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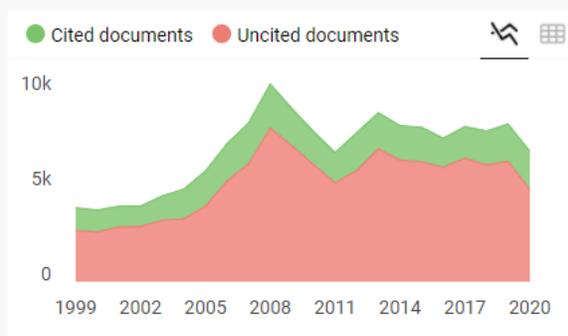
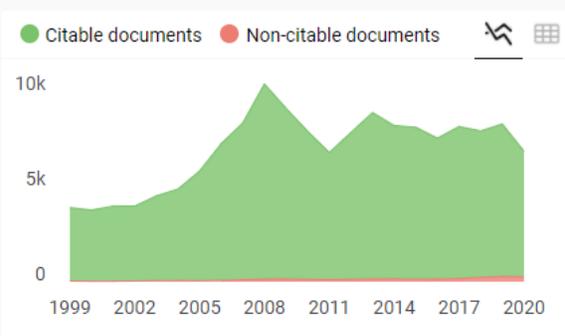
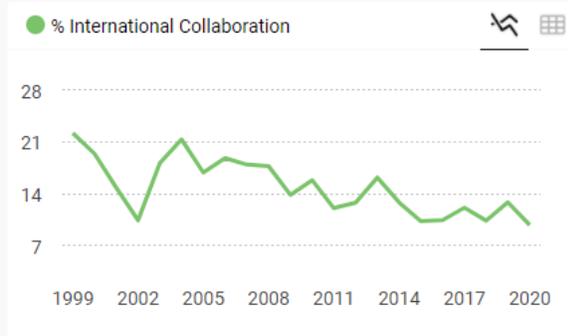
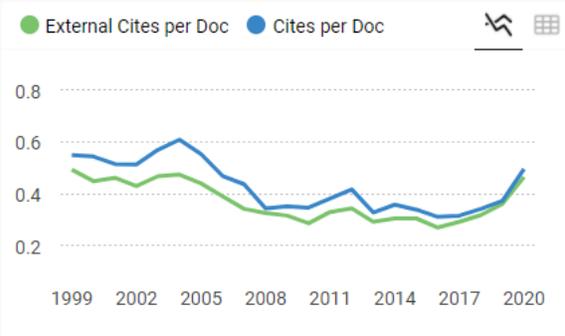
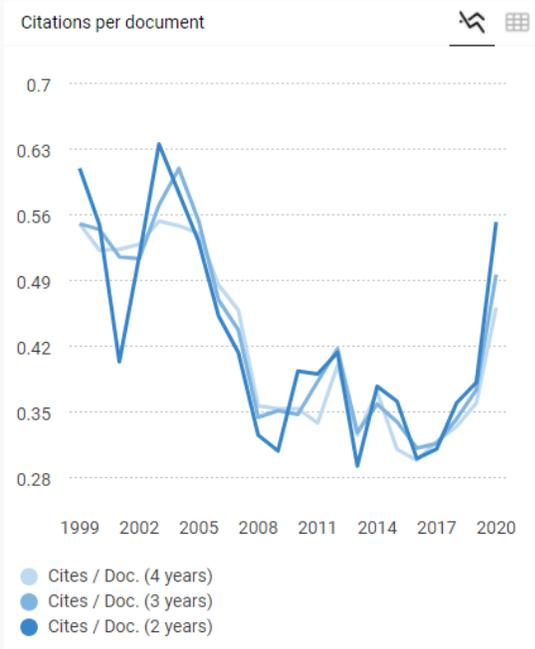
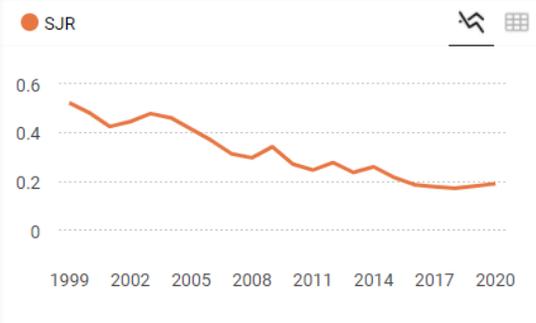
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Abstract:

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Introduction

The Semiconductors are materials that are flexible, meaning that in certain circumstances they act as conductors and in other cases are insulators [1]. Various ways have been done by researchers to maximize the function of semiconductor materials, including modifying the material in the form of a thin layer.

