

Judul Artikel : The Effect of Dopant Material to Optical Properties: Energy Band Gap Tin Oxide Thin Film

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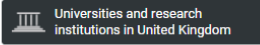
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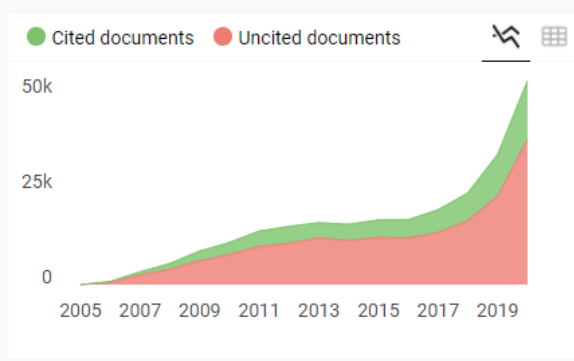
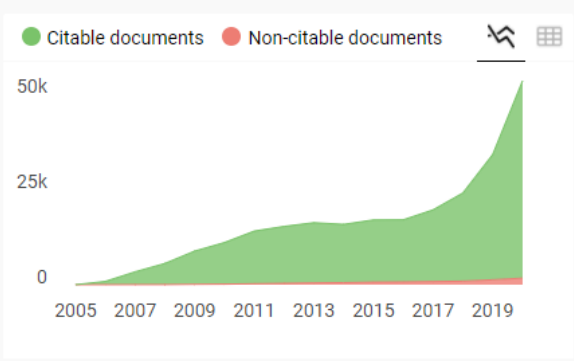
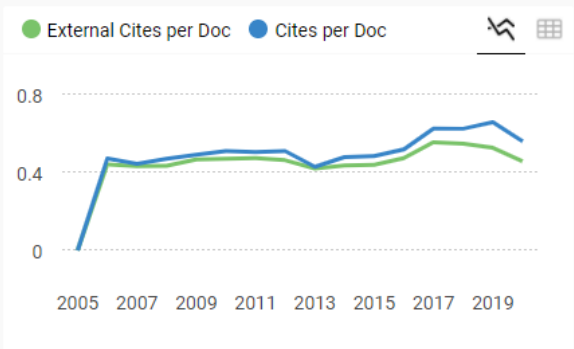
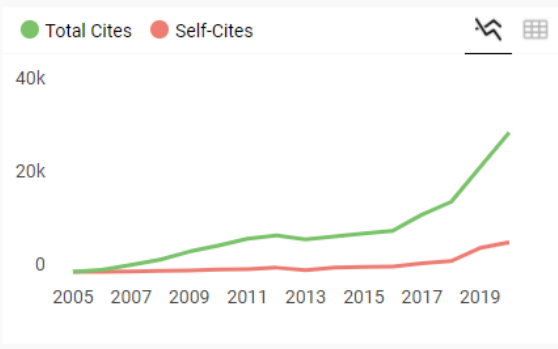
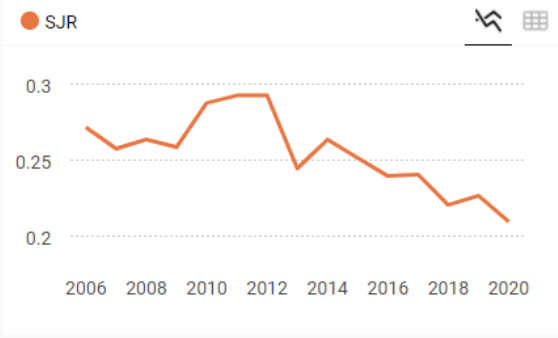
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The effect of dopant material to optical properties: energy band gap Tin Oxide thin film

