Design of High Concentration Reflected Photovoltaic Module with Light Guide Tube

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ABSTRACT--- ***A high concentration reflected photovoltaic (HCRPV) has been designed in 3x3 array module with light guide tube. In this paper, the simulation of the HCRPV system and measurement has been conducted. There are two phases for designing the tracking sun position system and getting the maximum peak power output from the solar chips. First, we had simulated the optimal condition of 3x3 array module of high concentration reflected photovoltaic system. The main parameters include the focal length and radius of curvature of the first and secondary mirror, the slope angle and the length of light guide tube. The simulation results of the light collective efficiency can be reached to about 94.8%. After simulation, the HCRPV module was then fabricated using Aluminum material and coated with silver material. The result of output voltage was measured to be 2.46V~2.47V, the output current was measured to be 0.267A~0.269A. The power can be calculated to be about 0.66W~0.67W. The ratio of concentration/power can be calculated to about 117.8~119.5.***

Keywords--- High Concentration Reflected Photovoltaic (HCRPV); Array modules; Solar Cell; solar tracking system; light guide tube

1. INTRODUCTION

Solar light is known as a renewable and no pollution power. Various materials can be used to make a solar cell such as silicon, III-V group compound semiconductor and organic materials etc. Normally, silicon materials were used to fabricate silicon-based solar cell, it can be made as single crystalline, polycrystalline or amorphous [1]. III-V group compound semiconductor can also be used to make solar cell, such as InAlAs/InGaAsP/InGaAs multi junction solar cell. The efficiency of solar cell using III-V group compound semiconductor can be more than 50% [2]. High Concentration Photovoltaic (HCPV) is an alternative solution to the application of Photovoltaic as the Fresnel lens structure [3]. However, the design and fabrication of Fresnel lens were difficult and cost is higher than the high Concentration Reflected Photovoltaic (HCRPV) [4] that is easy to design and manufactured [5-6]. Adding the light tracking system can enhance the efficiency of light transfer to electricity of both HCPV and HCRPV module. The tracking system can be controlled by various methods such as active tracking system [7-8], passive tracking system [9] and mix tracking system. In this paper, we will report the result of the new-designed 3x3 array solar cell module with light guide tube of high concentration reflected photovoltaic (HCRPV) structure.

2. EXPERIMENTAL METHODS

Figure 1 shows the configuration of designing HCRPV modules of 3x3 array structures with light guide. Nine sets of 10cmx10cm single module structure were combined to set a 3x3 array module. In this study, we designed the HCRPV structure such that the light direction after deflected from second reflecting mirror should fall into the light guide tube and to the solar cell (5.5mm x 5.5mm). The designed HCRPV structure is simulated first using software named TracePro by Alpha precession Instrumentation Corp. In simulation, the main parameters include the focal length and radius of curvature of the first and secondary mirror, the slope angle and the length of light guide tube. Table 1 shows the best physical parameters of designing structure obtained after simulation. Figure 2 shows the flow chart of the simulation procedure. After simulation, the HCRPV model can be fabricated according to the optimal conditions obtained after simulation. The cost of fabricates HCRPV solar cell unit is also the key to be considered. In this work, we use stamping method to manufacture the designed HCRPV unit. In order to fabricate and coating, Aluminum metal was chosen. Al material after stamping was coated with silver material to have the best light reflected. In solar tracking system, we use single module as the controlling sensor. A programmable logic controller (PLC) is used to control the motion of this

new-designed solar tracking system. When the position is correct, the programmable logic controller IC can read all the output power of 3x3 array solar cells. If sensors have different output power, the program will be auto operated again.

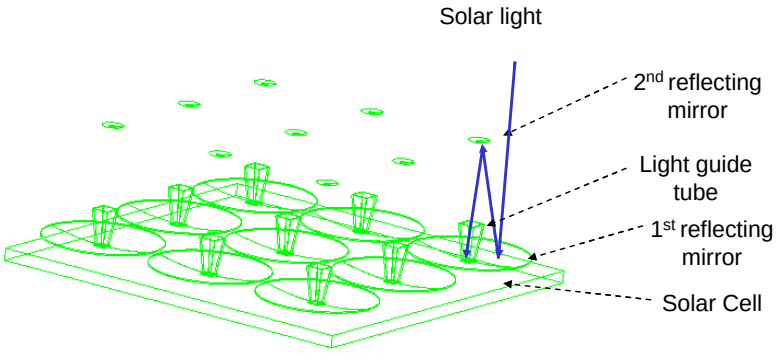

Figure 1 Configurations of designing HCRPV modules of 3x3 array structures with light guide tube

