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Design of a Array Micro-Lenses Silicon Photovoltaic Cell

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ABSTRACT

In this paper, another model for exhibit of smaller scale lenses concentrator was outlined. This concentrator comprises of exhibit of smaller scale lenses (MLA) to center sunlight based light on four rectangular slaps of photovoltaic Si sun based cell. The outline mean to diminish the expense of the concentrators by decreases the powerful range of the high cost silicon material region and rearranged the structure of the framework. The sunlight based cell with the MLA-concentrator includes vitality change productivity (11.98%) and decreasing the aggregate expense.

Keywords – **PV Cell, Efficiency, Concentrator.**

I. INTRODUCTION

Silicon-based photovoltaic (PV) change over under 20% of occurrence daylight into electrical vitality. High proficiency sunlight based cells created for the space business have shown more than 41% change effectiveness by layering numerous semiconductor intersections that catch huge bits of the sun oriented range. Manufacture and material expenses restrain these cells to just a couple square centimeters, making them unreasonable for level board establishments. Concentrator photovoltaic (CPV) consolidate extensive territory optics that gather and store vitality onto little, productive sunlight based cells with the guarantee of lessening power era expenses contrasted with silicon-based PV.

For CPV frameworks to be financially savvy, the complete expense of the optics, gathering and mechanical following must not surpass the expense investment funds picked up from utilizing little zone PV cells. Sun based beam following projects was utilized to discover new sorts of sunlight based lens concentrator to spare the expense by lessening the territory of PV cells.

High-flux concentrators regularly comprise of an extensive essential optic to center daylight and an optional optical component for flux homogenization. A typical configuration methodology isolates the upward-confronting essential into a few little openings, each with its own particular individual optional component and sunlight based cell.

The vitality issue has been picking up a great deal of consideration in numerous nations as of late. Among the sorts of energies, the sunlight based vitality is a standout amongst the most intriguing points of them. Notwithstanding the manufacture procedure and crude material, another point of convergence goes for sun oriented concentrator. This paper demonstrates another and simple approach to build the sun oriented vitality productivity. We use the small scale optics guideline to plan and create a miniaturized scale lens cluster of the sunlight based concentrator. With this concentrator, it can upgrade the measure of centered daylight on the sun powered cell so the optical retention on the sun oriented cell is moved forward.

The smaller scale lens cluster concentrator (MLA concentrator) is unique in relation to the traditional concentrator. The MLA-concentrator does not require any electric hardware to take after the daylight (sun tracker is not needed), and it is anything but difficult to produce. The size is littler than customary concentrator, particularly. The MLA-concentrator can diminish the impression of light at slanted points and builds the second reflection at the interface in the

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middle of concentrator and sun oriented cell, which makes the daylight uniform. This new-sort MLA concentrator is created by utilizing LIGA-like procedure, and afterward it is incorporated to the sunlight based cell for power era. Most critical, this sort of structure can be joined with a wide range of sun powered cell.

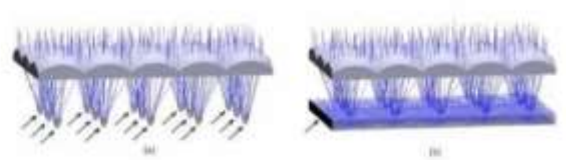

Fig. 1: Singular auxiliary optics obliges different PV cells (a). Every lens focus on individual optional optics (b) Replace the auxiliary optics by waveguide. Bolts demonstrate PV cell areas.

However, integrating hundreds of small PV cells all aligned to their respective optics leads to large-scale connectivity and cost concerns. A planer concentrator was investigated by replacing the secondary optics and their associated cell with a single waveguide connected to a shared PV cell.

In this paper, we explore an option approach for planar focus by supplanting different nonimaging auxiliary optics and their related PV cells with little rectangular slaps of PV silicon cell to decrease the quantity of mounting, arrangement and electrical association cost.

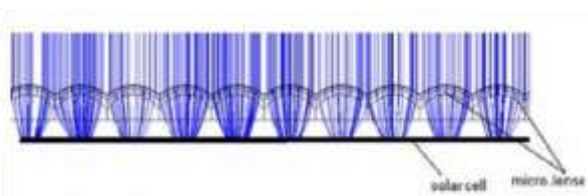

Fig. 2: New design of micro-lenses concentrator

II. CONCENTRATOR GEOMETRY

The geometric fixation proportion is the proportion of data to yield regions of the optical framework. Each lens cluster gap frames a demagnetized picture of the sun which subtends ± 0.26°. The abnormality free sunlight based picture tallness was figured utilizing

$2\ f\ tan\ \theta$ where f is the lens central length and θ is the acknowledgment half-edge. Every lens component has its own particular two dimensional geometric fixation characterized as:

$$C_{lens} = \frac{1}{(2F^{\#}tan\theta)^2} \dots \dots (1)$$

The lens opening to picture territory is communicated as far as the lens central length to breadth proportion, or F number (F/#), and accepted half-point.