A Doyan^{1,2}, Susilawati^{1,2}, L Mulyadi¹, S Hakim¹, H Munandar¹ and M Taufik²

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Abstract

The synthesis of the SnO₂ thin film with doped materials of aluminum, fluorin indium, a combination of aluminum and indium, a combination of aluminum and fluorine, an a combination of the three doping agents, namely aluminum, fluorine, and indium have be successfully carried out. The purpose of this synthesis is to determine the effect of the vario doping materials on the resulting bandgap energy value. The thin layer was synthesized usi the sol-gel spin coating technique with the ratio of the base material and doping material us were 95: 5% and 85: 15%. The results showed that the higher the doping materi concentration, the resulting bandgap energy value decreased. In addition, the highest bandg energy value is found in the SnO₂ thin film with indium doping, namely for direct 3.62 eV (9 5% percentage) and 3.59 eV (percentage 85: 15%), while the indirect bandgap energy value 3, 92 eV (percentage 95: 5%) and 3.67 eV (percentage 85: 15%). The lowest energy band g value is found in the SnO₂ thin film with a combination of the three doping aluminum, fluorin and indium, namely for direct 3.50 eV (95: 5% percentage) and 3.41 eV (percentage 85: 15% while the energy band gap value is indirect. namely 3.81 eV (percentage 95: 5%) and 3.55 e (percentage 85: 15%). All the energy band gap range in semiconductor materials.

The effect of dopant material to optical properties: energy band gap Tin Oxide thin film

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Abstract. The synthesis of the SnO₂ thin film with doped materials of aluminum, fluorine, indium, a combination of aluminum and indium, a combination of aluminum and fluorine, and a combination of the three doping agents, namely aluminum, fluorine, and indium have been successfully carried out. The purpose of this synthesis is to determine the effect of the various doping materials on the resulting bandgap energy value. The thin layer was synthesized using the sol-gel spin coating technique with the ratio of the base material and doping material used were 95: 5% and 85: 15%. The results showed that the higher the doping material concentration, the resulting bandgap energy value decreased. In addition, the highest bandgap energy value is found in the SnO₂ thin film with indium doping, namely for direct 3.62 eV (95: 5% percentage) and 3.59 eV (percentage 85: 15%), while the indirect bandgap energy value is 3.92 eV (percentage 95: 5%) and 3.67 eV (percentage 85: 15%). The lowest energy band gap value is found in the SnO₂ thin film with a combination of the three doping aluminum, fluorine, and indium, namely for direct 3.50 eV (95: 5% percentage) and 3.41 eV (percentage 85: 15%), while the energy band gap value is indirect, namely 3.81 eV (percentage 95: 5%) and 3.55 eV (percentage 85: 15%). All the energy band gap range in semiconductor materials.

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1. Introduction

The increase in various types of technology in the industrial era 4.0 is inseparable from the hard work of scientists. This development cannot be denied that the developing technology requires supporting materials such as semiconductor materials. The semiconductor is a material which in certain circumstances acts as an insulator and in other circumstances acts as a conductor [1]. One of the materials used as a semiconductor is SnO₂.

Tin oxide (SnO₂) is a semiconductor material that is unique with an energy bandgap of about 3.6 eV and is sensitive to the presence of surrounding gases [2]. Based on these properties SnO₂ is widely applied to diodes [3], transistors [4], liquid crystal displays [5], capacitors [6], solar cells [7], gas sensors [8], and other optoelectronic devices [9]. This shows that the role of SnO₂ as a semiconductor material is very much.

The nature of SnO₂ itself can be substituted or added to other elements to change the properties according to needs. SnO₂ is usually added to other elements such as fluorine [10], aluminum [11],



indium [12], antimony [13], and zinc [14]. Also, SnO_2 can be doped with a combination of antimony and zinc [15], a combination of aluminum and zinc [16], a combination of aluminum and indium [17], and a combination of aluminum and fluorine [18].

This study aims to determine the optical properties of the SnO_2 thin layer doping with aluminum, fluorine, indium, a mixture of aluminum and indium, a mixture of aluminum and fluorine, and the three doping mixtures, namely aluminum, fluorine, and indium. The optical property referred to in this study is the energy bandgap. With the addition of various types of doping, it is hoped that the bandgap energy produced by the thin layer will decrease or be less than 3.6 eV.