Table 1 The best physical parameters of designed mode obtained after simulation

Object	Dimension / Shape	3x3 array structures
light source	power	1000 Watts
	light path	10000 parallel
apex between 1st reflecting mirror and light source	distance	500mm
1st reflecting mirror	radius	232mm
	Focal length	113mm
	f-number	1.13
	bottom hole	10mmx10 mm
	Size (φ x H)	10mmx6.37 mm
2nd reflecting mirror	radius	35.55mm
	Focal length	141mm
	Size (φ x H)	17.5mmx5 mm
apex between 1st and 2nd reflecting mirror	distance	102.8mm
Light guide tube	Height	30mm
	Angle	5°
solar cell	square size	5.5mmx5.5 mm

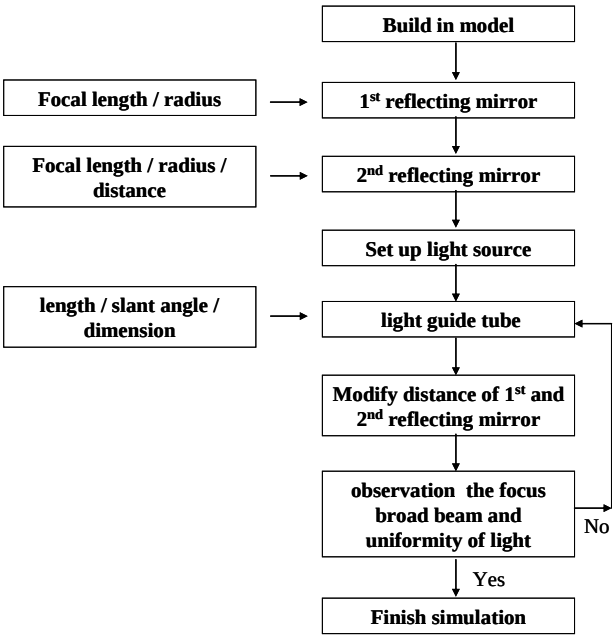

Figure 2 Flow chart of simulation procedure

3. RESULTS AND DISCUSSION

Figure 3 (a) shows the configurations of light spot diagram with the light guide tube and Figure 3 (b) shows the light spot diagram without the light guide tube. It clearly indicates that uniform energy of light can be obtained by using the light guide tube. Figure 3 (c) shows the configurations of 3x3 array module and Figure 3 (d) shows the light spot diagram with the light guide tube. From simulation, uniform energy of light can be obtained from all nine modules. Furthermore, based on the designed structure, the focal length of apex distance was changing between 1st and 2nd reflecting. The designed structure with the physical parameters in Table 1 have the best focus efficient and uniform energy of lighter than other parameters. The best distance is designed to be 102.8mm corresponding to HCRPV module from the first mirror vertex to the secondary mirror vertex, the light collective efficiency can be reached to about 94.8%. The HCRPV module was installed on a smaller solar tracking system and tested. Table 2 decipts the measurement results of 3x3 array HCRPV module. From the measurement results of this 3x3 array HCRPV module, the output voltage was measured to be 2.46V~2.47V, the output current was measured to be 0.267A~0.269A. The power can be calculated about

0.66W~0.67W. The ratio of concentration/power is calculated to be 117.8~119.5. Figure 4 shows the fabricated HCRPV module within the light guide tube.

