Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/M.Tech (ECE)/SEM-1/MVLSI-104/2010-11

2010-11
MICROELECTRONICS TECHNOLOGY & IC FABRICATION

Time Allotted : 3 Hours   *Full Marks :* 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer Question No. 1 and any *four* from the rest.

1.   Answer *all* questions :   7 × 2

   a)   Why is Silicon predominant in IC fabrication ?

   b)   What is the difference between Deionized and Distilled water ? What is the resistivity of Deionized water ?

   c)   Why are oxidation growth rates different in case of wet and dry oxidations ?

   d)   Why is cleaning of Silicon wafer important for microelectronics processing ?

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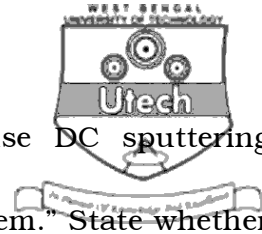
e) "To deposit the dielectric layers use DC sputtering system instead of RF sputtering system." State whether the statement is true or false. Why ?

f) "High Chamber pressure results in low deposition rate". Why ?

g) "Silicon (100) as starting surfaces are mostly used in MOSFET fabrication." Why ?

2. You have a plan to design a clean room facility for fabricating of integrated circuits (VLSI technology). What kinds of clean room classification should you adopt and why ?

How the semiconductor grade silicon (4N purity) from metallurgical grade silicon (98% purity) is obtained in industry ?

Prior to do the microelectronic fabrication on Silicon wafer RCA cleaning is necessary. What is the process of the RCA cleaning ?   1 + 3 + 5 + 5
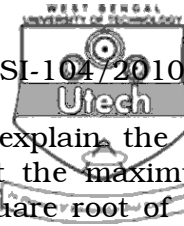
3. The following schematic is the model to explain the CZ technique to grow Silicon wafer. Show that the maximum pull rate is inversely proportional to the square root of the Silicon wafer diameter, considering the following schematic and the equation to derive the relation.

Modeling CZ Crystal Growth
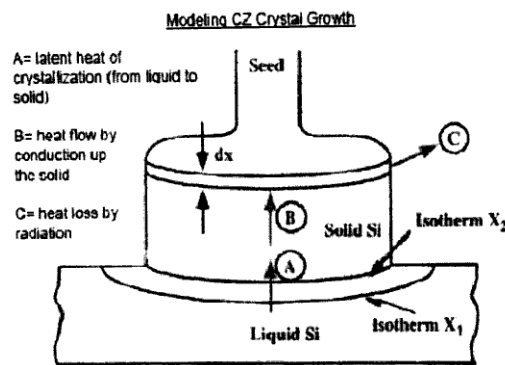
$$L \frac{dm}{dt} + k_L \frac{dT}{dx_1} A_1 = k_S \frac{dT}{dx_2} A_2$$

where :

L = latent heat of fusion (cal/gm)

$\dfrac{dm}{dt}$ = amount of freezing per unit time (gm/sec)

k_L = thermal conductivity of liquid (cal/cm-sec-°C)

$\dfrac{dT}{dx_1}$ = thermal gradient at isotherm x_1 (°C/cm)

k_S = thermal conductivity of solid (cal/cm-sec-°C)

$\dfrac{dT}{dx_2}$ = thermal gradient at x_2 (°C/cm)

You have a Silicon wafer. What is the technique you will prefer to determine the carrier concentration and type of wafer ? Explain.

If a Silicon oxide layer thickness x is grown by thermal oxidation, what is the thickness of Silicon being consumed ? The molecular weight of Silicon is $28 \cdot 9$ g/mol, and the density of Silicon is $2 \cdot 33$ g/cm^3. The corresponding values for SiO_2 are $60 \cdot 08$ g/mol and $2 \cdot 21$ g/cm^3.　　　　6 + 4 + 4
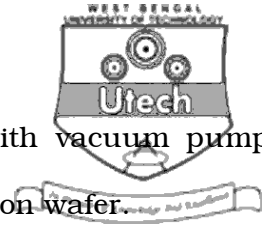
4. Design a deposition system integrated with vacuum pump and gauge system to deposit metal on Silicon wafer.

You want to create a vacuum of 10^{-6} torr for a metal evaporation system to deposit metal on Silicon wafer. Design the deposition system with proper pumping arrangement and the vacuum measuring (gauge) system.