The use of thin layers of semiconductor materials includes gas sensors, [2], LED (Light emitted diode) [3], solar cells [4], TCO (transparent Conducting Oxide) which are used in transparent electrodes [5], LCD [6] and so forth. The types of materials that have been utilized in the synthesis of thin films are titanium dioxide [7], aluminum, tungsten disulfide [8], and tin oxide [9].

The level of sensitivity of a thin film material is influenced by its optical properties. The optical property referred to is the energy value of the thin layer band gap. The higher the bandgap energy value of the layer, the more difficult the material is to conduct current. The bandgap energy value of the tin oxide (SnO₂) thin layer is still quite high, around 3.72 eV [10], so it needs to be modified by adding donors or other atoms to the material. Several other atoms are added namely, ferrum [11], aluminum-zinc [12], indium [13] and fluorine [14]. In this study, the doping materials used are aluminum, fluorine, and indium with the hope that the layer transparency rate increases and the bandgap energy obtained is lower than the previous band gap energy.

Experiments

The stages of this research consisted of synthesis and characterization. The first stage, synthesis, is the process of making a thin layer using the sol-gel spin coating technique with a SnO₂: (Al + F + In) ratio of 95: 5% and 75: 25%. The synthesis consists of glass substrate preparation, sol-gel preparation, coating preparation, and curing [15]. Substrate preparation is done by cleaning the glass with detergent to remove all the dirt on the glass. Sol-gel making is done by dissolving SnO₂, aluminum, fluorine, and indium in ethanol (C₂H₅OH) using a magnetic stirrer until a thick white solution is formed, then left for 24 hours. The coating was made using a spin coater with a rotating time of 3 minutes. The thin layer that has been formed is then heated with temperature variations of 25, 50, 100, 150, and 200 °C using a furnace for 1 hour. The second stage, namely characterization of thin films using the UV-Vis Spectrophotometer Thermo Scientific Genesys 150 with a wavelength of 200-1100 nm.

Result and Discussion

The results obtained from the synthesis of a thin layer of SnO₂ with doping aluminum, fluorine and indium (SnO₂: Al + F + In) made the layer formed more transparent. This is shown in Figures 1 and 2, where a thin layer of SnO₂: (Al + F + In) with a doping concentration of 75: 25% (Figure 2) is more transparent than a thin layer of SnO₂: (Al+F +In) with a doping concentration of 95: 5% (Figure 1).

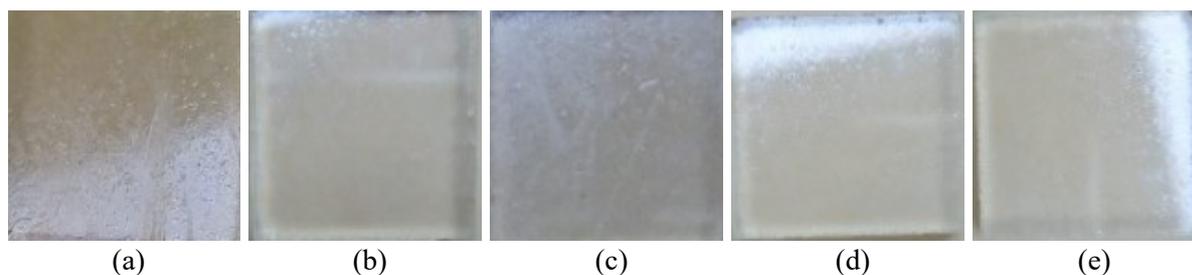


Figure 1. SnO₂ thin layer: (Al + F + In) (95: 5%) temperature variations (a) 25 °C, (b) 50 °C, (3) 100 °C, (d) 150 °C, (e) 200 °C.

