ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 4 , April 2016

Performance Evaluation of Triangle Grooves Solar Cell by Using ZEMAX

Dr.Alaa.B. Hasan, Maryam A. Ali Ghalib

Asst.Prof. Department of physics, College of Education for pure science -Ibn Al-Haitham, Baghdad University, Iraq
P.G.student, Department of physics, College of Education for pure science -Ibn Al-Haitham, Baghdad University, Iraq

ABSTRACT:In this work silicon solar cell has been designed with triangle grooves to improve its efficiency by reduce reflection of rays and increase optical path through the cell. Software program for optical design (zemax) has been used by ray tracing mode to evaluate prototype efficiency when using detector beneath the cell. The prototype increasment inefficiency as especially at (A.R=0.8) sample, and acceptance angle at (ϴ=50°).

KEYWORDS:solar cell, aspectratio, triangle grooves, program **(ZEMAX).**

I. INTRODUCTION

Renewable energy is the energy which comes from natural resources such as sunlight, wind, rain, tides, waves, biomass and geothermal heat, which are renewable (naturally replenished). About 16% of global final energy consumption comes from renewable. In its various forms, it derives directly from the sun, or from heat generated deep within the earth.[1]

Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solarthermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties.

Solar energy production has been increasing by an average of more than 20% each year since 2002, making it a fast-growing energy technology, while wind is often cited as the fastest growing energy source as shown in figure 1.1[3].

II. EXPERIMENTAL

In this work silicon solar cell has been designed with (10 cm x 10 cm x 0.5 cm) dimensions and designed with grooves texture its upper surface to increase efficiencyby reducing reflection of rays and increasing optical path through the cell and subsequently increasing absorption photons into the cell. The grooves is designed from silicon and appended to the upper surface of solar cell. There is detector positioned at the bottom of the cell which has sensitivity for visible light and ir that appropriate with silicon optical transmission and whenever increase internal reflections for cell increase the detector reading then the result it the quantity of ray from increasing optical path. The grooves designed of variable value of aspect ratio (0.5 , 0.6 ,0.7 ,0.8 , 0.9 ,1 , 1.2 ,1.4 , 1.6 , 1.8 and 2) and at any aspect ratio value either grooves length (z) or grooves width (w) variant. The grooves decrease the reflection and increasing optical path through the cell and subsequently increasing solar cell efficiency. Solar cell has been designed by using non-sequential ray tracing mode software program for optical design (zemax). The number of rays used in the program (1000) rays incident vertically on the cell (ϴ = 0°) and usedincident ray bevel angle(10° - 80°) in two directions parallel and cross with the grooves to explanation the effect of incident angle on cell efficiency and grooves effect range on incident angle. Figure (1) shows triangle shape grooves silicon solar cell. The grooves charactered with changed direction of its incident rays to happening angle higher than critical angle to abtainment total internal reflection, and possible happening reflections on internal surface of cell again.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 4 , April 2016

$L = 2R^{\backslash}$ … … … … … (1)
Were (L) = optical path long,
And ($R^{\backslash}$) = number of incident rays on detector,
(A.R = Z / W) … … … … … (2)
Were (A.R) = aspect ratio,
And (Z) = grooves length,
(W) = grooves width.

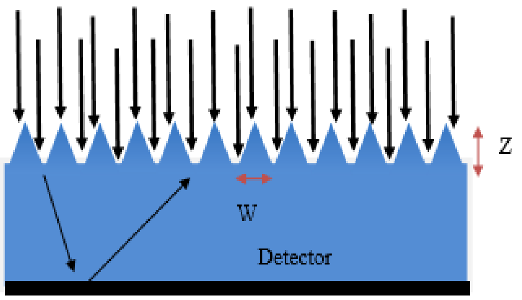

Fig. (1) triangle shape grooves silicon solar cell

Figure (2) shows layout ZEMAX for triangle shape grooves silicon solar cell, and incident rays on the cell.

