Name: Email: ID#

UNIVERSITY OF CALIFORNIA
Department of Electrical Engineering and Computer Sciences
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Test #2

1) Assume that the bandgap for SiGe varies linearly with germanium fraction between that of Si and Ge.

a) What approximate percentage of Ge would you use to obtain a bandgap of 0.9eV?

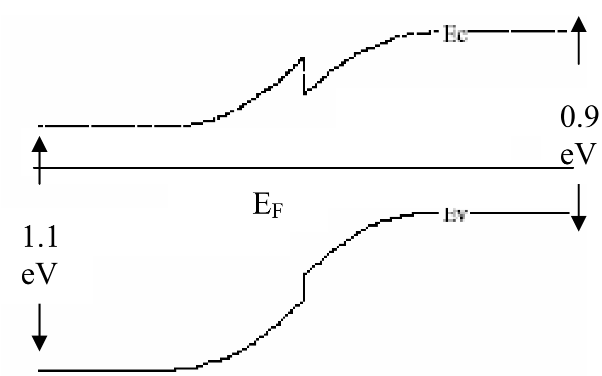
1 pt

~50%

b) Suppose you constructed a diode consisting of p-type SiGe with a bandgap of 0.9eV on n-type Si. Assume both sides are doped to 1E17 and that the electron affinity for SiGe and Si is identical.

i) Sketch a band diagram for the above diode. Label all values as appropriate.

3 pts



ii) Would you expect to have more electron current or hole current? Why?

2 pts

Should have more electron current, due to reduced barrier on conduction band side. (I also accepted an answer of no current due to equilibrium conditions, since I didn't specify a bias)

iii) Would you expect to breakdown voltage to be increased or reduced relative to a pure Si diode of similar doping? Why?

2 pts

Breakdown voltage is likely reduced since SiGe has a lower critical field than Si, resulting in increased likelihood of avalanche. Note that tunneling is probably not a problem in such a lightly doped device.

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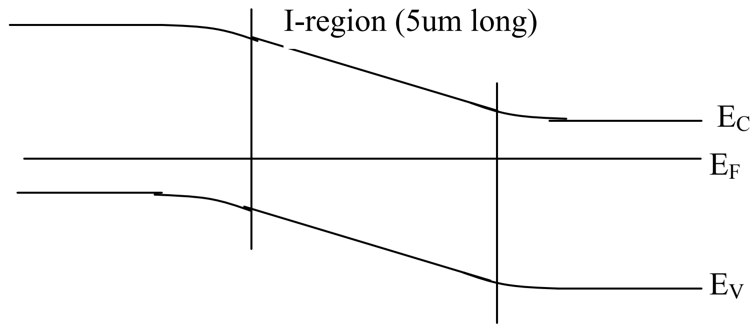
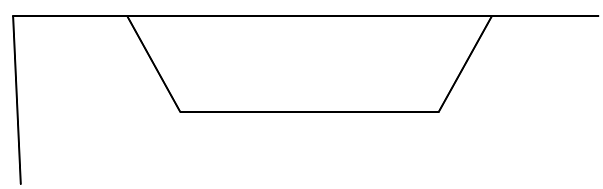
2) Consider a silicon PIN diode with doping on the P and N sides of ~1E18. Assume the I region is 5 microns long.

   a) Sketch the band diagram for the above diode, with the P region on the left and the N region on the right. Label as appropriate.



2 pts

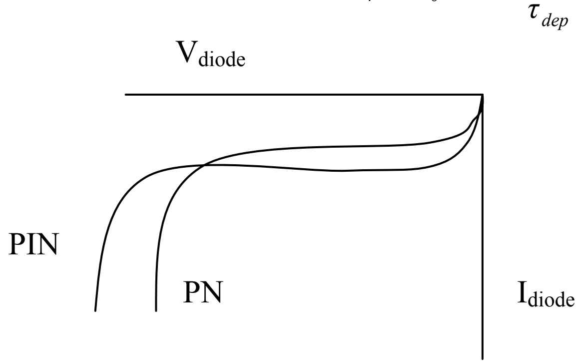
   b) Sketch the field vs. position plot for the above diode.



1 pt

   c) All else being equal, sketch the reverse bias IV characteristics for the above PIN diode and also for a PN diode with similar doping. Explain any differences, using equations as appropriate.

V_{BR} will be larger since peak field is reduced. I_{off} will be larger due to increased generation current, caused by larger depletion width $I_r = I_0 + A\frac{qn_iW_{dep}}{\tau_{dep}}$



3 pts

   d) List two advantages of the PIN structure over a PN structure in rectification applications?

Faster switching due to lower capacitance, and larger breakdown voltage due to reduced peak field.

2 pts

e) PIN diodes are often used in photo-sensing applications.

i) Compare the sensitivity of a PIN diode to an equivalently doped PN diode. Give reasons.

More sensitive due to larger depletion region, resulting in larger volume over which photons can be collected.

2 pts

ii) What phenomenon prevents us from making diodes with very wide I-regions? What is the consequence of this phenomenon on leakage-current and photodiode sensitivity? Give reasons.

Recombination; as the depletion region gets too long, recombination in the I-region is no longer negligible. This results in increased leakage current and reduced sensitivity vis a vis an identical structure with no recombination

3 pts

3) We often use the charge control relationship to model the transient behavior of diodes.

a) Suppose I were to add several trap states in the quasi-neutral regions of a diode. What would happen to the turn-off time? Give reasons.

2 pts

Turn-off time would reduce due to faster recombination of excess carriers.

b) What is the consequence of adding these traps on (give reasons):

i) Leakage current:

1 pt

Leakage current will increase due to reduced L, resulting in increased I_0

ii) Drive current:

Drive current will increase for the same reason as above.

1 pt