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Energy Procedia 18 (2012) 157 – 164
Energy Procedia

Study of the electrical characteristics of poly(o-toluidine) and application in solar cell

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Abstract

Substituted poly(o-toluidine) (POT) was synthesis by chemical polymerization method using ammonium persulphate as oxidizing agent. Thin fims of poly(o-toluidine) have been prepared by spin coating method and characterized by (FTIR) spectra and Atomic force microscope (AFM). Current-voltage characteristic of AL/POT/AL sample at different temperature (273-383)K is investigated .It is show ohmic behaviour at all applied voltage . The electrical conductivity increases with temperature increase from 1.49×10^{-7} S/cm at 293K to 6×10^{-6} S/cm at temperature 383K. This behaviour indicates that the POT polymer behaves as semiconductor material .The electrical conductivity as a function of reciprocal absolute temperature (1/T) was also investigation .The activation energy was obtained from the curve about (0.313eV). (J-V) Characteristics of POT solar cell devices was studies. The open circuit voltage Voc is about 0.22V at short circuit current about (1.7mA/cm). The fill factor (ff) obtained is about (0.235). The POT/n-Si solar cells obtained in this work have yielded a conversion efficiency is about **0.**88% .

Keywords: Solar cells, poly(o-toluidine), electrical characterisation, organic/inorganic heterojunction.

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1. Introduction

Electrically conductive polymers have been the subject of considerable research efforts due to their useful electronic and optical properties [1-3.] Poly(O-Toluidine) (POT) and polyaniline (PANI) are considered as the most important conducting polymers because of their environmental stability ,ease in preparation, exciting electrochemical, optical, and electrical properties, and possible application in rechargeable, microelectronics devices biosensors, electro chromic displays and chemical sensors[4-10] ,However, the main disadvantages of these polymers are insolubility in common organic solvents and the infusibility of (POT) is similar to (PANI) as for example this family of conducting polymers can be synthesized either chemically or electrochemically as a bulk powder or films[11] .Many studies have been devoted to the synthesis of soluble (PANI) derivatives [12-14] . Recently, PANI doped with β-naphthalene sulfonic acid and camphor sulfonic acid was successfully synthesized by solid-state polymerization method . This article describes a novel polymerization process for the direct synthesis of the conducting emeraldine salt phase of poly (O-Toluidine) without the need of post doping treatment. [15]

In the present work ,we report the synthesis as well as the optical and electrical characterization of (POT) doped with formic acid have been investigated.(POT) salts were examined by (FTIR) spectra and Atomic force microscope (AFM). Current-voltage characteristic of AL/POT/AL samples at different temperature (273-383)K were investigated. (J-V) Characteristics of POT solar cell devices (35 nm) thickness in dark and xenon illumination with intensity of 100mW/cm^2)also stidies.

2.Experimental

2.1The POT preparation

poly(o-toluidine) (POT), doped with hydrochloride acid was synthesis by chemical polymerization method using ammonium persulphate as oxidizing agent . The polymerization of the monomer (O-Toluidine) was initiated by the drop wise addition of the oxidizing agent(ammonium per sulphate) in an acidified solution prepared using doubly distilled monomer under constant stirring at (0-5 °c) .The monomer to oxidizing agent ratio was kept as (1:1). After complete addition of the oxidizing agent the reaction mixture was kept under constant stirring for 24hr′s > Precipitated polymer was filtered and washed with distilled water until the filtrate was colorless. Finally, the polymer was dried in oven at 70 °c for 12 hr´s .

2.Preparation of conducting polymer films.

The thin films of (POT) was synthesized by using spin coating method .the polymer was dissolved in formic acid and deposited on either interdigitated finger electrode, or n- type silicon wafer substrates. Figure (1) shows interdigitated finger electrode, that used to measure the surface conductivity of the samples from the following relationship [16] .

$$\sigma_s = [I/V]\ [L/Wt\ell] \quad ....(1)$$

where, t is thickness of polymer, W is the distance fingers (10mm), ℓ is number of fingers is to be (10), and L is the space between electrodes (100μm).

