Fabrication Solar Cell Device From CdTe Nanoparticles Suspension

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ABSTRACT
In the present study ,nanoparticles cadmium telluride (cdte) on si p-type substrates heterojunction solar cell has been made by using pulse laser ablation PLA.Q-switching, Nd: YAG laser (500mj,9ns),wavelength 532nm with number of pluses(60 and 120)pulse using of the bulk materials target in methanol solution. Optical, structure characterization of Nanoparticles suspensions studies by using UV-Vis spectrophotometry, X-ray diffraction (XRD), transmission electron microscopy (TEM).The photovoltaic characteristics included short circuit current and open circuit voltage (I_{SC} –V_{OC}), where the maximum (J_{sc}) and(v_{oc})obtained were 25.3 $mAcm^{-2}$ and 144.9mv respectively. The fill factor(ff) was(0.42) and the conversion efficiency(1.5%).

Keywords: CdTe Nanoparticles, LP_PLA, TEM, Heterojunction Device, solar cell.

تحضير نبيطة لخليه شمسيه من معلق نانوي للكادميوم تولورايد

الخلاصة:
في هذه الدراسه تم تحضير خليه شمسيه من خلال ترسيب المحلول النانوي لجسيمات الكادميوم تولورايد المحضرة بطريقة الاستئصال الليزري لهدف الكادميوم تولورايد في محلول الميثانول على قواعد السليكون الاحادي البلورة من النوع القابل.استخدم ليزر النيدميوم ياك وبطول موجي 532 نانومتر وبطاقة 500 ملي جول وبعدد نبضات 60 و120 نبضه. الخواص البصريه والتركيبيه للجسيمات النانويه تمت دراستها بواسطة مطياف الامتصاص, حيود الاشعه السينيه وجهاز مجهر الالكتروني النافذ.ودرست الخواص الفولطائية المتمثله بتيار الدائرة القصيره وفولتيه الدائرة المفتوحه وتم حساب عامل الملئ (0.428) وكفاءة الخليه الشمسيه% 1.5 .

INTRODUCTION
In recent years colloidal quantum dots solar cells have been the subject of extensive research. A promising alternative to existing sil-icon solar cells, quantum dot solar cells are among the candidates for next generation photovoltaic devices. Colloidal quantum dots are attractive in photovoltaic research due to their solution process ability which is useful for their integration into various solar cells [1].Among the most common II-VI semiconductor nanoparticles (NPs), CdTenanocrystals (NCs) are of great interest for applications in solar cells [2],light-emitting diodes [3, 4] and in biology [5,6]. Furthermore, the large variety of organic

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polymers on one side which are solution-process able and the excellent electronic and optical properties of quantum dots (QDs) on the other side can be well-combined and utilized in hybrid organic-inorganic optoelectronic devices, where the unique size dependent physical properties of QDs offer the possibility of tuning the device emission color [7–10].

Crystalline solar cells, particularly those made with silicon (Si) and gallium arsenide (GaAs), have achieved energy conversion efficiencies approaching the theoretical limits for their respective band gaps. Furthermore, the small remaining losses are reasonably well understood, and any additional effort would appear to offer only a modest improvement. However, during the last 15-20 years the photovoltaic world has been enriched with other interesting materials such as CdTe(Cadmium Telluride). An II-VI compound presents various properties (energy gap about 1.5 ev. Large atomic numbers of the components (Z_{cd}= 48, Z_{Te}= 52), direct fundamental transition, n or p- type conductivity, etc.), making it attractive for applications as different as gamma and X-ray detectors and photovoltaic devices [11], this material is considered very suitable for the fabrication of solar cells because of their direct band gap and CdTe has a much better band gap than silicon. The absorption edge is very sharp and thus, more than 90% of the incident light is absorbed in a few micrometers of the material. The maximum photocurrent available from a CdTe cell under the standard global spectrum normalized to 100 mW/cm2 is 30.5 mA/cm2and the theoretical maximum efficiency of CdTe is over 27%. Recently an energy conversion efficiency record for CdTe of 16.5% has been reported [12].

Purely physical production methods which allow the synthesis of uncapped particles are limited to mechanical ball milling processes [13–15].

