

Improving Solar Cell Efficiency with Surface Plasmons

Introduction

Tools used: Solar Cell Utility, FullWAVE

This example uses RSoft's **Solar Cell Utility** along with **FullWAVE** to determine how the addition of metallic nanoparticles to a solar cell design enhances the field within the cell and changes the resulting cell efficiency.

Structure Overview

This multi-junction solar cell contains two cells, each consisting of a copper phthalocyanine (CuPc) and 3,4,9,10-perylenetetracarboxylic bis-benzimidazole (PTCBI) region. A row of nano-scale silver dots is embedded between the cells. A simple silver reflector is used on the back of the cell, a layer of indium tin oxide (ITO) on the front, and the transverse magnetic (TM) polarized incident light is launched from silicon dioxide (SiO₂). This appears in the RSoft Computer Aided Design (CAD) as:

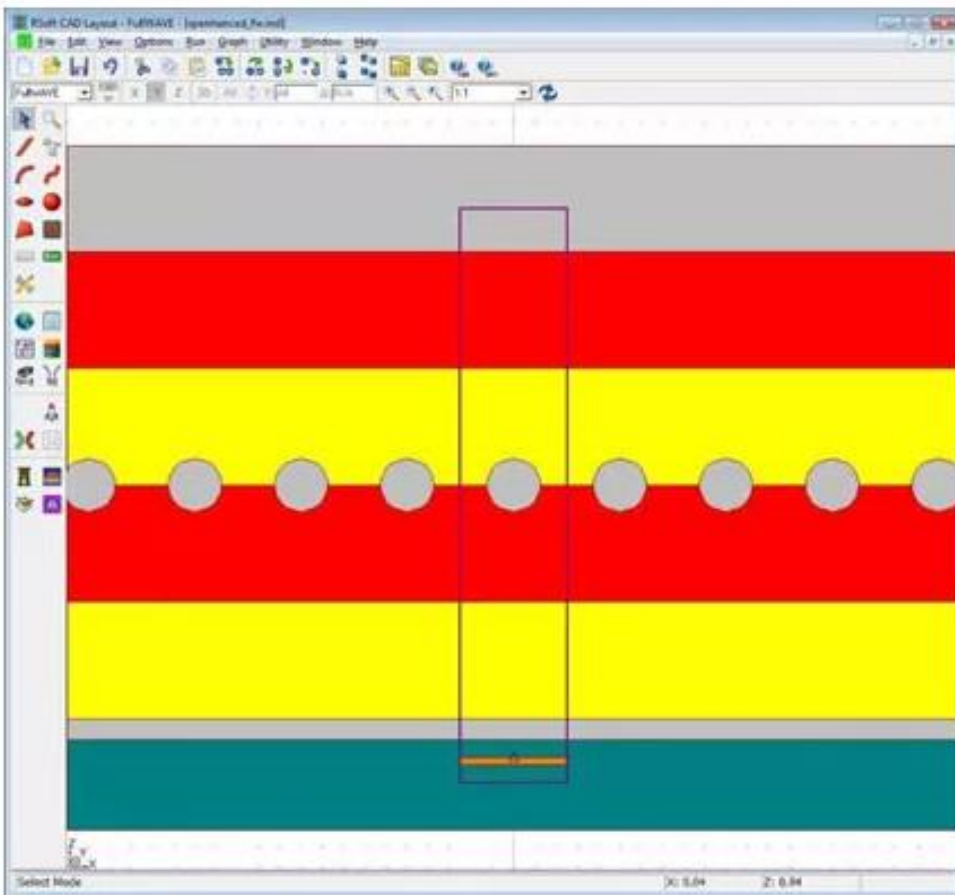


Figure 1. How the structure appears in RSoft CAD

Calculating the Absorption Spectrum

While thin-film devices can usually be designed via simple analytical formulas, ray-based optics cannot be used to model surface-plasmon effects and so a more rigorous approach is required. A simulation tool such as RSoft's FullWAVE, which is based on Finite-Difference Time-Domain algorithm (FDTD), provides a full-vector solution to model the electro-magnetic fields within the structure and to compute the absorption spectrum of the device. Given this spectrum and the incident solar spectrum (AM 1.5), the total number of photons absorbed in the CuPc and PTCBI regions can be computed for a specific wavelength range.

Using RSoft's Solar Cell Utility to Compute Efficiency

RSoft's Solar Cell Utility is designed to automate the computation of the absorption for various wavelengths and then, using the incident solar spectrum along with various other user-specified parameters about the solar cell such as collection efficiencies, etc, the cell efficiency can be computed.

