NUMERICAL MODELING OF P-i-N SOLAR CELL

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Introduction: Solar energy is the cleanest form of renewable energy. The most popular form of utilization of solar energy is through the use of photovoltaic cells. Currently the efficiency of available solar cells lies below 20%. To increase the efficiency multijunction can be used in solar cells. While developing such devices we need platform to study various characteristics and parameters to optimize device performance.

In our thesis, stress has been given on mathematical modeling of p-i-n solar cells. We have used COMSOL 4.3b for modeling. COMSOL MULTIPHYSICS is a new platform for modeling semiconductor devices. We have used partial differential equations for modeling the P-i-N photovoltaic system.

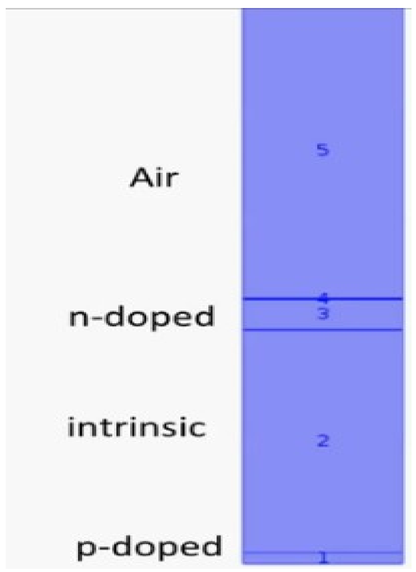

Figure 1. Model diagram of our simulated P-i-N solar cell

Computational Methods: We take two main studies while defining the equation for our model:

- ✓ Light study (Electromagnetism)
- ✓ Drift-Diffusion Model

$$G = -\frac{dP_{op}(y)}{dy}\frac{1}{hf}$$

From the light study we get the solution for electric field E. From that using Poynting theorem Pop i.e. optical power input can be calculated. From that we can calculate generation term G using the formula:

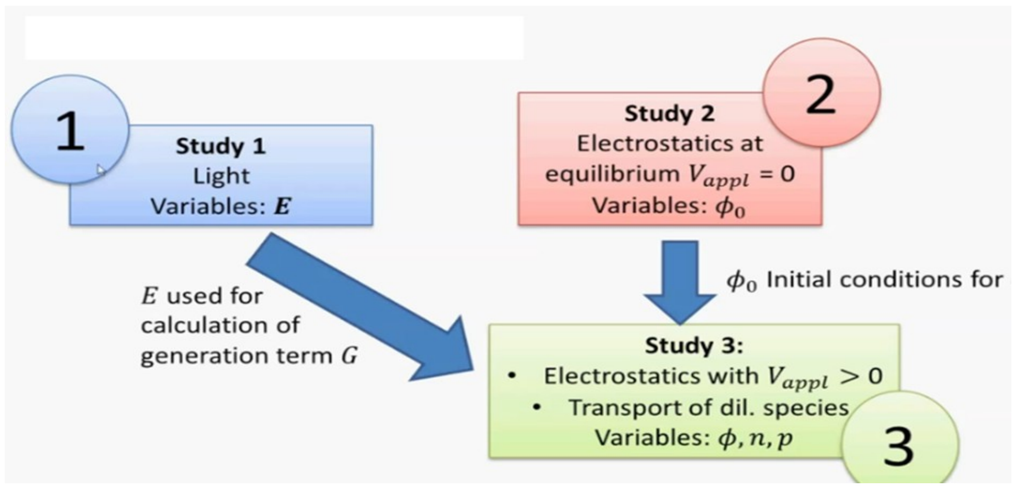

Figure 2. Block diagram of the steps involved in the study

Results: The wavelength of incident radiation is taken as 530 nm. The length of the air layer in the model is taken as 265 nm. The length of P doped region is taken as 10 nm, the length of intrinsic region is taken as 100 nm and the length of N doped region is taken as 27 nm.

The variation of doping profile, concentration gradient, potential distribution inside the device was seen under test conditions.

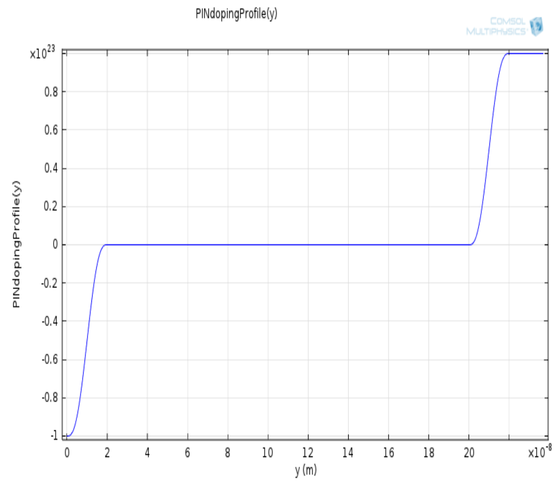

Figure 3. P-i-N doping profile

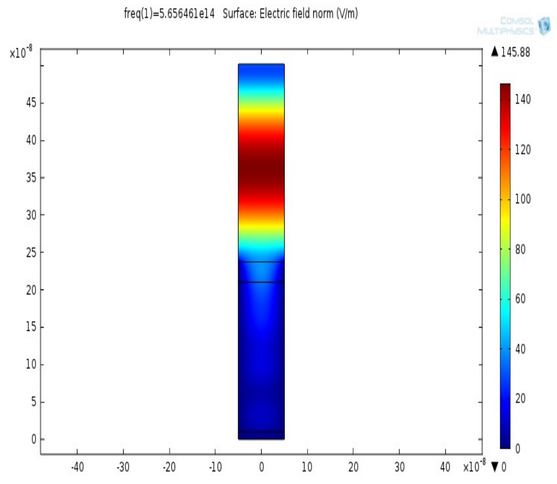

Figure 4. Variation of electric field inside device

Conclusions: This model is a numerical simulation of a basic p-i-n solar cell using COMSOL. This model can be used further for studying properties of advanced devices like multijunction solar cells.

While simulating we found out:

- Varying doping profile inside the device
- Change of refractive index of Si with thickness
- Deviation of actual generation term “G” from the generation predicted by Beer-Lambert.
- Change of concentration of electrons and holes inside the device under illumination condition
- How wavelength changes inside the device

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