2015

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 x 1=10**

(i) Velocity saturation causes the short channel device to saturate for _________ values of Vds
(a) larger (b) smaller (c) moderate (d) very large.

(ii) Short channel effect can be characterized by
(a) saturation drain current depending quadratically upon overdrive voltage
(b) bulk depletion region becoming asymmetrical in shape instead of a rectangular structure
(c) drain depletion region becoming larger than the source depletion region
(d) threshold voltage decreasing with effective channel length.

(iii) The mobility of carriers in the channel of a MOSFET is lower than in bulk semiconductors because of
(a) scattering (b) doping concentration change
(c) impact ionization (d) oxide wear out.

(iv) The full form of MODFET is
(a) modification of doping field effect transistor
(b) modulation doped field effect transistor
(c) moderately doped field effect transistor
(d) model for field effect transistor.

(v) 2DEG results in high mobility because
(a) there is negligible impurity scattering (b) there is no scattering
(c) electrons are in a quantum well (d) none of these.

(vi) In a quantum well, the effective energy gap for inter-band transition compared to bulk Eg is
(a) lower (b) higher (c) same (d) none of these.

(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) Change in drift velocity due to scaling is known as
(a) hot carrier effect (b) punch-through
(c) velocity saturation (d) velocity overshoot.

(ix) A FinFET with multiple fins of number N has an effective device width of
(a) $N(2 \times H_{fin} + T_{fin})$ (b) $N(2 \times H_{fin}) + T_{fin}$
(c) $(2 \times H_{fin} + T_{fin})$ (d) $(2 \times H_{fin} + N \times T_{fin})$.

(x) The equivalent oxide thickness when using a high-K gate dielectric of thickness 10 nm and having a dielectric constant of 25 is (given the dielectric constant of SiO_2 to be 3.9)
(a) 15.6 nm (b) 10.6 nm (c) 14 nm (d) 20 nm.

Group – B

2.(a) State the limitations of SiO_2 scaling. Explain how these may be overcome by the use of a high-K material as the gate dielectric.

(b) List the basic requirements of a high-K oxide. State some limitations of using high- K oxides.

(2+4)+(4+2)=12

3.(a) Differentiate between Partially-depleted (PD) and Fully-depleted (FD) Silicon-on-insulator (SOI) MOSFETs. What is floating body effect? How can it be removed?

(b) List the advantages offered by an FDSOI MOSFET.

(5+3+1)+(3)=12

Group – C

4.(a) Draw the cross-section of a planar Double Gate (DG)-MOSFET. State the salient features of a DG-MOSFET.

(b) What is volume inversion? How does it affect the mobility of the carriers?

(5+4)+(2+1)=12

5.(a) Point out the significant difference between planar and vertical DG-MOSFET with suitable structural illustrations.

(b) What is self-heating in SOI-based devices?

10+2=12

Group – D

6.(a) What is 'body effect' in a conventional bulk MOSFET? How is it eliminated in an SOI MOSFET?

(b) Differentiate between symmetric and asymmetric DG-MOSFETs. 'Though the DG-MOSFETs may be scaled down to a shorter channel length yet, it provides no inherent advantage over the conventional MOSFETs as far as intrinsic delay is concerned'. Justify this statement.

(3+1)+(4+4)=12

7.(a) Differentiate between local and global process variability.

(b) Discuss the various sources of random process variability.

5+7=12

Group – E

8.(a) What is band gap engineering? State its utility in the development of semiconductor circuits. Differentiate between homojunction and heterojunction.

(b) Explain with suitable band diagrams the different possible structures when a narrow band gap and a wide band gap material form a heterojunction.

(2+1+3)+6=12

9. Write short notes on the following:

(i) Volume inversion in DG-MOSFETs
(ii) Random Dopant Fluctuation.

(2x6)=12