SAMVAD E-JOURNAL
ISSN (Online) : 2583-8334
(International Peer-Reviewed Refereed Journal)
Volume 2, Issue-4, October to December: 2024
Published by Rangmati Publication http://www.rangmatipublication.com/

Hybrid solar cells based on dispersed $MoSe_2$- polyaniline composites

H. S. Patel
H. O. Parmar

ABSTRACT

The hybrid solar cells based on dispersed $MoSe_2$- polyaniline composites has been fabricated. An intensive research has been focussed on the area of solar cells since many decades. In this direction, several reports can be found in literature where in solid – solid junction and solid – liquid junction solar cells have been investigated. But in recent years, a lot of thrust has been directed towards some new structures of solar cells which can offer high stability along with high efficiency. In this regard, the conducting semiconducting polymers have been used in solar cells by several workers. The present paper contains the work on polyaniline which is known to be stable material against the environmental effects. This organic polymer is used along with Molybdenum diselenide ($MoSe_2$, a semiconducting material belong to group VI) to form a hybrid solar cell.The present paper contains the work on solar cell having polyaniline which is known to be a stable material against the environmental effects along with Molybdenum diselenide ($MoSe_2$, a semiconducting material belonging to group VI), which is also known to be relatively stable even in electrolytic environment.

We show that the current – voltage curves in the dark state could be modeled by using the Shockley equation. The photocurrent density dependence on light intensity has been found to be a nonlinear. An analysis of index n gives a value of 1.97 related to nonlinear recombination. The spectrum of photosensitivity of composite is corresponding to bulk $MoSe_2$ spectrum of photosensitivity. Proposed solar cells are characterized by higher open circuit voltage in comparison with other hybrid cells based on conjugated polymers and inorganic semiconductors.

KEY WORDS: dispersed $MoSe_2$, polyaniline, composites, solar cells.

INTRODUCTION

Over the past few years the structures based on inorganic-organic semiconductors are intensively studied due to their low-cost and simplicity of technology [1]. In order to investigate the possibility of hybrid organic inorganic systems application in solar cells and optoelectronics the dispersed composites based on conjugated polymer –$MoSe_2$ powders with submicron size of $MoSe_2$ grains have been studied. The choice of semiconductor material is ground on the high $MoSe_2$ photosensitivity in visible and near infrared region of spectrum [2]. As conjugated polymer the polyaniline (PANI) in undoped form of emeraldine base was used [3].

EXPERIMENTAL

For investigation of the electrical and photoelectrical characteristics of PANI-$MoSe_2$ composites (for 50% wt $MoSe_2$ in PANI) the size of powder particles was 0.7 μm. As experimental samples the sandwich-like structures SnO_2/PANI-$MoSe_2$ composite/Au have been fabricated. By the changing of the

[1]H. S. Patel, Assistant Professor, [1]Arts, Commerce and Science College, Borsad – 388540, Anand, Gujarat, India.
[2]H. O. Parmar, Assistant Professor, [2] Arts, Science & R. A. Patel Commerce College, Bhadran, Anand, Gujarat, India, [1]E-mail. : ghhspatel@gmail.com

shape and size of particles there is the possibility to control the photovoltaic properties of such composites.

RESULTS AND DISCUSSIONS

The typical I-V characteristic of device is presented in Fig.1. The forward curve is corresponding to positive potential on Au electrode and reverse curve is corresponding to negative potential on SnO_2 electrode (see the framing in Fig.1.). The I-V curve of p-type conductive PANI/n-type $MoSe_2$ micro particles exhibits typical rectifying junction behaviour. At room temperature the I-V characteristics shown on Fig.1. indicate a relatively large value of series resistance for investigated structure.

At bias of applied voltage there are a great value of series resistance connected with low charge-carrier mobility in polyaniline film [4] and presents of recombination via traps on the $MoSe_2$ participles that leads to transport of charges limit in the device. The current-voltage relationship, including the index n, can be written as [5]

