

## **INVESTIGATION OF TRANSMITTANCE AND HYDROPHOBIC PROPERTIES OF SiO<sub>2</sub>:ZnO:SiO<sub>2</sub> AS A MULTILAYER COATING SUBSTANCE**

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### **ABSTRACT**

Solar panel often facing problem that reduce the energy produced especially when dust and soil covers the surface of the solar panel, thus blocking the light. Not only that, reflection that occurred reducing the transmittance of light. Thus, to overcome these problems, multilayer coating of SiO<sub>2</sub>:ZnO:SiO<sub>2</sub> has been fabricated using sol-gel method, via dipping process and utilised glass sheet as a core. In this study, the SiO<sub>2</sub>:ZnO:SiO<sub>2</sub> coating was compared to the SiO<sub>2</sub>:ZnO coating in terms of their transmittance, absorption and hydrophobicity properties. The water contact angle was used to evaluate the hydrophobic properties, while the Ultraviolet-Visible Spectrometer was used to measure the transmittance and absorption. The triple layer coating initiated 90.2% on its average transmittance while the double layer coating had only 61.48%. The absorption peak revealed that SiO<sub>2</sub>:ZnO coating had 0.86 Å while SiO<sub>2</sub>:ZnO:SiO<sub>2</sub> coating was only 0.33 Å. On the other hand, the water contact angle for both coatings were good. However, the SiO<sub>2</sub>:ZnO:SiO<sub>2</sub> coating showed a higher water contact angle, 126° compared to the SiO<sub>2</sub>:ZnO coating, 82°. The higher contact angle the lesser the surface energy thus it allows the water droplet to maintain its shape longer. The result indicated that the multilayer coating of SiO<sub>2</sub>:ZnO:SiO<sub>2</sub> was successfully fabricated with better properties than conventional coating.

*Keywords: Double layer coating; Multilayer coating; Solar Energy; Anti-reflective coating; Hydrophobic*

### **INTRODUCTION**

Every year, new types of solar cells were created to increase the efficiency in harnessing the power of solar energy. Although solar cells are getting better by day, it also has its own limit. As we know, as light from the sun falls onto the solar panel, energy is produced. However, reflection that occurs during the energy synthesis process lowers the amount of energy produced. In order to avoid reflection from occurs; an anti-reflective (AR) coating is introduced and applied onto the solar cell <sup>[1]</sup>.

When light hits the solar panel, it will pass through different medium that has different refractive index. In current study, the light will experience the refractive index of glass

and air. Most of the light will be refracted while some of the light may be reflected out. Therefore, by introducing AR coating will definitely help in increasing photovoltaic system efficiency as it can reduce the reflection of light from occurring<sup>[2]</sup>.

Coating the solar panel with AR coating has lots of benefits. Each compound or element has its own band gap energy which allow it to absorb energy and excite the electron, same goes to the coating substances. Although it does increase the solar power transmittance, but now the coating might also absorb the light photon that should be use by the solar cell. Not only that, single layer coating can only be an anti-reflective at one wavelength, where transmittance produce is low on the entire visible spectrum<sup>[3,4]</sup>.

There are ways to reduce the energy band gap. One of it is by increasing or adding more layer of AR coating which is known as multilayer coating. When multilayer coating is produced, the conduction band allowed states may merge with its own conduction band, thus producing lower band gap<sup>[5]</sup>. Lower band gap resulting in lower absorption of photon, therefore increasing the transmittance.

Solar panel also facing another problem that can lower its energy produced. It is when dust, soil, dirt or water covers the surface of the solar panel, thus blocked the light. The desert areas for example is a vast area that allows the usage of solar energy to maximum. However, accumulation of dust and sand caused loss of transmittance around 25% to 30%. The best solution for this problem will be a coating that enable us to clean the solar panel surface easily which known as hydrophobic coating<sup>[6,7]</sup>.

In response to these problems, this research seeks a solution by using the multilayer coating. Therefore, this research is focussed on producing multilayer coating that has properties of anti-reflection and hydrophobic. The transmittance and hydrophobic properties of the multilayer coating will then be tested.