2. Method

The stages of this research include two processes, namely synthesis, and characterization. The synthesis process starts from the preparation of the glass substrate, the manufacture of sol-gel, coating the glass substrate with a sol-gel solution for coating growth, and finally the heating process. The second process is the characterization of thin films using thermoscientific Uv-Vis to obtain the optical properties of the coating. The SnO_2 thin film was synthesized using a sol-gel spin coating technique with doping materials for aluminum, fluorine, indium, a combination of aluminum and indium, a combination of aluminum and fluorine, and a combination of the three doping agents, namely aluminum, fluorine, and indium. The ratio of basic ingredients and doping materials used is 95: 5% and 85: 15%. The sol-gel material that has adhered to the glass surface is then heated for 60 minutes using a furnace at a temperature of 150 °C [19]. The finished sample was then characterized to obtain a thin layer optical value, namely the bandgap energy.

3. Result and Discussion

The synthesis of the SnO_2 thin film with dopants, namely aluminum, fluorine, indium, a combination of aluminum and indium, a combination of aluminum and fluorine, and the combination of the three aluminum, fluorine, and indium dopants produces a transparent film. The higher the number of dopants, the higher the level of transparency that is formed. Figures 1 and 2 show a thin film of SnO_2 for various types of dopant materials.

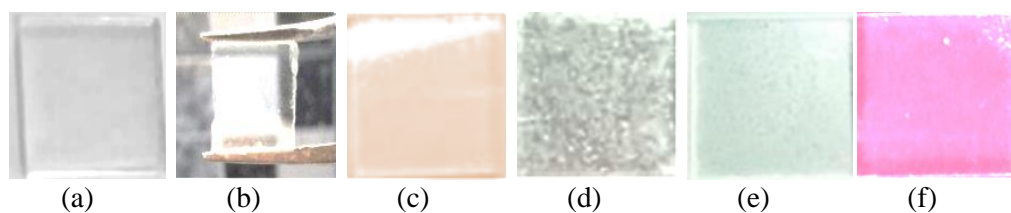


Figure 1. SnO_2 thin film: dopant material (95:5%). (a) SnO_2 :In, (b) SnO_2 :Al, (c) SnO_2 :F, (d) SnO_2 :(Al+In), (e) SnO_2 :(Al+F), (e) SnO_2 :(Al+F+In).

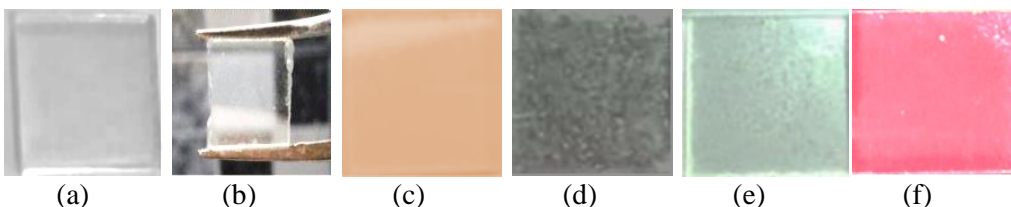


Figure 2. SnO_2 thin film: dopant material (85:15%). (a) SnO_2 :In, (b) SnO_2 :Al, (c) SnO_2 :F, (d) SnO_2 :(Al+In), (e) SnO_2 :(Al+F), (e) SnO_2 :(Al+F+In).

The optical properties of thin films obtained from the characterization results include absorbance and transmittance. The absorbance value is used to obtain the energy band gap value. The energy

value of the thin film bandgap is classified into two, namely the direct energy bandgap and the indirect energy bandgap. The energy gap value is obtained through equation 1 [20].

$$\alpha(h\nu)h\nu = C(h\nu - E_g)^m \tag{1}$$

Note: α is the absorbance coefficient, $h\nu$ is the incident energy of the photons, C is the constant, $m = 1/2$ for direct band-gap energy, and $m = 2$ for indirect band-gap energy.

The method of graphing the relationship between $(\alpha h\nu)^m$ photon energy can also be used to determine the energy value of the bandgap. Based on equation 1, the bandgap energy is obtained as shown in Figure 3, Figure 4, Figure 5, and Figure 6.

