Characteristics and Synthesis of ZnO/TiO_2 Semiconductor Using Sol- Gel, Spin Coating as Solar Cell Material

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Abstract. The purpose of this research was to characterize and synthesize ZnO-TiO2 using activated carbon, an electrolyte, a Micro Slides layer, and HCl as a precursor. Utilizing Sol-Gel or Spin Coating and grinding it with a stirrer, the characteristics and synthesis procedure was carried out. First, Scanning Electron Microscopy (SEM) type 250 Quanta, the surface morphology and XRD of ZnO-TiO2 samples with varying dehydrolysis temperatures (4000C, 5000C, and 6000C) were determined. The spectrum of the findings of SEM examination on ZnO, TiO2, and ZnO-TiO2 calcined at temperatures of ZnO 400o C, TiO2 500o C, and ZnO–TiO2 600o C ranges from (116.52), (114.84), and (600). (112.58). According to XRD examination, the crystal diameters for each dehydrolysis temperature of 400 °C, 500 °C, and 600 °C were 79.21 nm, 49.21 nm, and 45.34 nm, respectively. The fluctuation of the dehydrolysis temperature demonstrates that heating of the ZnO-TiO2 influences the performance of the solar cell, where the highest efficiency value is (5.10.045) x10-3% when measured with the IV-meter Keithley and (7.50.25) x10-3% when measured with a circuit at 600 C. This item can emit a maximum current of 2.5–3.5 mA and voltage of 3.3–8.5 eV.

Keywords: ZnO-TiO2 Semiconductor, Synthesis, 98% Ethanol, dehydrolysis, Thin Films Micro Slides

1 Introduction

The quantity of supply and oil reserves in Indonesia decreased by 1.2% as of January 1, 2015, compared to 2014's total of 3.70 billion barrels; consequently, energy demand will continue to rise. This indicates that Indonesia's use of fossil fuels is decreasing, so it is necessary to find replacement sources of energy, such as solar energy/solar cells. Considering the adequacy of solar heat generated in the radiation, Indonesia's potential to utilize solar energy is quite large. Indonesia has a solar energy potential of approximately 4.8 kWh/m2(112,000 GWp) per day, so it could be used as an alternative energy reserve (1). Alternative energy sources are energy sources that are not derived from fossil fuels (petroleum and coal) and can be used to generate energy to meet human needs. Excessive and uncontrolled use of fossil energy will have a negative impact on health because it will cause air pollution and damage to the ozone layer, causing global warming in which the polar ice caps are melting faster, sea levels are rising, and rainfall is not occurring. Uncertainty, as well as extreme climate change The supply of fossil energy will run out sometime in the next few decades, affecting the global economic sector (3) Renewable energy has advantages over non-renewable energy in that it will never run out as

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long as natural cycles continue, it can reduce pollution, and it is environmentally friendly. Meanwhile, non-renewable energy is energy that, if used continuously, will deplete and cause pollution (4). The use of sunlight or solar energy is one source of New and Renewable Energy that has the potential to be an alternative medium for producing electricity. The sun is a renewable source of energy that is abundant. The main advantage of developing solar energy in Indonesia is, of course, its high potential (4.8 kWh/m2/day on average) (5).

Titanium dioxide (TiO_2) is an attractive material for the development of solar cells and photocatalysts based on the phenomenon of photoinduction. The photoinduction phenomenon occurs because TiO_2 absorbs photon energy (h-) resulting in a transition of electrons from the valence band to the conduction band and a vacancy (h+) is formed. Electrons in the conduction band and vacancies (h+) in the valence band are used electrically for photovoltaic cells, while chemically for photocatalysts. Thus in the energy field, TiO_2 nanoparticles can be applied as dye-based photovoltaic cells (Dye Sensitized Solar Cells/DSSC) and photo electrolysis of water in conjunction with photo electrochemistry (6)

ZnO is one of the metal oxides that is widely researched and applied. ZnO has a band gap almost the same as TiO_2 which is 3.37 at room temperature. Another metal oxide material is SiO_2which is a p-type semiconductor material and is inert , hydrophilic, has high thermal and mechanical stability. SiO_2 and a wide surface area so that it is able to absorb dye than TiO_2, which implies that it can increase the amount of light absorbed. Then when ZnO material is mixed with SiO_2 composite2, the ability to absorb dye is greater than TiO_2. Therefore, the advantages of ZnO-SiO_2 in addition to having a band gap almost the same as TiO_2 , also has a greater absorbance of light. ZnO materials are alloy materials in groups II and IV between metals and oxides. ZnO is recognized as one of the most promising oxide semiconductor materials because it has good optical, electrical and piezoelectric properties (7).