## EXPERIMENTAL

### *Preparation of SiO<sub>2</sub> sol-gel*

The multilayer coating of SiO<sub>2</sub>: ZnO: SiO<sub>2</sub> were deposited on glass slide using dip coating method. Prior to each deposition, the glass slide was cleaned with soap, ethanol, distilled water and finally allowed it to dry for 15 minutes at 100°C. The sol-gel used in fabricating the coating consist of tetraethylorthosilicate (TEOS), ethanol, distilled water and concentrate hydrochloric acid (HCL). The chemical solution followed the molar ratio of 1: 10: 2: 0.25 for TEOS: Ethanol: Distilled Water: HCL respectively. The solution was stirred for 3 hours at 30°C and aged for 2 days. The sol-gel then was used to obtain SiO<sub>2</sub> thin film using dip coating technique and was dip for one minute each. The SiO<sub>2</sub> thin film was then dried at room temperature.

### *Preparation of ZnO sol-gel*

Zinc acetate 2-hydrate (99.5% purity, (CH<sub>3</sub>COO)<sub>2</sub>·2H<sub>2</sub>O) was needed to fabricate ZnO sol-gel. Absolute ethanol was used as a solvent, and diethanolamine

(HN(CH<sub>2</sub>CH<sub>2</sub>OH)<sub>2</sub>, DEA) as a sol stabilizer. Firstly, 0.05 mol of zinc acetate 2-hydrate was dissolved into 0.1 L of absolute ethanol in a 250 mL conical flask to produce a 0.5 M ethanolic solution of zinc acetate. After vigorously stirred for 30 minutes, DEA was slowly added while stirring. The molar ratio of DEA/Zn<sup>2+</sup> was fixed at 1. For about 20 minutes of continuous stirring, the solution became clear and homogeneous. This solution was continuously stirred overnight before final use for thin-film coating. Thin films of ZnO were prepared via a dip-coating method. The glass slide with SiO<sub>2</sub> thin film were dipped in the ZnO sol-gel for one minute, which produced a uniform film of the desired thickness. The ZnO thin film then were directly dried at 200°C in an oven for 2 hours. The double layer coating of SiO<sub>2</sub>: ZnO was produced. In order to produce the SiO<sub>2</sub>: ZnO: SiO<sub>2</sub> multilayer coating, it undergone another procedure to deposit the last SiO<sub>2</sub> coating layer. The last coating of SiO<sub>2</sub> gone through the same procedure to deposit SiO<sub>2</sub> thin film as before.

#### *The measurement of transmittance, absorption and water contact angle*

The double beam Ultraviolet-Visible Spectroscopy (UV-VIS) was used to measure the transmittance and absorption for the multilayer coating. For the wettability nature of the coatings, it was measured using contact angle measurement at room temperature. A water droplet was used for contact angle measurements and the contact angles were captured and the image was studied.

## **RESULTS AND DISCUSSION**

#### *Hydrophobic Properties Analysis*

The analysis of hydrophobic properties of the multilayer coating are presented in Figure 1 and Figure 2. From Figure 1 and Figure 2, the water contact angle of SiO<sub>2</sub>: ZnO was 82° while for SiO<sub>2</sub>: ZnO: SiO<sub>2</sub> coating was 126°. A good hydrophobic properties must produce an angle between 10° to 150° [8,9,10]. Higher water contact angle will result in better hydrophobic properties where it minimizes the water contact angle between the water droplet and the coating surface. This condition allows water to move smoothly with less energy. Therefore, from this experiment, it can be seen that SiO<sub>2</sub> produce better hydrophobic properties compared to ZnO. This is due to SiO<sub>2</sub> low surface energy than ZnO. Thus, SiO<sub>2</sub>: ZnO: SiO<sub>2</sub> triple layer coating resulted in a better hydrophobic properties compared to double layer SiO<sub>2</sub>: ZnO coating.