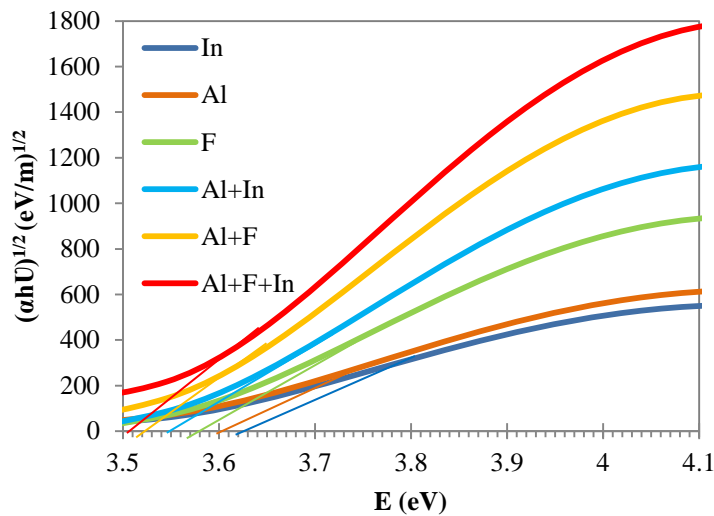


Figure 3. The energy band gap direct allowed a thin film of SnO₂ with a variety of dopant materials (95: 5%).

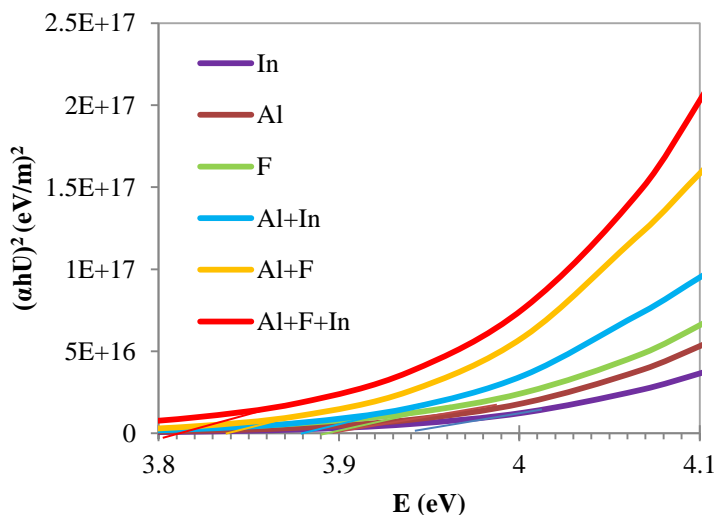


Figure 4. The energy band gap indirect allowed a thin film of SnO₂ with a variety of dopant materials (95: 5%).

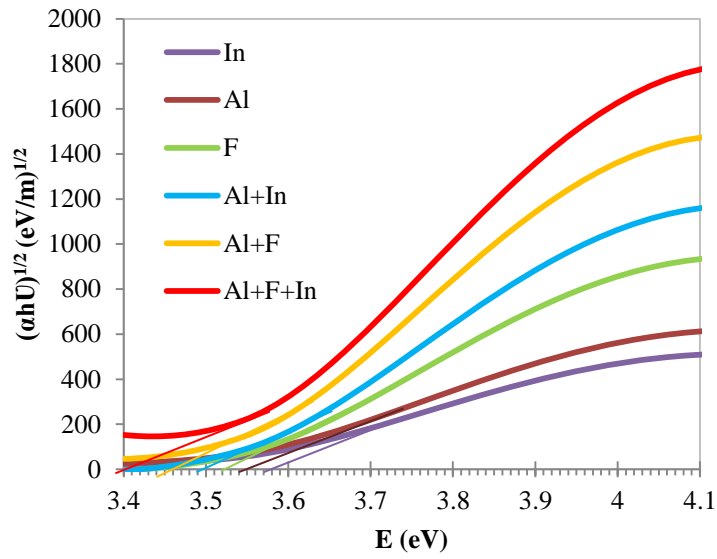


Figure 5. The energy band gap direct allowed a thin film of SnO₂ with a variety of dopant materials (85: 15%).

