Hybrid(Luminescent and Fresnel) Concentrators to Improve Solar Panel Conversion Efficiency

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Abstract:

The spectral response of the Si solar cell does not coincidence with the sun irradiance spectrum, so the efficiency of the Si solar cell is not high. To improve the Si solar cell one try to make use of most region of the sun spectrum by using dyes which absorb un useful wavelengths and radiate at useful region of spectrum (by stock shift). Fluorescence's dye is used as luminescent concentrator to increase the efficiency of the solar cell. The results show that the performance efficiency and out power for crystalline silicon solar cells are improved.

Key words: Solar energy, Luminescent, Fresnel and Hybrid concentrators.

Introduction:

Solar cells are capable of converting sunlight directly into electricity by photovoltaic affect; its long life, reliability, and low maintenance are well established. The major factor preventing widespread terrestrial use of solar cells is the price at which they deliver electricity to the user. [1-2].

One approach to the reduction of the effective energy cost of photovoltaic (PV) systems is to increase the solar cell output power density by concentrating sunlight on the cells. Many methods were adopted to improve the utilization ratio of sunlight for solar cell. , Fresnel lenses, mirrors, and luminescent solar concentrators, nanoparticle [3-5], and coating of fluorescent coloring agents on the surface of solar cells to increase the energy conversion efficiency of the cells by reducing the reflection of the incident light [6]. Also micro concentrators were used to improved solar energy conversion efficiency [7-9]. The energy conversion efficiency can be calculated using the equation:

$$\eta = \frac{I_m V_m}{p_i A}$$

where (I_m,V_m) are the maximum power points,p_i is the incident solar power density and A is the receiving area of the solar cell [10].

Materials and Methods :

Silicon Solar cell of diameter (10) cm was used of a surface (78.5 ± 1.5)cm^2 thickness (0.5 ± 0.15)mm. The applied base material of solar cell is a single –

crystalline silicon which is n – doped on sensitized face. The cell was supplied with tin-plated connections, which can be soldered using usual soldering process.

Two dimensional concentrators, Fresnel lens made of glass, it has a focal length of 60cm, width (across the prisms) of 35 cm and a length (parallel to the prisms) of 38cm. There were 20 prisms on each side of the center

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section, their widths decreasing monotonically from 1.8 to 0.4 cm at the outer edges. Grooves of the lens are used down for two reasons: first to reduce the transmission losses and to reduce the accumulation of dust and dirt on the lens side exposed to the sun, this dust and dirt reduce the transmitted light towards the focus, thereby reducing the performance of lens [11-12].

Solar panel was manufactured which consist of five solar cell type-p module CZ100-0, the effective area of the panel is 392.5 cm^2 with resistance between 0.5-3 Ω.cm (shown in figure 1)

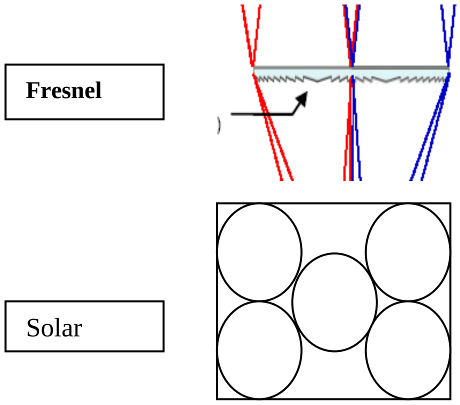

Fig.1, Solar panel and Fresnel lens concentrator

The luminescent solar concentrator were prepared by mixing four times a dye to one of poly. Vinyl. Alcohol (PVA) then serving the mixing on the panel surface unit it becomes a dry thin film on the panel surface.

Indoor and outdoor testing were used . For indoor measurements, Xenon lamp was used as artificial source of light supplied by Pasan Company (Flasher test- Rev 181/ 86), it gives intensity of 1-sun (1000W/m^2). The (I-V) characteristic of the panels were measured and drawn by a special program using computer (Hp-HEWLFT, PACKARD 85B). Outdoor measurement was also done, the intensity of the sun radiation in (537 W/m^2) measured using solar intensity meter.. The short –circuit current (I_{sc}) and open –voltage (V_{oc})are measured using (7045) digital multimeter supplied by (electron plant company). Solar intensity meter (118 from instruments Haeni Mesgerte) was used to give the radiation incident on the solar cell. The temperature of the solar cell is measured by digital thermometer model (2754-PT100).

