

ADVANCED MICRO & NANO DEVICES  
(VLSI 5231)

Time Allotted: 3 hrs

Full Marks: 70

*Figures out of the right margin indicate full marks.*

*Candidates are required to answer Group A and  
Any 5 (five) from Group B to E, taking at least one from each group.  
Candidates are required to give answer in their own words as far as  
practicable.*

**Group – A**  
**(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following: **10 × 1=10**
- (i) In a MOSFET channel with strong charge inversion, the dominant current component is due to
    - (a) drift
    - (b) diffusion
    - (c) both drift and diffusion
    - (d) leakage current of drain source p-n junctions.
  - (ii) MOSFET uses the electric field of
    - (a) gate capacitance to control the channel current
    - (b) barrier potential of p-n junction to control the channel current
    - (c) both a and b
    - (d) none of these.
  - (iii) In presence of volume inversion, the carrier mobility in thin film devices
    - (a) increases
    - (b) decreases
    - (c) remains unchanged
    - (d) none of these.
  - (iv) The mobility of carriers in the channel of a MOSFET is lower than that in bulk semiconductors because of
    - (a) scattering
    - (b) doping concentration change
    - (c) impact ionization
    - (d) oxide wear out.
  - (v) Doping in semiconductor will
    - (a) decrease scattering
    - (b) increase scattering.
    - (c) increase the speed of the device.
    - (d) both (b) & (c).

- (vi) The condition for punch through is  
 (a) electrons are generated by impact ionization  
 (b) device operates in breakdown region  
 (c) drain and source depletion regions touch each other  
 (d) channel length is less than mean free path between collision of charge carriers.
- (vii) Hot electron effect causes  
 (a) oxide wear-out and breakdown  
 (b) change in threshold voltage  
 (c) finite gate current  
 (d) all the above.
- (viii) Which of the following will serve as a donor impurity in silicon?  
 (a) Boron (b) Indium  
 (c) Germanium (d) Antimony.
- (ix) Polysilicon granularity is a type of \_\_\_\_\_ process variability.  
 (a) systematic (b) random  
 (c) global (d) peripheral.
- (x) Graphene is a \_\_\_\_\_ band gap semiconductor.  
 (a) zero (b) wide  
 (c) low (d) infinite.

**Group – B**

2. (a) Explain how work function engineering can be used to create step potential profile along the MOSFET channel.  
 (b) Explain the effect of higher work function gate material near the drain side of the device.  
**6 + 6 = 12**
3. (a) Derive why subthreshold swing cannot be below 60mV/decade for the conventional MOSFETs and how it can be improved.  
 (b) What is the reason for gate tunneling currents and how it can be overcome?  
**6 + 6 = 12**

**Group - C**

4. (a) Draw the structure of an SOI MOSFET. Differentiate between a partially depleted and a fully depleted structure.  
 (b) What advantages does an SOI MOSFET offer over a conventional MOSFET?  
**(5 + 4) + 3 = 12**
5. (a) Explain with suitable diagrams the difference between vertical and planar DG MOSFETs.  
 (b) What are the important effects associated with such devices?  
**6 + 6 = 12**

**Group - D**

6. (a) Distinguish between systematic and random process variability.  
 (b) How can these be addressed in the yield consideration of VLSI circuits?  
**6 + 6 = 12**
7. (a) Explain how 2DEG can be formed in the MOSFET. Compare between the 2DEG formed in MOSFET and high electron mobility transistor (HEMT).  
 (b) Explain the operation of a HEMT with the help of necessary illustration.  
**6 + 6 = 12**

**Group - E**

8. (a) Differentiate between intra-die and inter - die process variability.  
 (b) What is RDD in transistor channels? Explain how RDD can lead to an increase in the RTS noise in analog and mixed-signal circuits.  
**4 + (3 + 5) = 12**
9. (a) Write a short note on Graphene based transistor and its advantages over Silicon based transistor.  
 (b) Write a short note on binary semiconductor materials and their advantages.  
**6 + 6 = 12**