EE 130/230M   Spring 2013
Integrated Circuit Devices   Prof. Liu & Dr. Xu

QUIZ #4
Time allotted: 25 minutes

NAME: _____ _____ _____
(print)   Last   First   Signature

STUDENT ID#: _____

1. **Use the values of physical constants provided below.**
2. **SHOW YOUR WORK, and write legibly!**
3. **Underline or box numerical answers, and specify units where appropriate.**

Physical Constants

Description	Symbol	Value
Electronic charge	q	1.6×10^{-19} C
Thermal voltage at 300K	kT/q	0.026 V

Properties of silicon (Si) at 300K

Description	Symbol	Value
Energy band gap	E_G	1.12 eV
Intrinsic carrier concentration	n_i	10^{10} cm^{-3}
Permittivity	ε_{Si}	1.0×10^{-12} F/cm

Problem 1 [13 points] One-sided pn Junction

The excess hole concentration within the quasi-neutral n-type region of a silicon p$^+$n step junction of area $A = \mathbf{1mm \times 1mm}$ maintained at $T = 300K$ is plotted on a linear scale below. The hole lifetime $\tau_p = \mathbf{10^{-6}}$ s.
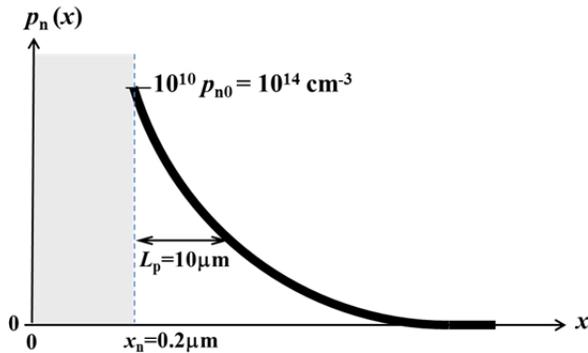
(a) Calculate the minority-carrier charge stored in this diode, Q_P. [3 pts]

(b) Calculate the diode current, I. [3 pts]

(c) **Estimate** the small-signal capacitance, C, of this junction. [3 pts]

$$\frac{1}{0.026} \cong 40$$

(d) Show on the plot above how $p_n(x)$ would change if τ_p were to be decreased by a factor of 4. [2 pts]
   Qualitatively, how would the diode turn-off transient response change? Explain briefly. [2 pts]

Problem 2 [5 points] Optoelectronic Diodes

Circle the correct choices in the sentences below.

(a) Light is generated in a [light-emitting diode *or* photodiode] when it is operated under [forward *or* reverse] bias due to [generation *or* recombination] within the [depletion region *or* quasi-neutral regions]. [2 pts]

(b) The amount of electric power generated by a solar cell [increases *or* decreases] with an increase in temperature (*e.g.* in the range from 300K to 400K). [1 pt]

Justify your answer. [2 pts]

Problem 3 [7 points] MOS Capacitor

(a) Identify the bias condition (accumulation, depletion, or inversion) for the MOS energy-band diagrams below [3 pts]
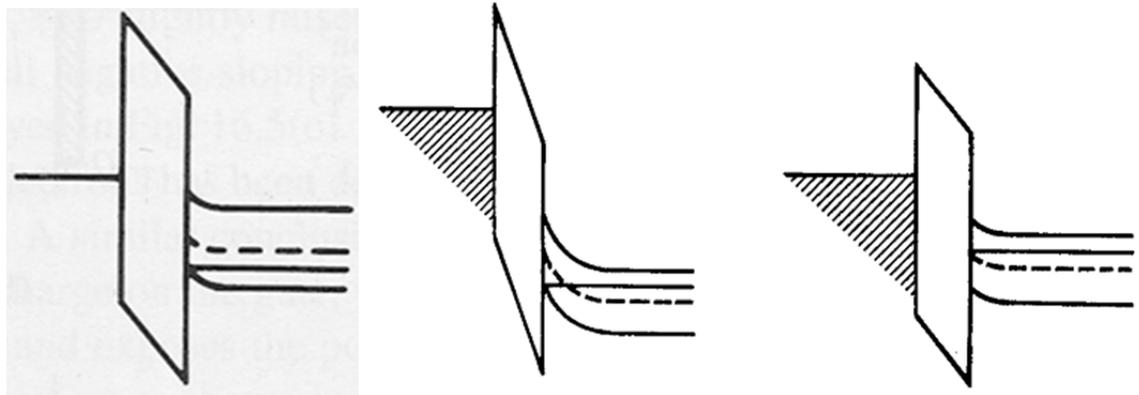
Bias
Condition: _____   _____   _____

(b) Consider a MOS capacitor with 3.45 nm = 3.45×10^{-7} cm SiO_2 and p-type Si with $N_A = 10^{17}$ cm^{-3} maintained at 300K. The flatband voltage V_{FB} = -0.8V. **Calculate the threshold voltage, V_T.** [4 pts]
(Note: The permittivity of SiO_2 is 3.45×10^{-13} F/cm.)