A beam following ZEMAX EE non-consecutive investigation programming was utilized to outline and upgrade the proficiency of this smaller scale cluster optic concentrator. The examination accepted circular, plano-curved refractive lenses framing an emphasis on a section of the PV. Lens variations, Encircled vitality, light dissemination on the PV cell and material assimilation were incorporated in optical effectiveness computations. Recreations utilized weighted AM 1.5 daylight from 0.4 to 1.06µm at ± 0.26° field point.

The recreated outline utilized PMMA lens material (n_d=1.49 lens cluster). The new rectangular concentrator comprises of exhibit of 22x12 smaller scale lenses along x and y heading, individually (Fig. 2) with aggregate territory 66x36 mm. Each an individual lens has rectangular opening with 3.0mm distance across, 2.6 mm sweep of arch, 2.0 mm thickness and PMMA material (refractive index=1.491). There is air prattle between the cluster lenses and the sun oriented cell of 1.1 mm. This variety of small scale lenses was utilized to center daylight onto four rectangular Si PV sun powered cell of measurement (6.4x60 mm for every), so the aggregate successful cell zone equivalent to 14.81cm^2. The separation between the slaps is 3.0 mm. (Fig. 3). The aggregate thickness of the concentrator didn't surpass 4 mm. Air thickness in the middle of lenses and slap cells was improved to give a uniform enlightenment on all territory of the silicon cell.

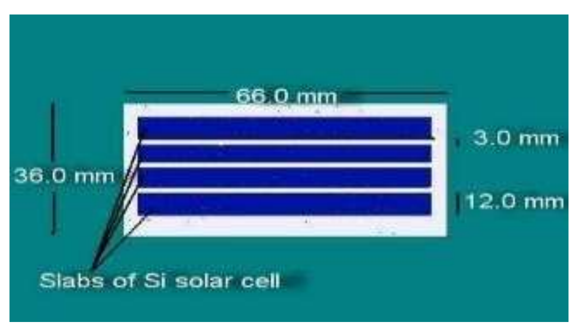

Fig. 3: Solar Cell consists of four rectangular slab.

III. PRACTICAL WORK

For current - voltage estimation, a Keithly-616 computerized electrometer, Tektronics CDM 250 multimeter and a double Farnel LT30/2 (- 3 to 3) V power supply were utilized. The forward current was recorded when a positive voltage was connected to Al metal contact with the nanostructure layer regarding Al anode on the crystalline silicon substrate and computed the perfect element n of this structure by utilizing the relation:

$$n = \frac{q}{KT}\frac{dV}{d\ln\frac{I}{I_0}} \ldots\ldots(2)$$

Where $\frac{dV}{d\ln\frac{I}{I0}}$ is the incline of the direct area of (I-V) plots, q is electron charge, K Boltzmann's constant and T temperature.

The checking electron microscopy SEM was utilized to look at the surface structure. The enlightenment was connected under reenacted air mass (AM1) condition ($100mW/cm^2$ by an incandescent light sort (Philips) with $120W$ Power. This light was associated with a variac and balanced by a Si force meter. We gauged V_{OC} and I_{SC} to ascertain the fill element (FF) and the proficiency (η%) of the miniaturized scale organized sun based cell utilizing the relation:

$$FF = \frac{I_m V_m}{I_{sc} V_{oc}} \ldots\ldots(3)$$

$$\eta = \frac{FF I_{sc} V_{oc}}{P_{in}} \% \ldots\ldots(4)$$

Where;

V_m = Maximum Voltage

I_m = Maximum Current,

This represents the maximum power output of the solar cell.

The present voltage attributes for the PV were measured with and without concentrator by utilizing the electric circuit indicated as a part of Figure-3. The 100 Watt Xenon light model Splender E27 Flood from Philips organization was utilized and two multi-meter model DM-9960 to gauge the current and voltage of the sunlight based cell.

IV. RESULTS AND CONCLUSIONS

Fig. 4 indicates to the present voltage attributes bend for of PV cell with and without the new concentrators. This figure shows the change in sunlight based cell characterizes.

