105 SEAT No._____ No. of Printed Pages : 2

# SARDAR PATEL UNIVERSITY

## M. Sc. (Physics) IV Semester Examination

## Day and Date: Tuesday, 26th March, 2019

## Time: 10.00 am to 1.00 pm

## Subject: Advanced Solid State Electronic Devices

## Paper No: PS04EPHY24

**Total Marks: 70**

**Q.1** Multiple Choice Questions. **(8)**

(1) The heavy emitter doping is responsible for the band gap shrinkage which is an important BJT design limitation. This limitation can be overcome by _____
(a) reducing base width (b) reducing base doping
(c) choosing a wide band gap semiconductor material for emitter
(d) reducing the temperature of observation

(2) The optoelectronic integrated circuits (OEIC) can be monolithically constructed using _____technology.
(a) Si (b) GaAs (c) Ge (d) GeSi

(3) _____ amongst the following is a heterojunction FET.
(a) JFET (b) MOSFET (c) TEGFET (d) CMOS

(4) Ionized impurity scattering can be suppressed drastically in an active channel of _____.
(a) SiMOX (b) MODFET (c) MOSFET (d) Bi-FET

(5) _____detector is the most sensitive photodetector.
(a) P-i-N (b) Avalanche (c) P-N diode (d) Photoconductive

(6) The multiplication of carriers takes place in _____ diode.
(a) p-n junction (b) P-i-N junction (c) avalanche (d) Schottky junction

(7) Positive voltage is applied to _____in CMOS.
(a) source of P-MOSFET, (b) drain of P-MOSFET,
(c) source of N-MOSFET, (d) drain of N-MOSFET

(8) The equivalent capacitance of MOS structure is _____ in inversion mode.
(a) $C_m$ (b) $C_s$ (c) $C_{ox}$ (d) combination of $C_{ox}$ $C_s$

**Q.2** Short answer questions (Attempt any seven) **(14)**

(1) Discuss in brief about advanced Si based HBTs and mention the high frequency limit of Si-SiGe based such devices.
(2) Why high frequency performance of HBTs is better than BJTs?
(3) Why the depletion width in channel is non-uniform in FET?
(4) How the impurity scattering is avoided in heterojunction FETs?
(5) Show by neat diagram the transfer of charges through an array of CCD.
(6) Draw the schematic structure of MOS capacitor. Write down the equation of equivalent capacitance of MOS structure. Why the capacitance of metal is neglected in it?
(7) Enlist the long channel effects in MOSFET.
(8) Give a difference between the operation and I-V characteristics of photodiode and solar cell.
(9) Compare the operation of photodetector and light emitter.

Q.3 (a) What are BJT design limitations? How are they addressed by HBT structure? Compare the band diagram of BJT and HBT and show differences and similarities in their structures. (6)

(b) How MESFETs are different from JFETs? Discuss the I-V characteristics of MESFET in active and saturation regimes. (6)

OR

(b) Discuss following effects in detail in case of FETs; (6)

(i) velocity – field relations and

(ii) channel length modulation

Q.4 (a) Explain the concept of MODFET constructed using AlGaAs. Also discuss its key motivations. (6)

(b) Derive the expression for sheet charge density of electrons in terms of gate voltage on the basis of charge control model of MODFET. (6)

OR

(b) Sketch the equivalent circuit and a cross-sectional diagram of MESFET and derive the expression for $f_T(max)$ in terms of n-type channel parameters. (6)

Q.5 (a) Mention three modes in which the MOS capacitor can be operated. Discuss the operation of MOS capacitor in all three modes. Draw and explain the density variation of electrons and holes in MOS capacitor constructed using p-Si. (6)

(b) Using the circuit diagram, explain in detail the operation of CMOS. Prove that it is used as an inverter. Why the current flowing through CMOS structure is always low? Draw the structure of CMOS. (6)

OR

(b) Describe the C-V characteristics of MOS capacitor at low and high frequencies. Also write the equation of equivalent capacitance of MOS structure in all the three modes. (6)

Q.6 (a) Draw the configuration of avalanche photodiode. Discuss its operation in detail. Why does it require heat sink? Mention its advantages and limitations. (6)

(b) Compare p-n junction photodetector and p-i-n photodetector. (6)

OR

(b) Why LED operates only in forward bias? What is the reason for necessity of a direct bandgap material in case of LED? Draw and explain the structure and characteristics of surface emitting LED. (6)

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