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The effect of different molarity on TiO_2 solution prepared by sol-gel method

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ABSTRACT – TiO_2 is a well-known material especially for organic solar cell. In this research the objective of this experiment that is to get high current that will improve the electron migration. The nanostructured TiO_2 was deposited onto glass substrate using the well-known sol gel spin coating method. In this experiment, eight TiO_2 solutions with different molarity were tested for their performance as the electron conductor layer in organic solar cell. The surface topology and morphology of nanostructured TiO_2 was observed using the Atomic Force Microscopy (AFM) and Field Emission Scanning Electron Microscope (FESEM). The electrical properties were investigated by using two probe current-voltage (I-V) measurements to study the electrical resistivity behavior, hence the conductivity of the film. Based on the result, lower the molarity of TiO_2, the surface becomes more uniform and the I-V becomes much better. As predicted, the best thin film characteristic is the 0.01M to be applied in organic solar cell in the future work.

1. INTRODUCTION

TiO_2 is widely used as a pigment in paintings (white), anti-reflection coatings for car windows, anti-microbial coatings, writings on food, cosmetics and nowadays this TiO_2 sol-gel were to use in organic solar cell as the n-type material.

There are many ways in depositing TiO_2 thin film such as thermal oxidation [1], chemical vapor deposition (CVD) [2], plasma oxidation [3], pulse laser deposition [4] and sol gel process [5]. Sol gel method was chosen since it is simple and cheap since it processed from solutions and the process was easy to conduct.

In this investigation, different low molarity solution based on TiO_2 nano powder as a precursor was deposited on the microscope glass as the substrate by using a spin coating technique [6]. Since spin coating technique has a simple operation, cheap since it uses solution and easy to run process. Still, there are a few disadvantages of spin coating which might be quite a problem, especially on wastage for a big manufacturing company since for a typical spin coating processes utilize only 2-5% of the material dispensed onto the substrate [7], while the remaining 95% - 98% is flung off into the coating bowl and disposed. Not only the prices of the raw material increased substantially, but disposal costs are increasing as well [8].

Then the development of the film characteristics was measured for structural morphology by using AFM, FESEM and surface profiler (SP) for thickness and the electrical properties were measured by using current-voltage (I-V) measurement to be recorded in table and figures to measure the conductivity of each film to relate with the electron migration on each film. Hence, the focus of this study is to see the effect of electron migration in different TiO_2 molarity.

2. METHODOLOGY

2.1 *Materials*

These are the materials that have been used during the preparation of TiO_2 solution:

i) Titanium Dioxide (99.7%) nano-powder.
ii) Absolute ethanol, as in Ethyl Alcohol.
iii) TTIP.
iv) PEG.

2.2 *Preparation of TiO_2 Solution*

Sol-gel method was used in order to prepare TiO_2 solution. All of the material above was mixed in a small beaker with specific order and stirred on a hotplate with magnetic stirrer in room temperature.

i) 0.8g TiO_2 nanopowder weight in a small beaker.
ii) 8ml of ethyl alcohol poured into the beaker.
iii) Stir for 30minute to let it mixed well.
iv) Add 200µl TTIP (Titanium (IV) isopropoxide).
v) Stir for 2 hour.
vi) Add PEG 0.24g and sonicate them to make sure that PEG blend well with the solution.

After sonicate, the solution were aged for 24 hours.

3. RESULTS AND DISCUSSION

In Table 1, the I-V characteristic was measured at 10V to see the highest current to be the best film for the layer in the organic solar cell. Then the surface roughness and resistivity was measured and calculated by AFM and based on I-V characteristic available. In terms of roughness 0.01M film is likely to have smooth film by having 69.087nm roughness. This means that the film has a uniform surface. As seen at the resistivity tab, the value is increasing with the molarity except for 0.06M and the same goes to the conductivity and this will be clarified next.

Table 1 Structural Properties by SP, AFM and IV.

Molarity (M)	**Current at 10V (A)**	**Roughness (nm)**	**Resistivity at 10V (ρ)**
0.14	6.34E-09	116547	3.12E+11
0.12	8.47E-09	154921	2.34E+11
0.10	9.28E-09	149952	2.13E+11
0.08	1.62E-08	231000	1.22E+11
0.06	3.41E-07	368	5.80E+09
0.04	8.86E-08	233	2.23E+10
0.02	2.17E-08	196	9.14E+10
0.01	3.50E-07	69.087	5.65E+09

In Fig. 1, the distribution of the grain size of each particle is not uniform in one size and when the molarities gets to 0.01 molarity, it tends to agglomerate.

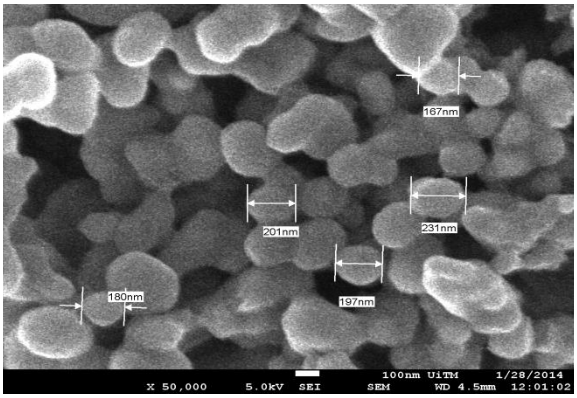

Figure 1 FESEM image of 0.01M.

By analyzing the grain size of each molarity, it can be seen that the lower the molarity the smaller the grain size. This may be due to the mixing technique by using the magnetic stirrer that the solution was not stirred continuously that makes the nanoparticles easily agglomerates [9]. This also may be due to the room temperature where by the mixing processes were conducted which is not fixed. Higher temperature by which the process were run will give the smaller diameter of TiO_2 grain sizes which the TiO_2 nanopowder that were used by Sigma Aldrich is 21nm in size. As investigated before, the higher the temperature, the higher the energy and this influence the reaction rate and the agglomeration rate in the solution [9].

In Fig. 2, the roughness of the thin film is decreasing with the increasing of the molarity. When the film is quite uniform with not much of porosity, the roughness will be low. The opposite happen to the low molarity because of the agglomeration, the porosity increase.

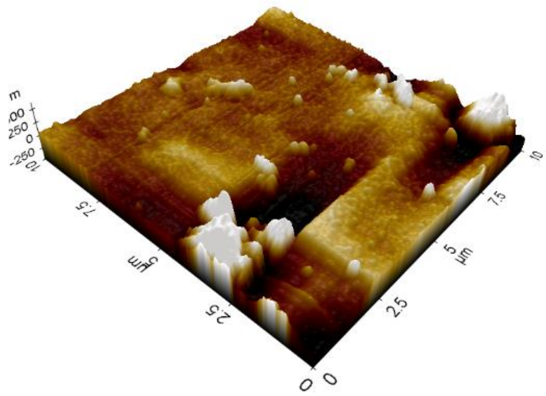

Figure 2 AFM image of 0.01M.

4. CONCLUSION

Sol-gel spin coating technique was chosen as the deposition process because of its simple and cheaper method in order to produce TiO_2 nanostructured thin film. The roughness of the thin films produced were decreasing by the increasing of molarity and this was supported by the AFM figure that 0.06 molarity have a quite uniform film compared to the other two. Then when compare the AFM figure and the FESEM figure, 0.06 molarity thin film have less porousity which then effects the resistivity and the conductivity of the thin film. The conductivity of 0.06 molarity is the highest that is 1.44E-05 supported by the IV characteristic graph that shows that the current at 10V is 3.409E-7 A. this conclude that 0.06 molarity is the best thin film.

5. REFERENCES

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