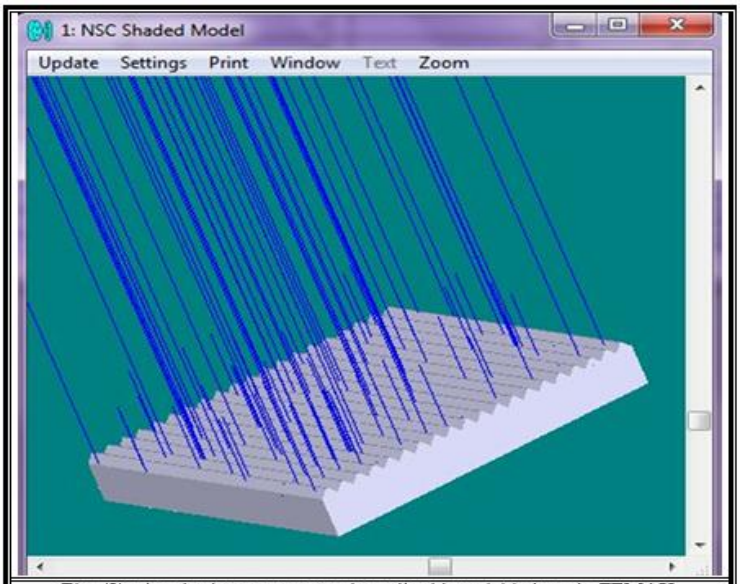

Fig. (2) triangle shape grooves solar cell with variable base in ZEMAX

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 4 , April 2016

Figure (3) shows triangle shape grooves solar cell with variable base, where the width of base was changing with aspect ratio value wereas increasing aspect ratio value, decreasing base width

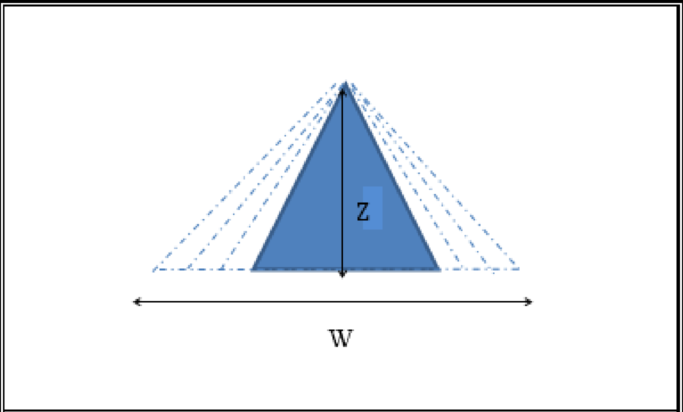

Fig. (3) triangle shape grooves solar cell with variable base

Figure (4) shows triangle shape grooves solar cell with variable apex, where the width of apex was changing with aspect ratio value were as increasing aspect ratio value, decreasing apex width.

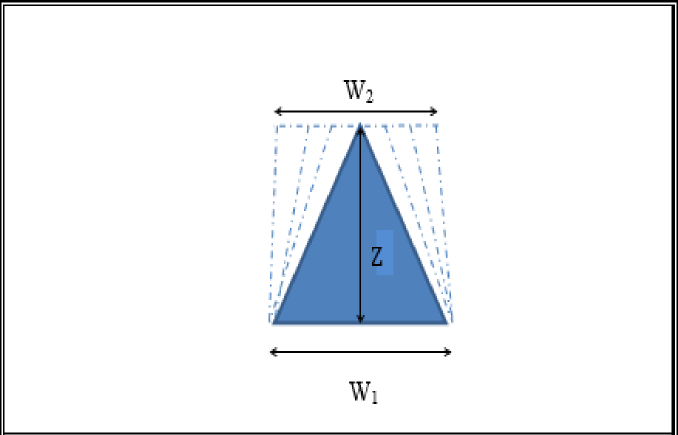

Fig. (4) triangle shape grooves solar cell with variable apex

.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 4 , April 2016

III. Results

The table (1) typify groove dimensions value and (Z) typify (groove high), and (W) typify (groove width), and (A.R) typify (Aspect Ratio), and (T.H) typify (reading detector) it's been typify the number of incidence angle on detector proportion to original number of incidence angle on cell and that it (1000) ray.

