**SCHOOL OF ENGINEERING**
**MECHANICAL ENGINEERING**
LRESE - Laboratory of Renewable Energy Sciences and Engineering

# Solar Energy Conversion Devices and Plants: Exercise 5

In this exercise, we will analyze and compute some characteristics of an intrinsic and doped c-Si solar cell.

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## Crystalline Silicon solar cell

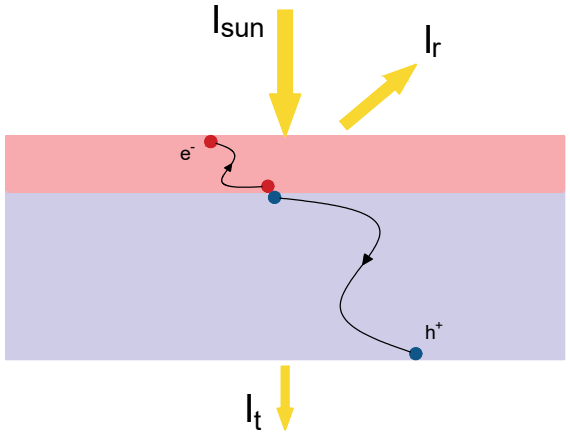


**Figure 1:** Scheme of the c-Si solar cell showing the input solar irradiation, and its reflected and transmitted portions.

### Assumptions

a) Normal incident irradiation of 1000 $\mathrm{Wm}^{-2}$.

b) The thickness of the c-Si layer is 300 $\mu$m.

c) The refractive index and extinction coefficients at a wavelength of 500 nm are $n = 4.293$ and $k = 0.045$.

### Questions

1. Compute and plot at 300 K:

   a) the density of states in the conduction and valence band.

   b) the Fermi level of the intrinsic material.

   c) the Fermi-Dirac distribution for different temperatures ($T = 0$, 273, 300, 353 K).

   d) the density of electron and holes in the conduction and valence band.

   e) the total number of electrons and holes in the conduction and valence band.

f) the intrinsic carrier concentration for $T = 0$, 273, 300, 353 K.

g) the Fermi level considering now a doping level $N_{\mathrm{D}} = 10^{17}$ cm$^{-3}$.

2. Assuming that the electron and hole mobilities for c-Si are 1360 and 450 cm$^2$V$^{-1}$s$^{-1}$, respectively. Calculate the diffusion coefficient at room temperature and estimate order of magnitude of the expected diffusion and drift fluxes as function of the electron-hole gradients, and the electric field.

3. Calculate the total absorption. For simplicity, assume all light arrives at only one wavelength (500 nm).

**Hints**
Use the following expressions to compute the properties of c-Si:

$$\chi = 4.05 \text{ eV}$$
$$Eg = 1.1695 - 4.73\text{e-}4 \cdot T^2/(T + 636)$$
$$m_e^* = [0.328 + 9\text{e-}3 \cdot (T/300)] \cdot m_0$$
$$m_h^* = [0.550 + 0.6 \cdot (T/300) - 0.1 \cdot (T/300)^2] \cdot m_0$$

Where $\chi$ is the electron affinity, $m_0$ is the free electron mass, and $\lambda$ is the wavelength.