NEW ORGANIC SEMICONDUCTOR MATERIALS APPLIED IN ORGANIC PHOTOVOLTAIC AND OPTICAL DEVICES

Andre F. S. Guedes[1], Vilmar P. Guedes[2], Simone Tartari[2], Mônica L. Souza[2] and Idaulo J. Cunha[3]
[1]Image Processing Laboratory, SENAI College of Technology - 8450, Assis Brasil Avenue - Zip Code 91140000, Porto Alegre, Rio Grande do Sul, Brazil.
[2]Nanotechnology Laboratory, Intellectos - 301, Sao Miguel Avenue - Zip Code 95560000, Torres, Rio Grande do Sul, Brazil.
[3]Department of Production Engineering, UFSC, Campus Trindade, Zip Code 88040-970, Florianopolis, Santa Catarina, Brazil.

ABSTRACT

The development of flexible organic photovoltaic solar cells, using an optically transparent substrate material and organic semiconductor materials, has been widely utilized by the electronic industry when producing new technological products. The flexible organic photovoltaic solar cells are the base Poly (3,4-ethylenedioxythiophene), PEDOT, Poly(3-hexyl thiophene, P3HT, Phenyl-C61-butyric acid methyl ester, PCBM and Polyaniline, PANI, were deposited in Indium Tin Oxide, ITO, and characterized by Electrical Measurements and Scanning Electron Microscopy (SEM). In addition, the thin film obtained by the deposition of PANI, prepared in perchloric acid solution, was identified through PANI-X1. The result obtained by electrical Measurements has demonstrated that the PET/ITO/PEDOT/P3HT:PCBM Blend/PANI-X1 layer presents the characteristic curve of standard solar cell after spin-coating and electrodeposition. The Thin film obtained by electrodeposition of PANI-X1 on P3HT/PCBM Blend was prepared in perchloric acid solution. These flexible organic photovoltaic solar cells presented power conversion efficiency of 12%. The inclusion of the PANI-X1 layer reduced the effects of degradation these organic photovoltaic panels induced for solar irradiation. In Scanning Electron Microscopy (SEM) these studies reveal that the surface of PANI-X1 layers is strongly conditioned by the surface morphology of the dielectric.

Keywords: Polyaniline, PANI, P3HT/PCBM Blend, Flexible Organic Photovoltaic.

INTRODUCTION

A new chapter in the evolution of organic semiconductor materials began, when Hideki Shirakawa, from the University of Tsukuba (Japan), Alan Macdiarmird, from the University of Pennsylvania, and Alan J. Heeger from the University of Santa Barbara (The U.S.), demonstrated the existence of conductive properties for doped Polyacetylene (intrinsically an insulator), which assured them the Nobel Prize in Chemistry, in 2000 [1][2]. Research studies, realized to synthesize and characterize the components of this new class of materials, have been currently passing through a continuous process of technological advance in search of new conductive polymers. In addition, the greatest interest in studying organic semiconductor materials has been present in its potential applications, among which are: batteries, organic solar cells, flexible organic solar cells, organic light emitting diodes and others [3].

Thin films made of organic semiconductor materials have drawn the attention of research groups, due to its enormous potential for its application in various industries as well as the impact their results can give to technological development. Moreover, the characterization and application of new techniques for the deposition of organic semiconductor materials has been the main focus of a large number of studies, being, thus, essential in reducing production costs. Among the several geometries for flexible organic photovoltaic devices investigated to date, including conjugated polymer blends with minimum 5 layers of low molecular weight organic molecules and also the recently reported halogendoped organic single crystals the polymer based devices were mostly attractive due to their easy production technology. These organic photovoltaic devices offer the possibility of lowcost fabrication of large-area solar cells for harvesting energy from sunlight. Aside from possible economic advantages, organic materials also possess low specific weight and are mechanically flexible properties that are desirable for a solar cell [4].

This research aims to develop thin films semiconductor organic material for Flexible Organic Photovoltaic Solar Cell, by using the Electrodeposition technique, and characterizing the layers and devices utilizing electrical Measurements and Scanning Electron Microscopy (SEM) techniques.

EXPERIMENTAL DETAILS

The Flexible Organic Photovoltaic Solar Cell, developed in this research, have been utilizing optically transparent material, covered on surface with Indium Tin Oxide (ITO), as a substrate. The ITO has high conductivity and transmittance in the visible region of the electromagnetic spectrum, which enables their utilization, for instance, in organic solar cells, organic gas sensors, organic transistors and other devices [5].

The poly(ethylene terephthalate) substrate, based on polymeric material,, and utilized for the spin-coating of Poly (3,4-ethylenedioxy thiophene), PEDOT, with thickness of 100 nm, was covered by a layer of ITO, with a thickness of 200 nm. The PEDOT layer was deposited through the spin-coating technique, adding from 100 to 100 µL at 750 rpm for ten seconds in each deposition. On these layers, an conjugated polymer, corresponding to the active layer, has been deposited. This layer deposited through the spin-coating technique of P3HT/PCBM Blend prepared with chlorobenzene using 150 to 150 µL at 500 rpm for five seconds in each deposition. The PANI-X1 layer was deposited through the Electrodeposition system in solution prepared with perchloric acid ($HClO_4$), and applying voltage of 10,0 Volts for 5 minutes, resulted in an active layer of PANI-X1, with thickness between 180 nm and 220 nm. The metal contact, utilized on the last layer of this device, is made of aluminum, with thickness of 100 nm, and it was deposited through the sputtering system.

