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Abstract

Enhancement of the photovoltaic performance of single-crystal silicon solar cell has been achieved by packing the surface of the cell with Polystyrene membrane. This membrane was casted out from the toluene solution. The results of quantum efficiency showed visible enhancement. Conversion efficiency at AM1 condition was raised to 9.5% from its primary value after Polystyrene-coating.

استخدام البولي ستايرين كتقنية جديدة في تصنيع كطبقة مضادة للانعكاس في الخلايا الشمسية

الملخص

جرى تحسين الخصائص الفولتائية الضوئية للخلية الشمسية السليكونية أحادية التبلور وذلك بترسيب مادة البولي ستايرين على سطح الخلية كطبقة مضادة للأنعكاس, حيث تم ترسيب هذا الغشاء من محلوله الذائب في التلوين . أظهرت نتائج الكفاءة الكمية تحسنا في المنطقة المرئية . ارتفعت قيمة كفاءة التحويل عند كتلة هواء 1 بمقدار 9.5% في قيمتها الأصلية عد مادة البولي ستارين.

1. Introduction

It is well-known fact that silicon surface is visible semi-reflector, this fact inspired a great deal of investigations to reduce significantly this side effect on the performance of silicon solar cells. The forefront is the investigations on the passivation of the cell surface [1,2] and / or deposition of ant reflecting layers (ARL) on the cell surface [3,4]. In the latter technique, the rule used for the selection of the suitable material is by choosing a dielectric material which has a refractive index value intermediate between these of silicon and air because reflectivity is given by the ratio $(n_0n_1-n_2^2)$ / $(n_0n_1+n_2^2)$ where n_0,n_1 and n_2 respectively are the refractive indices of air, antireflecting layer, and silicon cell.

Titanium dioxide is widely used as single antireflecting layer (SARL) [5]; it is often prepared by electron technique. Polystyrene (PS) is an insulating plastic material. The extended usage of PS in the last tow decades prompted intensive studies on it [6-8]. No data have been found on the use of PS as antireflection coating.

In this paper, we developed a new technique including the deposition of PS antireflecting the layer. This material is easy to cheaper, to prepare, cheap, and powerful as ARL. The principle is based on the fact that PS has a refractive index intermediate between Si and air (1.56 at 600 nm wavelength [9]).

2. Experiment.

The solar cell used in this research was monocrystalline silicon p-n junction cell. This cell was already produced locally in Al-Mansoor company. This assembled cell consists of four equi-parts. The net sensitive are of the cell (neglecting the grid electrode and the guard ring) was $40cm^2$ .AM1 conversion efficiency is certificated to be 8.5% .No antireflecting coating was deposited on the cell.

Standard white grins of Polystyrene were dissolved by toluene at $50^{\circ}C$ with concentration near to the saturation point. The solution of this dielectric polymer was poured on the top surface of the cell. After few minutes, polymer film was formed. Prior the deposition, wires soldered on the front and back electrodes. Photovoltaic performance of the cell has been measured under simulated sunlight AM1 condition. Spectral response was examined using monochromator in the rang 400-1050 nm wavelength. The measurements have been carried out before and polymer coating.

3. *Results and Discussion*

The visual test on PS coated solar cell shows surface discoloration from the gray-metallic to the dark-gray that PS-membrane reduces the visible reflection. Reduction in reflection leads to an increase in transmission, and consequently, the absorption of visible in the bulk silicon will be increased. Thus, an enhancement in the conversion efficiency of the will be expected.

Figure 1 demonstrates the spectral quantum efficiency curve for both as received and PS-coated cells, it is evident that that the electron-hole generation in the visible spectrum is reinforce in the PS-coated cell rather than that of as received cell. Slight decrease in the infrared spectrum is observed. This decrease is related to the hot-mirror effect of the PS-membrane. No shift in peak response is registered, this is because PS is dielectric material and never contributes in the absorption process.

The fourth quadrant curve is illustrated in figure 2. From this figure, it is obviously shown that the photovoltaic performance of PS-coated cell is enhanced. Load resistance at peak power was 5Ω for both cells, this result indicates that series resistance is not changed. The rectangularity of this Figure reveals that PS-membrane have little effect upon cell fill factor.

The variation of output power density with photo-emf is apparent in Figure which compares the output power of PS-coated cell as received cell. A noticeable improvement in the delivered power for PS-coated cell is attributed to the increase in the absorption of shorter wavelengths. At peak power, conversion efficiency η and fill factor FF have been calculated and listed in Table I.

Table I. Output characteristics of PS-coated and as-received cells.

Cell under test	V_{oc} (mV)	J_{sc} (mA/cm^2)	FF(%)	η (%)
As-received	1.99	6.85	61	8.40
PS-coated	1.99	7.40	62	9.18

The above table shows that η is raised to about 9.5% from is primary value when the cell coated by polystyrene. The open circuit photovoltage V_{oc} showed insensible variation while the short-circuit photocurrent I_{sc} demonstrated appreciable increase after coating.

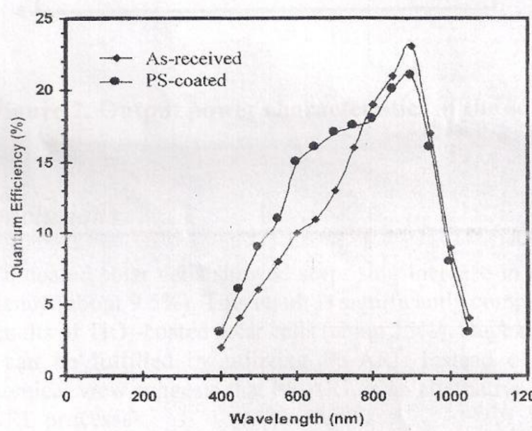

Figure 1. Spectral quantum efficiency curve.

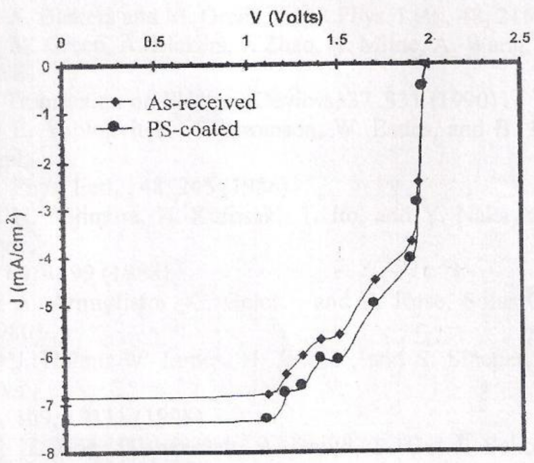

Figure 2. Output power characteristics of the solar cell.

4. conclusions

PS-coated solar cells showed surprising increase in conversion efficiency (about 9.5%). This result is significantly comparable with the results of TiO_2-coated solar cells (about 15%). Huge reduction in cost can be fulfilled by utilizing PS-ARL instead of TiO-ARL Economical view suggests that PS-ARL is an alternative material in the ARL processes.

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