From the background of the identified issue, the researchers expanded and developed this research using: semiconductor nanomaterials ZnO–TiO_2 as a synthetic material and dye as a mixture, the sol gel or spin coating method, and various precursor process, calcination variation, data analysis, effect, characterization of the test: UV-Vis, XRD, SEM, and measurement of current and voltage**.**

2 Methodology

In this study, three steps will be taken to synthesize ZnO, TiO_2, and ZnO and TiO_2. The first stage is ZnO, which has a mass of 0.5 gram. The ZnO was then pulverized with a stirrer after 2 ml of 98% ethanol was added. As a stirrer, a mortar was added. At 500 rpm, the ZnO semiconductor takes one hour to synthesize; the synthesis treatment for the 80OS semiconductor2 is the same as for ZnO.The second stage involved preparing a 0.5-gram mixture of ZnO and TiO_2 and adding 3 ml of 98% ethanol. This semiconductor material is synthesized in the same way as ZnO and TiO_2, by grinding it with a stirrer at 80 oC and 500 rpm for 1 hour.

Following the completion of the synthesis, which results in sol gel treatment, each sol gel is affixed to a thin film or microslide measuring 2 cm x 2 cm, and then spin coated for 30 seconds at a speed of 1000 rpm. Each completed spin coating sample is then purified for 1 hour using a Nabertherm tool made in Germany, as shown in the figure below with a clock, with each

calcination at 400 oC, 500 oC, and 600 oC. Following the completion of the calcination, the sample is allowed to stand for 30 minutes, depending on the temperature of the room.
The third step is to characterize each sample using XRD and SEM-EDX, as illustrated in the semiconductor materials below:

1. ZnO with a calcination temperature of 400oC
2. TiO2 with a calcination temperature of 500oC and
3. ZnO + TiO2 with a calcination temperature of 600oC

3 Result and Discussion

3.1. XRD Characterization using Micro Slides

XRD Test : ZnO with a calcination temperature of 400oC, TiO2 with of 400oC and ZnO + TiO2 with of 400oC.
The XRD test result from the element mention above are described in the following charts :

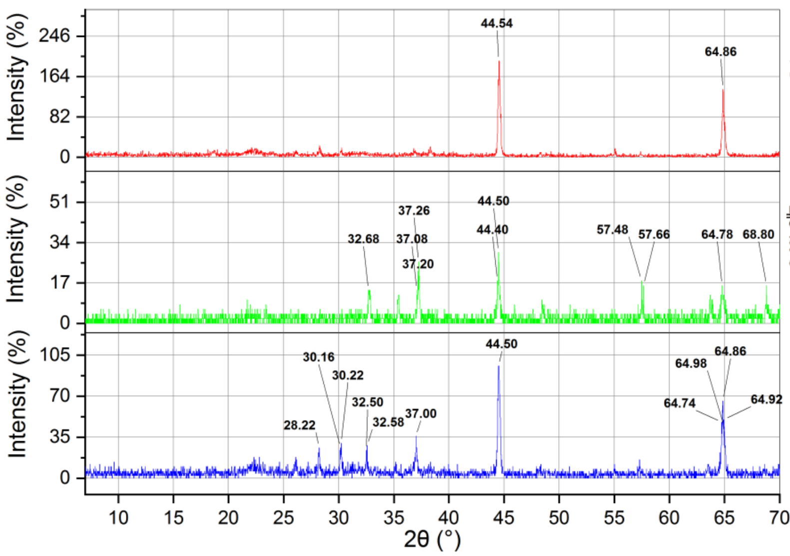

Fig 1. graph of XRD test Result; ZnO with a calcination temperature of 400oC, TiO2 with of 400oC and ZnO + TiO2 with of 400oC

XRD Test,; ZnO with a calcination temperature of 500oC, TiO2 with of 500oC and ZnO + TiO2 with of 500oC.
The XRD test using micro slides resulted from the element mention above are described in the following charts :