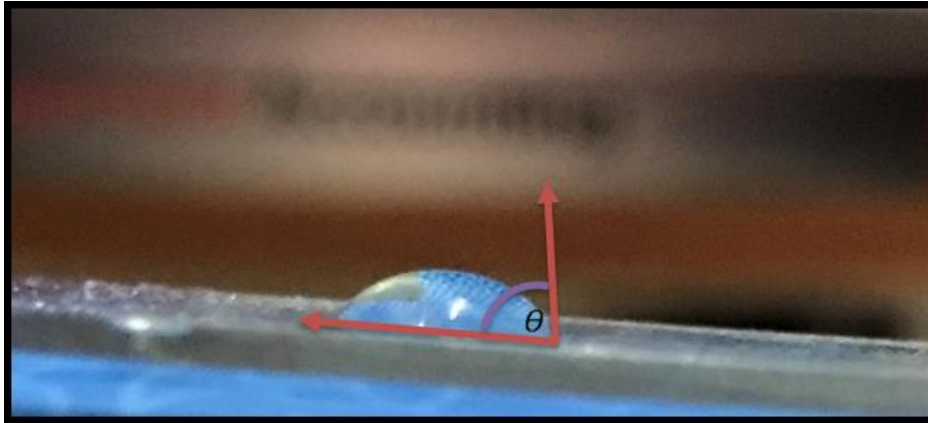


Figure 1: Water contact angle of SiO<sub>2</sub>: ZnO

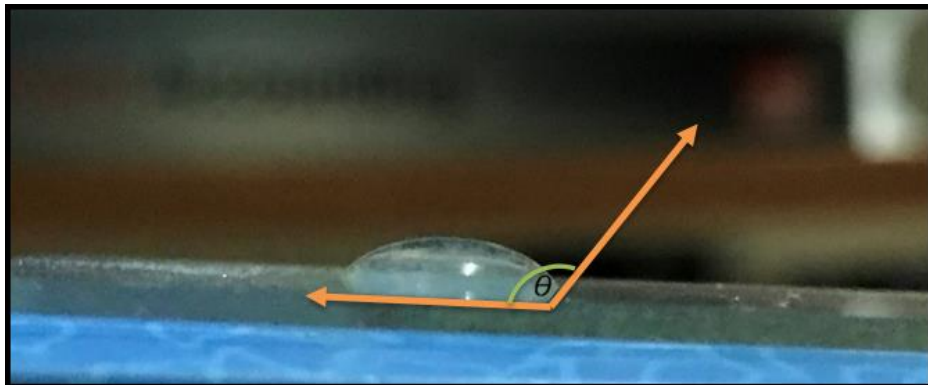


Figure 2: Water contact angle of SiO<sub>2</sub>: ZnO: SiO<sub>2</sub> coating

The summary of measurements of water contact angle for both coatings is represented by Table 1. These readings are viewed easily and clearly by respective summary table.

Table 1: Summary table of water contact angle for double layer and triple layer coating

Coating	Water contact angle
SiO <sub>2</sub> : ZnO	82°
SiO <sub>2</sub> : ZnO: SiO <sub>2</sub>	126°

*Transmittance*

The current research aims to investigate the optical properties of SiO<sub>2</sub>: ZnO coating and SiO<sub>2</sub>: ZnO: SiO<sub>2</sub> coating by measuring the transmittance of coatings. The Figure 3 demonstrated that the transmittance of double layer SiO<sub>2</sub>: ZnO coating was decreasing with its wavelength of about 77% to 62% at 800 nm to 500 nm respectively. SiO<sub>2</sub>: ZnO

exhibit a maximum transmittance of 77.5% and its average transmittance from 300 nm to 800 nm is 61.48%. Therefore, it can be deduced that almost 13% to 38% of the light was lost due to absorption and reflection.

While for triple layer  $\text{SiO}_2$ : ZnO:  $\text{SiO}_2$  coating, a constant transmittance of 98% was produced from 500nm to 800nm. The  $\text{SiO}_2$ : ZnO:  $\text{SiO}_2$  managed to produce its average transmittance of 90.2%. It can be highlight that less reflectance is occurred for the  $\text{SiO}_2$ : ZnO:  $\text{SiO}_2$  coating with only 10% of light loss, which is far lower than the  $\text{SiO}_2$ : ZnO coating.

The difference between average transmittance between the double layer and the triple layer coatings may due to the arrangement of the coating itself. According to Priyardishini, (2016)<sup>[11]</sup>, to fully utilise multilayer coating ability, a higher refractive index coating must be place in between lower refractive index coating.  $\text{SiO}_2$  has a refractive index of 1.55, while ZnO has a refractive index of 2.0. Since the arrangement of the triple layer coating of  $\text{SiO}_2$ : ZnO:  $\text{SiO}_2$  sandwiching a higher refractive index material, thus it leads to maximum transmittance and minimum reflectance compared to the  $\text{SiO}_2$ : ZnO coating.