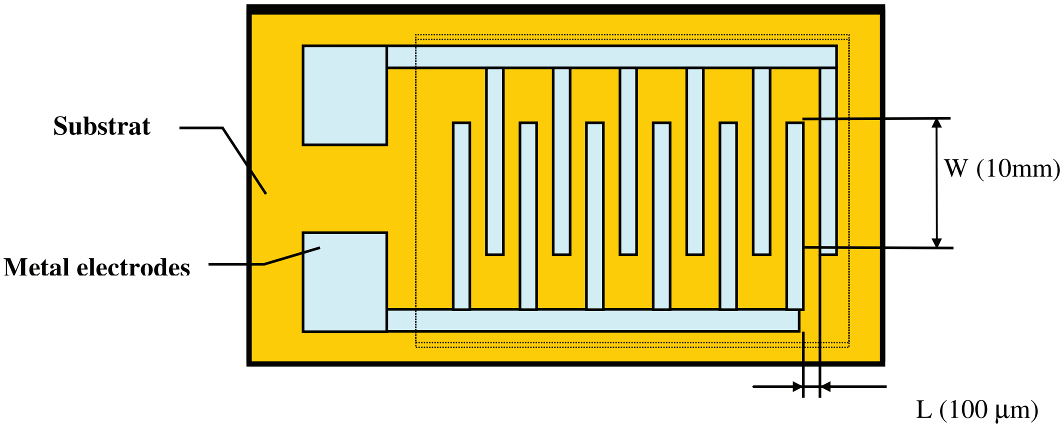

Fig. (1): A schematic diagram of interdigitated finger electrode.

2. Results and Discussion

The polymers were characterised by (FTIR) spectroscopy as a powder, the FTIR spectra was shown in Fig. (2). the characteristic bands for the functional groups are listed in Table 1

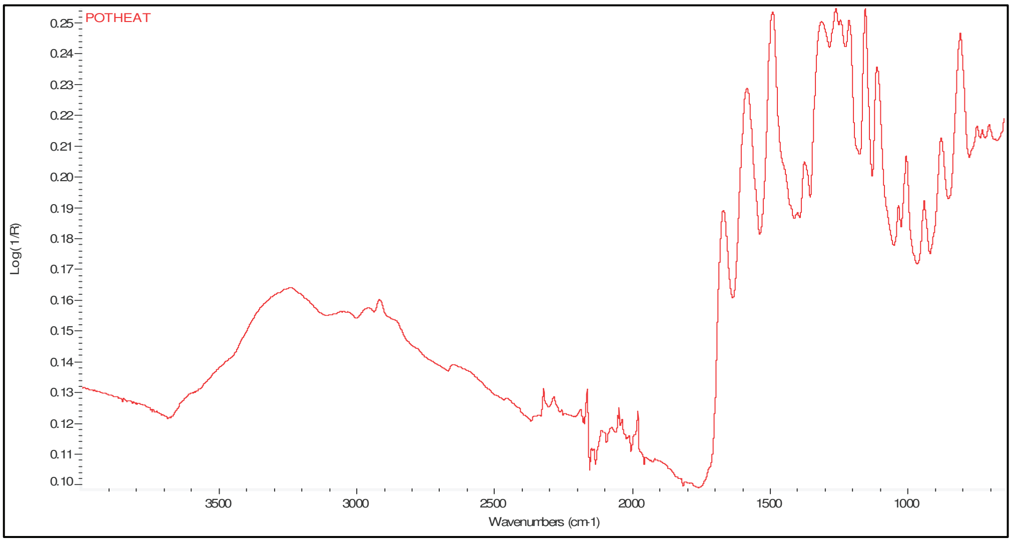

Fig.

Fig.(2): FT-IR spectra of (POT).