What are the advantages of turbo molecular pump over diffusion pump ?

What will be the time to achieve the vacuum of 50 μ torr from 1 torr pressure in a 2500 c.c. chamber using mechanical pump with pumping speed 100 c.c./min ? Derive the required expression.   6 + 3 + 2 + 3

5. You want to grow a $Si_{1-x} Ge_x$ epitaxial layer (70 nm) on Silicon wafer using molecular beam epitaxy system. Give a schematic of experimental arrangement.

What are the basic components of photoresist material ?

Differentiate the positive and negative photoresist material with proper schematic. What are the advantages of Rapid thermal oxidation over Thermal oxidation ?   4 + 3 + 4 + 3

6. Define photolithography. You have a cleaned Silicon wafer. You want to make a pattern for metal oxide semiconductor capacitor. What will be the process flow using optical lithography ?
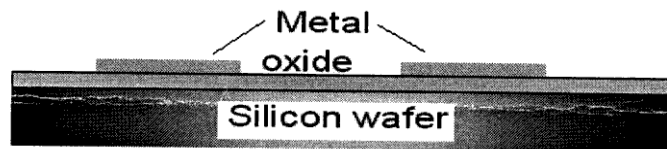
Estimate the resolution and depth of focus (DOF) of a state-of-the art eximer laser stepper using a KrF light source $(\lambda = 248 \, \text{nm})$ with a NA = 0·6. Assume $K_1 = 0·75$ and $K_2 = 0·5$. Do you think the state-of-art is suitable for SIA NTRS 0·25 μm generation ?

What are the different printing techniques used in photolithography ? Give the detailed schematic illustration for defect-free mask at larger demagnification technique.

2 + 5 + 3 + 1 + 3

7. Design a boron diffusion process (say for the well of a CMOS process) such that sheet resistance $= 900$ Ω/square, $X_j = 3$ μm and $N_b = 1 \times 10^{17}$ cm^{-3} (substrate concentration). If the diffusion is done at 1100° C, then what will be the drive-in time ? Given : The boron diffusivity @ 1100° C is $1 \cdot 5 \times 10^{-13}$ cm^2 sec^{-1}.

What are the basic differences of dry and wet etching ?

Illustrate the ion implantation process with proper schematic. 6 + 2 + 6

Irvin curve for p-type impurity, gaussian profile.
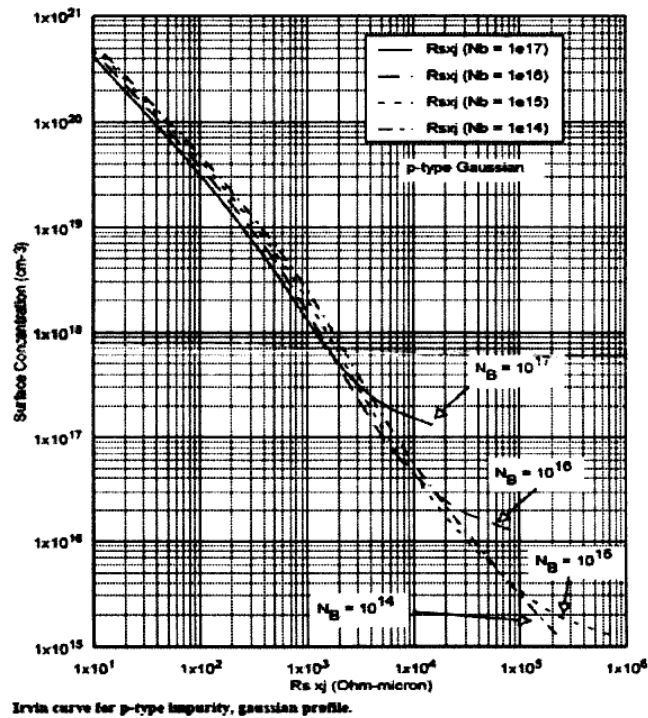
8. You want to measure 10^{-3} torr pressure using gauge system. What will be your preference ? Give the basic measurement set-up.

If you want to deposit dielectric materials (good quality as well as good step coverage) using physical vapour deposition system, which technique should you follow and why ?

What are the steps involved in a chemical vapour deposition process ? Discuss with a schematic.

Why is Ion implantation the dominant method of doping for IC industry ? $1 + 3 + 1 + 3 + 4 + 2$

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