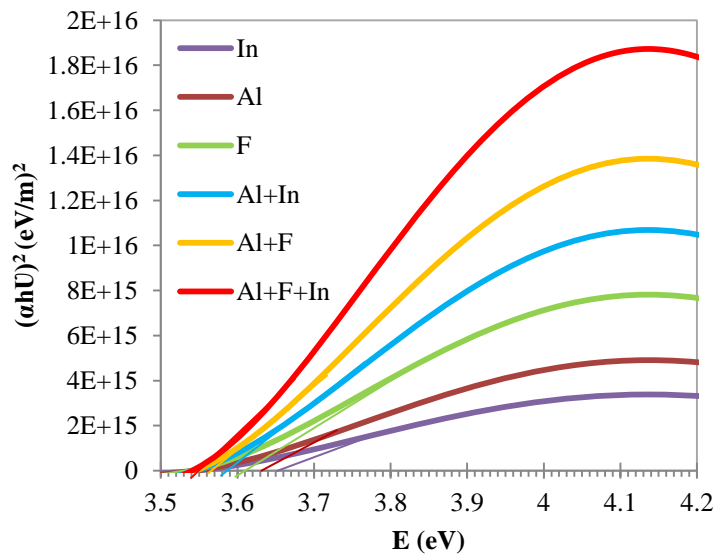


Figure 6. The energy band gap indirect allowed a thin film of SnO₂ with a variety of dopant materials (85: 15%).

The energy band gap values of direct allowed and indirect allowed are shown in Figure 7 and Figure 8.

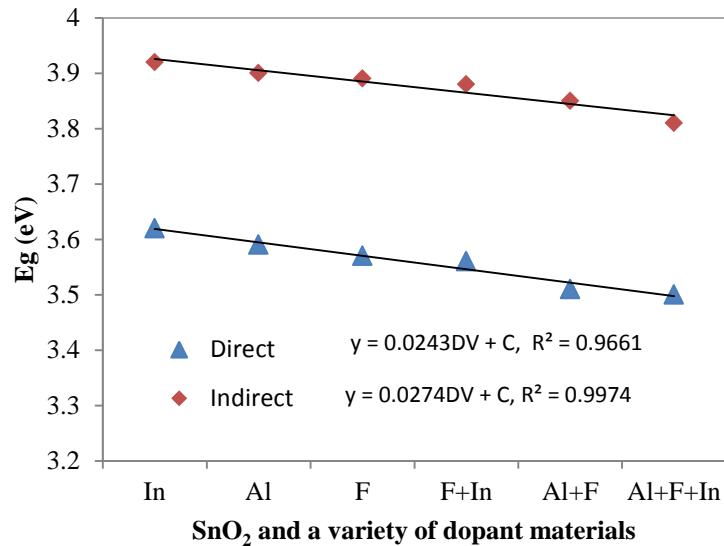


Figure 7. Graph of energy band gap direct and indirect allowed a thin film of SnO_2 variation of dopant material (95: 5%).

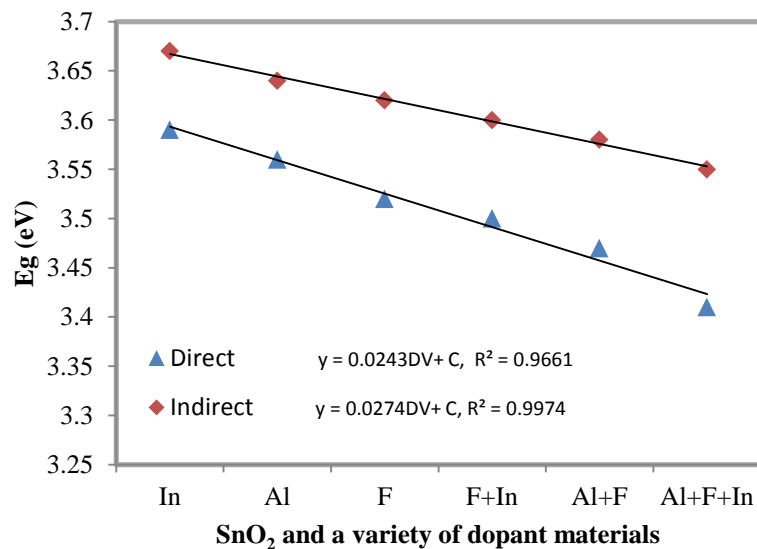


Figure 8. Graph of energy band gap direct and indirect allowed a thin film of SnO_2 variation of dopant material (85: 15%).