In this letter we report the synthesis of CdTe NPs in solution by using the method of laser ablation of a solid target in a liquid environment [16]. The principle of the method is similar to the method of pulsed laser deposition of thin films [17] with the exception that the ablated plume species condense and form NPs within the liquid which surrounds the ablated target. This method has some advantages. The cost is comparatively low, because expensive instruments such as a vacuum apparatus are unnecessary. The recovery of the product is higher than that of laser ablation in the gas phase. Moreover, ablation surroundings can be easily changed by replacing solvent [18]. In this work we prepared a heterojunction solar cell device using Nanoparticles colloidal of CdTe.

Experimental Work:

A pulsed Nd-YAG laser system type (HUAFEI) providing the required laser pulses. High purity (99.99) CdTe bulk from (Fluke) was used as a target, so it fixed at the bottom of open a glass cell containing 3 ml methanol solution which represents the liquid media. The pure target was irradiated by laser with energy of (500 mJ), (532nm) and (60 and 120 laser pulses). The absorption of the nanoparticles suspensions was investigated inspectoral range (200–900) nm using UV-VIS Shimatzu double beam spectrophotometer .X-ray diffraction measurement has done using Philips PW 1050 X-ray diffract meter of 1.54 Å from Cu-kα.Transmission electron microscopy (TEM) (typeCM10 pw6020, Philips-Germany) were used to study the particle size and themorphology, by depositing the CdTeNPs colloids onto copper mesh coated with an amorphous been CdTe film. Heterojunction solar cell Device was fabrication by drop casting method of the CdTeNPs colloidal using The colloidal solution dropped on the Si p- type substrate, dried in an oven at 60C°

temperature in order to convert CdTe nanoparticles colloidal to nanoparticles thin films and to obtain uniform distributed Nanoparticles thin film, and heterojunction solar cellCdTe/ p-Si was fabricated shown in figure (1). For devise characterization A Kiethley- 616 electrometer was used to measure the flow current in a solar cell manufactured from the produced structure in dark condition as voltage been applied from a Farnell power supply of range (0.2-3) V in forward biasing and reverse biasing, current sort circuit and voltage open circuit (I_{SC} $-V_{OC}$),*F.F* and ***η*** measurements for solar cell.

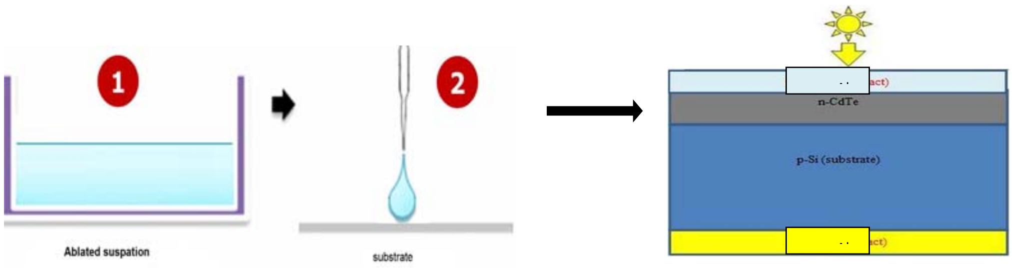
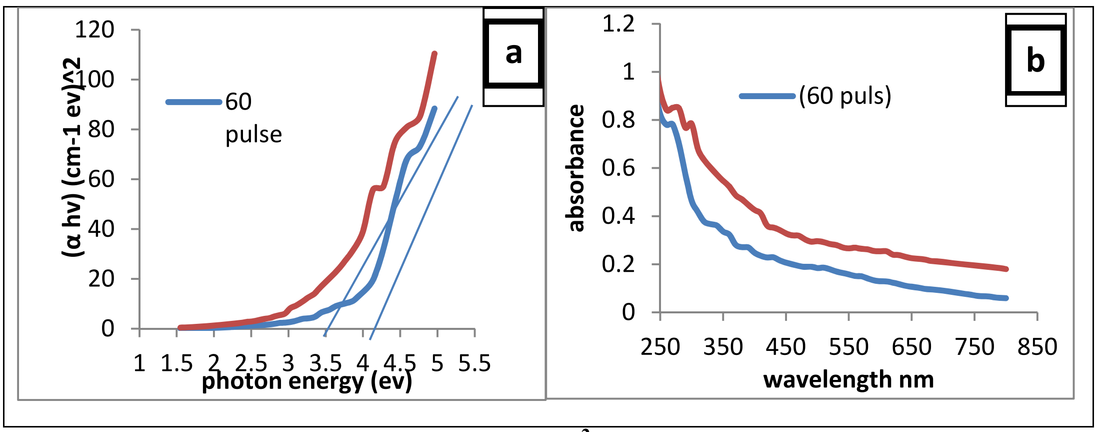


