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Study on Photovoltaic Performance of Cu_2O_Chitosan Composite Thin Film Solar Cell

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***Abstract*— Cuprous oxide thin film (Cu_2O) was prepared on conducting glass support (indium tin oxide ITO coated glass) by spin coating method and was subsequently annealed at 300°C. The structure and surface morphology of the Cu_2O thin film was determined by X-ray diffraction (XRD) and scanning electron microscopy (SEM). The Cu_2O_Chitosan thin film was prepared by Spin Coating method. Cu_2O_Chitosan thin film was studied by scanning electron microscopy (SEM). The open-circuit voltage (V_{oc}), short-circuit current (I_{sc}) and solar power conversion efficiency were obtained from the Cu_2O_Chitosan thin film solar cell. Photovoltaic study revealed that Cu_2O_Chitosan thin film exhibited higher efficiency as compared to the Cu_2O thin film.**

Keywords*— Cuprous Oxide; Open-Circuit Voltage; Short_ Circuit Current; Composite;

I. INTRODUCTION

Copper (I) oxide or cuprous oxide is the inorganic compound with the formula Cu_2O. Cuprous oxide is a promising material with potential applications in solar energy conversion [1]. Cuprous oxide is a p-type semiconductor having a direct band gap of 2 eV [2,3,4] which make it very suitable for solar applications. It forms a cubic structure with lattice parameter of 4.27Å [5]. Organic materials are inexpensive, easily processable and functionality can be tailored by molecular design and chemical synthesis. The source of chitin in the nature is very wide as well as cellulose source. Chitin could be found in marine animals such as fish and crustacean shell. Chitin is a white, hard, inelastic, nitrogenous polysaccharide found in the exoskeleton as well as in the internal structure of invertebrates. The waste of these natural polymers is a major source of surface pollution in coastal areas. Chitin and chitosan were waste products of the crabbing and shrimp canning industry. Chitosan is a very simple substance. It is derived from chitin, a polysaccharide that is found in the cell wall of fungi and also in the exoskeleton of crustaceans, They are then being processed by removing the shell from shellfish such as shrimp, lobster, crabs etc. Chitosan is a semi crystalline polysaccharide that unlike many biodegradable polymers, is insoluble in water at neutral pH. Chitosan is a fiber-like substance and a homopolymer of ß-(1→4)-linked N-acetyl-D-glucosamine. The actual difference between chitin and chitosan is the acetyl content of the polymer. Chitosan is a non-toxic, biodegradable polymer of high molecular weight and is very much similar to cellulose, a plant fiber. The only difference between chitosan and cellulose is the amine ($-NH_2$) group in the position C-2 of chitosan instead of the hydroxyl (-OH) group found in cellulose.

II. EXPERIMENTAL DETAILS

A. *Preparation of the Cu_2O Thin Films*

Firstly, 2 ml of 2-methoxyethanol was added to 1 g of cuprous oxide. Then the solution was stirred by heat magnetic stirrer with 720 rpm at 100ºC to get homogeneous solution. After that, indium tin oxide glass substrates were cleaned. The solution was deposited onto ITO coated glass-substrate by spin coating method with 1000 rpm for 30 s. After the spin coating process, the sample was annealed at 300ºC for 1 h. The crystal structure of the film was studied by X -rays diffractometer (XRD) and the crystallite sizes were calculated. The surface morphology of the film was examined by scanning electron microscopy.

B. *Preparation of the Cu_2O_Chitosan Composite Thin Film*

1 g of chitosan was dissolved in 100 ml of 1% acetic acid solution under magnetic stirring. When the solution was homogeneous, 1 g of cuprous oxide (Cu_2O) was added to the solution. Then, the solution was stirred by magnetic stirrer with 700 rpm to obtain the Cu_2O_Chitosan homogeneous solution. Using spin coating method, the sample was deposited onto ITO coated glass. Next, the thin layer was annealed at 300°C for 1 hour. Finally, the Cu_2O_Chitosan composite thin film was obtained. Then, XRD, SEM and I-V analysis were performed.

II. RESULT AND DISCUSSION

A. *XRD Analysis*

Fig 1 showed the XRD spectrum of Cuprous Oxide thin film at annealing temperature 300 ºC. According to the XRD profile, including the dominant peak (111) and seven peaks of Cu_2O of [(110), (111), (200), (211), (220), (221) and (310)] were clearly observed. The average crystallites size of Cuprous Oxide thin film was found to be 40.89 nm. It was also observed that the lattice parameter of the Cu_2O thin film was well matched to the literature value 4.27Å of Cu_2O [5].

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The average crystallite size of the Cu_2O thin film was 40.89 nm. The XRD pattern of the Cu_2O_Chitosan composite thin film at annealing temperature 300°C was shown in Fig 2.The characteristic crystalline peak at around 2θ = 20 corresponds to nanosized chitosan and similar to[6]. There are six other peaks [(110), (111), (200), (211), (220), and (310)] corresponding to the standard XRD pattern. All peaks of cuprous oxide matched well with the standard cubic cuprite structure. The crystallite size of dominant peak (111) plane of cuprous oxide was 36.44 nm. And The average crystallite size was found to be 46.00 nm.