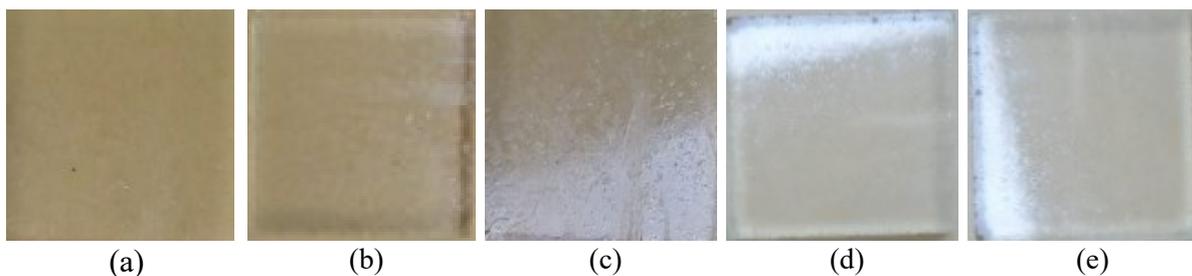


Figure 2. SnO₂ thin layer: (Al + F + In) (75: 25%) temperature variations (a) 25 °C, (b) 50 °C, (3) 100 °C, (d) 150 °C, (e) 200 °C.

The next analysis is characterization of the optical properties of thin films using UV-Vis. The data obtained from the results of characterization of optical properties include absorbance, transmittance, band gap energy and activation energy.

Absorbance

Figure 3 shows the relationship between the wavelength and the absorbance of the SnO₂: (Al + F + In) thin film temperature variations.

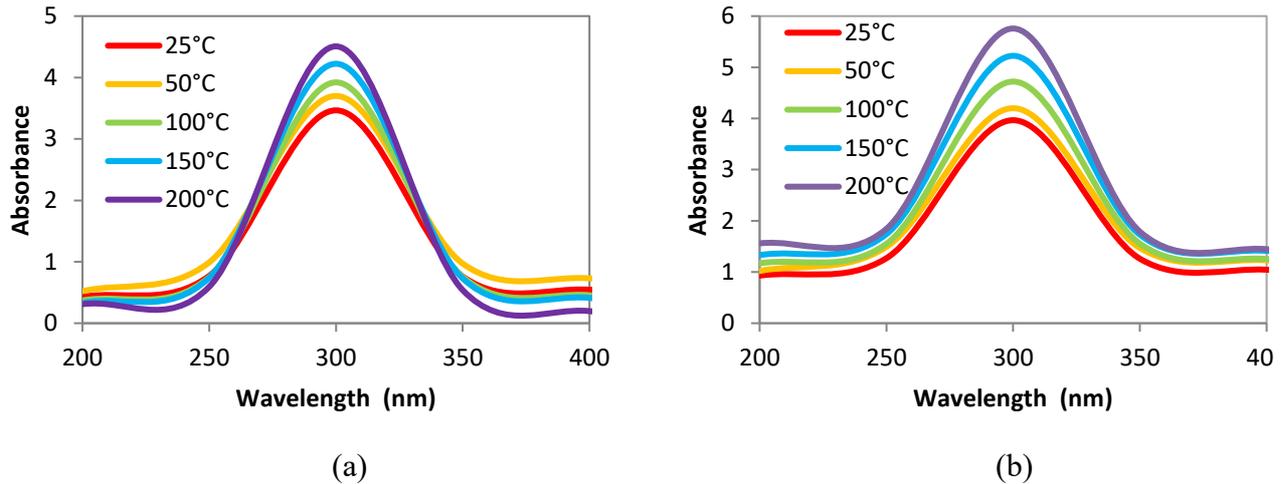


Figure 3. Graph of wavelength relationship with absorbance of thin layer SnO₂: (Al + F + In) temperature variation. (a) 95: 5%, (b) 75: 25%.

In Figure 3, it is clear that the absorbance value of the SnO₂: (Al + F + In) thin film absorbs temperature variations. The maximum absorbance values for temperature variations of 25, 50, 100, 150 and 200 °C for the percentages 95: 5% and 75: 25% at a wavelength of 300 nm are 3.46-4.50 and (Figure 3a) and 3.96-5.76 (Figure 3b), respectively. Based on Figure 3, it is clear that the higher the temperature, the resulting absorbance value increases, especially in the ultraviolet region with a wavelength of 300 nm.

Transmittance

The graph of the relationship between the wavelength and the transmittance of the SnO₂: (Al + F + In) thin layer variation is shown in the following figure.

