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RESEARCH ARTICLE

UPRIGHT PYRAMIDAL TEXTURED SURFACES OF BIFACIAL PERC SOLAR CELLN TYPE SILICON, DUAL LAYERSSiNx/SiO_2 IMPACT OF THE SUBSTRATE THICKNESS ON THE SOLAR CELL EFFICIENCY

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Abstract

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Textured surface morphology plays an important rol for solar efficiency by reducing the reflections at surfaces (front or rear) of the device.Adding films is also benefic .The substrate used is the silicon added two films of SiNx and SiOx.The silicon is in between the films.The surfaces both front and rear are passived.The photon current absorbed is not changing when the substrate thickness changes.Then it doen not affect the solar cell efficiency.

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Introduction:

Photovoltaics [1] is a most elegant energy source. Light shines on a crystal and produces electricity. There are no moving parts. The fuel source (sunlight) is free, abundant, and widely distributed, available to every country and person in the world. At over 165,000 TW the solar resource dwarfs the world's current power usage of 16 TW or even our projected future usage of 60 TW[2].

The many advantages of photovoltaics lend itself to being the ultimate energy source[3]. However, it required the semiconductor [4] revolution and advances in manufacturing before photovoltaics could begin to reveal its full potential.While the reduction of reflection [5] is an essential part of achieving a Hight efficiency solar cell [6], it is also essential to absorb all the light in the silicon solar cell[7]. The amount of the light absorbed depends on the optical path length [8] and the absorption coefficient. The aim of this work is to check out how the substrate thickness affect the solar cell efficiency when the surfaces morphology are uprightpyramids.And the material is bifacial perc solar cell.

Material and method:

The material used in this work, isa bifacial perc solar doubled film SiNx and SiO_2. The substrate layer is in between the films as shown the figure below.

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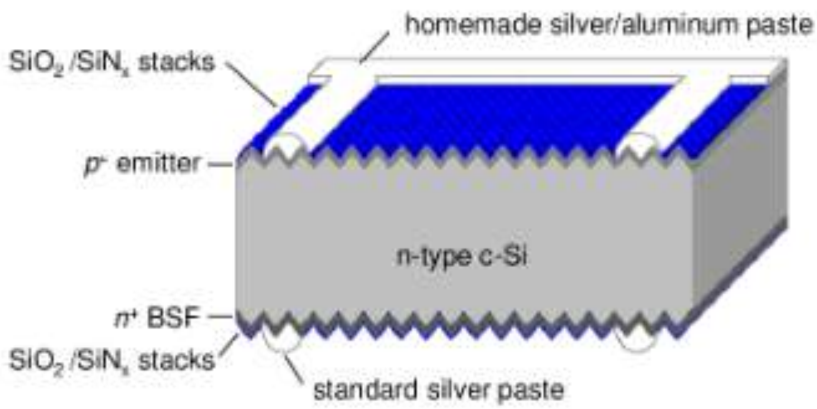

Figure 1:- BificialPerc Solar cell [9].

Table 3:-

Layers	Thickness	Materials
Surrounds		Air
Front film	75nm	SiO_2
Front film	75nm	SiN_x
Substrate	180um, 190um ,200um	Silicon
Rear film	100nm	SiN_x
Rear film	100nm	SiO_2
Surroundss		Air

The materials characteristic
The standard test condition is applied; The illumnition used is the sunlight with the AM1.5g Model .

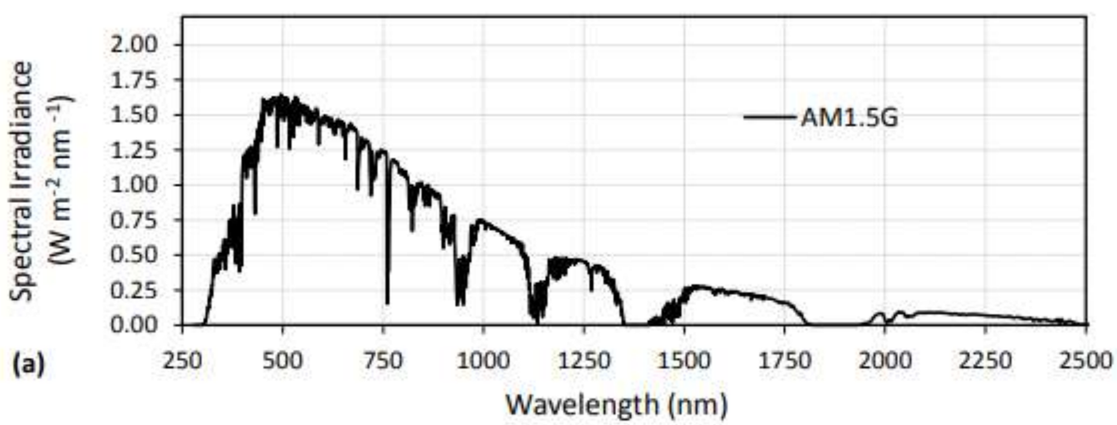

Figure 2:-Spectral Irradiance in Am1.5g condition with respect to the wavelength *[10]*

Table 2:- The surfaces smorphologyof the perc solar cell:

Side	Morphology	periodicity	Angle (°)	Height(um)	Width (um)
Front	Upright pyramids	Regular	54.74	3.536	5
Rear	Upright pyramids	Regular	54.74	3.536	5

The simulation is done over the range of 300nm-1200nm.And the maximum of rays launched is 50000; The illumination of incident is isotropic.