Figures 7 and 8 show the bandgap energy values for the dopant material variations. The energy value of the dopant bandgap for aluminum, fluorine, indium, a combination of aluminum and indium, a combination of aluminum and fluorine, and a combination of aluminum, fluorine, and indium dopants for a percentage of 95: 5%, respectively 3.62; 3.59; 3.57; 3.56; 3.51; and 3.50 eV for direct allowed, while for indirect allowed respectively 3.92; 3.90; 3.89; 3.88; 3.85; and 3.81 eV.

Energy band gap for the percentage of 75: 25% respectively 3.59; 3.56; 3.52; 3.50; 3.47 and 3.41 eV for direct allowed, while for indirect allowed respectively 3.67; 3.64; 3.62; 3.60; 3.58; and 3.55 eV. This shows that the higher the dopant material concentration, the resulting bandgap energy value decreases. Also, the highest bandgap energy value was found in the SnO₂ thin film with indium dopant, while the lowest bandgap energy value was found in the SnO₂ thin film with a combination of the three dopants, namely aluminum, fluorine, and indium.

This reduction in the energy bandgap is due to the presence of Indium in the SnO₂ structure which induces the formation of new recombination centers with lower emission energies [21]. Also, the presence of fluorine dopants causes the bandwidth built up by localization conditions in each film to be greater [22]. The decrease in the energy band gap value is also influenced by the presence of aluminum in the SnO₂ structure. This is because aluminum is a type of metal that is a good conductor of electricity [23]. The smaller the bandgap energy value possessed by the thin film, the easier it will be for electrons to move from the valence band to the conduction band [24, 25]. This results in the quality of a film being better used as a semiconductor material [26, 27, 28].

4. Conclusion

The optical properties of the SnO₂ thin film of various dopant materials for aluminum, fluorine, indium, a combination of aluminum and indium, a combination of aluminum and fluorine, and a combination of the three dopants namely aluminum, fluorine, and indium have been successfully carried out. The results showed that the higher the dopant concentration, the resulting bandgap energy value decreased. In addition, the highest bandgap energy value is found in the SnO₂ thin film with indium dopant, namely for direct 3.62 eV (95: 5% percentage) and 3.59 eV (percentage 85: 15%), while the indirect bandgap energy value is 3, 92 eV (percentage 95: 5%) and 3.67 eV (percentage 85: 15%). The lowest energy band gap value is found in the SnO₂ thin film with a combination of the three dopants, namely aluminum, fluorine, and indium, namely for direct 3.50 eV (95: 5% percentage) and 3.41 eV (percentage 85: 15%), while the energy band gap value indirect, namely 3.81 eV (percentage 95: 5%) and 3.55 eV (percentage 85: 15%). This shows that the three doping mixtures, namely aluminum, fluorine and indium, are very well used to produce a thin layer with a small bandgap energy.

Acknowledgments

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Drs. Aris Doyan, Ph.D.
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Letter of Invitation (LoI)

No: 11/committee/ICTAP /2020

Author (s) : A. Doyan, Susilawati, M. Taufik, L. Mulyadi

Dear Dr. Aris Doyan,

On behalf of the 10th ICTAP & SFN XXXIII Committee, I would like to thank you for submitting your full paper. This conference will hold virtually on November 20th – 22nd, 2020; therefore, I am pleased to inform you that your initial article entitled “**The Effect of Dopant Material to Optical Properties: Energy Band Gap Tin Oxide Thin Film**” is accepted to be presented at this conference as **invited speaker**.

This Letter of Acceptance is for your presentation only. Your paper will be reviewed before publication and assigned to its appropriate platform by the board of reviewers. For this purpose, the final revision of your article must include any suggestions during your presentation and the review results.

Thank you for participating in the 10th ICTAP & SFN XXXIII. Kindly read the following important information about your participation in the conference on our website <http://ictap.unram.ac.id>. We are looking forward to seeing you at this conference.