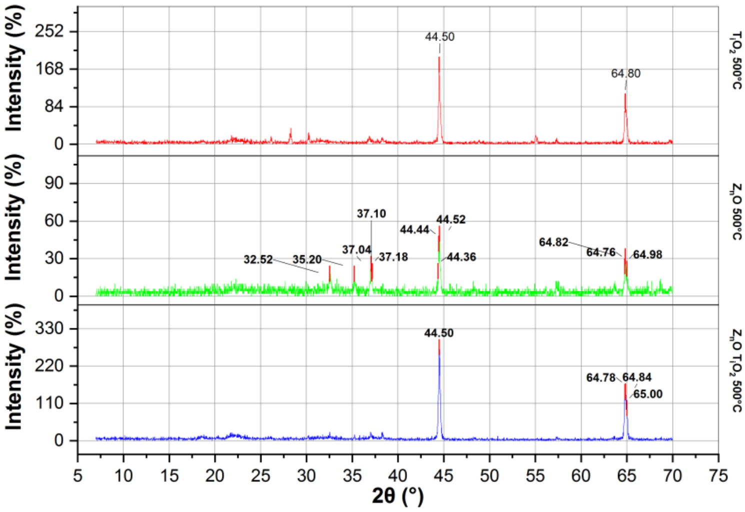

Fig 2. Graph of XRD test Result using micro slides; ZnO with a calcination temperature of 500°C, TiO_2 with of 500°C and ZnO + TiO_2 with of 500°C

XRD Test,; ZnO with a calcination temperature of 600oC, TiO2 with of 600oC and ZnO + TiO2 with of 600oC.

The XRD test using micro slides resulted from the element mention above are described in the following charts :

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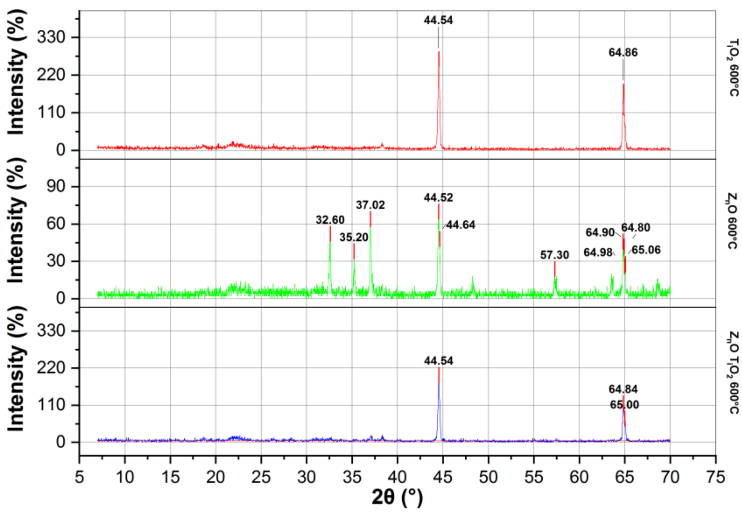


Fig 3 Graph of XRD test Result using micro slides; ZnO with a calcination temperature of 600oC, TiO2 with of 600oC and ZnO + TiO2 with of 600oC

Of the three temperature variations calcined in the peak graph above, the highest peak point calcination is:

1. ZnO + TiO2 + calcined at 500oC, namely: Integrated Int (counts) is 2043 and The intensity (counts) is 209.
2. TiO2 calcined at a temperature of 600oC, namely: Integrated Int (counts) is 2041 and the Intensity (counts) is 187
.3. TiO2 calcined at a temperature of 400oC namely : Integrated Int (counts) is 1510 and the Intensity (counts) is 138

3.2 Calculation of the crystal size of the highest peak using Micro slides with the variation of calcination temperature of 400oC, 500OC and 600oC

In order to calculate the crystal size from the highest peak with various calcination temperature, we can use Debye Scherrer:

$$D = \frac{0.9\lambda}{\beta cos\theta}$$

:

D = Crsytal sizel (nm)
= wave length ()
= FWHM (Full Width Half Maximum)
= Difraction angel

1. ZnO 400ºC

Dik:

$$2\theta = 44.4973$$

$$\beta = 0.14130;\ \ 1^{o} = 0.01745 \lambda = 1.541874Å$$

$$So:$$

$$D = \frac{0.9\lambda}{\beta cos\theta}$$

$$= \frac{0.9(1.541874)}{(0.14130)(0.01745)\ cos\ cos\ \left(\frac{44.4973}{2}\right)}$$