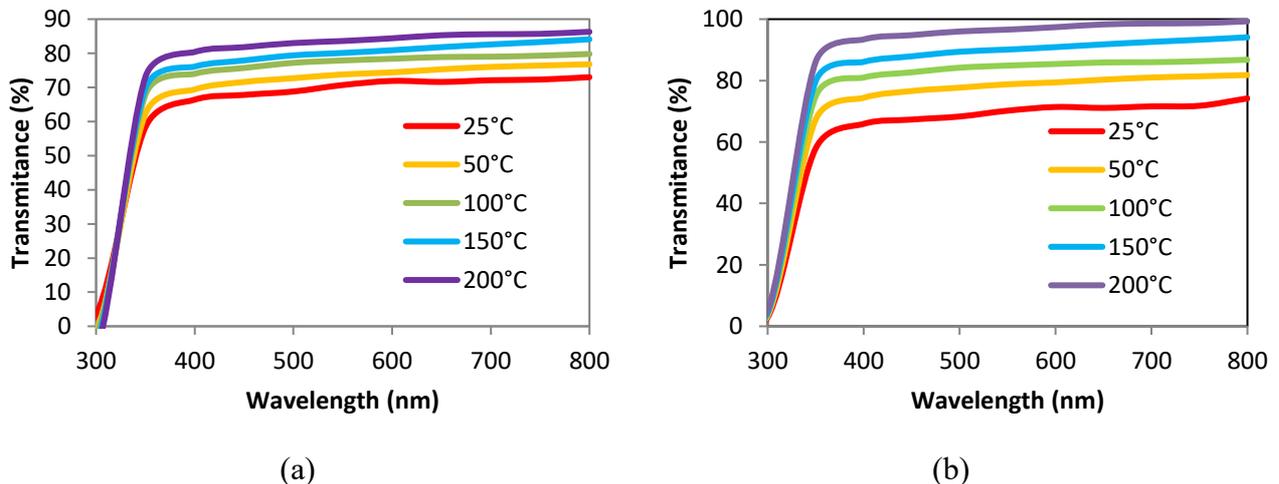


Figure 4. The graph of the wavelength relationship with the transmittance of the thin layer SnO₂: (Al + F + In) temperature variation (a) 95: 5%, (b) 75: 25%.

The transmittance value for temperature variations in the 300-800 nm wave range is shown in Figure 4. The transmittance values for temperature variations of 25, 50, 100, 150 and 200 °C are 95: 5% and 75: 25% respectively 73.00-86.30% (Figure 4a) and 74.20-99.30% (Figure 4b). This means that the transmittance value increases with increasing temperature. This is because the energy possessed by photons is smaller than the energy gap so that it is unable to excite electrons. This resulted in the photons being only transmitted [16].

Bandgap Energy

Bandgap energy consists of direct allowed bandgap energy and indirect allowed bandgap energy. Bandgap energy is obtained by graphing the photon energy with respect to $(\alpha h\nu)^r$. The amount of bandgap energy is shown by the slope of the photon energy graph with respect to $(\alpha h\nu)^r$. The amount of bandgap energy is obtained from equation 1 [17]. While the activation energy of the thin layer is obtained from $1/m$ or one per gradient of the photon energy graph with respect to $\ln \alpha$.

$$\alpha(h\nu)h\nu = K(h\nu - E_g)^r \quad (1)$$

Note: α is the absorbance coefficient, $h\nu$ is the incident energy of the photon, K is a constant, $r = 1/2$ for direct and $r = 2$ for indirect band-gap energy. Based on equation 1, it is obtained that the direct and indirect energy band gap allowed for the SnO₂: (Al + F + In) layer with the tauc plot method is shown in Figures 5 and 6.