Figure (1): Schematic View the drop drying method and then prepared hetrojunction Solar Cell

Result and Discussion:

The optical properties of the colloidal suspension could be show in figure (2) where the optical absorption as a function of laser wavelength was measured, show that CdTenanoparticles exaction absorption , the optical band gap (Eg) of CdTe NPs is determine from extrapolating of the linear part of $(\alpha h\nu)^2$ with incident photon energy (hν)it's about (3.4 – 3.9eV) . The absorption increases monotonically with decreasing wavelength towards the UV. This indicates a rather wide distribution of particle sizes in comparison to chemically synthesized nanocrystals, which usually exhibit a well-defined onset of the absorption spectrum well in the visible region and an absorption maximum according to the average (capped) particle size [19]



Figure(2).Optical properties a-$(\alpha h\nu)^2$ with incident photon energy b-absorbance with wavelength.

The XRD pattern of the CdTe NPs is shown in figure (3) X-ray diffraction (XRD) spectra recorded by using a diffract meter with a CuKsource (Siemens D-5000) on NPs from droplets of the colloidal solution dried out onto a clean glass substrate, show the structure of films is polycrystalline with sharp peaks at different Bragg angles (111), (200), (220), (311), (400) and (331) of 24.25°,26.336, 39.75°, 46.83°,53.101 and 59.499 respectively, which correspond to the cubic (zinc blende) structure of bulk CdTe[20]. Confirming the crystal structure of the synthesized NPs, is the same as that of the bulk material. And films have crystallized with a strong peak at (111) direction, this means that this plane is suitable for crystal growth [21].And sharp peaks at different Bragg angles (*) and (#) refers to Cd and Te at 20.536, 35.412, 30.111, 51.8149, 55.700.Respectively.

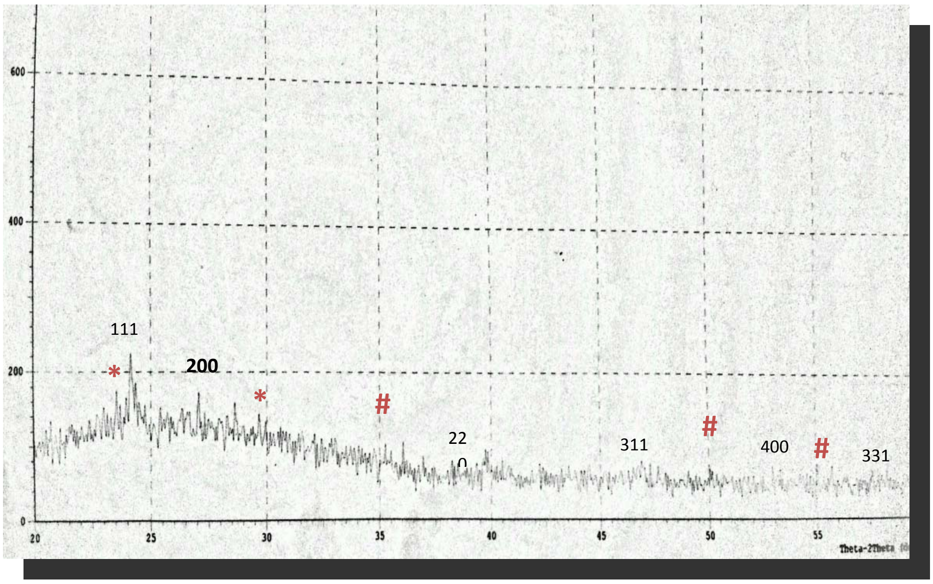


Figure.(3)X-ray diffraction patterns for CdTeNanocolloidal condense on glass substrate prepared by laser ablation of CdTe target in methanol solution [* and # indicates Te and Cd peaks respectively].

