

Instructions: (i) Answer All questions.

(ii) Any required data not explicitly given, may be suitably assumed and stated.

(iii) All answers and figures should be written using PEN only.

(iv) Enclose the final answer in a box.

Q1. The Fig.1 shows the plot of steady state carrier concentrations inside a pn junction diode maintained at  $T=300K$ .

- Is the diode forward biased or reverse biased? Explain how you arrived at your answer.
- Do low level injection conditions prevail in the quasineutral regions of the diode? Explain how you arrived at your answer.
- Determine the applied voltage,  $V_A$ .
- Determine the hole diffusion length,  $L_p$ .
- What is p-side and n-side doping concentrations?

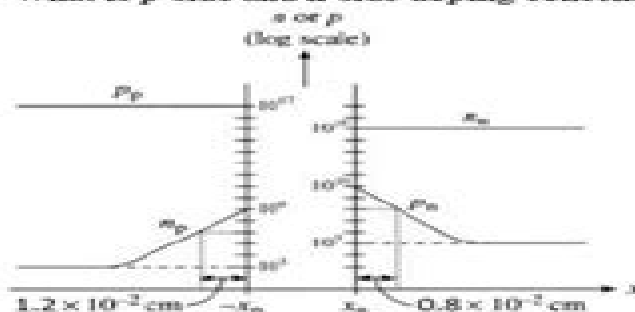


Fig.1

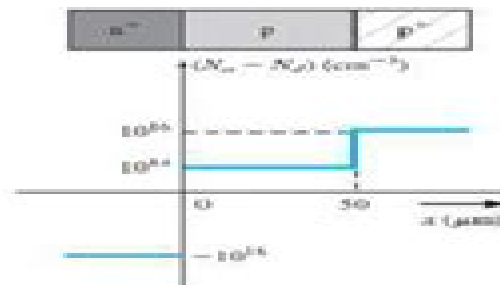


Fig.2

- Consider a silicon pn junction with the doping profile shown in the Fig.2 at  $T=300K$ .
  - Calculate the applied reverse bias voltage required so that the space charge region extends entirely through the p-region.
  - Determine the space charge width into the n+ region with the reverse bias voltage calculated in part(a).
  - Calculate the peak electric field for this applied voltage.
- Assume that an MOS capacitor is designed with a p<sup>+</sup>-polysilicon gate and a n-type silicon substrate of doping  $10^{17}/cm^3$ .
    - Draw the energy band diagram at zero applied voltages.
    - Determine the voltage required to achieve the flat band condition.
    - Identify the state of the MOS capacitor at zero applied voltage.
  - In order to improve the performance of the MOS capacitor, an electrical engineer replaced  $SiO_2$  (oxide layer) with  $Si_3N_4$  (high dielectric material) with dielectric constant of 7.5. If the thickness of the  $Si_3N_4$  is 4 nm, find the equivalent oxide thickness of the  $SiO_2$ . Assume the dielectric constant of  $SiO_2$  is 3.9. Comment on the advantage of designing MOS capacitor with  $Si_3N_4$ .
- A Schottky diode with an n-type Si at  $T=300K$  yields the  $1/C^2$  versus  $V_A$  plot shown in the fig.3, where  $C$  is the capacitance per  $cm^2$ . Determine the (a) the built-in potential (b) the doping concentration (c) the barrier height.

# Ocr F214 June 2013 Past Paper

**AW Chickering**



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