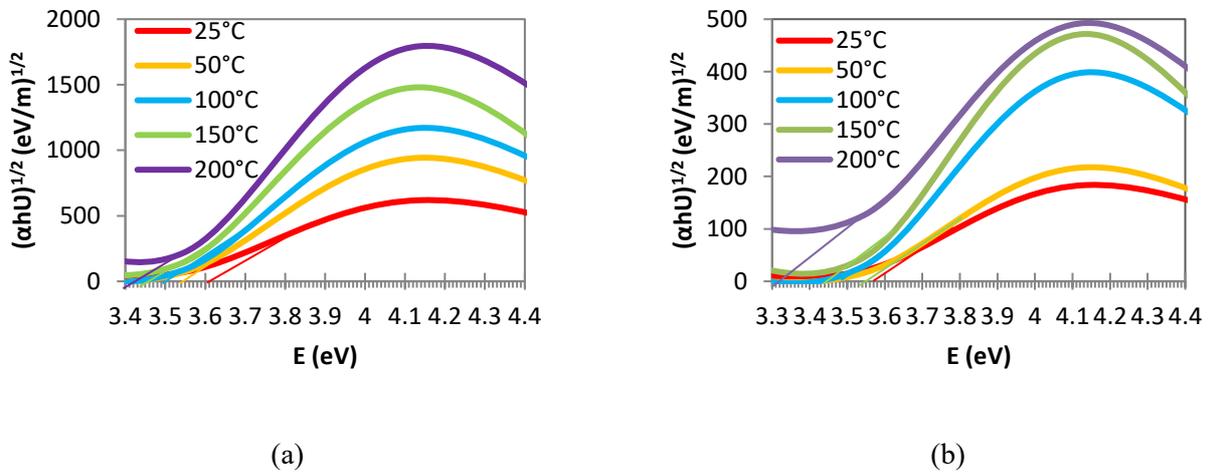


Figure 5. Energy band gap direct allowed SnO₂: (Al + F + In) thin layer. (a) 95: 5%, (b) 75: 25%.

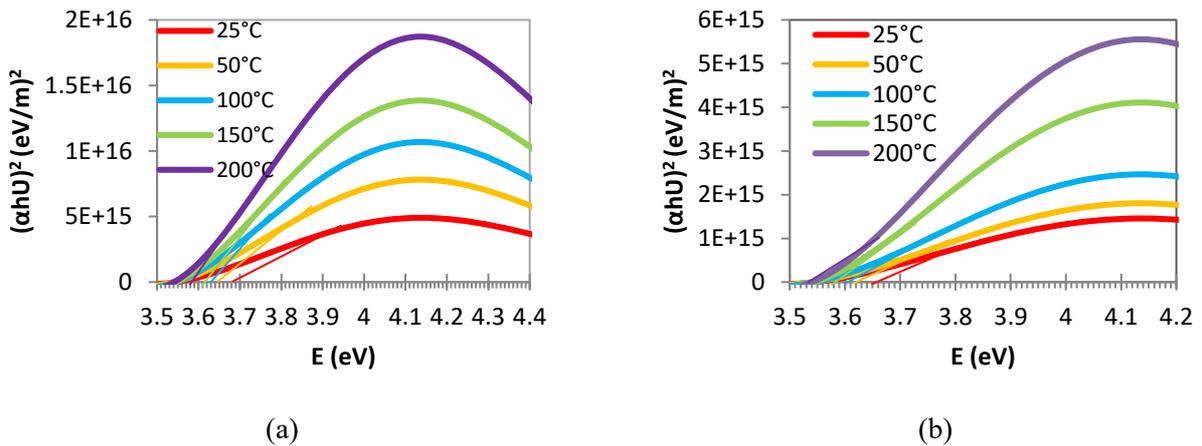


Figure 6. Energy band gap indirect allowed SnO₂: (Al + F + In) thin layer. (a) 95: 5%, (b) 75: 25%.

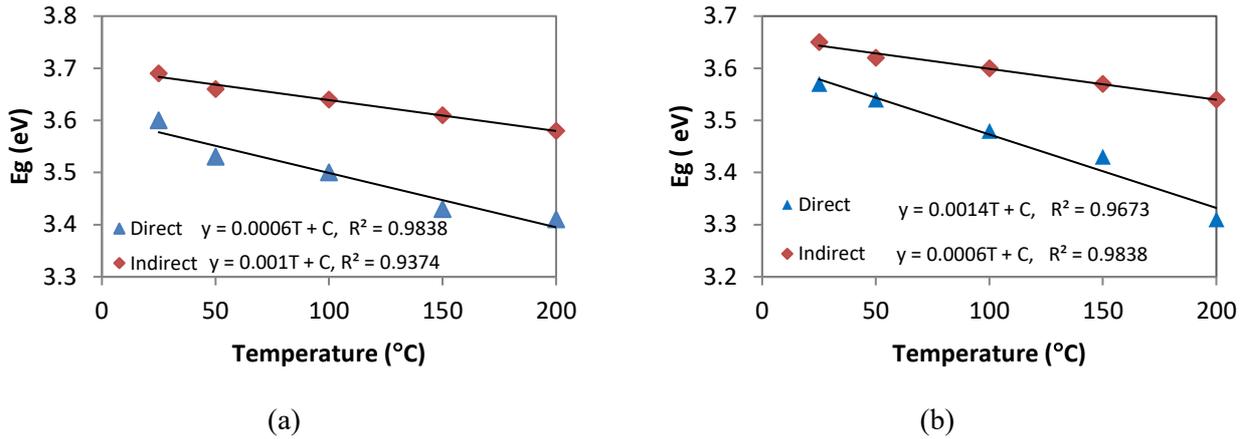


Figure 7. The relationship between temperature variations and the energy band gap of the SnO₂: (Al + F + In) thin layer. (a) 95: 5%, (b) 75: 25%.

