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ENHANCING PERFORMANCE OF THIN FILM SOLAR CELLS USING METAL-LIKE SMALL PARTICLES: A COMPUTATIONAL APPROACH

A.N. Wijenarayana* and M.L.C. Attygalle

Department of Physics, University of Sri Jayewardenepura, Nugegoda, Sri Lanka
**amadie12wijenarayana@gmail.com*

Thin-film solar cells are ideal for energy harvesting due to their low cost in manufacturing. However, one of the major drawbacks is the low absorption of the material layers which can reduce the solar cell's performance. In this computational study, we tried to improve the key performance of the solar cell by increasing the light absorption of the cell by introducing metal-like small particles in the semiconductor layers of two thin-film solar cells; amorphous silicon solar cell (a-Si: H) with p-i-n layers structure and cadmium telluride solar cell (CdTe) with p-n layers structure. This study was carried out using two open-source software. The MiePlot software was used to find the refractive index of the modified semiconductor layer for each wavelength and the data was used to find the absorption coefficients corresponding to each wavelength in the spectrum range of 300-800 nm. The SCAPS-1D software was used to model the solar cells under the AM 1.5 solar spectrum and obtain the key performance parameters of the solar cells. Gold and silver metal nanoparticles of radius 10 nm were introduced separately in the p-a-Si: H layer, n-a-Si: H layer and i-a-Si: H layer of the a-Si: H solar cell. Similarly, the same type of metal nanoparticles was introduced separately in the p-CdTe and the n-CdS layers of the CdTe solar cell. Due to the limited computational power, only fifty nanoparticles were dispersed at a 1% standard deviation in the surrounding semiconductor medium in each case. Each solar cell with the new layer properties was modelled using SCAPS-1D software and compared with the solar cells without the metal nanoparticles. The key performance parameters: short circuit current, open circuit voltage, and efficiency of the solar cells, were improved in each case when the active semiconductor layers (i-a-Si: H and p-CdTe) were modified with gold and silver nanoparticles. By introducing metal nanoparticles, the localized surface plasmon resonance enhances the electromagnetic field in the vicinity of the metal spheres by improving the absorption. The a-Si: H and CdTe solar cell's efficiencies were increased at the introduction of silver nanoparticles in the active layers (i-a-Si: H and p-CdTe) compared to the introduction of gold nanoparticles, and this can be due to the stronger plasmonic resonance produced by silver nanoparticles compared to gold nanoparticles.

Keywords: Localized surface plasmon resonance, Nanoparticles, SCAPS 1D, Solar energy, Thin-film solar cells