Design of Opto-Electronic Nano-Structures, Capability for Optimization of different Solar Cells

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Development of CAD tools for optical devices is under way to include multi-physics tools. Previously, tools like "RCWA" was used for the diffraction mode of periodic structure analysis, while FDTD is typically used as a general numerical method for analyzing field propagation in the time domain to investigate transmission, reflection, and absorption of electromagnetic energy for devices like optical ring resonators. Meanwhile, for sources it is essential to analyze the semiconductor physics, generation and recombination of electron/hole pairs and the photons generation efficiency linking current to light like in lasers, LEDs, photodiodes, and solar cells.

Today, emerging multi-physics CAD tools can combine various required analysis. They are the best option to extract different optoelectronic results like total light absorption or transmission, electric field intensity, J-V curves and quantum efficiency. It can provide EM analysis, electrostatic, and carrier transport analysis. This analysis can provide a simultaneous solution for the physics involved in the operation of optoelectronic devices. Such multi-physics tools include RSOFT and COMSOL. For example, COMSOL has different modules for electromagnetic analysis, chemical analysis, and thermal analysis as well.

In this paper, we simulate different kinds of solar cells by using an optoelectronic simulator (RSOFT) and compare their characteristics. Such analysis can be used to optimize the optical and electrical efficiency related to solar cells such as increasing effective path length, using nano structures as a grating or DBR reflectors, thin film surface Plasmon, and nano particles. An example of a very thin solar cells made by organic materials will be given including methods to improve their efficiency.