Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

SIXTH SEMESTER B.Tech. (E & C) DEGREE END SEMESTER EXAMINATION

APRIL 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 silicon ingot of 300mm diameter and 1m length is grown using C-Z technique. Initial mass of the melt is twice the mass of the final silicon ingot. Given, k_{As} = 0.3, ρsilicon = 2.33 g/cm^3, molecular weight of arsenic = 74.92 g/mol, and Avogadro's number = 6.022×10^{23} atoms/mole.

i) At the middle of the wafer length (0.5m), measured dopant (arsenic) concentration is 5×10^{16} atoms/cm^3. Determine the concentration of arsenic atoms in the melt.

ii) Calculate the mass of the silicon ingot and initial silicon charge

iii) Calculate weight of arsenic to be added to the silicon melt

iv) Plot arsenic concentration along the length of the ingot. Values at 0, 0.5, and 1 units of total length are sufficient.

v) Do you anticipate similar trend in radial direction? If yes, Why?

1B. Describe the F-Z process for growing single-crystal Si. Explain how this method can be used to purify Si ingots.

1C. Draw the n-type and p-type wafers for the <111> and <100> surface orientations.

(5+3+2)

2A. It is required to grow a 0.9μm thick oxide on the (100) Si wafer at 1200 °C. Answer the questions given below assuming both wet and dry oxidation.

i) How long does it take to grow the first 300nm?

ii) How long does it take to grow the second and third 300nm?

iii) Sketch the graph of the oxide thickness as a function of growth time

iv) Explain why the trend is not linear

2B. Briefly describe the "LOCOS" process. What is "Bird's Beak"? What materials/chemicals are essential to do LOCOS? Why do you need a "recessed" structure? Explain.

2C. Define packing density and calculate the same for a BCC structure.

(5+3+2)

3A. A p-type silicon substrate with background doping concentration of 1×10^{17}cm^{-3} is used to make P-N junction. A pre-deposition step at 1000°C followed by a drive-in diffusion of 3 hours at 1100°C is performed. Calculate

i) the pre-deposition time and surface concentration. Assume dopant dose of 1×10^{16} cm^{-2}.

ii) the surface concentration after drive-in diffusion

iii) the junction depth after pre-deposition and drive-in

iv) the final sheet resistance of the diffused layer

3B. List the merits and demerits of dry etching over wet etching

3C. What are molecular beams? Why are they used in Ion Implantation system over Ion beams?

(5+3+2)

4A. A boron doped silicon wafer with background dopant concentration of 1×10^{16} cm^{-3} is ion implanted with phosphorus at a dose of 1×10^{16} cm^{-2}. If the implantation results in a projected range of 135nm and a straggle of 53.5nm and an average mobility of $1000cm^2/V.s$,

i) Is the junction formed is P^+-N or N^+-P?
ii) What is the maximum implant concentration in the implanted layer?
iii) What is the resulting junction depth?
iv) What is the sheet resistance of the implanted layer?
v) If a beam current of 100μA was swept over a square area of 10cm × 10cm, how long was the implantation process?

4B. Explain the various ways of realizing resistors in an IC.

4C. List the problems associated with thermal evaporation system and explain how some of the problems can be overcome using sputter deposition.

(5+3+2)

5A. With necessary diagrams explain two ways of realizing a negative of a given mask.

5B. List the various isolation techniques used in p-n junction and explain them with necessary diagrams.

5C. What is electro-migration? What are the problems associated with it? What is the problem in using copper over aluminium to overcome electro-migration?

(5+3+2)

$$C_S = kC_M(1-X)^{k-1}$$

RATE CONSTANTS FOR WET OXIDATION OF SILICON

Oxidation Temperature (°C)	A (μm)	B (μm²/hr)	B/A (μm/hr	τ (hr)
1200	0.05	0.720	14.40	0
1100	0.11	0.510	4.64	0
1000	0.226	0.287	1.27	0
920	0.50	0.203	0.406	0

RATE CONSTANTS FOR DRY OXIDATION OF SILICON

Oxidation Temperature (°C)	A (μm)	B (μm²/hr)	B/A (μm/hr)	τ (hr)
1200	0.040	0.045	1.12	0.027
1100	0.090	0.027	0.30	0.067
1000	0.165	0.0117	0.071	0.37
920	0.235	0.0049	0.0.0208	1.40
800	0.370	0.0011	0.0030	9.0
700	—	—	0.00026	81.0

	D at 1000°C	**D at 1100°C**	**Solubility at 1000°C**	**Solubility at 1100°C**
Boron	$3\times10^{-15}cm^2/s$	$2\times10^{-14}cm^2/s$	$2\times10^{20}cm^{-3}$	$3\times10^{20}cm^{-3}$
Phosphorus	$4\times10^{-15}cm^2/s$	$3\times10^{-14}cm^2/s$	$8\times10^{20}cm^{-3}$	$1.2\times10^{21}cm^{-3}$
Hole mobility = $250cm^2/V.s$ and Electron mobility = $1000cm^2/V.s$				

z	erfc(z)	z	erfc(z)	z	erfc(z)
0.0	1.00000000	1.3	0.06599207	2.6	0.00023603
0.1	0.88753708	1.4	0.04771489	2.7	0.00013433
0.2	0.77729741	1.5	0.03389486	2.8	0.00007501