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P.Y. Stakhira[1], Ya.I. Vertsimaha[2], O.I. Aksimentyeva[3], B.R. Cizh[4], V.V. Cherpak[1]

Hybrid solar cells based on dispersed InSe- polyaniline composites

[1]*Lviv Polytechnics National University, 12 Bandery-St., 79013, Lviv, Ukraine, E-mail:stakhira@polynet.lviv.ua*
[2]*Institute of Physics of NASU, 46 Prospect Nauki, 03022, Kiev, Ukraine*
[3]*Ivan Franko Lviv National University, 8 Kyryla-Mefodia, 79005, Lviv, Ukraine*
[4]*The Kazimiez Wielki Academy of Bydgoszcz, Chodkiewicza Str., 30, Bydgoszcz, 85-064, Poland*

The hybrid solar cells based on dispersed InSe- polyaniline composites has been fabricated. We show that the current – voltage curves in the dark state could be modelled 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 1.98 related to nonlinear recombination. The spectrum of photosensitivity of composite is corresponding to bulk InSe 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 InSe, polyaniline, composites, solar cells..

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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 – InSe powders with submicron size of InSe grains have been studied. The choice of semiconductor material is ground on the high InSe photosensitivity in visible and near infrared region of spectrum [2]. As conjugated polymer the polyaniline (PAN) in undoped form of emeraldine base was used [3].

For investigation of the electrical and photo-electrical characteristics of PAN-InSe composites (for 50% wt InSe in PAN) the size of powder particles was 0,7 μm. As experimental samples the sandwich-like structures SnO_2/PAN-InSe composite/Au have been fabricated. By the changing of the shape and size of particles there is the possibility to control the photovoltaic properties of such composites.

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 PAN/p-type InSe microparticles 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

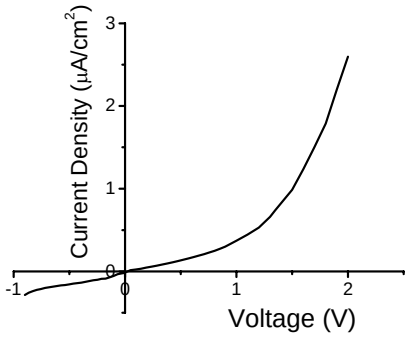

Fig. 1. The dark I-V curve for 50% wt 0,7 μm InSe in PAN device with gold and SnO_2 electrodes.

recombination via traps on the InSe participles that leads to transport of charges limit in the device.

The current-voltage relationship, including the index n, can be written as [5]

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

From the model, we obtain the index n a value of 1.98, and I_0 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 midgap states [5, 6]. In real devices, loss mechanisms are important to consider, and a value of n=1,98 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).

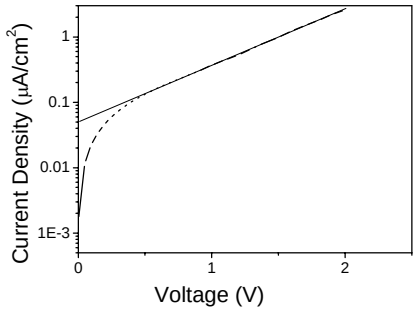

Fig. 2. Logarithmic dependence of current density on voltage of forward bias for 50% wt 0,7 μm InSe in PAN device with gold and SnO_2 electrodes

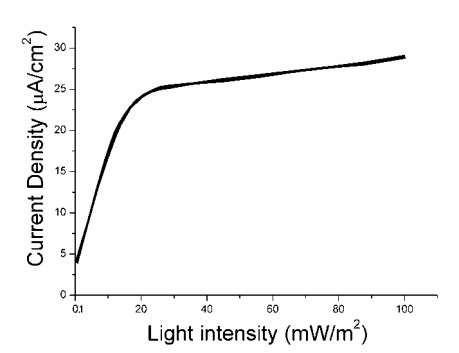

Fig. 3. Current density as a function of white light intensity of 50% wt 0,7 μm InSe in PAN device with gold and SnO_2 electrodes

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-microparticle 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 U_{xx} (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

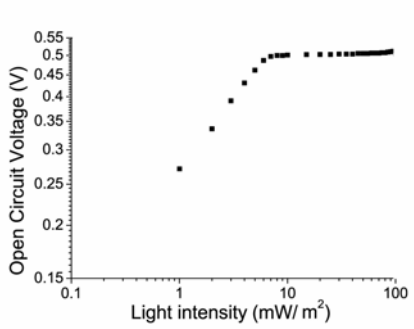

Fig. 4. Open circuit voltage as a function of white light intensity of 50% wt 0,7 μm InSe in PAN device with gold and SnO_2 electrodes

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 InSe, where the quantum yield changing on 50% on a spectral range from 0.35 to 1.6 μm [1]. The influence of PAN

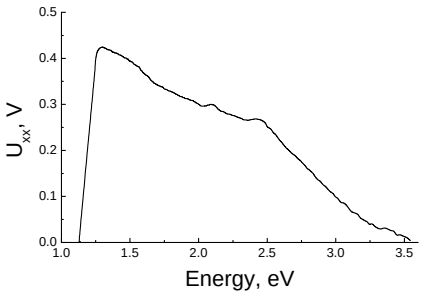

Fig. 5. Open circuit voltage spectral dependence of 50% wt 0,7 μm InSe in PAN device with gold and SnO_2 electrodes

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 PAN photosensitivity is higher then 4eV. 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/PAN/Au [0,18 V [7]).

Conclusion

It has been shown that volt-ampere characteristics of obtained structure may be described by Shockly equation. The index n a value of 1.98 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 InSe. 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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П.Й. Стахіра[1], Я.І. Верцімаха[2], О.І. Аксіментьева[3], Б.Р. Ціж[4], В.В. Черпак[1]

Гібридні сонячні комірки на основі композитів диспергований InSe - поліанілін

[1]Ужгородський національний університет, вул. Підгірна, 46, Ужгород, 88000, Україна, тел.: (03122) 3 23 18; Національний університет "Львівська політехніка", вул. С. Бандери, 12, Львів, 79013, Україна, E-mail:stakhira@polynet.lviv.ua
[2]Інститут фізики НАН України, пр. Науки, 46, Київ, 03022, Україна
[3]Львівський Національний університет ім. Івана Франка, вул. Кирила і Мефодія, 8, Львів, 79005, Україна
[4]Академія Казимира Великого, вул. Чоткевіца, 30, Бидгошч, 85-064, Польща

Розроблено гібридну сонячну комірку на основі композитів диспергований InSe – поліанілін. Показано, що темнові вольт-амперні характеристики можуть бути описані рівнянням Шоклі. Знайдено, що залежність густини фотоструму від інтенсивності світла є нелінійною. Визначенна величина коефіцієнта ідеальності n = 1.98, що свідчить про можливість нелінійної рекомбінації нерівноважних носіїв в композиційній структурі. Спектри фоточутливості композитів добре корелюють зі спектром фоточутливості кристалічного InSe. Запропоновані комірки характеризуються підвищеною напругою холостого ходу порівняно з іншими гібридними елементами на основі спряжених полімерів і неорганічних напівпровідників.