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ICSGTEIS

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CONFERENCE PROCEEDING

Smart Green Technology for Sustainable Living

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BALI - INDONESIA

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2018 International Conference on Smart Green Technology in Electrical and Information Systems (ICSGTEIS)

WELCOME MESSAGE

As the General Chair of the 2018 International Conference on Smart Green Technology in Electrical and Information Systems (ICSGTEIS), it is my great pleasure to welcome you to the conference held in Kuta Bali of Indonesia. The ICSGTEIS 2018 conference aims to provide a forum for international researchers, experts, and students to share, exchange ideas, innovation, and experience of the research in the field of Smart-Green Technology. The conference provides an opportunity to strengthen collaboration and networking among participants while enjoying a religious atmosphere and traditional culture of Bali.

The ICSGTEIS covers a number of topics organized into tracks such as Energy and Power Engineering, Electronic Devices and Systems, Multimedia Telecommunications, and Software Engineering and Information Systems. All accepted papers are selected through a peer review process. The committee has received 110 submissions, and 43 papers are selected for presentation. In addition to the technical sessions, the conference program also includes plenary lectures and social event.

I would like to take this opportunity to thank the keynote speakers: Professor Jean-Marie BONNIN from *Institut Mines Télécom* France, Dr Tania Urmee from School of Engineering and Information Technology Murdoch University, Perth, Australia, and Associate Professor Wei-Chung Teng from Department of Computer Science and Information Engineering, National Taiwan University of Science and Technology, Taiwan for sharing their latest research in their respected fields within electrical and information systems.

I would also like to express my appreciation to Professor AAR Sudewi as Rector Udayana University, Professor NG Antara as Vice Rector Udayana University for Academic Affairs, Professor NPG Suardana as Dean Faculty of Engineering, Dr IBG Manuaba as Head of Department of Electrical Engineering, Dr Linawati as Head of Postgraduate Program in Electrical Engineering, Faculty of Engineering, Udayana University who have supported the ICSGTEIS conference this year. I also would like to thank Professor FY Zulkifli as Chair of IEEE Indonesia Section for their continuous support to the conference. Many thanks also go to the Technical Program Committee and the Organizing Committee, Center for Community Based Renewable Energy (CORE) Udayana University, Udayana Center for Learning Innovation in Asia Pacific (UCLEAP), and IEEE Student Branch Udayana University. Last but not least, thanks to all Presenters and Authors who have chosen ICSGTEIS 2018 to publish their research findings which without their participation this conference would not be possible.

I wish you all to have a great time and a successful conference while sampling the hospitality of Bali.

Dr I Nyoman Satya Kumara, MIEEE
General Chair of ICSGTEIS 2018

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The Optical Band Gap Based on K-M Function on Layer of $LiTaO_3$ with Variation Treatment of Annealing Temperature

Nani Djohan
Dept. of Electrical Engineering
Krida Wacana Christian University
Jakarta, Indonesia
nani.djohan@ukrida.ac.id

Nina Sevani
Dept. of Information Technology Krida Wacana Christian University
Jakarta, Indonesia
nina.sevani@ukrida.ac.id

Richie Estrada
Dept. of Electrical Engineering
Krida Wacana Christian University
Jakarta, Indonesia
ichie.estrada@ukrida.ac.id

Hendradi Hardhienata
Dept of Physics
Bogor Agricultural University
Bogor, Indonesia
hendradi_h@yahoo.com

Irzaman
Dept. of Physics
Bogor Agricultural University
Bogor, Indonesia
irzaman@apps.ipb.ac.id

***Abstract*—The thin layer made from the material of $LiTaO_3$ on a P-type silicon wafer has been produced by using Chemical Solution Deposition (CSD) technique. In this study, the thin films have been annealed with thermal differences in the furnace (Nabertherm B410) for 15 hours at a temperature of 750°C, 800°C, and 850°C. The reflectance data related to the characteristic of thin films have been measured by using deuterium-halogen light sources (Ocean Optics DH-2000-BAL) and spectrometer (Ocean Optics USB4000-UV-VIS) in the wavelength that ranges between 230-850 nm. The K-M (Kubelka-Munk) function is applied to estimate the optical band gap value referred to the reflectance data and photon energy. The result of this study shows that the optical band gap of $LiTaO_3$ material on P-type silicon wafers are having a sensitivity shift in accordance with the increment of temperature. Based on the result of optical band gap values related to light spectrum, it is concluded that the thin films have the potential to be applied as a sensor with sensitivity to the ultraviolet and visible region.**