Figure 7 shows that the band gap energy values for temperature variations. The band gap energy values for temperature variations of 25, 50, 100, 150 and 200 °C for a percentage of 95: 5% (Figure 7a) are 3.60, 3.53, 3.50, 3.43 and 3.41 eV for direct allowed, respectively, while for indirect allowed respectively 3.69, 3.66, 3.64, 3.61, and 3.58 eV, respectively. The energy value of the band gap for temperature variation for the percentage of 75: 25% (Figure 7b) is 3.57, 3.54, 3.48, 3.43, and 3.31 eV for direct allowed, respectively, while for indirect allowed the amount is 3.65, 3.62, 3.60, 3.57, respectively and 3.54 eV. The energy band gap obtained decreases with increasing ripening temperature and increasing the doping percentage of aluminum, fluorine, and indium [18, 19].

Activation Energy

Activation energy can be obtained from the slope of the straight line $\ln(\alpha)$ versus photon energy ($h\nu$). The value of $\ln(\alpha)$ is obtained from the equation.

$$\alpha(\nu) = \alpha_0 \exp\left(\frac{E_f}{E_u}\right) \tag{2}$$

Where $\alpha(\nu)$ = absorption coefficient, α_0 = constant, E_f = photon energy, and E_u = Urbach energy. The values for $\ln(\alpha)$ and the activation energy are shown in Figures 8 and 9.

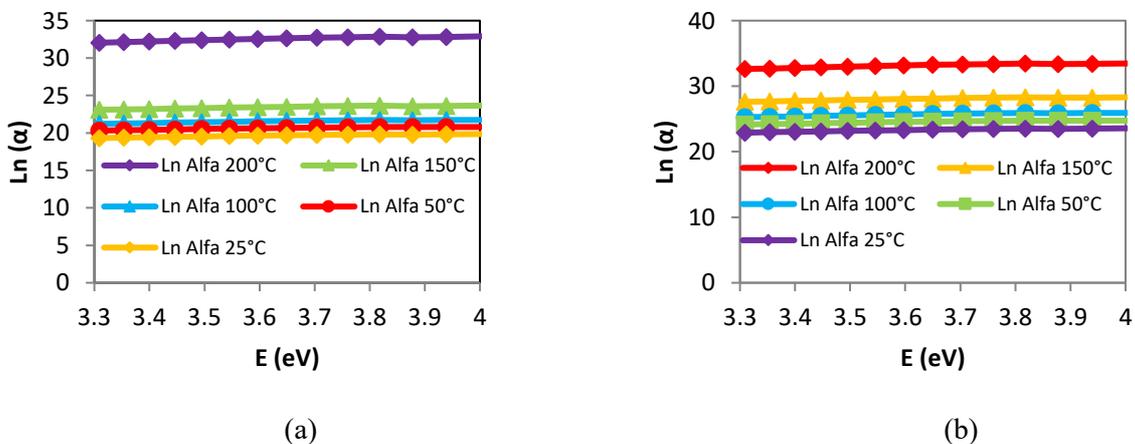


Figure 8. Graph of the relationship between photon energy and $\ln(\alpha)$ of the SnO₂: (Al + F + In) layer variation. (a) 95: 5%, (b) 75: 25%.