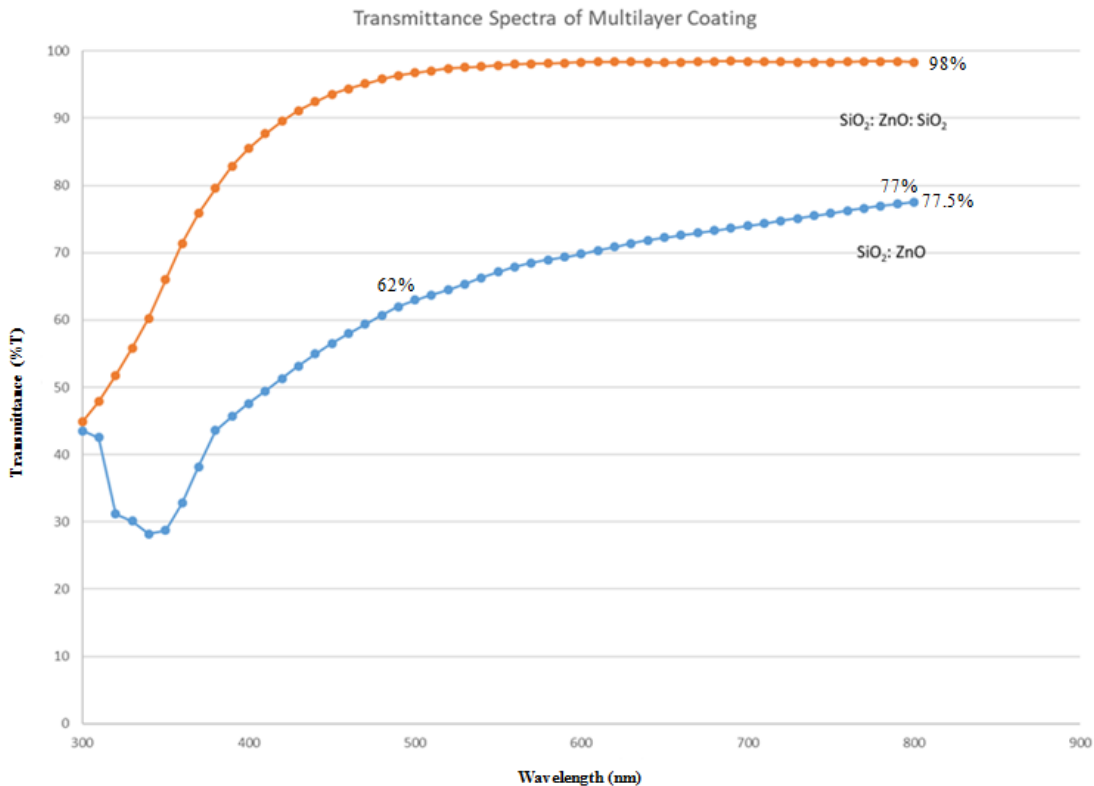


Figure 3: Transmittance spectra of multilayer coating

### *Absorption*

A clear difference in absorption peak value was shown by the Figure 4 where the double layer coating of SiO<sub>2</sub>: ZnO having about 0.86 A for its absorption peak value. By comparing with the triple layer coating of SiO<sub>2</sub>: ZnO: SiO<sub>2</sub>, the absorption peak value was only 0.33 A.

Higher absorption peak means lower transmittance produced because the light was absorbed by the coating materials. The SiO<sub>2</sub>: ZnO transmittance started to lose its transmittance at low wavelength because of the higher absorption. In order to reduce the absorption, multilayer coating was introduced. Ali Yıldırım & Ateş, (2010) <sup>[12]</sup> stated that, multilayer coatings are able to reduce their band gap, thus causing it to have a lower absorption and produce higher transmittance. This has been clearly showed from the absorption graph where the absorption peak of the double layer coating started to diminish as soon as the triple layer coating was introduced. On the other hand, by adding more layer of coating does not really able to remove the absorption completely. However, by adding too many layers of coating, will increase the thin film thickness, therefore harder for light to penetrate through <sup>[12]</sup>.

Another reason why did the transmittance decreased at lower wavelength is because of the overlapping absorption spectra between SiO<sub>2</sub> and ZnO. Previous study <sup>[11]</sup> did mentioned, the SiO<sub>2</sub> absorption was in the range between 400nm to 500nm. While ZnO was from 300nm to 400nm. The overlapping absorption spectra causing most of the light unable to pass through both SiO<sub>2</sub> and ZnO coating with wavelength from 300nm to 500nm and especially at 400nm. This can be seen at Figure 4 where the absorption peak for SiO<sub>2</sub>: ZnO coating was tremendously increased at about 300nm. Since the SiO<sub>2</sub>: ZnO: SiO<sub>2</sub> consisted of triple layer coating, this absorption peak managed to be controlled and reduced. This proved that the triple or multilayer coating worked well in reducing the absorption of coating material thus increased its transmittance.

