Plasmonic Effect on Microcrystalline Silicon Solar Cell for Light Absorption Enhancement

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1. Introduction

In the recent year, plasmonic effect in thin films by using metal nanoparticles, for enhancement of light trapping is considerably important among the researchers. Light trapping enhancement is a huge challenge in the thin film solar cell because of its limited thickness. Effective Light trapping can enhance the conversion efficiency up to 2-3% of the solar cell [1]. Surface plasmon resonance (SPR) is used for enhancement of light trapping in solar cell by interacting conduction electrons of metal nanoparticles to the incident photons [2].

Thin-film solar cell technology emerging very rapidly since it has potential to reduce the material cost of current photovoltaic cells. Light absorption enhancement (G) is generally done by pyramid-texturing the surface but this method fails for thin film devices as the overall thickness is small [4]. Hence, light trapping by putting metal nanoparticles on top of the device becomes popular for such devices.

Shape and size of metal nanoparticles play an important role for good resonance [3]. Coherent oscillations of conduction electrons is created by Surface plasmon resonance (SPR) on a metal surface excited by electromagnetic radiation which causes scattering of incident light that results increase in the path length and absorption factor increases [3].

In this work we have shown how light absorption factor is enhanced with Silver (Ag) nanoparticles with help of LUMERICAL, by varying its diameter and resonance condition due to plamonic effect.

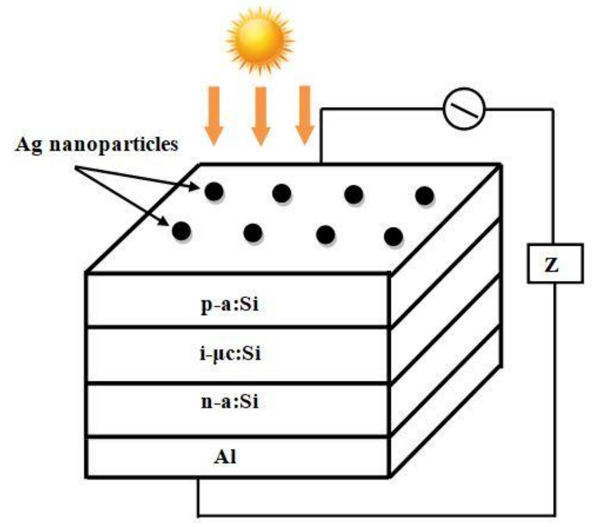

Figure-1: Schematic diagram of PIN solar cell with Silver nanoparticles.

2. Results and discussion

When light falls on metal nanoparticle, gets scatterd that can increase in light absorption up to 20%. Selection of shape and size of metal nanoparticle is very important, as can be seen from figure-2, Ag(D=200 nm) has higher light absorption as compared to Ag(D=100 nm) & Ag(D=50 nm). For the plasmonic resonance, metal nanoparticles must have diameter grater then 5 nm.

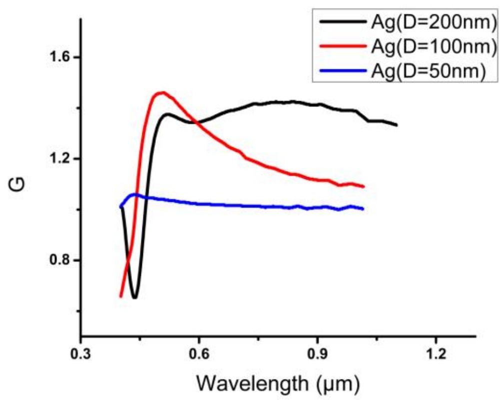

Figure-2: Comparison of light absorption enhancement (G) for different diameters of Silver nannoparticles.

The overall light absorption enhancement factor (M) for the wavelength range from 400 nm to 1100 nm is tabulated below.

$$M = \frac{IQE\_Silver}{IQE\_Bare}$$

Size	Ag, D =200nm	Ag, D =100nm	Ag, D = 50nm
M	1.200	1.124	1.012

3. Conclusions

Silver nanoparticles of diameter 200 nm has best overall light enhancement factor as compared with other small nanoparticles. Hence, we concluded that size selection of nanoparticles is very crucial for thin film. One major drawback of these nanoparticles is they may acts as recombination centers that can reduce the performance of solar cell [5].

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