Transmission electron microscopy (TEM) images of CdTeNPs are shown in Figure. 4(a) confirming that, the NPs are spherical. The histogram of particle size distribution (shown in Figure. 4(b, d) by counting approximately 60 particles in the image of Figure.4(c) as well as in images of particles ensembles obtained on other areas on the grid, shows that the as-prepared cadmium telluride consists of highly agglomerated Nano sized particles with irregular shape. confirms that nanoparticles are spherical in shape and the distribution of particle size is relatively narrow.

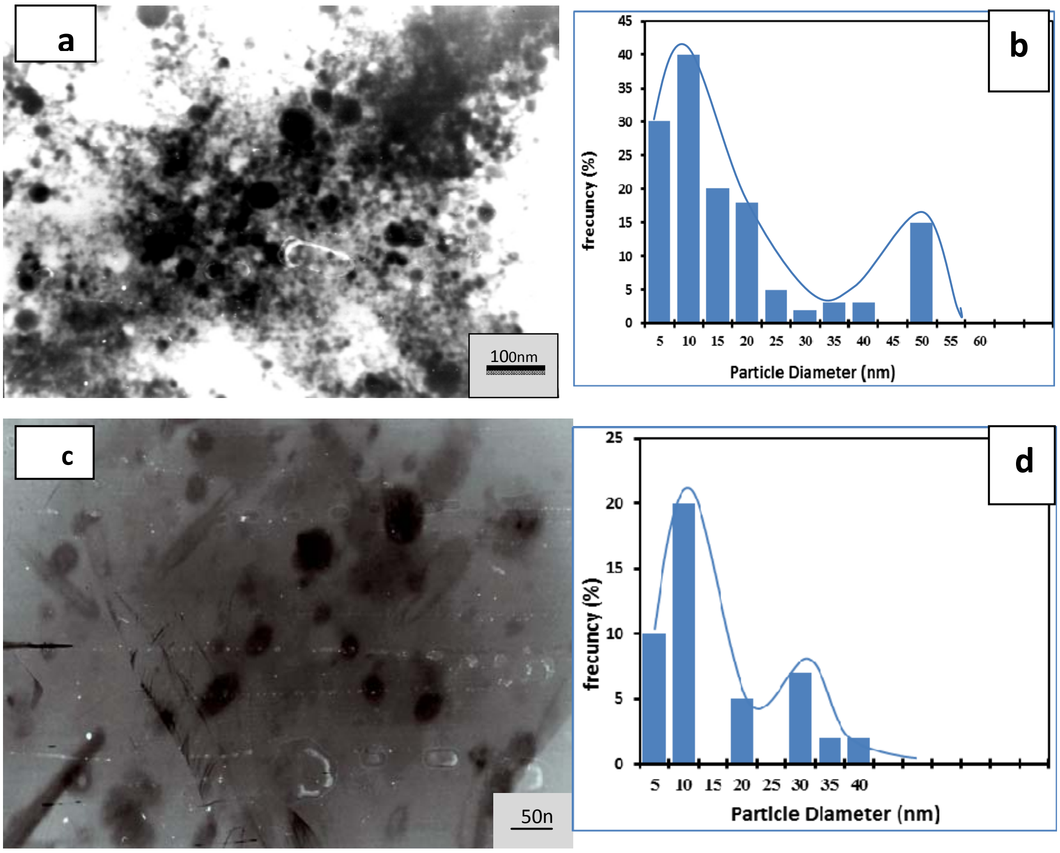


Figure.(4) (a and c) Transmission electron microscopy (TEM) images of CdTe NPs, (b and d) size distribution for CdTe NPs.

By drop casting method the CdTe NPs suspension on the p-Si substrate a heterojunction solar cell (CdTe/ p-Si) was prepared. One of the important parameters of a heterojunction measurement is a current-voltage characteristic which explains the behavior of the resultant current with the applied forward and reverse bias voltage.

Figure (5) describe the results of the current-voltage (I-V) measurements in the dark for the prepared heterojunction in the forward and reverse bias. In general the forward dark current is generated due to the flow of majority carriers and the applied voltage injects majority carriers which lead to the decrease of the built-in potential, as well as the width of the depletion layer. In forward bias, Two regions are recognized; the first one represents recombination current the first current established when the concentration of the Generated carrier be larger than the intrinsic carrier concentration (ni), i.e. (n*p>ni2),which lead to recombination process for mass low applicable . The second region at high voltage represented the diffusion or bending region which depending on series resistance, In the reverse bias, It is clear that the curve contains two regions; the first is the generation region where the reverse current is slightly increased with the applied voltage and this leads to generate electron-hole pairs at low bias. In the second region, a significant increase can be recognized the reverse bias is increased. In this case, the current is resulted from the diffusion of minority carriers through the junction. We can also note from this figure the rapid increment in the reverse current at high reverse voltage, which is probably due to the leakage current arising from the surface layer.