Table (1): The location of the most important peaks of (FTIR) spectrum of the (POT).

Functional groups	Vibrations(cm^{-1})	Reference (17,18)
Hydrogen-bonded(N-H)	3300	3229
stretching vibration of the methyl($-ch_3$)	2910	2917
Quinoid	1590	1585-1591
Benzenoid	1480	1487-1492
Symmetric deformation of methyl group	1320,1210	1207-1213
C-N	1320,1210	1318-1324 ,1207-1213
C-H	1150,1110,1105	1150-1110, 1003-1005
C-H	810,880,940	807-812, 877-882, 939-941

Current-voltage characteristic of AL/POT/AL sample at different temperature (273-383K) is shown in figure (4). The thickness of the sample was (35nm). The curve shows ohmic behaviour at all applied voltage [19]. The electric conductivity is calculated by equation (4-1) and tabulated at table (4-1) for each temperature. The electrical conductivity increases with temperature increase from $1.49x10^{-7}$ S/cm at 293K to $6x10^{-6}$ S/cm at temperature 383K. This behaviour indicates that the POT polymer behaves as semiconductor material [20-22] .

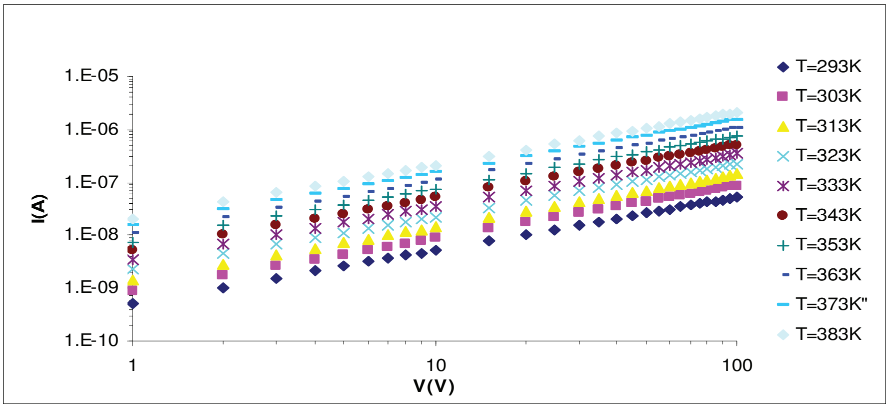

Fig. (3): (current-voltage) characteristic for (POT) at different temperatures (293-383K).

Figure (4) shows the electrical conductivity as a function of reciprocal absolute temperature (1/T). The activation energy was obttained from the curve is to be about (0.313eV).

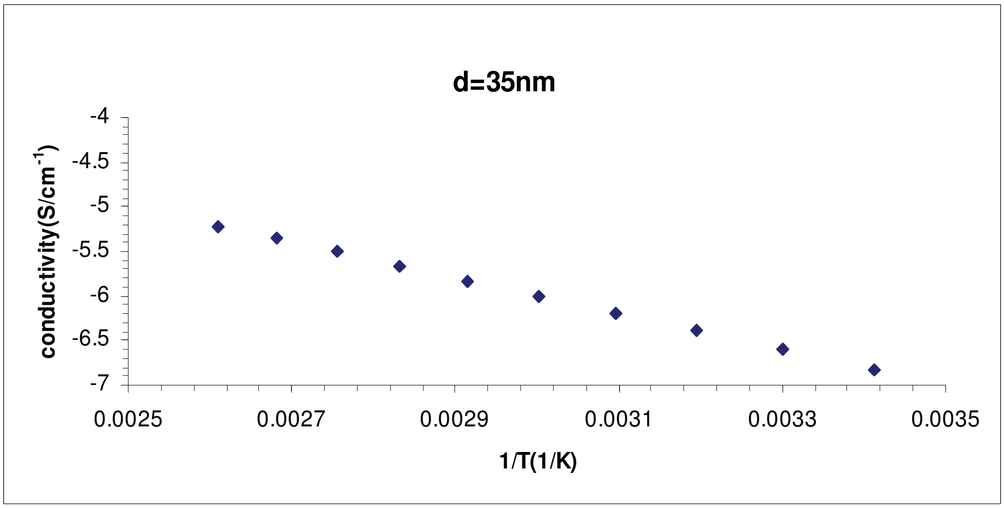

Fig. (4): The conductivity as a function of (1/T) for (POT) film.

