Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 119 (2017) 891–897

Energy Procedia

www.elsevier.com/locate/procedia

International Conference on Technologies and Materials for Renewable Energy, Environment and Sustainability, TMREES17, 21-24 April 2017, Beirut Lebanon

Enhancement of Transparent Conductive Electrodes for Third Generation Photovoltaics

Abdul Hai Alami[a], Jinan El Hajjar,[a]*, Lama El Qadri[a], Alya Alhammadi[a]

[a]*Sustainable and Renewable Energy Engineering, University of Sharjah, Sharjah, P.O.Box 27272, United Arab Emirates*

Abstract

This work investigates the feasibility of fabricating a flexible transparent photoelectrode for dye-sensitized solar cell applications. The traditional electrodes are brittle but highly conductive and transmissive ITO, and thus the advantages of introducing flexibility are explored in this research project. PET (Polyethylene Terephthalate) is a material that can withstand bending without significant change in its mechanical or optical properties. Coupling this material with AgNWs (Silver nanowires) enhances the conductivity without sacrificing optical transmission. AgNWs are deposited on the PET substrate by a number of methods (spincoating, rod coating, and drop casting) and the effects of using each method are compared to determine the optimum way of deposition. The resulting photoelectrodes are then characterized by their sheet resistance and transmissivity.

Keywords: AgNWs; ITO free; PET; PEDOT:PSS; DSSCs; Transparent electrode

1. Introduction

Until very recently, the field of photovoltaics has been saturated with silicon solid state-junction photovoltaics, or as they are called, first-generation solar cells. However, because of the imminent depletion of fossil fuels, the need to find something that is more efficient as well as less costly birthed the third-generation solar cells. [14] Made of

* Corresponding author. Tel.: +971507072721.
E-mail address: U00042335@sharjah.ac.ae

1876-6102 © 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the Euro-Mediterranean Institute for Sustainable Development (EUMISD).
10.1016/j.egypro.2017.07.142

organic materials or flexible polymer films, they are promising what the industry needs; higher efficiency along with very low production cost. [8]

One of the most common types of third-generation solar cells are dye-sensitized solar cells (DSSCs). However, despite the great characteristics they possess, they have their own problems. With low production cost as one of the main notions behind the production of DSSCs, the need to replace the glass, that is typically used, with something even cheaper arised. It was found that glass could be replaced with Poly(ethylene Terephthalate) (PET) as not only is it cheaper, but it is also highly flexible and therefore more durable and longwearing. [10] Another thing that needed to be addressed was the Indium Tin Oxide (ITO) layer. ITO is the material that makes the electrodes conductive. While it has low sheet resistance (R_s), high optical transparency, and high conductivity, indium is rare and expensive and once the electrodes were made flexible, a new complication appeared. [15] ITO is brittle and would crack if put on a flexible film like PET. [10] Once cracked, its R_s becomes extremely high, rendering it useless. Studies show that graphene, carbon nanotubes, and metal nanowires can be used instead. [6,20]

Out of all metal nanowires, silver is the common material of choice because it has the highest conductivity of all metals as well as high flexibility and transparency. However, as this paper will discuss, when the AgNWs are deposited, they do not initially have high conductivity. Without any further treatments, they form a poor network of uncoalesced wires with large non-conductive gaps as well as a low adhesion to the substrate. [3] Various forms of treatments are needed to overcome this problem such as mechanical pressure, thermal treatment, acid treatment, and vacuum filtration. [3] Poly(3,4-Ethylenedioxythiophene) Polystyrene Sulfonate (PEDOT:PSS), is a liquid polymer solution that has also been used in this research to fill the gaps and to create conductive bridges between the silver nanowires. [3,15]

In this work, thin films of PET were first coated with PEDOT:PSS and then with a solution of silver nanowires mixed with IPA before being annealed at 160°C for 15 minutes. Annealing helped the AgNWs to form a better conductive network. The samples were then treated with H_2SO_4 in order to enhance adhesion.

Nomenclature

PET	Poly(ethylene Terephthalate)
AgNWs	Silver Nanowires
PEDOT:PSS	Poly(3,4-Ethylenedioxythiophene) Polystyrene Sulfonate
ITO	Indium Tin Oxide
IPA	Isopropanol
R_S	Sheet Resistance
H_2SO_4	Sulphuric Acid

2. Materials and Experimental Method

2.1 Materials Used

The following materials were bought from Sigma-Aldrich; a 25ml bottle of 5mg/ml AgNWs suspended in IPA, a 25ml bottle of highly conductive PEDOT:PSS, and two rolls of 0.125 mm PET. Meyer rod was bought from R.D. Specialties, ¼ inches x 16 inches, wire size #3. Bottle of 0.5M H_2SO_4 was already available.

2.2 Method

Before beginning to test different deposition methods, a filtered PEDOT:PSS solution was made. Since PET is hydrophobic and PEDOT:PSS is dissolved in water [12], extracting that water is essential to be able to apply a uniform layer of PEDOT:PSS on the PET. To do that, PEDOT:PSS was mixed with IPA in a ratio of 1:5 in a beaker.