

(REVISED COURSE)

( 3 Hours)

[ Total Marks : 100

N.B.(1) Question No. 1 is compulsory.

(2) Attempt any four questions out of remaining six questions.

(3) Assume suitable data, wherever required.

1. (a) The segregation coefficient of oxygen is 0.25. Find the concentration of oxygen in the silicon ingot at a fraction solidified of 0.3. The concentration of oxygen in the silicon at the top of the crystal is  $12.5 \times 10^{17}$  atoms/cm<sup>3</sup> at fraction solidified of 0.1. 6
- (b) Implement the following function using CMOS gate.  $F = \overline{(A + B + C)DE}$  6
- (c) Describe the hot electron effect and short channel effect in MOS devices and explain their effect on characteristic of MOSFET. 8
2. (a) What are the factors controlling the threshold voltage ? Explain analytically (required mathematical expressions). How threshold voltage is related with flatband voltage ? 10
- (b) Calculate the threshold voltage  $V_{TO}$  at  $V_{SB} = 0$ ,  $Q_{BO}$ ,  $C_{OX}$  for a poly gate n-channel, MOS transistor.  $N_A = 10^{16}/\text{cm}^3$ . (Substrate doping),  $N_D = 2 \times 10^{20}/\text{cm}^3$  (polysilicon gate doping) ;  $t_{ox} = 500 \text{ \AA}$  and oxide - interface fixed charge density  $N_{OX} = 4 \times 10^{10}/\text{cm}^2$ .  
(Given  $n_i = 1.45 \times 10^{10}/\text{cm}^3$ ,  $\epsilon_{si} = 11.7 \times 8.854 \times 10^{-14} \text{ F/cm}$ ,  
 $\epsilon_{OX} = 3.97 \times 8.854 \times 10^{-14} \text{ F/cm}$ ) 10
3. (a) Explain the concept of pass transistor logic useful to implement logic function clearly explain the limitations of PMOS/NMOS pass transistors. Also explain how it can be taken care of. 10
- (b) Compare constant voltage and constant field scaling with clearly stating their merits and demerits. 10
4. Draw the stick diagram and layout using  $\lambda$  based rule for NMOS depletion load two input NAND and two I/P NOR gate. Use proper color coding and aspect ratio. 20
5. CMOS inverter is to be fabricated with p-well process. Discuss various steps involved in fabrication. Sketch the masking steps in cross-sectional view giving mask sequence and color of Mask to be used. Clearly mention the number of Mask required in complete process. 20
6. (a) Explain the operation of CMOS inverter with clearly mentioning five cases given below : 10
  - (i)  $V_{in} < V_{TO, n}$
  - (ii)  $V_{in} = V_{IL}$
  - (iii)  $V_{in} = (\text{inverter threshold})$
  - (iv)  $V_{in} = V_{IH}$
  - (v)  $V_{in} > V_{DD} + V_{TO, P}$
- (b) Compare Resistive load, Depletion load and Enhancement load inverters. Write their merits and demerits. 10
7. Write detailed notes on any three :— 20
  - (a) Electron beam lithography
  - (b) VHDL in VLSI Design
  - (c) Custom and Semicustoms design methods
  - (d) Butting and burried contacts in VLSI
  - (e) CMOS latchup and protection circuits.