Keywords*—*$LiTaO_3$, CSD, temperature, K-M function, optical band gap

I. INTRODUCTION

Atom is the smallest fraction of an element structured from proton, neutron, and electron [1]. In the crystalline structure, the atoms or groups of atoms are uniquely composed in a three-dimensional pattern that is very ordered [2, 3]. The smallest repeating pattern that represents the atomic lattice in the crystalline structure is called a unit cell [2]. According to the experimental study of optical materials, the presence of light can lead to a number of phenomena referring to the recombination process of electron-hole pairs (motion of electrons) in the lattice [4].

The optical properties of materials can be characterized from the interaction with visible light particles or electromagnetic radiation (called photons) [5, 6, 7]. More importantly, the interaction of photons in the crystalline structure of a material can affect the motion of electrons that are capable of generating a number of phenomena related to absorption, refraction, and transmission intensities [5, 7]. In addition, the classification of a group of materials (metal, insulator, and semiconductor) can be determined from the behavior of electrons (excitation and transfer) based on band gap which is expressed in terms of electron volts (eV) [8, 9, 10].

Absorbance, reflectance, and transmittance are the basic measurements used for investigating the properties of materials regarding the interaction of photons on the surface area [5, 7, 11]. In this study, the spectral of reflectance from the fabrication of thin films ($LiTaO_3$ on the surface of P-type silicon wafers) were measured by using spectrometer with deuterium-halogen light sources in the regions of 230-850 nm. Furthermore, the K-M (Kubelka-Munk) function is used to estimate the band gap value and identify the sensitivity of light spectrum of a thin film by utilizing the reflectance data (spectral reflectance) [12-17].

II. METHODOLOGY

The preparation was done by shaping the piece of a silicon wafer into an area of 1×1 cm^2, then it was cleaned sequentially using acetone (C_3H_6O), methanol (CH_3OH), and deionized water for 15 minutes in an ultrasonic tub. Moreover, the silicon wafers were dried at room temperature. In this study, the molecular formula of lithium tantalate ($LiTaO_3$) was obtained from the synthesis of lithium acetate ($C_2H_3LiO_2$) and tantalum (v) methoxide ($Ta(OCH_3)_5$) in accordance with the balance of chemical equation:

$$2C_2H_3LiO_2 + 2Ta(OCH_3)_5 + 19O_2 \rightarrow 2LiTaO_3 + 14CO_2 + \ldots \\ \ldots + 18H_2O \qquad (1)$$

According to (1) and the molarity of chemical reaction organized at 1 M, composite of the mass of $C_2H_3LiO_2$ (0.16496 g) and $Ta(OCH_3)_5$ (0.84030 g) were dissolved in 2.5 ml of 2-methoxyethanol, accompanied with homogenizing the chemical solution for 90 minutes by using an ultrasonic device. For the further summary, Fig. 1 shows the sequential scheme that is involved in this methodology related to fabrication and measurement of thin films made from the layer of $LiTaO_3$ on the surface of P-type silicon wafer.

Based on Fig. 1, the coating process of $LiTaO_3$ on a silicon wafer (see Fig. 2) was taken place by referring to the Chemical Solution Deposition (CSD) technique, i.e. dripping the solution on the surface of a silicon wafer and spinning it on the rotating disc (spin coater device) at a speed of 4000 rpm for 30 seconds. The fabrication of thin films was terminated by heating the $LiTaO_3$ material on a P-type silicon wafer in the furnace (Nabertherm B410) at a temperature of 750°C, 800°C, and 850°C for 15 hours [18, 19, 20].