Figure (5) shows the J-V characteristics of the fabricated POT/n-Si solar cell structures, measured both in dark and under illumination. The polymer film thickness for this particular result is 35nm as determined by spectroscopic ellipsometry measurements and the illumination intensity is of 100 mW/cm2. The rectifying junction is expected to exist at the interface between the silicon substrate and the polymer film. This can be further justified by the fact that the silicon substrate used in this work is of n-type while the POT films are considered as the hole transporting layer [(6)]. Solar cell parameters, i.e., open-circuit voltage (Voc), short circuit current density (Jsc), maximum current (Imax), maximum voltage (Vmax) and fill factor (FF) have been determined. The solar conversion efficiency η is given by the formula:

$$\eta = (FF\, V_{oc}\, J_{sc} / P_{in}) \text{------------------------}(3)$$

where Pin is the power of the incident light. The open-circuit voltage of these solar cells is Voc =0.22V, short circuit density current Jsc =1.7 mA/cm2, and fill factor FF=0.235. A typical solar conversion efficiency of 0.88% has been obtained, which is of small value as compared with aluminium/polyaniline/GaAs metal-insulator semiconductor solar cell which was found to give efficiencies in the region of 5% [23].The series resistance R_s and shunt resistance R_{sh} can be obtaind from the slope in the first and third quadrant. At first quadrant the curve theses 3980 Ω and at the third quadrant 95541 Ω. The low value of FF is associated with a high series resistance and a high shunt resistance. High values for R_S may originate from electrode contact resistance and high Rsh is related to morphology of the film; a poor absorber morphology limiting the electron hopping transport [24-25].

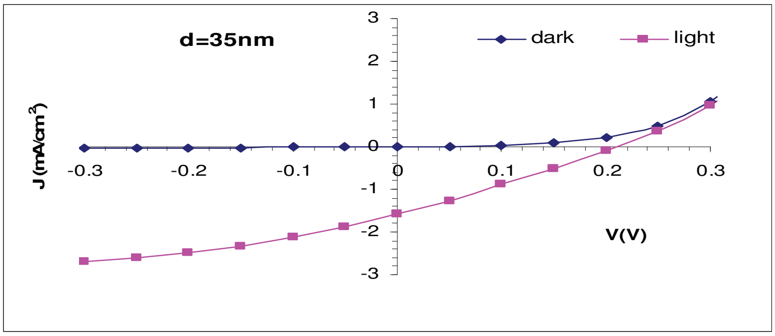

Fig (5): Current density as function of voltage for (POT) solar cell The white light illuminator intensity was (100mW/cm^2).

4.Conclusion

1- poly(o-toluidine) (POT) was synthesis by chemical polymerization method using ammonium persulphate as oxidizing agent.

2-Thin fims of poly(o-toluidine) have been prepared by spin coating method.

3-current -voltage characteristic of AL/POT/AL sample at different temperature (273-383)K show ohmic behaviour at all applied voltage .

4-The electrical conductivity increases with temperature increase from 1.49x10^{-7} S/cm at 293K to 6x10^{-6} S/cm at temperature 383K.

5-The activation energy was obtained from the curve about (0.313eV).

6- (J-V) Characteristics of POT solar cell devices was studies. The open circuit voltage Voc is about 0.22V at short circuit current about (1.7mA/cm). The fill factor (ff) obtained is about (0.235). The POT/n-Si solar cells obtained in this work have yielded a conversion efficiency is about 0.88% .

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