$$I = I_0\left[\exp\left(\frac{qv}{kT} - 1\right)\right] \qquad (1)$$

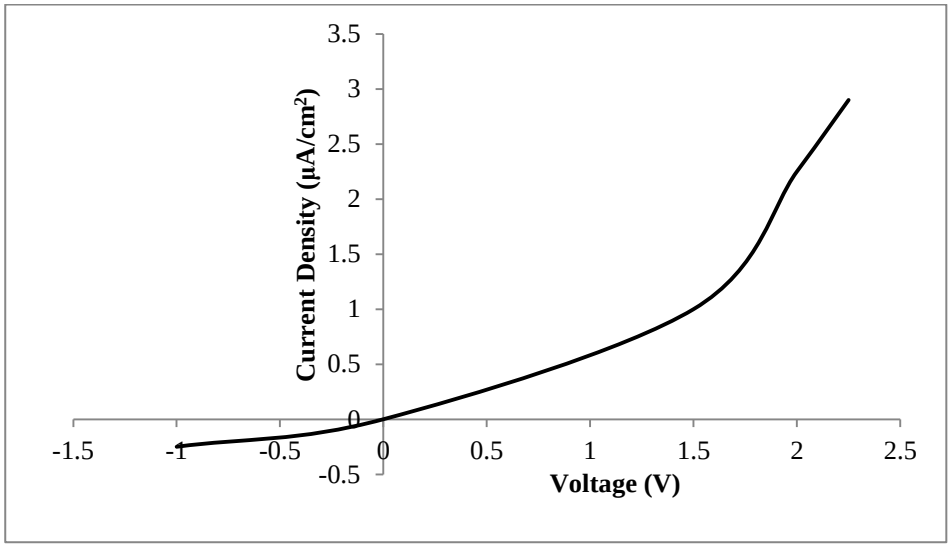

Fig. 1. The dark I-V curve for 50% wt 0.7 μm$MoSe_2$ in PANI device with gold and SnO_2 electrodes.

From the model, we obtain the index n a value of 1.97, and I_o a value of 40nA/cm^2 (Fig.2). While the n value of 2 correspond to dominating the current losses such as direct recombination, the recombination via traps, or mid-gap states [5, 6]. In real devices, loss mechanisms are important to consider, and a value of n=1.97 for our device is similar to values for n found for photovoltaic cells made of bulk inorganic semiconductor [5].

Current density and open circuit voltage as a function of white light intensity of investigated device is shown in Fig.3. Unlike inorganic semiconductors, which have a linear dependence for the current with light intensity, proposed structure show a nonlinear dependence. The current dependence on light intensity is slow (Fig.3).

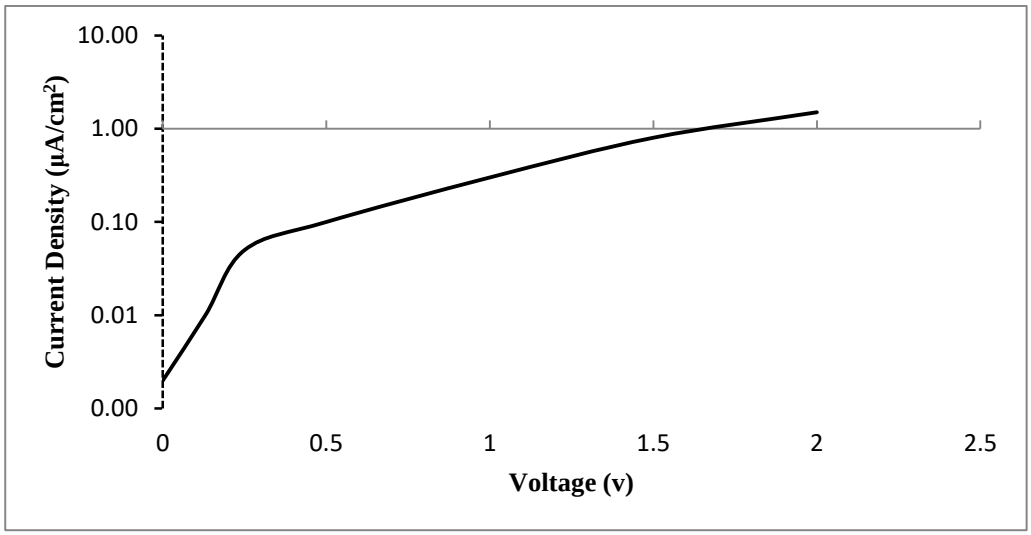

Fig. 2. Logarithmic dependence of current density on voltage of forward bias for 50% wt 0.7 µm $MoSe_2$ in PANIdevice with gold and SnO_2 electrodes.

