^{18} cm^{-3}$ and $Nd = 5 \, x \, 10^{15} cm^{-3}$. Assuming abrupt depletion layer approximation applies

  i. Calculate the fermi level position in the p and and regions of the function (2marks)
  ii. Draw a well labelled equilibrium band diagram for the junction and determine the barrier potential from the diagram (2marks)

SECTION TWO: ANSWER ANY TWO QUESTIONS

QUESTION TWO (20 MARKS)

a) A crystalline silicon solar cell generates a photocurrent of Jph=25mA/cm^2. The water is doped with 10^{17}cm^{-3} acceptor atoms and the emitter layer is formed with a uniform concentration of 10^{19}cm^{-3} donor atoms. The minority caner diffusion length in the p type region and n-type region is 500 x 10^{-6} m and 10 x 10^{-6}m, respectively. Further, the intrinsic corner concentration in silicon at 300k is 1.5 x 10^{10} cm^{-3}, the mobility of electrons in the p type region is Mn=1000cm^2/v-s and hole in the n type region is M_____=100cm^2/vm. Assume that the solar cell behaves like an ideal diode, Calculate the under listed parameters of the solar cell.

  i. Built-in voltage (3marks)
  ii. Open circuit voltage (4marks)
  iii. Fill factor (4marks)
  iv. Conversion efficiency (3marks)

b) With the aid of suitable diagram, briefly explain the effect of variation of light intensity and variation of cell temperature on the j-v characteristic of a solar cell. (6marks)

QUESTION THREE (20 MARKS)

a) A p + n junction of uniformly doped silicon in channel JFET at T = 300k has doping concentrations of Na=10^{18}cm^{-3} and Nd=1016cm-3. Considering a channel thickness of a=0.75mm, channel width w=30mm, channel length = 10mn and mobility of eletrons Un=1000cm^2/v-s

i. Calculate the internal pinch-off voltage and pinch-off voltage (5marks)

ii. Determine maximum current for the channel I_{Di}(max) (4marks)

iii. Determine the maximum transconductance assuming the a channel depletion mode JFET is biased in the saturation region (3marks)

b) Consider an n-channel GuAs MASFET at T=300k with gold schottky barner contact and a barrier of $\emptyset_{Bn} = 0.89v$ the channel doping concentration is $Nd = 2\ x\ 10^{15} cm^{-3}$

i. Design a channel thickness of the GuAs MESfET to achieve a threshold voltage of VT =+0.25, No=4.7 x 10^{17}cm^{-3}, Er=13.1 (6marks)

ii. From your design in (i) above, comment on the relationship between channel thickness “a” and threshold voltage “VT” (2marks)

QUESTION FOUR (20 MARKS)

a) Consider a silicon pn junction at T=300K with doping parameters as Na=Nd=10^{16}cm^{-3}, Dn=25cm^2/s, Dp=10cm^2/s _______________

i. Determine the ideal reverse saturation current density of the junction (3marks)

ii. Calculate the electric field strength in the neutral region of the silicon diode to produce a given majority carrier drift current density with an applied forward bias voltage Va =0.65V. Assume Mn=1359cm^2/v-s

b) Derive the ideal-diode equation which gives a proper description of the j-v characteristics of a pn junction over a wide range of currents and voltages (6marks)

c) With the help of a suitable diagram and appropriate equations, explain the difference of the j-v characteristics of a pn junction in the dark and under illumination (7marks)

Useful constrants;

Plank’s constant, h =6.626 x 10^{-34} m^{2}kg/s

Boltzman constant, k=1.38 x 10^{-23} J/k

Charge of an electron e=1.6 x 10^{-19} coloumb

___ Intrinsic curner concentration, ni=1.5 x 10^{10} cm^{-3}

Per______ of free space, _____8.85 x 10^{-12} F/m