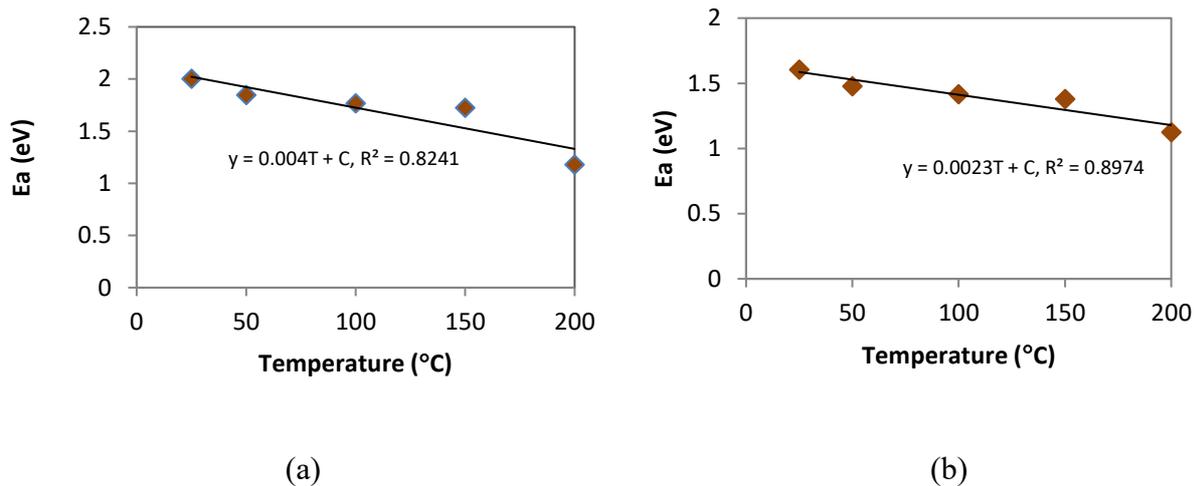


Figure 9. The relationship between temperature variations and the activation energy of the SnO₂: (Al + F + In) thin film. (a) 95: 5%, (b) 75: 25%.

Figure 9 shows that the activation energy for temperature variations of 25, 50, 100, 150 and 200 °C for a percentage of 95: 5% (Figure 9a) is 2.00, 1.84, 1.76, 1.72 and 1.18 eV, respectively, while for a percentage of 75: 25% 1.60, 1.47, 1.41, 1.37, 1.12 eV, respectively. In general, the activation energy decreases with increasing ripening temperature and the doping percentage of aluminum, fluorine, and indium. This shows that the movement of electrons increases so that the transfer of electrons from the valence band to the conduction band increases [20, 21].

Summary

The synthesis of SnO₂: (Al + F + In) thin films has been carried out using the sol-gel spin coating technique. The data obtained from the characteristics of the optical properties include absorbance, transmittance, band gap energy and activation energy. In the ultraviolet area with a wavelength of 300 nm, the absorbance value increases with the increase in ripening temperature and the addition of doping of aluminum, fluorine, and indium, while the transmittance value increases at a wavelength of 350 nm to 800 nm in the area (ultraviolet-visible) as the ripening temperature increases. and increasing amounts of aluminum, fluorine, and indium doping. In general, the absorbance and transmittance values increase with increasing ripening temperature and the addition of doping aluminum, fluorine, and indium, while the bandgap energy and activation energy values obtained decrease with increasing ripening temperature and increasing the doping percentage of aluminum, fluorine, and indium. This is because the energy possessed by photons is smaller than the energy gap so that it is unable to excite electrons and results in the photons being only transmitted. In addition, the bandgap energy and activation energy obtained decreased with increasing ripening temperature and increasing the doping percentage of aluminum, fluorine, and indium. The decrease in the value of the bandgap energy and the activation energy can make it easier for electrons to move from the valence band to the conduction band so that the material is slightly conductive and acts as a semiconductor.