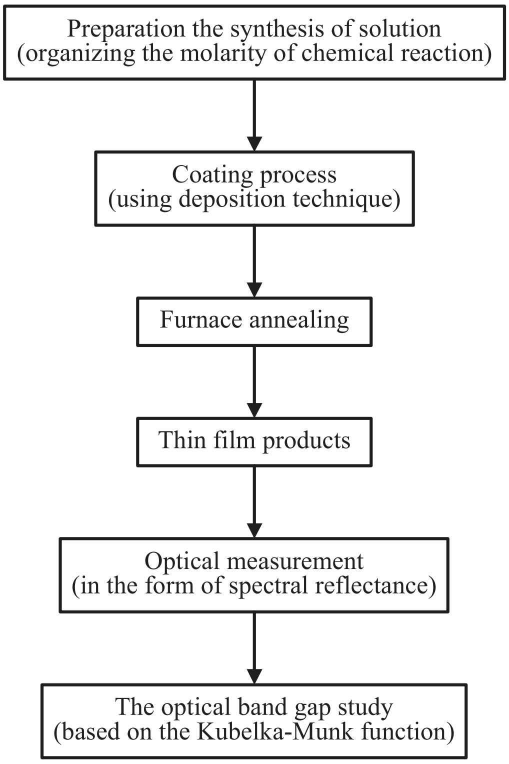


Fig. 1. Schematic of methodology

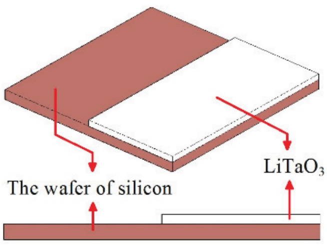


Fig. 2. $LiTaO_3$ on the silicon wafer

To support this study, the devices of deuterium-halogen light sources (Ocean Optics DH-2000-BAL) and spectrometer (Ocean Optics USB4000-UV-VIS) were specifically used to measure the optical characterization of thin films in the form of spectral reflectance in which the wavelength range was between 230 and 850 nm. Based on this measurement, the Kubelka-Munk function was utilized to estimate the optical band gap on each thin film that has been fabricated in this study.

III. Result and Discussion

In this study, the measurement of thin films was displayed in the form of spectral reflectance (Reflectance (%)) as a function of the wavelength of light (see Fig. 3). Based on Fig. 3, the refractive index (n) of thin films can be displayed using the following relation [21]:

$$n = \frac{1 + \sqrt{R}}{1 - \sqrt{R}} \quad (2)$$

with:
R = reflectance value (in the regions of 230-850 nm)

Furthermore, the absorption coefficient and the optical band gap of thin films were obtained from the Kubelka-Munk function which can be expressed as [22, 23]:

$$F(R) = \frac{(1 - R)^2}{2R} \propto \alpha_{K\text{-}M} \quad (3)$$

$$(\alpha_{K\text{-}M}\, h\upsilon)^{1/n} = A\,(h\upsilon - E_g) \quad (4)$$

with:
R = reflectance value (in the regions of 230-850 nm)
A = constant
$h\upsilon$ = the energy of photon (eV)
E_g = the optical band gap (eV)
n = 2 and 0.5 for allowed indirect and direct transition