Table (1) Detector reading to aspect ratio for triangle shape groove model

Z	W	A.R	Total hit (T.H)
1	2	0.5	030
	.66	06	1035
1	1.42	0.7	1630
1	1.25	0.8	2500
1	1.11	0.9	1140
1	1	1	1025
1	0.83	1.2	1337
1	0.714	1.4	1041
1	0.625	1.6	1401
1	0.555	1.8	1010
1	0.5	2	1064

Triangular shape grooves with variable base that gives detector reading (2500) ray equal twice and half of the grand number of incident rays, and then triangular shape grooves with variable apex that gives detector reading (1400) rays, grooves texture it's upper surface to increase efficiencyby reducing reflection of rays and increasing optical path through the cell and subsequently increasing absorption photons into the cell. The illuminance distribution shows variation of ray's distribution on the cell that give uniform illuminance distribution for all cell dimensions.

Figure (5) showsincidence angle that incoming to detector for parallel with the grooves to explanation the effect of incident angle on cell efficiency and grooves effect range on incident angle and knowing acceptance angle for the using models. And the Figure (5) it's been typify gradual drift from higher detector reading value in the angle ($\Theta = 0^{\circ}$) for the usually using models that different aspect ratio coming to the angle ($\Theta = 80^{\circ}$) where sun light ray nearly from the horizon, this normally with the increase of incidence angle that perform to bigger deviation to refraction angle in the cell and subsequently light scattering even to happening enough internal reflections and decrease detectorreading. Noting that the curve have (A.R = 1.6) higher of incoming ray value to detector (1800) rays at the angle ($\Theta = 20^{\circ}$), while the curve have (A.R = 1.2) give (1400) rays at the angle ($\Theta = 40^{\circ}$), while remnant curves show slightly variations when the angle of incidence is increasing.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 4 , April 2016

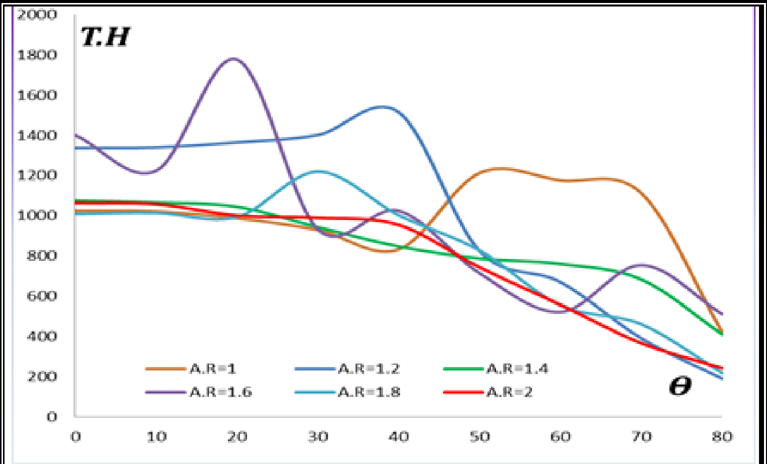

Fig.(5) The ray that incoming to detector for parallel incidence angle of the grooves with different aspect ratio

Figure (6) shows the number of incidence angle that incoming to detector for cross with the grooves for variable aspect ratio, Noting the ray number value incoming to detector better than the case in figure (4), where noting contrast in curves whereas higher value of incoming ray to detector more than (3000) rays at (A.R = 1) and (ϴ = 60°), and the curves at (A.R = 1.8, 1.4) value about (2500) rays at (ϴ = 30°, 40°) .