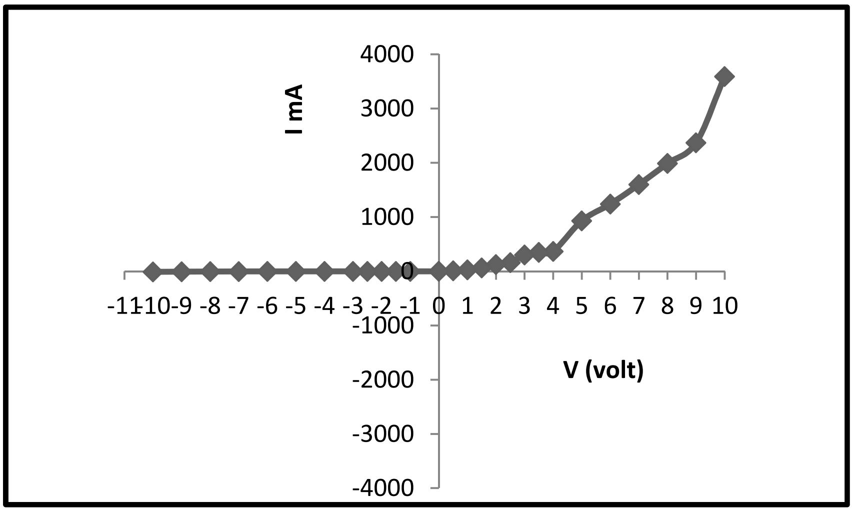


Figure.(5)the I-V characteristics in the dark for CdTe/p-Si heterojunction solar cellatforward and reverse bias voltage.

The current-voltage (I-V) measurement in the illumination for CdTe/p-Si heterojunction is shown in figure (6), photo electric behavior of the device under illumination condition could be recognized. It is understood that photo electric effect result from light-induced electron-hole generation at the device and particularly at the depilation region of the P-type silicon. Under external reverse bias, depilation region of the device extends, more incident photons will contribute to the electron-hole pair's generation that takes place in the depletion region. The internal electric field in the depletion region causes the electron-hole pairs to separate from each other and this bias becomes larger with the applied external bias. In the figure below, we can see the increase in the photo-current with increasing incident light intensity, where the large intensity refers to a great number of incident photons and hence large number of separated electron-hole pairs. This figure shows the behavior of the current as a function of the applied reverse bias voltage with different illumination powers, operating the detector under external revers bias causes the depilation region to be extended so that large number of incident photon will transmitted through the CdTelayer and absorbed mainly in the depilation region, creating electron –hole pair's which incorporate in photocurrent generation. the internal electric fields in the depletion region cause separation of the electron and the holes, this electric field is much higher when the device in the reverse bias. So, when the incident power density increased large number of electron –hole pair is generated.

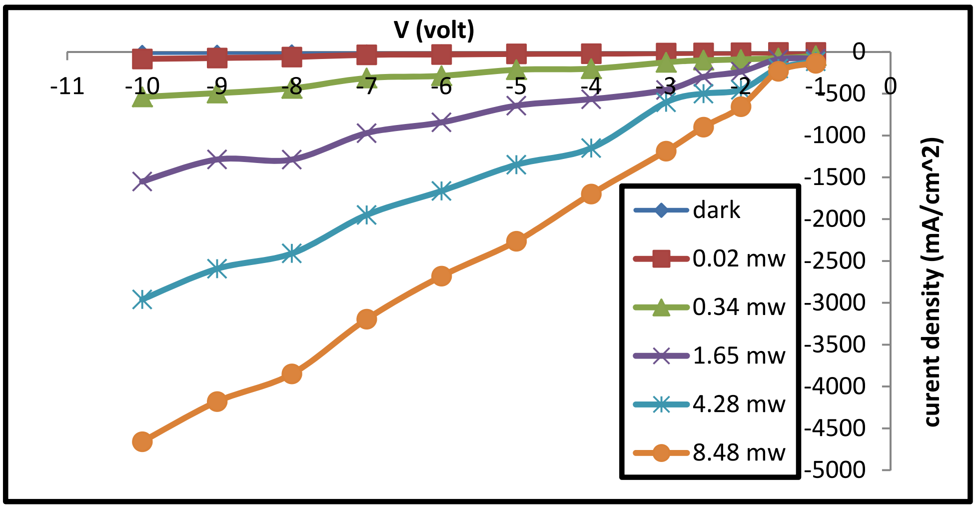


Figure (6).Photo I-V characteristics under reverse bias for CdTe\Si heterojunction device.

