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A Review on the Organic Solar Cells

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ABSTRACT

Background: Organic solar cells are the latest generation of photovoltaic cells. They contain one or several photoactive materials sandwiched between two electrodes. They can convert sunlight to electrical energy effectively. Objective: In this work, the main aim is to study the power conversion efficiency of different organic solar cells prepared under various conditions. Results: The performance of solar cell was evaluated by using current density voltage characteristic under the darkness and light exposure. Experimental findings indicate that the photoactive materials will affect the power conversion efficiency of solar cells. Therefore, comparison of fabricated organic solar cells under different experimental conditions will be carried out. Conclusion: In this work, there are several transparent anode materials were used in order to fabricate organic solar cell in the presence of active layer. The obtained research findings indicated that the experimental conditions can control the power conversion efficacy of samples.

INTRODUCTION

Organic solar cell can convert sunlight to electrical energy. Generally, it contains one or several photoactive materials sandwiched between two electrodes. In this cell, light is absorbed in the photoactive layers consisted of donor and acceptor materials, which play the role transports holes and electrons, respectively. The photoactive materials harvest photons to produce excitons. Then, the excitons move to the donor/acceptor interface because of the concentration gradient. Lastly, the combination of diffusion and migration of these charge carriers to the collection electrodes, produces a current in the external circuit. In the past few years, many research groups have an increasing interest in the development and study of inorganic solar cell. Generally, this type of solar cell contains chalcogenide metal thin films (Table 1). Currently, researchers emphasize on the organic solar cells. It is due to organic solar cells have many advantages including cheaper than silicon based materials (Park *et al*., 2009), light weight, simple process, flexibility (Lee *et al*., 2014), it is used in large area and roll-to-roll mass production (Kim *et al*., 2015).

The main objective of this work is to investigate the influence of using various types of thin films as the transparent anode in the presence of active layer on the power conversion efficiency. The current density voltage behaviors were studied and simulated AM 1.5 G sunlight in air.

Literature Survey:

Wang *et al* (2014) have constructed organic solar cells contain active layer such as poly-(3-hexylthiophene) and 6,6-phenyl-C61-nutyric acid methyl ester films. In their work, thermally evaporated silver thin films were employed as the transparent anode. The influence of thickness of anode on the power conversion efficiency was studied. The obtained results reflect that the highest power conversion efficiency of 2.57% is obtained for the

silver thin films with the 11 nm thick layer. However, the reduced of power conversion efficacy with the 13 nm (1.88 %) and 15 nm (1.7 %) thick layer due to the decreased transparency of the electrode.

Yu *et al* (2015) have investigated the nanostructure of Al-doped zinc oxide (AZO) on the efficiency of organic solar cells. They claim that the sol gel derived zinc oxide (ZnO) thin films have attracted much attention because of their good transparency in the visible spectral range. The active layer contains poly-3-hexylthiophene (P3HT) and 6-6-phenyl-C61-butyric acid methyl ester (PCBM). The atomic force microscopy analysis indicated that the average grain size increased when the aluminum content was increased from 0.5 % to 1 %. However, grain size reduced as the aluminum content was further increased to 2 %. In the power conversion efficiency results, the solar cells constructed by using a ZnO/AZO (0.5:1 %) exhibited the most significantly enhanced performance with a value of 3.43 % comparable to that of zinc oxide thin films without aluminium doping layer (2.11 %). This is due to some reasons such as efficient light transmission, charge carrier transport, denser and more uniform surface morphologies.

In this work, the studies of electrodeposited bilayer ZnO/Cu_2O solar cells with and without a poly(9,9,dioctyl-fluorene-co-bis-N,N'-(4-butylphenyl)-bis-N,N'-phenyl-1,4-pheny-lenediamine (PFB) layer were reported by Talia *et al* (2012). It is clear that the solar cells without a PFB layer is less efficient (0.24 %) compared to those with a PFB layer (0.36 %). On the other hand, the influence of Cu_2O film thickness in the range of 0.5 to 0.62 µm on the properties of solar cell was investigated. They conclude that the best power conversion efficiency (0.46 %) could be obtained in the thicker sample (0.85 µm) than those of thinner sample such as 0.5 µm (0.19 %) and 0.62 µm (0.29 %). They explain that the magnitude of the electric field at the interface between zinc oxide and 0.5 µm Cu_2O films is smaller, which leads to the low carrier density. In other words, they point out that the built in potential is constrained by the Cu_2O thickness.