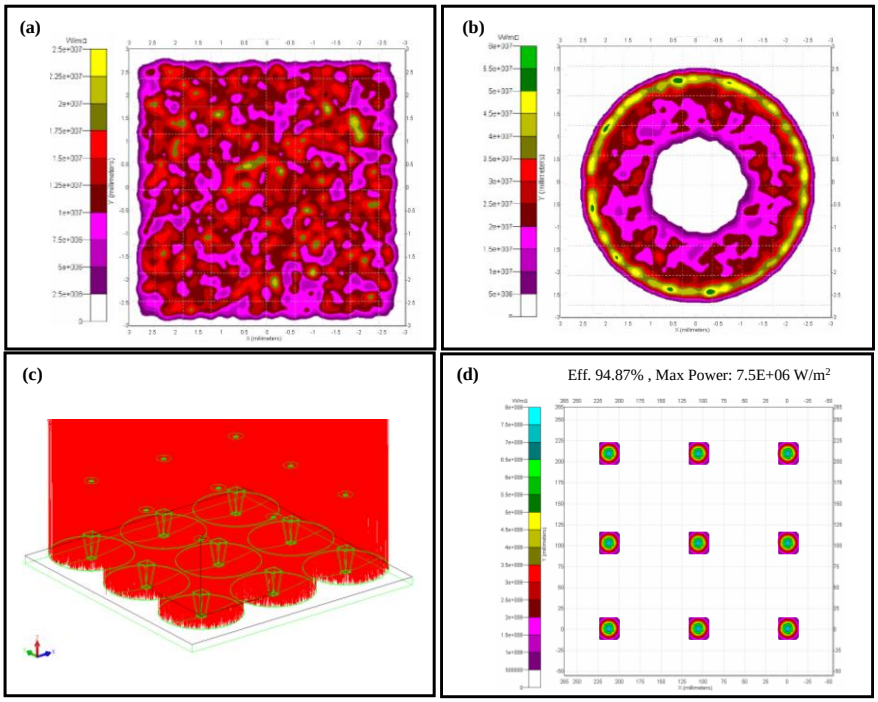

Figure 3 Configurations of desiged structures and simulation results: (a) light spot diagram with the light guide tube and (b) light spot diagram without the light guide tube and (c) 3x3 array modules and (d) light spot diagram of 3x3 array modules.

Table 2 Measurement results of 3x3 array HCRPV module with the light guide tube.

Unit cell Number of 3x3 array	Ratio of Concentration	Voltage (V)	Current (A)	Power (W)	Ratio of Concentration／Power
#1	78.5	2.46	0.267	0.66	119.5
#2	78.5	2.47	0.269	0.67	117.8
#3	78.5	2.47	0.268	0.66	118.4
#4	78.5	2.47	0.269	0.67	117.8
#5	78.5	2.46	0.268	0.66	118.9
#6	78.5	2.47	0.269	0.67	117.8
#7	78.5	2.46	0.268	0.66	119.1
#8	78.5	2.47	0.269	0.67	117.8
#9	78.5	2.46	0.267	0.66	119.4

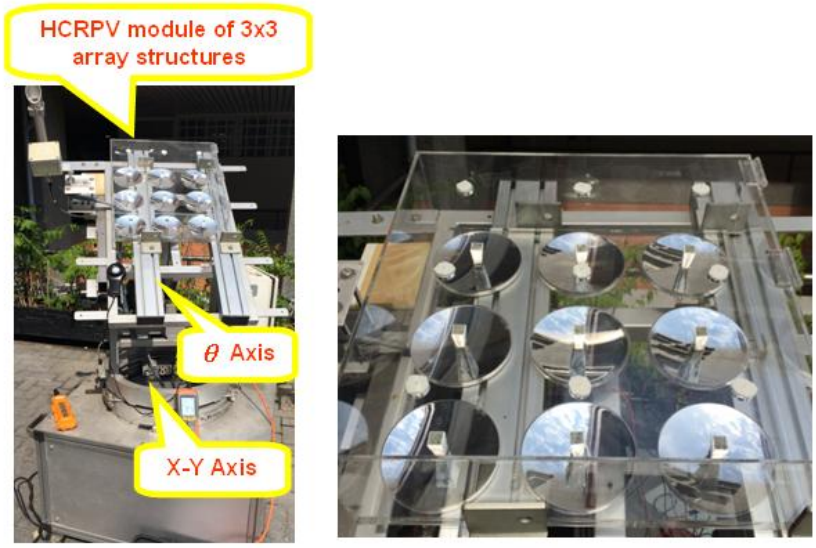

Figure 4 The fabricated HCRPV module with the light guide tube

4. SUMMARY

1. Uniform energy of light can be obtained in this designed structure on the high Concentration Reflected Photovoltaic (HCRPV) of 3x3 array module.
2. The best distance from the first mirror vertex to the secondary mirror vertex is found to be 102.8mm in our design structure; the light collective efficiency can be reached to about 94.8%.
3. The output voltage of HCRPV module was measured to be 2.46V~2.47V, the output current was measured to be 0.267A~0.269A. The power can be calculated about 0.66W~0.67W.

5. REFERENCES

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