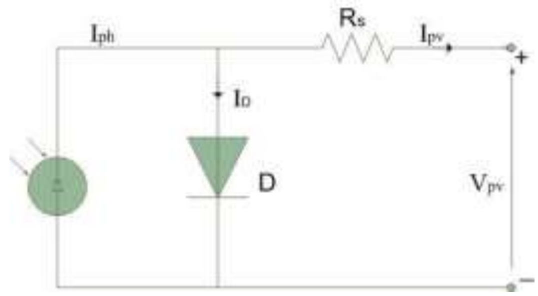

Fig. 4: Electrical diagram represent I-V characteristic measurements circuit.

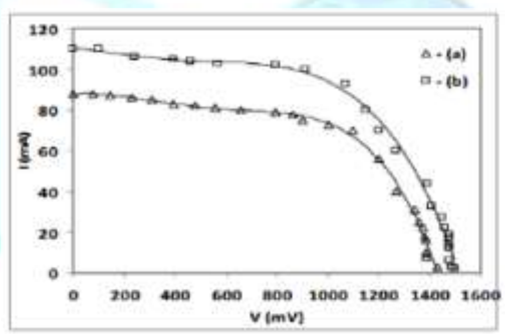

Fig. 5: V-I characteristics for PV Si cell without (a) and with (b) array micro-lens.

Table 1: Performance parameters for PV without and with concentrator

	Without Concentrator	With Concentrator	Improvement %
I_{sc} mA	88	110	25
V_{oc} mV	1430	1497	4.6
$P_{max}mW$	77000	99510	29.2
FF	125840	164670	30.85
η%	6.75	8.7	11.98

Table-1 demonstrates the short circuit current Isc, open circuit voltage Voc, greatest yield power $Pmax$ full component FF, and productivity η% for PV without and with exhibit concentrator. Additionally the change in proficiency $\Delta\eta\%$ is indicated.

As table demonstrates, the productivity enhanced from 6.75% to 8.7% without and with the new concentrator individually, i.e., there is $\Delta\eta = 11.98\%$ change in the proficiency of PV with concentrator. One infers that there is a change in the framework cost by diminishing the high cost Si material.

ZEMAX-EE code is utilized to think about the circulation of the vitality on the sunlight based cell chunks. What's more, the outcomes from this code gives that 62% of the episode sun based radiation is on the sunlight based cell organized as (13%, 18.5% , 13.7% and 16.0% on to begin with, second ,third and fourth chunk separately).

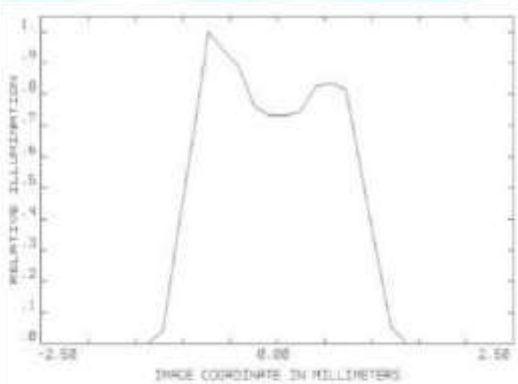

Fig. 6 : Illumination distribution on the PV cell slap.

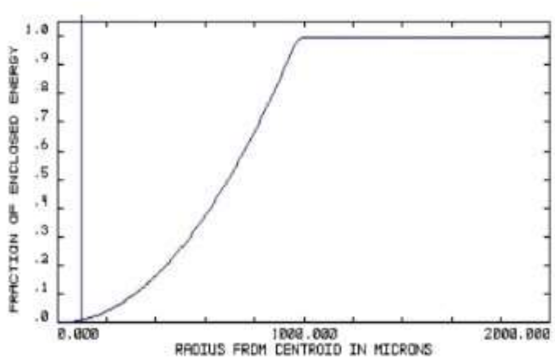

Fig. 7: Encircled energy on the PV cell.

The enlightenment appropriation additionally inspected by utilizing ZEMAX physical proliferation properties, Fig. 6 demonstrates that the enlightenment appropriation along x and y directions of the PV slaps has a mean light esteem 90% of the aggregate data brightening which show the great lens cluster concentrator outline. Additionally Seidel variations were examined, the outcomes demonstrate that the planned cluster lenses concentrator experience the ill effects of round abnormality (0.0029λ) and all out distortion change 0.0045.

Fig. 7 demonstrates the measures of vitality gathered on the cell. This figure shows that the circle sweep at 90% of the gathered vitality is 1mm. which is littler than the sun oriented cell distance across (12 mm). One must fulfill the conditions put on the FOV are: size of sun oriented cell (one piece) must be forced that the picture length won't be bigger than the pitch (the separation from one lens focus to the neighboring lens focus is known as the pitch) must be watched.

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