The developed Flexible Organic Photovoltaic Solar Cell device has presented a configuration layered of PET/ITO/PEDOT/ P3HT:PCBM Blend/PANI-X1/Al, as represented schematically in figure 1.

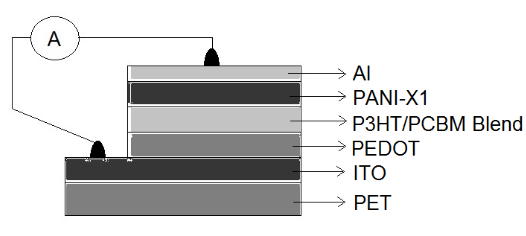

Figure 1. Configuration of Flexible Organic Photovoltaic Solar Cell.

DISCUSSION

The electrical characterization of Flexible Organic Photovoltaic Solar Cell was made at room temperature using an Electrometer Keithley 6517A semiconductor parameter analyzer. All measurements were made without vacuum and no precautions were taken to prevent the degradation of multilayer polymeric films [6][7].

Fig. 2 shows the current density/voltage relation under the illumination with 100 mW/cm^2. The devices with 40x40 cm using spin-coating active layers have a short-circuit current density of 7.6 mA/cm^2, open-circuit voltage of 0.59 V, and power conversion efficiency (PCE) of 12%.

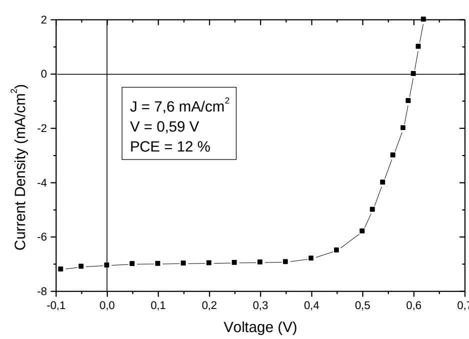

Figure 2. Current density (J) in function of voltage (V).

The microscopic analysis performed in Flexible Organic Photovoltaic Solar Cell by Scanning Electron Microscopy, has allowed us to observe the induction on the surface of the samples before and after the application of illumination with 100 mW/cm^2. Figure 3 has shown the micrograph of Flexible Organic Photovoltaic Solar Cell before applying illumination. It may be observed that the surface of the sample has some homogeneous aspect, plane and without changes.

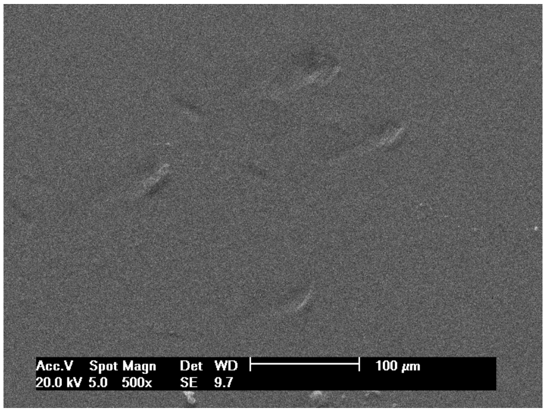

Figure 3. SEM of Flexible Organic Photovoltaic Solar Cell before applying illumination.

Figure 5 has shown the micrograph of Flexible Organic Photovoltaic Solar Cell after application of illumination with 100 mW/cm^2 during 2600 hours. In this micrograph, it may be observed the surface of the sample in some irregular aspect, with cracks. Furthermore, an increase of time, when utilizing the Flexible Organic Photovoltaic Solar Cell, and an increase in the application of illumination, may be observed as well as the existence of an increase in the formation of other cracks. Therefore, these cracks can contribute to reducing the lifetime of the Flexible Organic Photovoltaic Solar Cell, since the accumulation of organic semiconductor material may cause short circuit in the device.

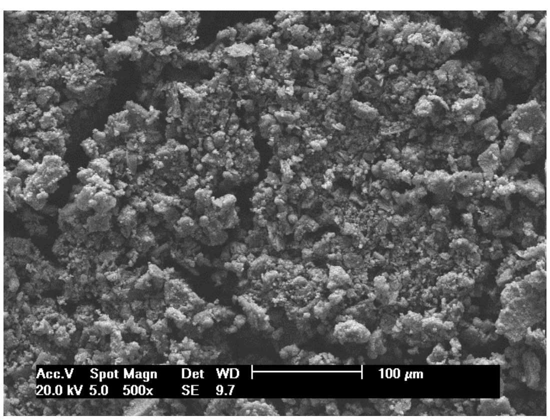

Figure 5. SEM of Flexible Organic Photovoltaic Solar Cell after applying illumination.

CONCLUSIONS

The results presented in this research are that PEDOT/P3HT/PCBM/PANI-X1 can be utilized as an active layer of Flexible Organic Photovoltaic Solar Cell. These organic semiconductor materials can be deposited, spin-coating and electrodeposition, respectively. although some recent record efficiencies, research on organic solar cells is still in its infancy when stability and efficiency have to be compared with the performances of silicon cells. But a nominal top value 12% in power conversion efficiency is the research target for the next few years. The phenomenon of cracks, observed in Flexible Organic Photovoltaic Solar Cell, demonstrated similarities with that observed in surfaces of interconnections of microelectronic devices. In Flexible Organic Photovoltaic Solar Cell devices this phenomenon of cracks that rises with the application of illumination can influence the lifetime reduction of Flexible Organic Photovoltaic Solar Cell.

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