Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
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SIXTH SEMESTER B.Tech. (E & C) DEGREE END SEMESTER EXAMINATION
APRIL/MAY 2018
SUBJECT: VLSI/ULSI PROCESS TECHNOLOGY (ECE - 4016)

TIME: 3 HOURS **MAX. MARKS: 50**

Instructions to candidates
- Answer **ALL** questions.
- Missing data may be suitably assumed.

1A. A Czochralski crystal is grown with an initial 'Sb' concentration in the melt of 1×10^{16} cm^{-3}. After 80% of the melt has been used up in pulling the crystal, pure silicon is added to return the melt to its original volume and the growth is resumed. What will be the Sb concentration in the crystal after 50% of the new melt has been consumed by growth? Assume $k_{Sb} = 0.02$.

1B. With necessary diagrams, explain the lift off technique. What are the uses of such technique? What is the precaution to be taken in successfully achieving the lift off process?

1C. i) Among BCC, FCC, SC, and Diamond lattices, ___ lattice has the maximum packing density
ii) To grow field oxide in MOSFET, ___ oxidation is preferred over ___ oxidation
iii) RIE is an ___ etching process
iv) [101] represents ___ of ___. **(5+3+2)**

2A. Determine the time needed to grow 0.35µm of oxide on a silicon wafer with initial oxide thickness of 0.1µm. The oxidation temperature is 1000°C. The wafer has (100) orientation. Do the calculations for both wet and dry oxidations.

	C_1 (μm^2/hr)	C_2 (μm^2/hr)	E_1 (eV)	E_2 (eV)
Dry Oxidation	7.72×10^2	3.71×10^6	1.23	2.0
Wet Oxidation	3.86×10^2	0.97×10^8	0.78	2.05

2B. With necessary diagram explain the dual Damascene process.

2C. i) CZ grown wafer is doped with Boron. Its concentration ____ at the tail end than at the seed end.
(a) more (b) less (c) equal
ii) $SiHCl(l) + H_2(l) \leftarrow \rightarrow Si(s) + 3HCl(g)$; This chemical equation needs ___ corrections.
(a) 4 (b) 2 (c) 3
iii) 1. Heavily doped Si oxidizes slower. 2. Parabolic rate constant is orientation dependent. 3. When compared to growth at atmospheric pressure, high pressure oxidation gives thicker oxide at relatively low temperature. With respect to above statements, select the appropratite answer from the options given below.
a) All statements are correct b) All statements are wrong c) Two statements need correction
iv) To form deep junctions such as n-tubs in a CMOS device, ____ is commonly used.
(a) Phosphorus (b) Arsenic (iv) Antimony **(5+3+2)**

3A. With an initial dose of $10^{14}cm^{-2}$, an arsenic, constant-dose diffusion is performed at 1100°C for 2 hours. The starting wafer had a p-type background doping of $10^{17}cm^{-3}$. Calculate the concentration of the 'As' at the surface and find the junction depth. $D_0=9.17cm^2/s$, $E_A=3.99eV$, $k=8.6\times10^{-5}eV/K$.

3B. With respect to VPE systems;
i) What is boundary layer effect? How is it overcome?
ii) What is auto doping? Why is it problematic when the epi-layer is thin?

3C. i) What is masking efficiency in Ion Implantation?
ii) What is the Importance of Depth of Focus in Lithography?
iii) What is the significance of angle of incidence in sputter evaporation?
iv) What should be the features of metal holder in a thermal evaporation system? **(5+3+2)**

4A. Figure Q4(A) shows a cross-section of a silicon wafer with oxide over it undergoing a lithography process using NPR. Observe that there is small pin hole at the centre of the middle pattern. Following this process, oxide is etched using an **isotropic** etchant - Buffered Hydrofluoric Acid (BHF). Draw the final oxide profile if Oxide thickness is (i) 1μm (ii) 3μm.

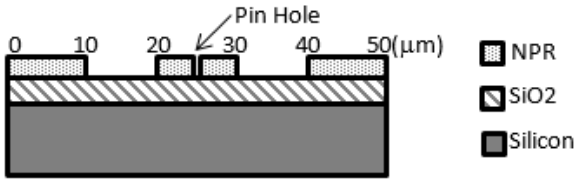

Fig. Q4(A)

4B. With respect to Ion Implantation;
i) What is channelling effect? How can it be overcome?
ii) What are molecular beams? When are they used? Why?
iii) What is range and straggle?

4C. Check if the statements are True or False.
i) [1 0 0] represents family of (1 0 0) planes
ii) In ion implantation, the range of damage created by lighter ions is more than heavy ions
iii) A h-line lithography machine uses a UV source of 365nm wavelength
iv) Hafnium oxide is an example of high-k dielectric material **(5+3+2)**

5A. Figure Q5 (A1) and (A2) are with respect to a PPR. Using these plots and conditions of table I, Draw the photoresist profile (Fractional PR left versus Distance) with respect to the pattern shown.

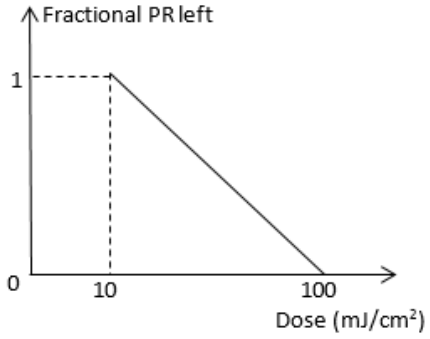

Fig. Q5(A1)

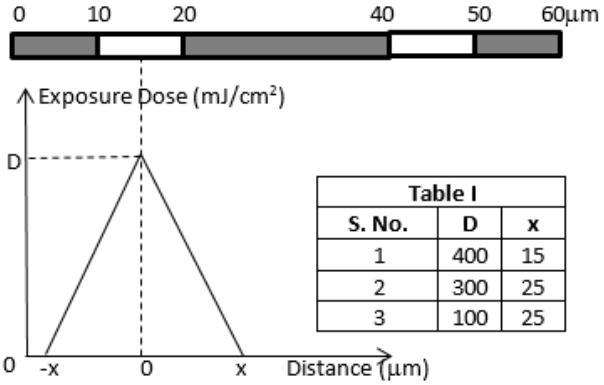

Table I		
S. No.	D	x
1	400	15
2	300	25
3	100	25

Fig. Q5(A2)

5B. Lithography is carried out using
i) Contact ii) Non-contact with a separation of 5μm iii) Projection Printing (k=0.75 & NA=0.26)
Determine the wavelength in each case if the resolution requirement is 2μm and photo resist thickness is 2μm.

5C. Match the following **(5+3+2)**

1	e-beam	bird's beak
2	LOCOS	Dry etching
3	Plasma	Self-align technology
4	Poly silicon gate	Mask writer