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SARDAR PATEL UNIVERSITY

M.Sc. (PHYSICS) (IVth Semester) Examination

Tuesday, 17th April, 2018 10:00 am to 1:00 pm

Course No.: PS04EPHY04

ADVANCED SOLID STATE ELECTRONIC DEVICES

Notes: **Q.1:** Eight multiple choice questions (MCQ) carrying one mark each.
Q.2: Short answer questions carrying two marks each
(attempt any seven out of nine).
Q.3 to Q.6: Long answer questions carrying 12 marks each.

Total Marks:70

Q.1(1) Bandgap shrinkage for an n-p-n transistor having emitter doping of $10^{20}cm^{-3}$ **(8)**
is____.
(a) 0.022eV, **(b)** 0.225 eV, **(c)** 22.5eV, **(d)** 2.25 eV

(2) Which among the following is a high carrier mobility and good quality substrate used for fabrication of HBTs?
(a) Si, **(b)** GaN, **(c)** GaAs, **(d)** Ge

(3) Which of the following material provides opportunity to integrate monolithically electronic and optoelectronic devices in the form of Optoelectronic ICs (OEICs)?
(a) Si, **(b)** Si_xGe_{1-x}, **(c)** Ge, **(d)** GaAs

(4) Which of the following devices has a highest high frequency response?
(a) JFET, **(b)** MESFET, **(c)** MODFET, **(d)** BJT

(5) The capacitance of MOS structure is minimum when it is operated in _____ mode.
(a) Accumulation, **(b)** inversion, **(c)** depletion, **(d)** linear

(6) The charge density of carriers in MOS structure decreases_____.
(a) in bulk region, **(b)** near the interface, **(c)** at the interface, **(d)** both b and c

(7) _____ is used as photodetector.
(a) LASER, **(b)** PiN diode, **(c)** LED, **(d)** Heterojunction LED

(8) In optoelectronics, _____is always connected in forward bias.
(a) photodiode, **(b)** PIN diode, **(c)** LED, **(d)** APD

Q.2(1) What is band gap shrinkage and how it affects the performance of a BJT? **(14)**

(2) Compare the energy band diagrams of BJT and HBT and show similarities and differences in them.

(3) What are different ways by which an active channel of FET is isolated from Gate terminal? Name the devices in each case.

(4) What is channel length modulation? Explain.

(5) What is HMOS? How minimum channel length, L_{min} is obtained for high performance?

(PTO)

(6) Write down the equation representing equivalent capacitance of MOS structure. Justify this equation.

(7) Draw the I-V characteristics of MOSFET and explain them briefly.

(8) Why photodiode is always connected in reverse bias?

(9) Distinguish between photodiode and LED.

Q.3(a) Explain how semiconductor material parameters and device dimensions put limitations on BJT performance. (6)

(b) State the key motivations for MODFET and with the help of energy band diagram of GaAs/AlGaAs MODFET, explain its working. Discuss how the triangular quantum well is formed at the interface and mention its role in the performance of MODFET. (6)

OR

(b) With the help of a schematic and energy band diagram explain the working of MESFET and derive the equation for its I_{Dsat}. (6)

Q.4(a) Discuss the following advanced MOS devices. (6)

(i) HMOS

(ii) SIMOX

(b) With the help of equivalent circuit of a MESFET, discuss the small signal characteristics. Also show the origin of each of the components used for equivalent circuit by presenting a cross-sectional diagram of MESFET and derive expression for maximum cut-off frequency - f_T (max). (6)

OR

(b) Sketch the structure of CCD and explain the process of charge transfer in it. Mention few of its chief applications. (6)

Q.5(a) Enlist important effects observed in long channel MOSFET and describe them in detail. (6)

(b) Draw the structural sketch of CMOS and explain its operation. Also show how this arrangement of FETs leads to substantial power saving. (6)

OR

(b) Draw the charge density variation for electrons and holes with applied bias in MOS capacitor and explain three operating modes of MOSFET. (6)

Q.6(a) Explain the absorption of light in semiconductors. Calculate the maximum wavelength of light absorbed in GaAs (Eg=1.42 eV) (6)

(b) Distinguish between edge emitting and surface emitting LED structures. Discuss any one of this in detail with reference to its operation. (6)

OR

(b) Distinguish between LED and LASERs. Mention various properties of LASERS and discuss the operation of a semiconductor LASER in detail. (6)

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