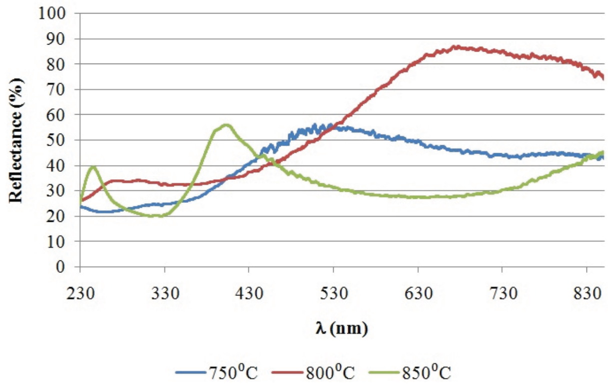


Fig. 3. Spectral of light reflectance

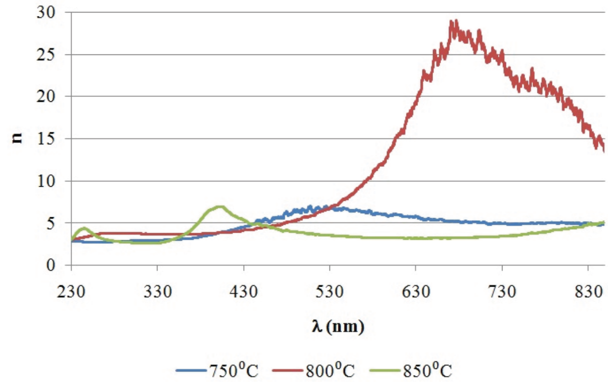


Fig. 4. The refractive index (n) of thin films

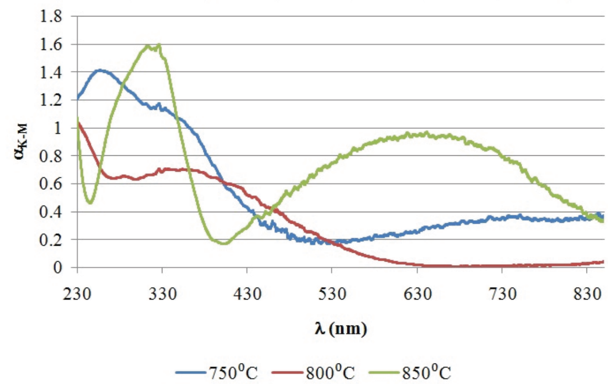
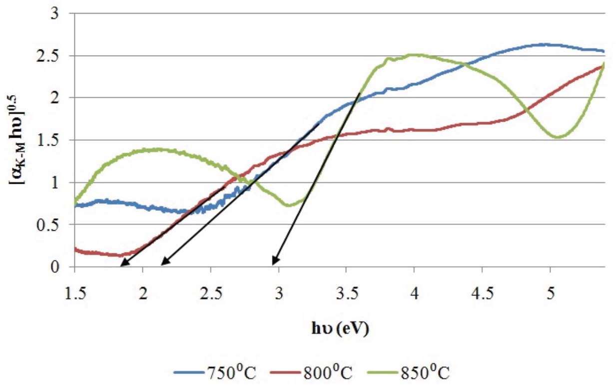


Fig. 5. Spectral of absorption coefficient

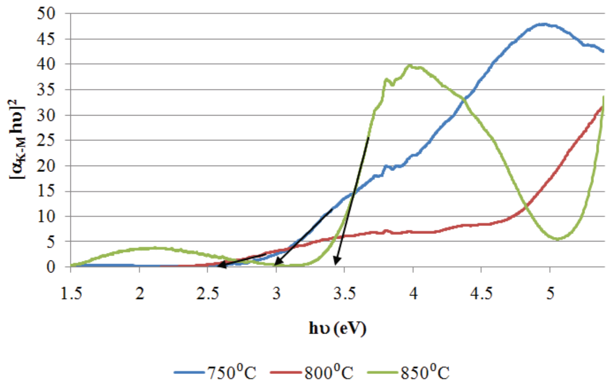
Related to the previous study, the Tauc plot method was used to extrapolate the optical band gap value of thin films by a withdrawing straight line from $(\alpha_{K\text{-}M}\ h\upsilon)^{1/n}$ – hv to the energy axis $(\alpha_{K\text{-}M}\ h\upsilon)^{1/n} = 0$ (see Fig. 6). The estimated values of the optical band gap of thin films were listed in TABLE I. Moreover, the wavelength of each thin film can be discovered through the calculation (listed in TABLE II) using the following equation [9, 19, 22]:

$$\lambda = \frac{h\,c}{(1.602\times10^{-19}\ \mathrm{J})\,(\text{the optical band gap})} \qquad (5)$$

with:
h = Planck's constant (6.626×10^{-34} J·s)
c = speed of light (2.998×10^{8} m·s^{-1})



(a)



(b)

Fig. 6. The optical band gap: (a) indirect transition (b) direct transition

TABLE I. THE OPTICAL BAND GAP OF THIN FILM

Annealing Temperature (°C)	Optical Band Gap (eV)	
	Indirect Transition	Direct Transition
750	2.13	2.97
800	1.83	2.56
850	2.94	3.43

TABLE II. THE WAVELENGTH OF LIGHT OF THIN FILM

Annealing Temperature (°C)	Wavelength of Light (nm)	
	Indirect Transition	Direct Transition
750	583	418
800	678	485
850	422	362

IV. CONCLUSION

In this fabrication, the Chemical Solution Deposition (CSD) technique and annealing process were applied to form the thin layer of $LiTaO_3$ on the surface of P-type silicon wafer. Furthermore, the optical response of the thin layer was identified based on the measurement in the form spectral of light reflectance in the wavelength that ranges between 230 and 850 nm. Then, it was investigated by using the Kubelka-Munk function to obtain the optical band gap values. Based on the result of this study, it is concluded that the thin films have the potential to be applied as a sensor with sensitivity to the ultraviolet and visible region.

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