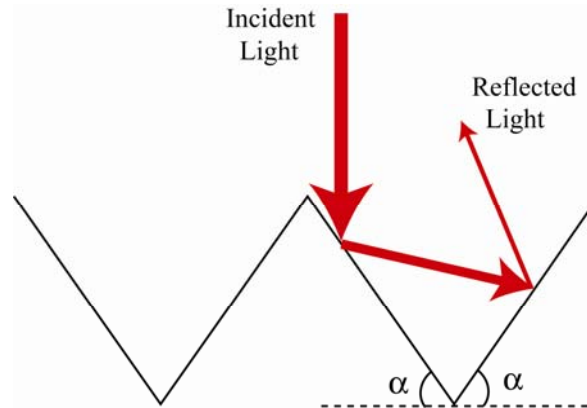


University of Delaware
Department of Electrical and Computer Engineering
ELEG620: Solar Electric Systems

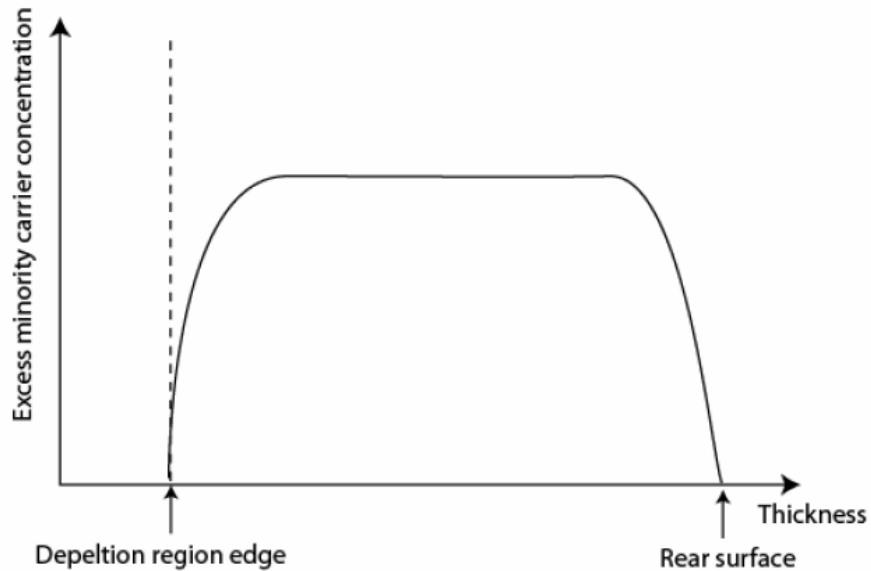
Homework #3
Solar Cells

1. Consider the cut-away of a textured pyramid surface shown below. For a given wavelength of light the fraction of reflected light is given by R .
 - a) Find an expression for the total reflectivity of the light incident on the textured surface, in terms of both R and α , the angle of the pyramid side relative to a flat surface that is normal to the incident light. You can stop increasing the angle when 100% of incident light bounces three times.
 - b) Given that the side of the pyramid is created in a (001) surface by exposing (111) planes, what is the angle α ?
 - c) If the reflection is 20% at a particular wavelength then compute the reflectivity of the textured surface (use the angle from b))



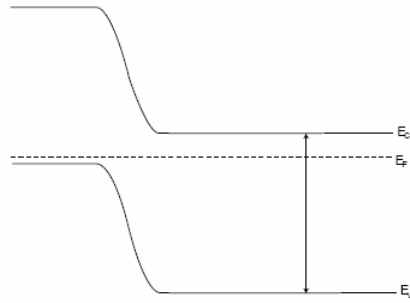
2.
 - a) A silicon solar cell (band gap 1.12 eV) is uniformly illuminated by monochromatic light of wavelength 800 nm and intensity $20\text{mW}/\text{cm}^2$. Given that the quantum efficiency at this wavelength is 0.80 find the short circuit current if the area of the cell is 4cm^2 .
 - b) For the same quantum efficiency, what would be the short circuit current if the cell were made of a semiconductor with band gap (i) 0.7 eV, and (ii) 2.0 eV.
 - c) For the silicon solar cell in a), calculate the open circuit voltage, fill factor and energy conversion efficiency, given the ideality factor is 1.2 and the dark saturation current density is $1\text{ pA}/\text{cm}^2$.

3. A 1 cm^2 solar cell at 300 K under AM1.5G spectrum has an open-circuit voltage of 650 mV, a short circuit current density of 35 mA/cm^2 and an ideality factor of 1.3. Find the fill factor and hence efficiency of the solar cell under the following conditions:
- series resistance is zero and shunt resistance infinite (ideal)
 - series resistance is 0.8Ω , shunt resistance infinite
 - series resistance is zero, shunt resistance is $2 \text{ k}\Omega$
 - series resistance is 0.8Ω , shunt resistance is $2 \text{ k}\Omega$
4. The following is a plot of excess minority carrier concentration in the base of a solar cell.

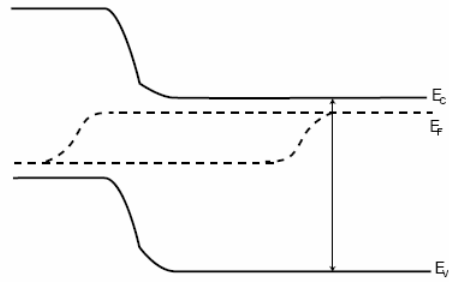


- What are the bias conditions for the solar cell, based on the plot given above?
- Is the surface recombination velocity high or low at the rear of the solar cell? Justify your answer.
- What can you say about the generation rate in the base?
- Estimate the collection probability (roughly) for minority carriers in the base. Justify your answer.

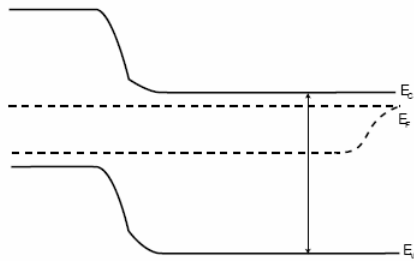
5. The following band diagrams are all for the same solar cell under varying conditions. Determine the following a) which side is more heavily doped, b) bias condition in each case, c) any information regarding the minority carrier lifetime and surface recombination velocity.



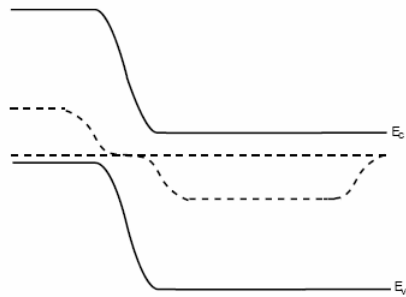
Case (1)



Case (2)



Case (3)



Case (4)