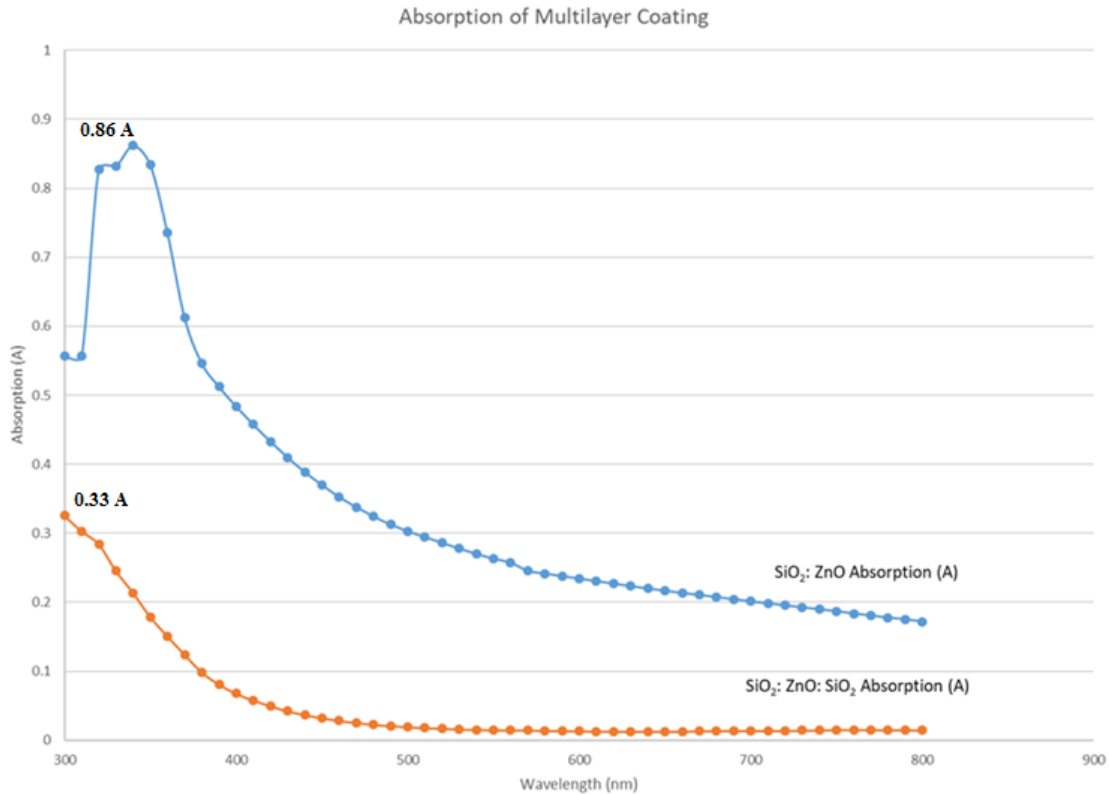


Figure 4: Absorption graph of multilayer coating

## CONCLUSION

The dual function hydrophobic and anti-reflective multilayer coating was successfully fabricated. The multilayer coating of the SiO<sub>2</sub>: ZnO: SiO<sub>2</sub> was able to produce good hydrophobic properties with high water contact angle of 126. Higher water contact angle will produce less surface energy thus it can help to clean the coating surface easier. Triple layer coating of SiO<sub>2</sub>: ZnO: SiO<sub>2</sub> showed transmittance as high as 98% between 800nm to 500nm. Low absorption spectra were also produced through this research, where the SiO<sub>2</sub>: ZnO: SiO<sub>2</sub> multilayer coating was able to produce absorption as low as 0.33 A, which is way lower than the double layer coating of SiO<sub>2</sub>: ZnO, 0.86 A. Sandwiching a material that has higher refractive index in the middle between lower refractive index, enhanced the anti-reflective properties of the multilayer coating which reduces reflection and increases the transmittance of the coating. Furthermore, as layer of coating increase, the lower the absorption of light. Therefore, it can be concluded that multilayer coating of SiO<sub>2</sub>: ZnO: SiO<sub>2</sub> that has the hydrophobic properties was successfully fabricated. This multilayer coating demonstrated better performance in its properties, especially the transmittance and absorption; compared to the conventional coating.

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