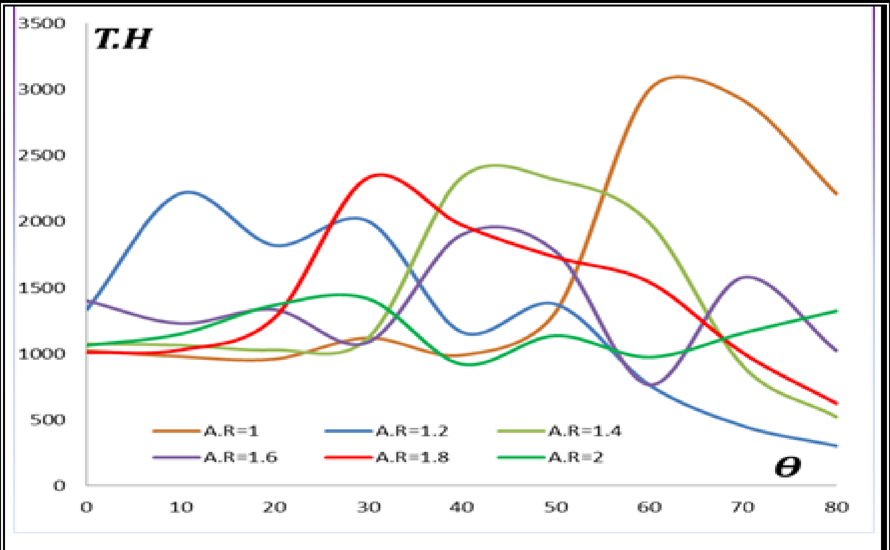

Fig.(6) The ray that incoming to detector for cross incidence angle of the grooves with different aspect ratio

Figure (7) shows the number of incidence angle that incoming to detector for parallel incidence angle with the grooves to explanation the effect of incident angle on cell efficiency and grooves effect range on incident angle and knowing acceptance angle for the using models. And the Figure (5) it's been typify gradual drift from higher detector reading value in the angle (ϴ =0°) for the usually using models that different aspect ratio coming to the angle (ϴ =80°) where sun light ray heel nearly from the horizon, this normally with the increase of incidence angle that perform to bigger deviation to refraction angle in the cell and subsequently light scattering even to happening enough internal reflections and subsequently decrease reading detector. Noting that the curve have (A.R = 1.8) higher of incoming ray value to detector (1500) ray at the angle (ϴ =50°), while the curve have (A.R = 1.2) give (1400) rays at the angle (ϴ =40°), while remnant curves value whereas the angle was increase the incoming ray value to detector decrease.

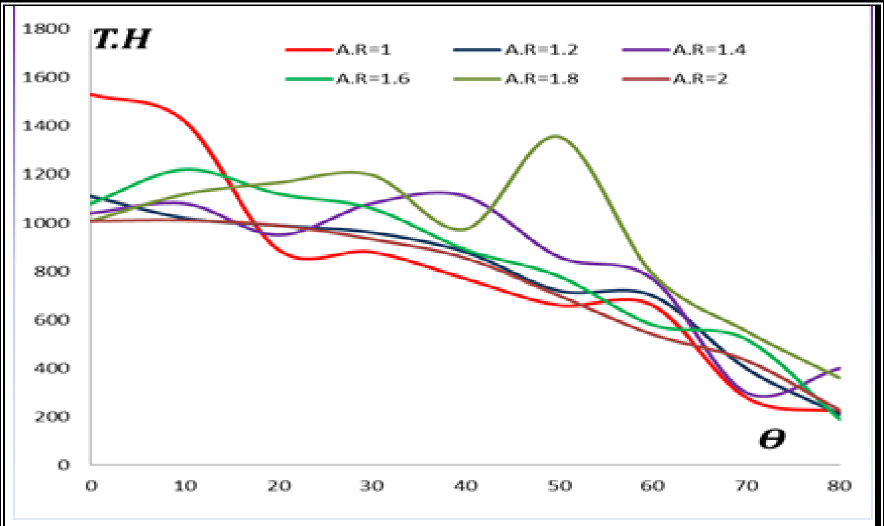

Fig.(7) The ray that incoming to detector for parallel incidence angle of the grooves with different aspect ratio