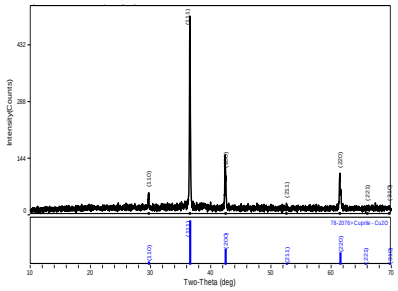

Fig 1 XRD Profile of the Cu_2O thin film at 300ºC

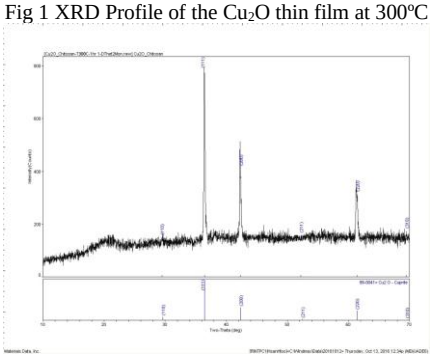

Fig 2 XRD pattern of the Cu_2O_Chitosan composite thin film

B. *Investigation of the Cu_2O Thin Film by SEM*

Fig 3 showed the SEM image of the Cu_2O thin film and the average grain size was examined to be 1.6 µm.

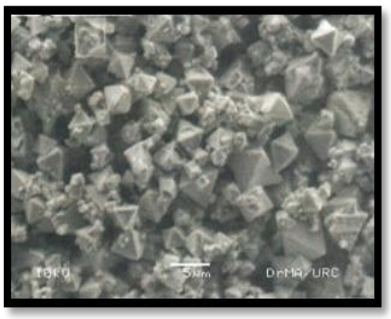

Fig 3 SEM image of the Cu_2O thin film at 300ºC

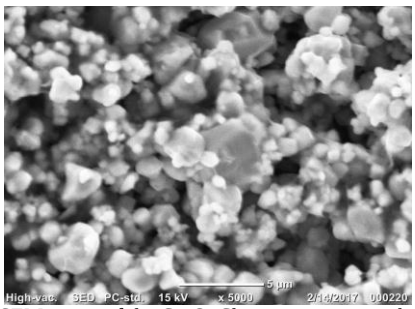

Fig 4 SEM image of the Cu_2O_Chitosan composite thin film

Fig 4 showed the SEM image of the Cu_2O_Chitosan composite thin film. The morphology of the Cu_2O_Chitosan composite thin film was observed using scanning electron microscope (SEM). From SEM image, the sample surface was not seemed to be uniform but fairly smooth, and some porous structures were found. It was observed to be more porous than the Cu_2O thin film.

C. *Comparison of the I_V Characteristics of the Cu_2O Thin Film and Cu_2O_Chitosan Thin Film Solar Cells*

The solar cells were illuminated through the side of the ITO coated glass substrates, and the illuminated areas were measured to be 1 cm^2 each. The solar cells with ITO coated glasses structure provided power conversion efficiency (η) and fill factor (F_f). The photocurrents were observed under illumination and the ITO coated glass structures showed characteristic curves of short-circuit current and open-circuit voltage. Fig 5 showed the I_V characteristic of the Cu_2O/ITO thin film. Fig 6 showed the I-V characteristics of the Cu_2O_Chitosan composite thin film. Comparative facts of photovoltaic parameters of Cu_2O and Cu_2O_Chitosan composite thin film solar cells were also listed in Table 1 and 2.

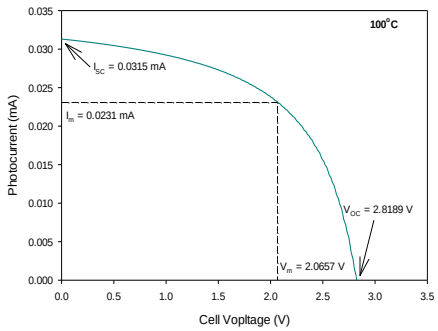

Fig 5 the I-V curve of the Cu_2O thin film solar cell

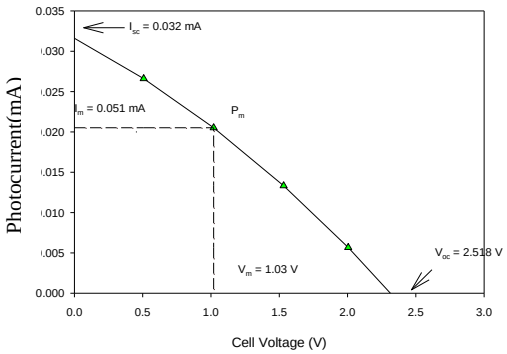

Fig 6 I-V curve of the Cu_2O_Chitosan composite thin film solar cel

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Table 1 The maximum current (I_m), maximum voltage (V_m), short circuit current (I_{SC}) and open circuit voltage (V_{OC}) of Cu_2O thin film and Cu_2O_Chitosan composite thin film solar cells

Thin Film	I_m (mA)	V_m (V)	I_{sc} (mA)	V_{oc} (V)
Cu_2O	0.023	2.07	0.032	2.82
Cu_2O_Chitosan	0.051	1.03	0.032	2.52

Table 2 Comparison of the conversion efficiency (η) and fill factor (F_f) of both thin film solar cells

Thin Film	η(%)	F_f
Cu_2O	2.07	0.54
Cu_2O_Chitosan	2.43	0.65

D. Conclution

From the I-V analysis, the power conversion efficiency of the Cu_2O thin film is 2.07% and that of Cu_2O_Chitosan composite thin film is 2.43%. So the Cu_2O-chitosan thin film solar cell has the larger efficiency value than the Cu_2O thin film solar cell. And the fill factor value the Cu_2O_Chitosan thin film solar cell provided is also larger than the Cu_2O thin film solar cell. Thus, photovoltaic study revealed that the Cu_2O_Chitosan composite thin film exhibited higher efficiency than the Cu_2O thin film.

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