Nickel oxide (NiO) thin films were produced using RF magnetron sputtering by Park *et al* (2010). They choose NiO films because of these materials display p-type semiconducting characteristic with a wide band gap energy in the 3.5-4 eV range. These conditions lead to sufficient optical transparency in the visible spectral region to allow solar photon access to the active layer. They designed the organic solar cell using nickel oxide thin films under different experimental conditions. For example, they observe that poor performance (1.93 %) of power conversion efficacy for the solar cell fabricated with 5 nm thick nickel oxide layer deposited in pure argon ambient. However, the obtained experiment findings show that solar cell produced with a nickel oxide layer grown in more than 10% oxygen systematically to increase the device efficiency (2.8 %) and more stability.

Table 1: Chalcogenide metal thin films.

Thin films	Researcher(s)
Copper indium sulphide	Aggour *et al*., 2002
Zinc sulphide	Anuar *et al*., 2011a
Zinc selenide	Anuar *et al*., 2011b
Copper sulphide	Anuar *et al*., 2011c
Tin sulphide	Anuar *et al*., 2011d
Nickel sulphide	Anuar *et al*., 2011e
Lead selenide	Anuar *et al*., 2011f
Manganese sulphide	Anuar *et al*., 2010a
Iron sulphide	Anuar *et al*., 2010b
Copper tin sulphide	Anuar *et al*., 2009
Indium sulphide	Asenjo *et al*., 2010
Zinc indium selenide	Babu *et al*., 2011
Copper indium selenide	Bari *et al*., 2007
Cadmium sulphide	Caballero-Briones *et al*., 2015
Antimony copper sulphide	Ekuma *et al*., 2010
Antimony sulphide	Ezema *et al*., 2007
Nickel lead sulphide	Ho, 2014
Lead iron sulphide	Joshi *et al*., 2004
Cadmium bismuth sulphide	Mishra *et al*., 2014
Tin selenide	Mustafa *et al*., 2011
Indium selenide	Rabchynski *et al*., 2004
Lead sulphide	Raniero *et al*., 2010
Cadmium selenide	Rashwan *et al*., 2007
Zinc cadmium sulphide	Song *et al*., 2009
Tin Sulphide selenide	Subramanian *et al*., 2003
Bismuth sulphide	Ubale *et al*., 2010

On the other case, Jung *et al* (2012) explore the stability enhancement of NiO based organic solar cell in the presence of active layer such as PCBM and P3HT. In order to optimize the baking conditions for nickel oxide films, they design the experiment under various baking times of 3, 5 and 7 hours. They compare the obtained power conversion efficiency results and found that the nickel oxide films prepared using baking time of 5 hours had the best performance (1.97 %) than that of other samples such as 3 hours (1.13 %) and 7 hours (1.77 %).

There are some disadvantages can be seen in this type of solar cell. When the mobility is too low or the layer too thick, the transit time of photogenerated charges in the device becomes longer than the lifetime, resulting in charge recombination. On the other hand, researchers have observed that the one of the main causes of the degradation of organic cells is the interface between the indium tin oxide (ITO) anode and the poly-(3,4-ethylenedioxythiophene): poly (styrenesulfonate) (PEDOT:PSS) hole transport layer, leads to be unstable. This is due to the fact that the strongly acidic nature of PSS, an aqueous solution of PEDOT:PSS is expected to etch indium tin oxide, which is highly sensitive to acidic substances.

There are some future developments in organic solar cells as mentionoed here. Firstly, the improvement in organic solar cell could be carried out such as increasing the photocurrent, so that enhance the absorption of more photons. This may be achieved by increasing the layer thickness and by shifting the absorption spectrum of the active layer to longer wavelengths. Secondly, the active layer which is employed in experiment should be photo chemically stable. In other words, organic solar cell should be stable during the operation and must be protected from air to prevent degradation of the active layer. Lastly, the nanoscale uniformity of donor-acceptor blend in the active layer should be preserved.

Conclusion:

In this work, there are several transparent anode materials were used in order to fabricate organic solar cell in the presence of active layer. Examples of transparent anode materials included nickel oxide, copper oxide, silver thin films, zinc oxide and aluminium-doped zinc oxide as indicated in literature review. The performance of solar cell was evaluated by using current density voltage characteristic under the darkness and light exposure. The obtained research findings indicated that the experimental conditions can control the power conversion efficacy of samples.

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