Figure (8) it's been typify the number of incidence angle that incoming to detector for different cross incidence angle with the grooves for variable aspect ratio, Noting the ray number value incoming to detector better than the case in figure (4), where noting contrast in curves whereas higher value of incoming ray to detector more than (2400) ray at (A.R = 1.2) and (Θ = 50°), and the curves at (A.R = 1) value approximate it's (1800) ray at(Θ = 30°, 60°) .

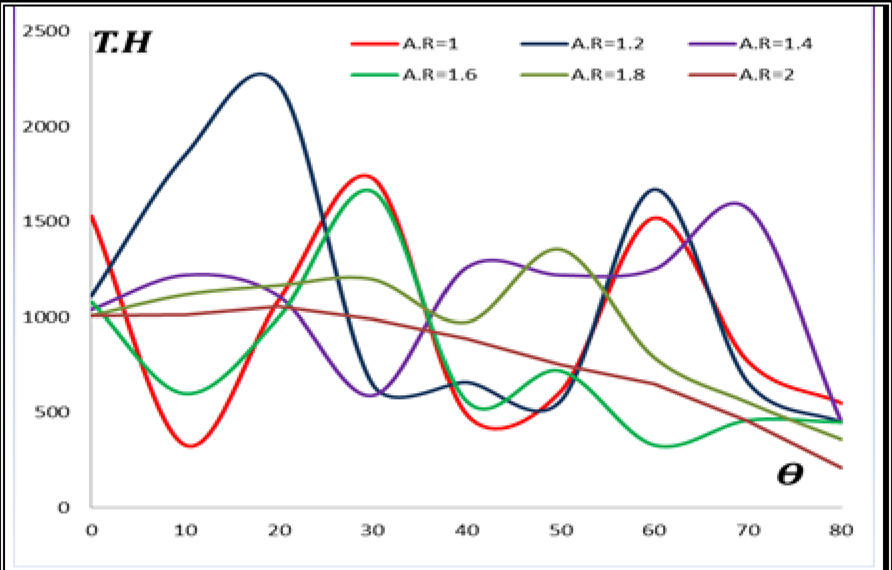

Fig.(8) The ray that incoming to detector for cross incidence angle of the grooves with different aspect ratio

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 4 , April 2016

REFERENCES

1. J. Mark and M. Delucchi, "A Path to Sustainable Energy by 2030", Scientific American, 301 (5), 58–65 (2009).
2. R. Pearson, "Energy Storage via Carbon-Neutral Fuels Made From CO_2, Water, and Renewable Energy". Proceedings of the IEEE 100 (2): 40–60 (2012).
3. G. Christopher, A. Ebbesen, D. Sune, M. Mogens, F Lackner and S. Klaus "Sustainable hydrocarbon fuels by recycling CO_2 and H_2O with renewable or nuclear energy",Renewable and Sustainable Energy Reviews 15(1), 1–23(2011).
4. R. Willson and A. Mordvinov, "Secular total solar irradiance trend during solar cycles", Geophys. Res. Lett., 30(5), 21–23 (2003).
5. Sargon Murad.M ،2006 ،"Effect of Surface Texturing on Silicon Solar Cell Absorption".
6. R. Willson and A. Mordvinov, "Secular total solar irradiance trend during solar cycles", Geophys. Res. Lett., 30(5), 21–23 (2003).Jason H. Karp, Eric J. Tremblay and Joseph E. Ford ،2010 ،"Radial Coupling Method for Orthogonal Concentration within".
7. Hammil.S.A ،2000 ، "Texturing and Top Grid Effects To Enhance the Local Solar Cells Efficiency".
8. Ruggiero.C.W ،" Aray Tracing Investigation of Ligh Trapping due to Grooves in Solar Cells", 2007.