First, the cell efficiency was computed both with and without the silver nanoparticles; the case with the nanoparticles shows an increased efficiency of about 40%. These results show that the addition of the nanoparticles results in an increased efficiency due to field enhancement within the solar cell. The following plots show the field within the structure with and without the silver nanoparticles:

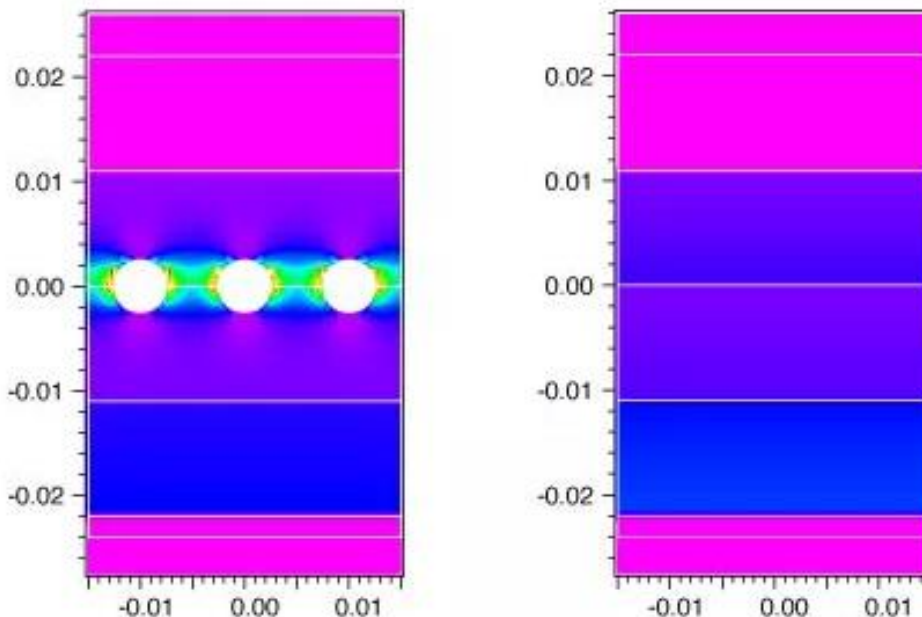


Figure 2. The field within the structure with and without the silver nanoparticles

The comparison of the quantum efficiency for both cases is shown below:

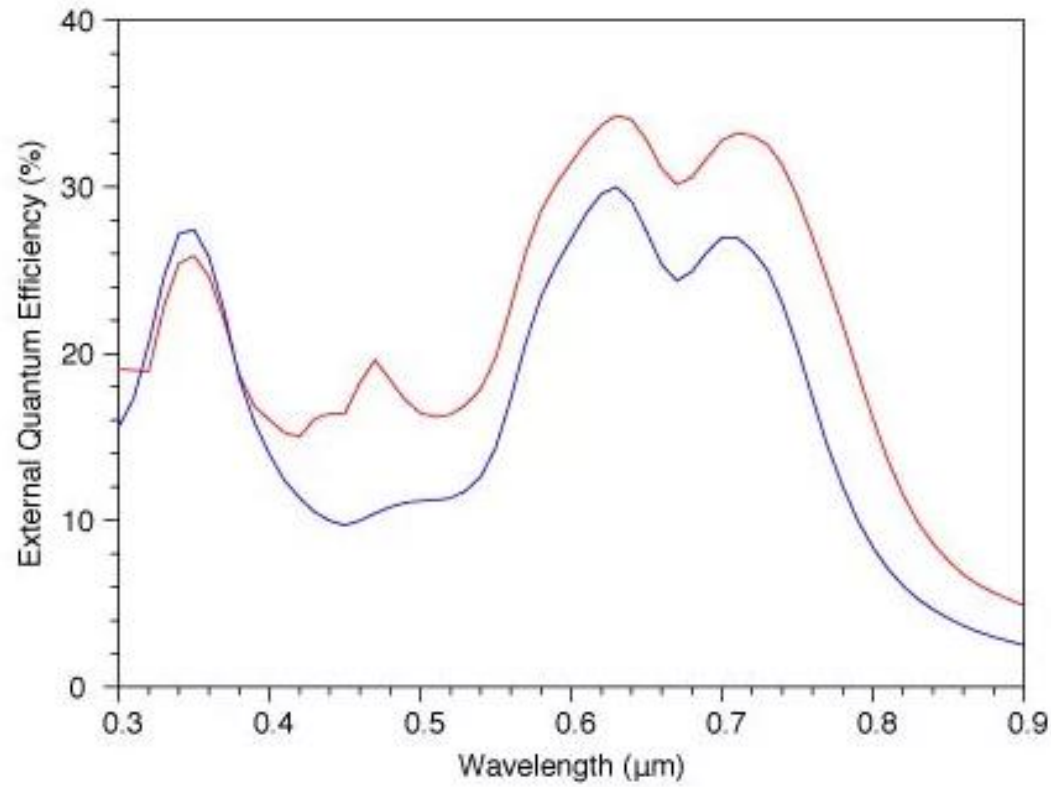


Figure 3. The comparison of the quantum efficiency

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