1. RADIATION

1.1. Determine the photon flux, power density and spectral irradiance for AM1.5 spectrum. [use spreadsheet and excel data file]

1.2. Use the PVGIS tool to determine the increase in yield using monthly inclination adjustment [reference: fixed system with optimum inclination for location; use insolation data for your hometown]

2. ABSORPTION

Consider the absorption coefficient of silicon at 500nm and 800nm (check data plot on Handouts 3). Determine the minimum thickness of a slab of silicon in order to absorb 90% of the incoming radiation. Compare it with a slab of germanium.

3. BANDGAP

The bandgap of crystalline silicon is 1.12eV.

3.1. The energy of photons with energy below the bandgap will be lost. Considering the AM1.5 spectrum, determine the fraction of energy loss due to these photons.

3.2. The photons with energy above the bandgap will be absorbed and contribute to the cell current. The useful energy of those photons is however limited to the bandgap energy (the rest is lost as heat). Determine the fraction of energy lost due to this inefficient energy conversion.

3.3. Determine the 'ideal' efficiency of a silicon solar cell under AM1.5 irradiation (we are neglecting other very relevant loss mechanisms such as reflection and recombination).

3.4. Repeat 1-3 for a different semiconductor with a bandgap of 2.0eV. Discuss the results.

3.5. Consider a solar cell made of two different layers, one with a bandgap of 2.0eV and the other one with a bandgap of 0.94eV.

3.5.1. Repeat 1-3 for this multijunction solar cell. Discuss the results.

3.5.2. Which layer ought to be on top? Why?

4. TRANSPARENT MODULES

For some applications (e.g. solar windows) it might be interesting to allow the visible part of the spectrum to get through the solar cell, only capturing the infrared part of the spectrum. Determine the ideal efficiency of a transparent solar module.

5. CURRENT

Considering the AM1.5 spectrum, determine the maximum current density (mA/cm^2) of a silicon solar cell (assuming that every useful photon will produce an electron-hole pair).

6. FILL FACTOR

If a 100cm^2 solar cell has a rated efficiency of 15%, an open circuit voltage of 0.6V and a short current of 3.33A, what is the fill factor?

7. DIODE EQUATION

7.1. Looking at the diode equation $I = I_L - I_s\left\{e^{\frac{q}{k_B T}V} - 1\right\}$ write out the equations describing

- 7.1.1. in the dark,
- 7.1.2. illuminated short circuit conditions, i.e. no applied voltage, and
- 7.1.3. illuminated open circuit conditions i.e. no current flow.

7.2. Determine the expression describing the short circuit current I_{SC} and open circuit voltage Voc. What do these expressions tell us?

7.3. Considering the solar cell in question 4, and the diode equation, what does this tell us about the magnitude of the saturation current for the specific solar cell?

7.4. In ideal conditions the current produced by a solar cell at short circuit is linear with the light intensity. Assuming these conditions, how does V_{OC} vary with light intensity?