$$= \frac{1.3876866}{(0.002465)(0.71328)}$$

$$= \frac{1.3876866}{0.0017582}$$

$$= 792.0585Å$$

$$= 79.205nm$$

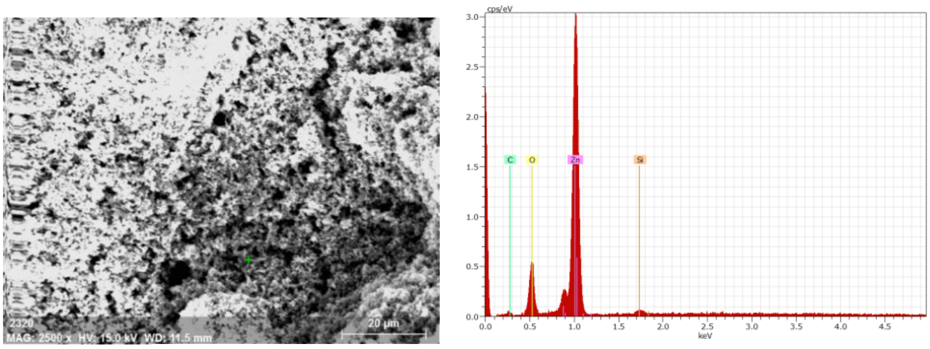
The result of calculation describing the crystal size and length of wave with the holding time using Micro Slides are seen in the table 1 below ;

Table 1. Crystal size calculation

No	Material	Calcination Temperature	ƛ (Amstrong)	Crystal Size (nm)
1	ZnO	$400^{O}C$	792.0585	79.21
2	TiO_2	$500^{O}C$	492.1049	49.21
3	$ZnO + TiO_2$	$600^{O}C$	453.4400	45.34
4	ZnO	$600^{O}C$	452.2096	45.22
5	$ZnO + TiO_2$	$500^{O}C$	437.0597	43.71
6	TiO_2	$600^{O}C$	435.9540	43.60
7	TiO_2	$400^{O}C$	425.1881	42,52
8	ZnO	$500^{O}C$	409.1370	40.91
9	$ZnO + TiO_2$	$400^{O}C$	404.5249	40.45

As it is seen in table 4, Zno with calcination temperature of 400oC has the highest peak point (no 1); ƛ = 792.0585 A and the crystal size approximately reaches 79.21 nm . The second highest crystal size is TiO2 with calcination temperature of 500oC ; ƛ = 492.1049 with the 49.21 nm as the crystal size. Finally the third highest peak is ZnO + TiO2 with calcination temeperature of 600OC point at ƛ = 453.4400 Ao with 45.34 of crystal size

3.3. The characterization of SEM – EDX Using Micro Slides

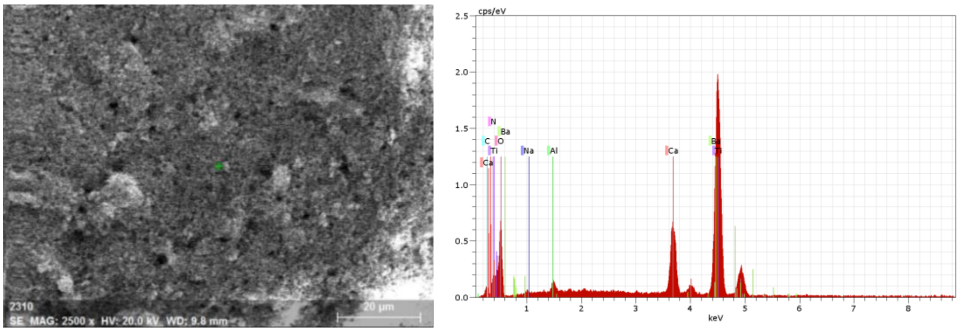


Spectrum: ZnO 400

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]	K fact.	Z corr.	A corr.	F corr.
Zn	30	K-series	95.06	84.44	57.38	3.65	0.922	0.876	1.000	1.046
O	8	K-series	16.95	15.06	41.82	2.96	0.210	0.716	1.000	1.000
Si	14	K-series	0.57	0.50	0.80	0.08	0.004	1.412	1.000	1.004
C	6	K-series	0.00	0.00	0.00	0.00	0.000	0.000	1.000	1.000
		Total:	112.58	100.00	100.00					

Fig. 4. SEM – EDX Test : ZnO with 400o C Calcination Temperature

From the results of the SEM – EDX test, ZnO using Micro Slides glass at a calcination temperature of 400oC, it was found that the total spectrum produced was 112.58 unn [wt %], 100.00 C norm [wt %] and 100.00 C Atom [at %]. The amount of semiconductor material (, Zn, O, Si and C) obtained is in the table above.