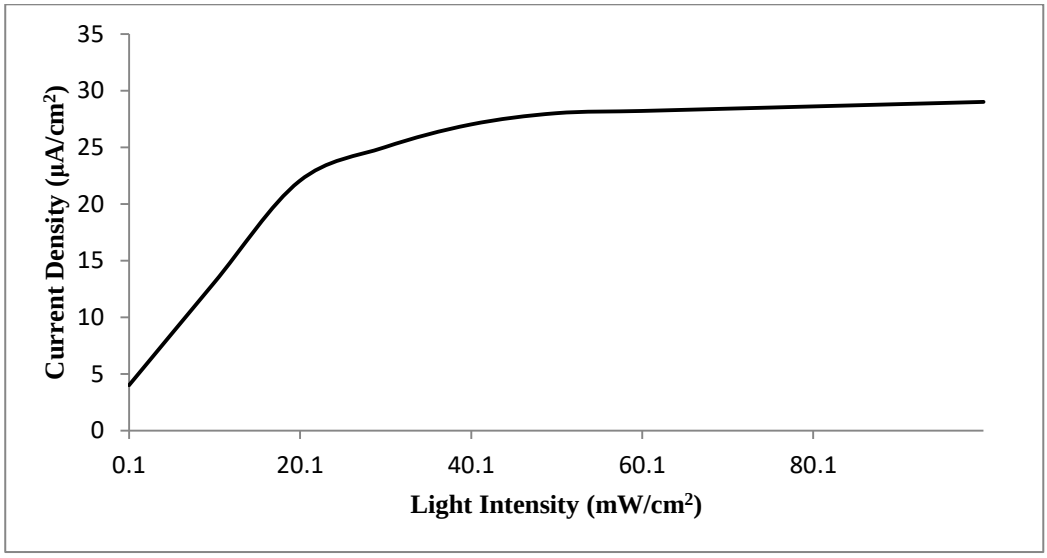

Fig. 3. Current density as a function of white light intensity of 50% wt 0.7 µm $MoSe_2$ in PANI device with gold and SnO_2 electrodes.

Observed nonlinear dependence can be explained by nonlinear recombination, because the low mobility of carries results in a high density of electrons and holes in the polymer-micro particle device due to light intensity increasing. One of the methods to decreasing the nonlinear recombination is decreasing the charge-carrier density within the device. This can be obtained by increasing the charge carries mobility. Possible methods for enhancing electron mobility are increasing the length of microparticle or ordered the polymer chains.

The logarithmic relationship between open circuit voltage of device is shown in Fig.4. The shift of experimental dependencies of open circuit voltage *xx U* (P) on light intensity may be caused by the influence of serial resistance and recombination processes. The spectrum of photosensitivity of composite device at photovoltaic regime for room temperature, obtained at illumination of device on side of SnO_2