Algorithm description:-
The wafer optics calculator combines Monte Carlo [11] ray tracing with thin film optics. It calculates the photogenerated current in a wafer via the following algorithm:

Several light rays are created above the front surface of the defined structure.

Each light ray proceeds along a straight line until it intersects with a facet of the wafer surface.

At each interaction:
reflectance, transmittance and absorptance are calculated; the value of each depends on the wavelength λ and the electric field (polarisation), as well as the refractive indices of any thin films or materials on either side of the interface.

The magnitudes of reflectance and transmittance are translated into probabilities. Next, a random decision, weighted by these probabilities, is taken to either reflect or transmit the ray at this interface.

As the ray passes through absorbing media, its intensity is reduced. In a semiconductor like silicon, this absorption process equates to the photogeneration of electron-hole pairs.

Steps 2 to 4 are repeated for each ray until:

The ray is lost from the structure (it may have been reflected from the front surface, escaped, or transmitted through the wafer); the ray's intensity falls below a threshold (its energy has been absorbed by the wafer or thin films); orthe ray has intersected with the maximum allowable number of interfaces.

The gains (photogeneration) and losses (reflection, transmission, parasitic absorption) are recorded for each ray. The global gains and losses are determined by averaging many rays. With a sufficiently large number of rays, the Monte Carlo simulation converges to the physical model.

Results and Discussion:-
The rays tracing under the PV lighthouse calculator gives the following results.

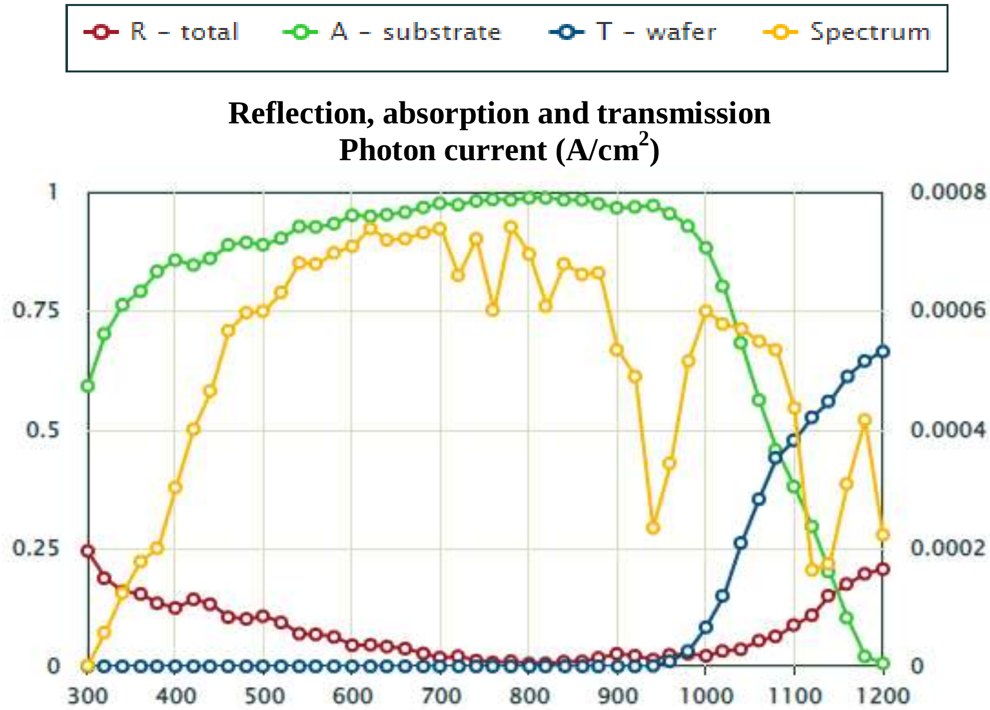

Figure 3:- Reflection, absorption and transmisson, and photon currunt density with respect to the wavelength for 170um substrate

R - total A - substrate T - wafer Spectrum

Wavelenght (nm)
Reflection, absorption and transmisson
Photon current (A/cm^2)