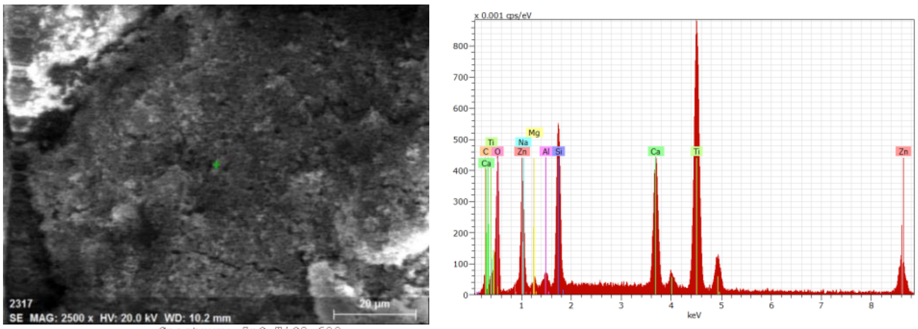


Spectrum: TiO2 500

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]	K fact.	Z corr.	A corr.	F corr.
Ti	22	K-series	45.26	39.41	22.95	1.34	0.332	1.162	1.000	1.021
O	8	K-series	44.16	38.45	67.00	7.81	0.896	0.429	1.000	1.000
Ba	56	L-series	13.82	12.03	2.44	0.48	0.135	0.877	1.000	1.015
Ca	20	K-series	9.91	8.63	6.00	0.35	0.063	1.236	1.000	1.115
Al	13	K-series	1.12	0.98	1.01	0.11	0.011	0.863	1.000	1.006
Na	11	K-series	0.57	0.49	0.60	0.10	0.007	0.679	1.000	1.002
C	6	K-series	0.00	0.00	0.00	0.00	0.000	0.000	1.000	1.000
N	7	K-series	0.00	0.00	0.00	0.00	0.000	0.000	1.000	1.000
		Total:	114.84	100.00	100.00					

Fig. 5. SEM – EDX Test : TiO with 500º C Calcination Temperature

From the results of the SEM – EDX test, TiO_2 using Micro Slides glass at a calcination temperature of 500ºC, it was found that the total spectrum produced was 114.84 unn [wt %], 100.00 C norm [wt %] and 100.00 C Atom [at %]. The amount of semiconductor material (Ti,O,Ba,Ca,Al,Na,C dan N) obtained is in the table above.



Spectrum: ZnO TiO2 600

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]	K fact.	Z corr.	A corr.	F corr.
O	8	K-series	37.50	38.36	63.60	6.62	0.823	0.466	1.000	1.000
Ti	22	K-series	27.93	28.57	15.83	0.85	0.204	1.368	1.000	1.025
Zn	30	K-series	15.44	15.79	6.41	0.60	0.121	1.216	1.000	1.070
Ca	20	K-series	8.73	8.93	5.91	0.32	0.058	1.447	1.000	1.068
Si	14	K-series	5.90	6.04	5.70	0.30	0.045	1.330	1.000	1.007
Na	11	K-series	1.29	1.32	1.52	0.15	0.017	0.775	1.000	1.002
Al	13	K-series	0.53	0.54	0.54	0.07	0.005	0.992	1.000	1.006
Mg	12	K-series	0.44	0.45	0.50	0.08	0.005	0.909	1.000	1.004
C	6	K-series	0.00	0.00	0.00	0.00	0.000	0.000	1.000	1.000
		Total:	97.75	100.00	100.00					

Fig. 6. SEM – EDX Test : ZnO + TiO_2 with 600º C Calcination Temperature

From the results of the SEM – EDX test, ZnO + TiO2 using Micro Slides glass at a calcination temperature of 600oC, it was found that the total spectrum produced was 97.75 unn [wt %], 100.00 C norm [wt %] and 100.00 C Atom [at %]. The amount of semiconductor material (O,Ti,Zn,Ca,Si,Na,Al,Mg dan C) obtained is in the table above. Overall, from the result of SEM - EDX test using micro slides described through picture, graph and table, it can be concluded that some highest points of SEM - EDX are:

1. Spektrum TiO2 500OC = 114.84
2. Spektrum ZnO 400OC = 112.58
3. Spektrum ZnO + TiO2 600O = 97,75

4 Conclusion

Using micro slides in XRD testing, ZnO + TiO2 with calcination temperature of 500oC has the highest in which Integrated Int (counts) is 2043 and the Intensity (counts) is 209. The crystal size of ZNO with calcination temeperature of 400º C has the longesta nd highest size measuring at ƛ = 792.0585 Aº and 79.21 nm as the crystal size. At a calcination temperature of 500 °C, TiO2 has the highest spectrum which is 114,84.

5. Suggestion

This research was carried out by formulating the sample mixture, concentration and pH described in the national and international journal. Yet the researchers develop different and sample comparison as analyzed above. For further implication, This research can be continued and developed by varying the extract, synthesis and characterization of each test.

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