Figure (7) shows current–voltage characteristics of a solar cell. Under illumination , the current–voltage curve exhibit a vertical shift caused by light-induced current generation. Found that the solar cell with CdTe NPs layer showed enhanced photovoltaic performance. Moreover, the full factor, conversion efficiency, short circuit current, and open circuit voltage of the resultant were measured as 0.428, 6.12% and 25.3 mA cm^2, 144.9 mV respectively.

A reduction in the cell efficiency at low insulation level may be caused due to recombination currents, parallel resistance, and other effects. It is reported in the literature [7].

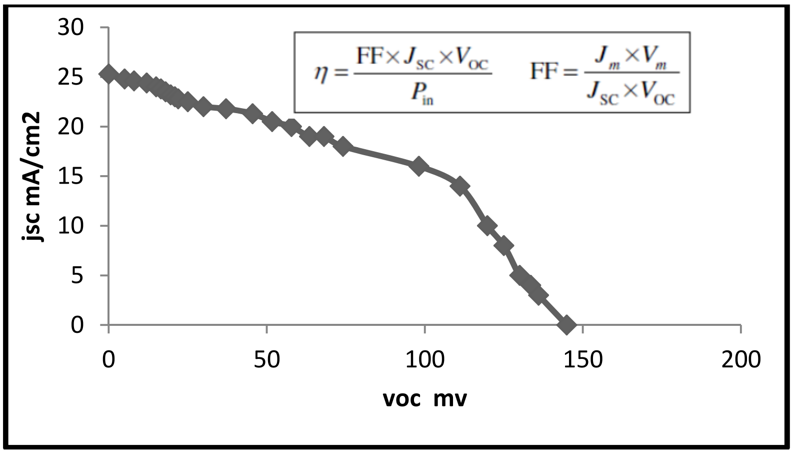


Figure.(7)The Current–voltage characteristics of a solar cell under illumination.

Figure (8) shows the variation of the output power that generated by the cell under versus voltage across the load resistance.

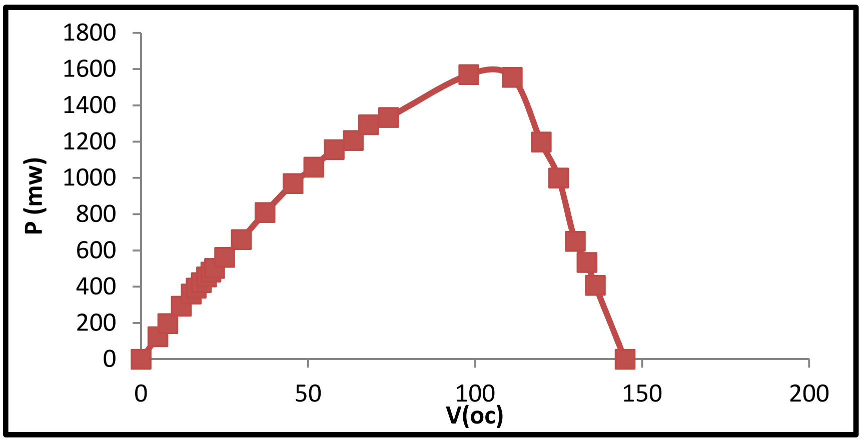


Figure (8) the output power generated by the cell.

CONCLUSION:

CdTe/p-Si nanostructure heterojunction solar cell formed by drop casting of NPs of colloidalcdTe which prepared by using a pulsed 532 nm Nd:YAG laser. Result of these cell showed that this technique is an appropriate to fabricate highly efficient solar cells with conversion efficiency about 1.5% and fill factor about 0.428 .The variation of J_{sc} with illumination intensity showed the exponentbehavior, illumination that explained to the saturate in carriers.

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