Result and Discussion:

Figure2, Shown the absorption and emission spectra of the dye (Rh-6G) ($C_{28}H_{31}ClNO_2$) of concentration 2.314x10^{-5} (mol/L). The emission wavelength is ≅ 570 nm.

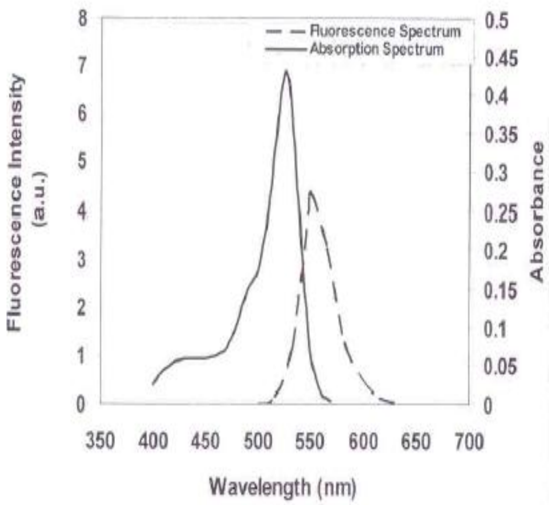

Fig.2, Absorption and Fluoresce spectra of Rd 6G 2x10-5 mol/l concentration solution sample)

In Figure 3, the 1st curve shows the electrical characteristics and energy conversion efficiency of the solar panel , the 2nd curve for panel with Fresnel lens concentrator and the 3rd curve for panel with hybrid concentrator consist of Fresnel lens and luminescent dye over it.

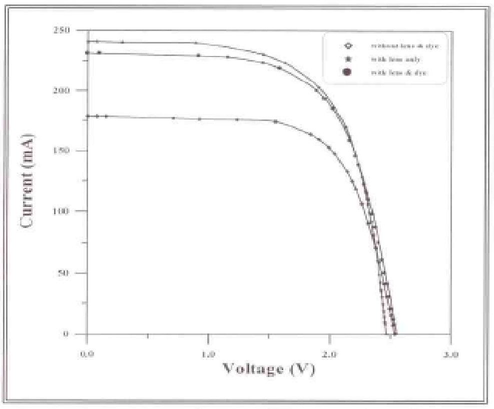

Fig.,3 Characteristics of solar panel ,with Fresnel and with hybrid (Luminescent +Fresnel) concentrators

The result in this figure and table 1, indicate that the panel conversion efficiency with Fresnel concentrator is 9.65% which increased to reach 10.484% by using hybrid concentrator (Fresnel and luminescent). This means that the dye with thickness 0.5 mm increase the efficiency by 12.414%.

Table (1) Electrical characteristics for cell with and without the luminescent concentrator

Coating Thickness (mm)	Voc (V)	Isc (mA)	H (%)	P_m (W/m^2)	Δ η(%)
0.5	2.47	241.08	10.848	0.4248	12.414
1.0	2.474	234.07	9.752	0.3079	8.74

Also the results show that the improvement in the performance of the solar panel depend on the thickness of luminescence concentrator. The increase in the energy conversion efficiency of the solar cell module in dominated by the positive effect of decreasing the reflectivity due to the absorption of the exciting light [6]. Increase the thickness (for fixed concentration) of the dye reduce the efficiency since the probability of photon interaction with dye molecules and fluoresces is approximately equal.

Conclusions:

In this paper one conclude that using Hybrid concentrators (consist of Luminescent and Fresnel lens) improve the conversion efficiency of the panel more than that for either concentrator alone.

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الخلاصة:
أن حساسية الخلية السليكونية لا تتوافق مع الطيف الأشعاعي الشمسي. لذلك تكون كفاءة الخلية الشمسية ليست عالية. ولتحسين هذة الكفاءة فيجب الأستفادة من معظم الطيف الشمسي . في هذا البحث تستخدم المواد العضوية المتفلورة للأستفادة من ازاحة ستوك واظهرت النتائج تحسن في كفاءة الخلية السليكونية باستخدام هذة التقنية