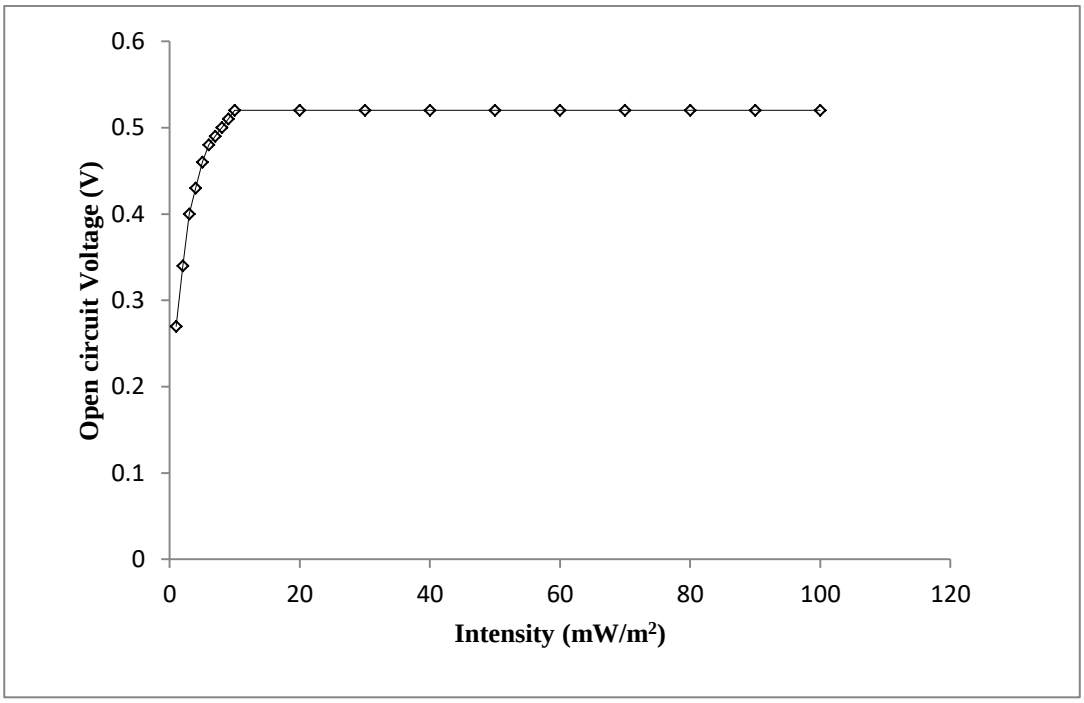

Fig. 4. Open circuit voltage as a function of white light intensity of 50% wt 0.7 μm$MoSe_2$ in PANI device with gold and SnO_2 electrodes.

electrodes is shown in Fig 5. The spectrum of light was used in interval of photon energies (from 1 to 3.5 eV). The spectrum of photosensitivity corresponds to spectrum of photosensitivity of bulk $MoSe_2$, where the quantum yield changing on 50% on a spectral range from 0.35 to 1.6 μm [1]. The influence of PANI photosensitivity on bulk device photosensitivity is inessential due to two reasons: first - low photosensitivity of PAN in comparison to semiconductor and second – the peak of PANI photosensitivity is higher than 4 eV. The investigated solar cell have a significantly better characteristics in the open circuit voltage (0.5 V) than characteristics of other organic-inorganic devices (0.08- 0.09 V[1]), particularly based on SnO_2/PANI/Au [0.18 V [7]).

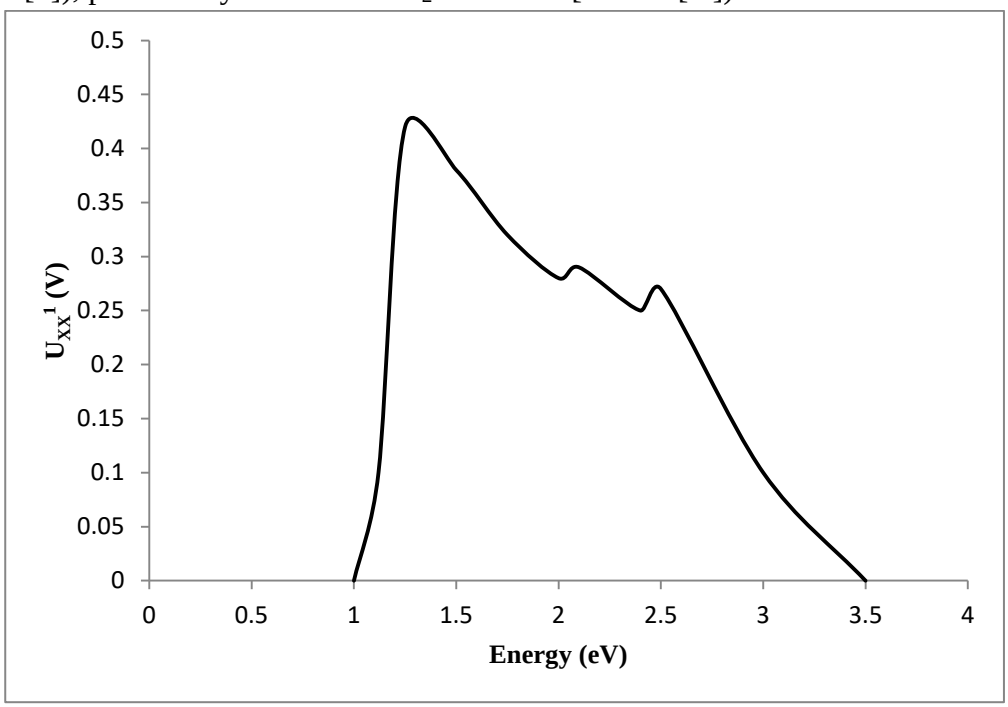

Fig. 5. Open circuit voltage spectral dependence of 50% wt 0.7 μm $MoSe_2$ in PANI device with gold and SnO_2 Electrodes.

CONCLUSION

It has been shown that volt-ampere characteristics of obtained structure may be described by Shockly equation. The index n a value of 1.97 corresponding to nonlinear recombination was calculated. Proposed structure show a nonlinear dependence for the current with light intensity, especially on a high light illumination. The spectrum of photosensitivity correspond to spectrum of photosensitivity of bulk $MoSe_2$. Proposed solar cells are characterized by higher open circuit voltage in comparison with other hybrid cells based on conjugated polymers and inorganic semiconductors.

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