Mataram, November 06th, 2020

Sincerely,



Aris Doyan, Ph.D

Chairman of ICTAP & SFN 2020





Letter of Acceptance (LoA)

No: 09/committee/ICTAP /2020

Dear Dr. Aris Doyan,

It's my pleasure to inform you that we have **ACCEPTED** your paper as **invited speaker**:

Title : The Effect of Dopant Material to Optical Properties: Energy Band Gap Tin Oxide Thin Film

Authors : A. Doyan, Susilawati, M. Taufik, L. Mulyadi

on ICTAP and SFN 2020. In order to fit into the event, please re-submit your Full Paper in <http://ictap.unram.ac.id/full-paper-submission/> before 20th October 2020. Be sure you have been paid conference registration fee (include publication fee) for **IDR 1.750.000,-** before 20th October 2020 through the Account Committee:

Bank Name: BANK MANDIRI

Account Name: NI NYM SRI PUTU VERAWATI

Account Number: 1610005918078

Please submit/share your proof payment transfer to WhatsApp no 081224774718 (Aris Doyan) or 081805255663 (Ni Nyoman Sri Putu Verawati) for the payment confirmation.

We also want to inform you that the conference was held by teleconference in 20th-22nd November 2020, because of the COVID-19 situation. For more information, please visit ictap.unram.ac.id. Also, please do not hesitate to contact me if you have any questions.

Mataram, October 06th, 2020

Sincerely,

Aris Doyan, Ph.D

Chairman of ICTAP and SFN 2020





Payment Confirmation Receipt

No: 113

To :

A. Doyan, Susilawati, M. Taufik, L. Mulyadi

aris_doyan@unram.ac.id

The organizing committee of 10th International Conference of Theoretical and Applied Physics (ICTAP) and Simposium Fisika Nasional XXXIII (SFN) has received the payment:

From : Aris Doyan
No IR : 003 Invited Speaker
Affiliation : Universitas Mataram
Country : Indonesia
Amount : Rp. 2.000.000,-
For : Registration fee of ICTAP and SFN 2020

Date of Payment Accepted : November 05th, 2020

Date of Payment confirmation receipt : November 08th, 2020

We sincerely appreciate and thank you for the payment.

Cordially yours,



Ni Nyoman Sri Putu Verawati, M.Pd

10th ICTAP and SFN XXXIII Committee

University of Mataram

Registration from Mr doyan (aris_doyan@unram.ac.id) Kotak Masuk x

Registration ICTAP & SFN 2020 <ictap_sfn2020@unram.ac.id>
 kepada ictap_sfn2020, saya ▾ Sel, 29 Sep 2020 17.54 ☆ ↶ ⋮

Inggris ▾ > Indonesia ▾ [Terjemahkan pesan](#) Nonaktifkan untuk: Inggris x

Thank You for Registered to **ICTAP** and SFN 2020

Registration Summary:
E-mail
aris_doyan@unram.ac.id

Mr/Mrs/Ms
 Mr

First Name
 aris

Last Name
 doyan

Date of Birth
 1967-11-15

Phone
 +6281224774718

Organization/Department/University

Reminder for sending PPT File Kotak Masuk x

ictap Conference2020 <ictap_sfn2020@unram.ac.id>
 kepada Suryajaya, Hiden, saya, azlian, Rahadi, nazarudin, yusmawati, titis_pfis, Edy, rifai.hamdi ▾ Rab, 11 Nov 2020 01.17 ☆ ↶ ⋮

Inggris ▾ > Indonesia ▾ [Terjemahkan pesan](#) Nonaktifkan untuk: Inggris x

Dear Author(s) of **ICTAP & SFN 2020**

Thank You very much for your participation in the 10th **ICTAP & SFN XXXIII**. To do so, we would like to remind you to send your PPT file through <http://ictap.unram.ac.id/power-point-presentation-submission/> for your presentation in Parallel Session of the 10th **ICTAP & SFN XXXIII** as an invited speaker. **Each invited presenter has 15 minutes to present your research and 5 minutes to discuss.**

Please submit the ppt file no later than November 18th, 2020.

We hope you can attend the online conference of 10th **ICTAP & SFN XXXIII** held on November 20-21, 2020.

We are looking forward to seeing you at this conference.

Best Regards,
Aris Doyan, Ph.D
 Chairman of **ICTAP & SFN 2020**

Virus-free. www.avast.com

[Thank you for the information.](#) [I will send it soon.](#) [Noted with thanks.](#)

⏪ Balas ⏩ Balas ke semua 📎 Teruskan