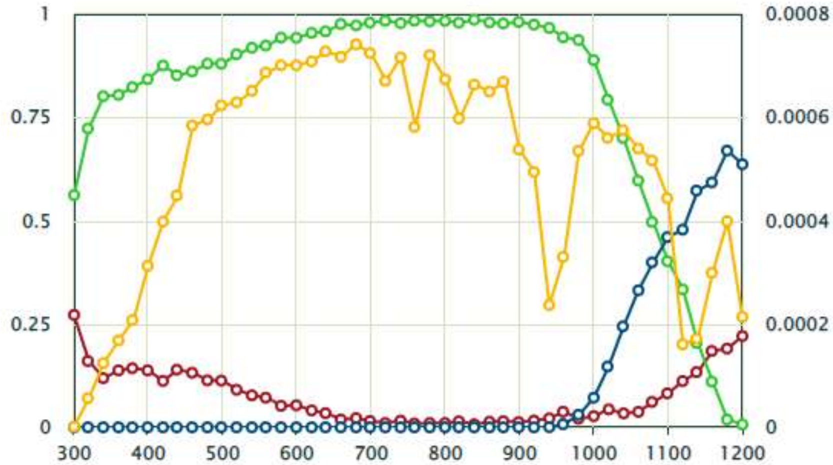

Figure 4:- Reflection, absorption and transmisson, and photon currunt density with respect to the wavelength for 180um substrate
Wavelenght (nm)

R - total A - substrate T - wafer Spectrum

Photon current (A/cm^2)
Reflection, absorption and transmisson

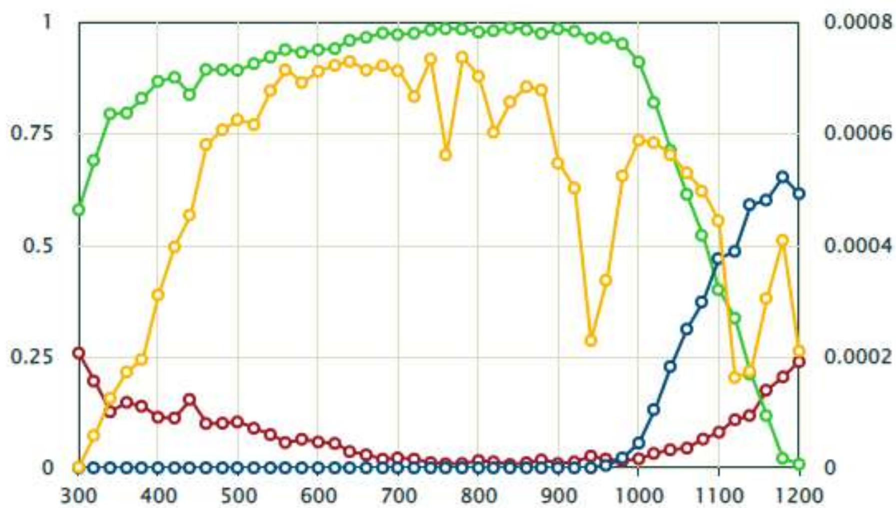

Figure 5:- Reflection, absorption and transmisson, and photon currunt density with respect to the wavelength for 180um substrate
Wavelenght (nm)

Figure 3,figure 4 and figure 5 shows the reflection , absorption and transimission of the light in one hand , and the other hand the photon current , with respect to the wavelenght.

The absorption of light by the substrate is important over the range 300nm and 1000nm.In that range the photon current is increasing as well .But still some maximum and minimum values.The

The optical loss is decreasing over the range 300nm and 700nm and then gets close to zero over ther range 700nm and 1000.nm

For wavelenght greater than 1000nm the total optical increasing tha corrpond the region where the absorption at substrate and the wafer decrease.And the photon density decreases and reach its minimum value.The absorption is very important on substarte than on the films.The films are used in order to minimize the reflection at the surface of the solar cell.Even if the substrate thickness changed

The results is observed for each types of substrate thickness.And the results are approximetively the same for each substrate.So the substrate thickness does not affect the optical loss at the surface of the solar cell.

Table 3:- Photogenration absorbed by the substrate and the remainder.

	Mean $\pm$ 95% CI (mA/cm^2)	Frcation of J_{in}%
Photogeneration (absorbed) J_G	19.83 $\pm$ 0.1014	85.82
Remainder	0.04237$\pm$ 0.002775	0.1883

Table 4:- Photogenration absorbed by the substrate and the remainder.

	Mean $\pm$ 95% CI (mA/cm^2)	Frcation of J_{in}%
Photogeneration (absorbed) J_G	19.86$\pm$ 0.1385	85.96
Remainder	0.03957$\pm$ 0.003442	0.1712

Table 5:- Photogenration absorbed by the substrate and the remainder.

	Mean $\pm$ 95% CI (mA/cm^2)	Frcation of J_{in}%
Photogeneration (absorbed) J_G	19.97 $\pm$ 0.1701	85.84
Remainder	0.03988$\pm$ 0.002898	0.1723

Table 3, table 4 and table 5 show the photogeneration absorbed by the substrate depending on its thickness.

The amount of photogeneration is the approximativetly the same; 19.83mA/cm^2 is absorbed for 170 um of silicon substrat, then19.86 mA/cm^2 for 180um and 19.97mA/cm^2 for 200 um.The Change of photogeneration absorbed is not greater thant 1% if the substrate thickness changes form 170um to 200um.That's the substrate thickness that not effect the solar cell efficient in the standard test conditions.

Conclusion:-

This results of this work show the substrate thickness does affection the solar cell efficiency.Threesubstrat thickness are used but the change of photgeneration absorbed on the substrate is very week no more than 1% .The solar used in this study is the bifacial perc solar cell with double films .The work can be enlarge to perovski solar cell.

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