



# INDIAN INSTITUTE OF INFORMATION TECHNOLOGY UNA (HP)

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School of Electronics

CURRICULUM: IITUGECE22

Cycle Test – I

16, Aug. '23

Degree	B. Tech.	Branch	ECE
Semester	VII		
Subject Code & Name	ECPE61 / Nanoscience and Nanotechnology		
Time: 60 Minutes	Answer All Questions	Maximum: 20 Marks	

S. No.	Question	Marks
1.a	What is zink blende or diamond lattice structure ? Explain by drawing proper unit cell with all dimensions marked.	1
1.b	Lattice constant of Silicon is $a = 5.43 \text{ \AA}$ . Calculate the inter-planar separation for $\{111\}$ and $\{112\}$ family of planes. Comment on their packing density. Out of these two, which family of planes will etch faster ?	2
1.c	What are surface states? why they are so detrimental to nano-devices? Why does a nano particle have such huge density of surface states? Mention and explain briefly about one technique to reduce these unwanted surface states.	2
2.a	How can dry and wet oxidation techniques be compared based up on the quality of oxide grown by them ? Write down one application of oxides grown both techniques.	1
2.b	Given oxidation rate constants for (111) planes of Si, at temperature $T = 1100^\circ\text{C}$ wet oxidation : $A = 0.11 \text{ }\mu\text{m}$ , $B = 0.51 \text{ }\mu\text{m}^2/\text{hr}$ , $\tau = 0 \text{ hr}$ . dry oxidation : $A = 0.090 \text{ }\mu\text{m}$ , $B = 0.037 \text{ }\mu\text{m}^2/\text{hr}$ , $\tau = 0.076 \text{ hr}$ . If oxidation is carried out for 1 hour, calculate the oxide thickness in both cases (in nm) and compare the results.	2
2.c	Prove that packing density of silicon or silicon-like lattice structure is 34%.	2
3.a	What are three variants of optical lithography ? Based up on which parameter such classification is done ?	1
3.b	A proximity printer operates with a $10 \text{ }\mu\text{m}$ mask-wafer gap with wavelength of $\lambda = 430 \text{ nm}$ . Another proximity printer uses $40 \text{ }\mu\text{m}$ mask-wafer gap with wavelength of $\lambda = 250 \text{ nm}$ of light source. Which has higher resolution ?	2
3.c	To make resolution better water droplets are introduced between mask and wafer of a projection lithography system. The angle at which images are formed on wafer is $\alpha = 20^\circ$ and refractive index of water is $n = 1.33$ . The system uses an excimer LASER with ArF for illumination that emits light at $\lambda = 193 \text{ nm}$ . Calculate the resolution and depth of focus.	2

4.a Fig. 1 shows a variation of nano transistor called FinFET's.



Fig. 1: Vertical narrow Fin's of Silicon.

What kind of etch profile are they called? Which etching technique will be use to fabricate such nanostructures, from given silicon wafer?

4.b

Fig. 2 shows the layer diagram of a MOSFET, aluminium metallic contact for Source, Drain and Gate:

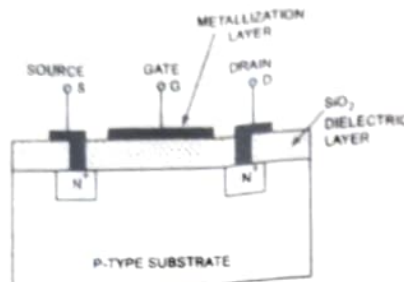


Fig. 2: Cross-section diagram of NMOS with ohmic contacts.

If these contact are kept exposed to environment, they will be converted into  $\text{Al}_2\text{O}_3$  by atmospheric oxygen, which will destroy their ohmic conductivity. Suppose it is desired to protect the aluminium by masking them with an  $\text{SiO}_2$  layer. Which oxidation technique will be used to grow this new  $\text{SiO}_2$  layer? Describe the oxide growth with proper necessary chemical reactions. How did  $p$ -type Silicon wafer help in this oxide growth process?

4.c

Mention two major differences between the doping techniques (i) diffusion, (ii) ion implantation. Give one application of each of these two doping techniques, with respect to the fabrication of an  $npn$  bipolar junction transistor.