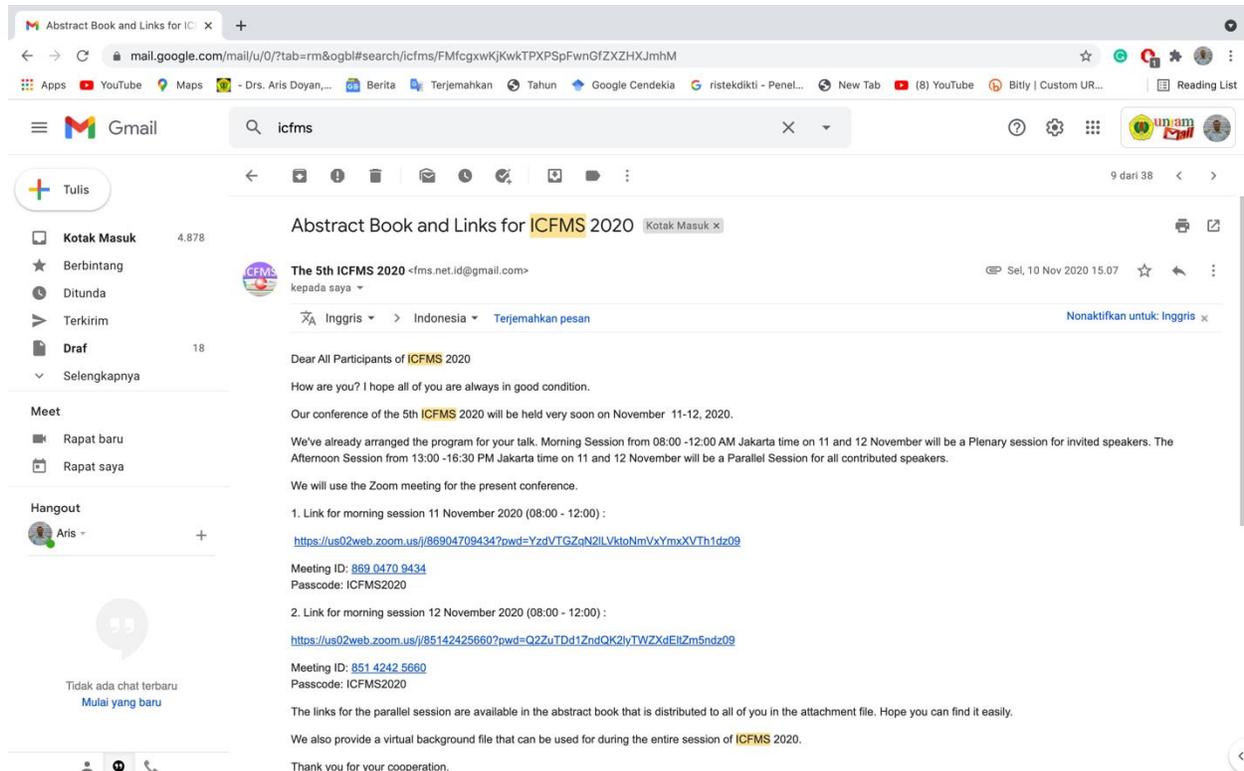
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Dear All Participants of **ICFMS 2020**

How are you? I hope all of you are always in good condition.

Our conference of the 5th **ICFMS 2020** will be held very soon on November 11-12, 2020.

We've already arranged the program for your talk. Morning Session from 08:00 -12:00 AM Jakarta time on 11 and 12 November will be a Plenary session for invited speakers. The Afternoon Session from 13:00 -16:30 PM Jakarta time on 11 and 12 November will be a Parallel Session for all contributed speakers.

We will use the Zoom meeting for the present conference.

1. Link for morning session 11 November 2020 (08:00 - 12:00):
<https://us02web.zoom.us/j/86904709434?pwd=VzdVTGZqN2lVktNmVxYmxXVTh1dz09>
 Meeting ID: **869 0470 9434**
 Passcode: ICFMS2020

2. Link for morning session 12 November 2020 (08:00 - 12:00):
<https://us02web.zoom.us/j/85142425660?pwd=Q2ZuTDd1ZndQK2lyTWZkdElkZm5ndz09>
 Meeting ID: **851 4242 5660**
 Passcode: ICFMS2020

The links for the parallel session are available in the abstract book that is distributed to all of you in the attachment file. Hope you can find it easily.

We also provide a virtual background file that can be used for during the entire session of **ICFMS 2020**.

Thank you for your cooperation.

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Our conference of the 5th **ICFMS 2020** will be held very soon on November 11-12, 2020.

We've already arranged the program for your talk. Morning Session from 08:00 -12:00 AM Jakarta time on 11 and 12 November will be a Plenary session for invited speakers. The Afternoon Session from 13:00 -16:30 PM Jakarta time on 11 and 12 November will be a Parallel Session for all contributed speakers.

We will use the Zoom meeting for the present conference.

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Thank you for your cooperation.

See you soon via Zoom soon.

Best regards,

Organizing Committee of the 5th **ICFMS 2020**

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Thank you for your cooperation.
See you soon via Zoom soon.

Best regards,

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Dear Dr. Aris Doyan

Thank you for completing the review papers of the 5th **ICFMS 2020**.
We appreciate your contribution to improve the quality of the papers that we will publish.

Best regards,
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Your paper has been accepted

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Dear Aris Doyan,

Your article «The Effect of Temperature Variations on the Optical Properties of Tin Oxide Film with Doping Aluminum, Fluorine and Indium for Semiconductor Electronic Devices» has been **preliminary accepted** for publication in Key Engineering Materials (KEM) or Materials Science Forum (MSF).

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