Available online at www.sciencedirect.com

ScienceDirect

Procedia Environmental Sciences 24 (2015) 329 – 334

Procedia Environmental Sciences

The 1st International Symposium on LAPAN-IPB Satellite for Food Security and Environmental Monitoring

Development of lithium tantallite ($LiTaO_3$) for automatic switch on LAPAN-IPB Satellite infra-red sensor

Agus Ismangil[a,]*, Renan Prasta Jenie[b], Irmansyah[c], Irzaman[c]

[a]*Post Graduate of BioPhysics, Faculty of Mathematics and Natural Sciences, Bogor Agricultural University, Indonesia*
[b]*Post Graduate of Nutrition Community, Faculty of Human Ecology, Bogor Agricultural University, Indonesia*
[c]*Department of Physics, Faculty of Mathematics and Natural Sciences, Bogor Agricultural University, Indonesia*

Abstract

Automatic switch is an automatic electrical device that uses sensor technology to detect movement, or body temperature that was detected in the switch. The sensor uses passive infra-red receiver (PIR) by using lithium tantalite ($LiTaO_3$) that will capture a moment as a response in temperature changes. In this research, we synthesized a thin film of lithium tantalite ($LiTaO_3$) on a substrate silicon p-type. The film was produced by *chemical solution deposition* (*CSD*) and engineering spin coatings with temperature annealing on 550°C, 600°C, 650°C, 700°C, 750°C and 800°C with 3000 rpm in speed for around 30 seconds. The value of high absorbent showed that the $LiTaO_3$ film has a large number of photon energy. This research obtained the energy band-gap film $LiTaO_3$ in the range 3.41-4.56 eV. This result concludes that annealed temperatures affects the optical properties of the $LiTaO_3$ film in the substrate of Si (100) p-type semiconductor. The sensitivity of this high intensity absorbent for energy and high value of band-gap is great and is therefore potential to be used prospectively for the automatic switch sensor on the satellite platform.

Selection and peer-review under responsibility of the LISAT-FSEM Symposium Committee

Keywords: semiconductor; automatic switch sensor; Lapan-IPB Satellite (LISat)

1. Introduction

During this era of technology, people are encouraged to be creative in constructing a simple environmental friendly instrument. An automatic switch device is a tool that helps to automatically switch off electrical equipments

* Corresponding author. Tel.: +62-862-5728; fax: +62-862-5728.
E-mail address: a.ismangil.physics@gmail.com.

Selection and peer-review under responsibility of the LISAT-FSEM Symposium Committee
doi:10.1016/j.proenv.2015.03.043

that uses sensors to detect movement, or body temperature changes. The Sensor employs a PIR (Passive Infra-Red Receiver) by using material of $LiTaO_3$ that possesses a momentary response to changes in body temperature.

Lithium tantalite ($LiTaO_3$) constitutes ferroelectric materials have the nature of piezoelectric and pyro electric. It also has the nature of electro-optic and coefficients which is non-linear optics [2, 4]. $LiTaO_3$ has the constant high dielectrics, and storage capacity for charging [7]. $LiTaO_3$ is crystalline ferroelectric which subjected to the process of temperature Currie higher by (601± 5,5) °C [8].

This research developed a film lithium tantalite ($LiTaO_3$) made using a method of chemical solution deposition (CSD) with coatings technique. Spin excellence this method can control stoichiometric movement with a good quality procedures that are easy to conduct at low temperatures and relatively costly [5,9] Some methods can be used to grow this film such as chemical vapor deposition (CVD), pulse laser ablation deposition (PLAD),solution gelatin (sol-gel), metal organic chemical vapor deposition (MOCVD) and sputtering [10, 19]

2. Experimental

An undersized Si (100) substrate that has 1 cm x 1 cm in size must be cleanead by the leaching process and then soaked by deionized water for around 10 minutes and then let it drained. The drained soils substrate placed on a surface of hot plate with 100^{o}C in temperature for 1 hour. A film was made by the $LiTaO_3$ powder (tantalum oxide of lithium acetic) and 2.5 ml dissolved 2-metoxiethanol [18]. After that, grow this $LiTaO_3$ film on the surface of reactor using CSD spin coater methods at the speed of 3000 rpm [9, 11]. The development of $LiTaO_3$ film as follows: the cleared substrate laid on the surface record spin reactor coater then closed 1/3 spare-parts with adhesive. Part 2/3 substratum solution $LiTaO_3$ by one drop with 3 times test every 30 seconds. After that, the substrate was heated on a hot plate to evaporate the fluid [6, 16]

The process of annealing aims to diffuse $LiTaO_3$ solution to the silicon substrate. The process of annealing was done gradually useing 3-130 Vulcanite ™ furnace [20]. Warming starts from room temperature and then raised gradually to the desired temperature annealing such as 550^{o}C, 600^{o}C, 650^{o}C, 700^{o}C, 750^{o}C and 800^{o}C for eight hours. $LiTaO_3$ The thickness of the film after the annealing process were then calculated with the volumetric methods [13]. the next process is making contact on 1 mm x 1 mm film using aluminum 99.99 %. Then the installation of copper wire smooth uses a paste of silver on contact. Characterization optical properties is done by using spectrophotometer UV-Vis ocean optics USB 1000 [14, 15]

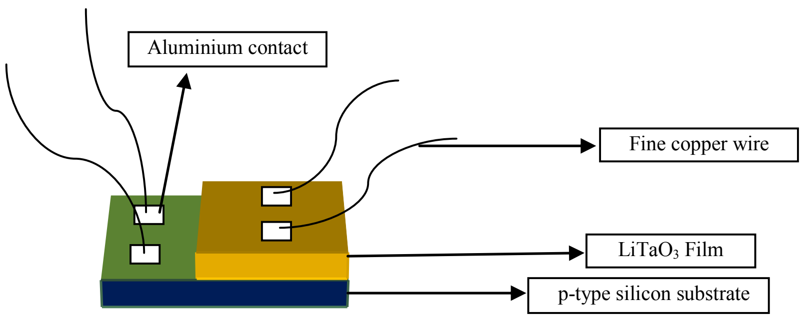

Fig. 1 The design of $LiTaO_3$ ferroelectric

3. Result And Discussion

3.1. The Thickness of Film

The thickness of $LiTaO_3$ film after the annealing process of an annealing is showed in Table 1. The thickness of volumetric film was calculated by the equation (1):

$$d = {m_2 - m_1}/{\rho\ film^{-A}} \quad (1)$$

Table 1 $LiTaO_3$ during the annealing process

No	Sample film Temperature (°C)	Thickness d (cm)
1	550	1.34×10^{-4}
2	600	6.97×10^{-4}
3	650	5.36×10^{-4}
4	700	1.74×10^{-4}
5	750	4.29×10^{-4}
6	800	6.17×10^{-4}

The thickness moves in ranged 1.34-6.97 μm. It is in the same range with the literature that used the same method (1-400 μm) [12].

3.2. The Character of Absorbents

The value of high absorbent shows that the $LiTaO_3$ film absorbs energy of photons and. Figure 1 shows the relationship between absorbance and wave length of $LiTaO_3$ film during the annealing process.

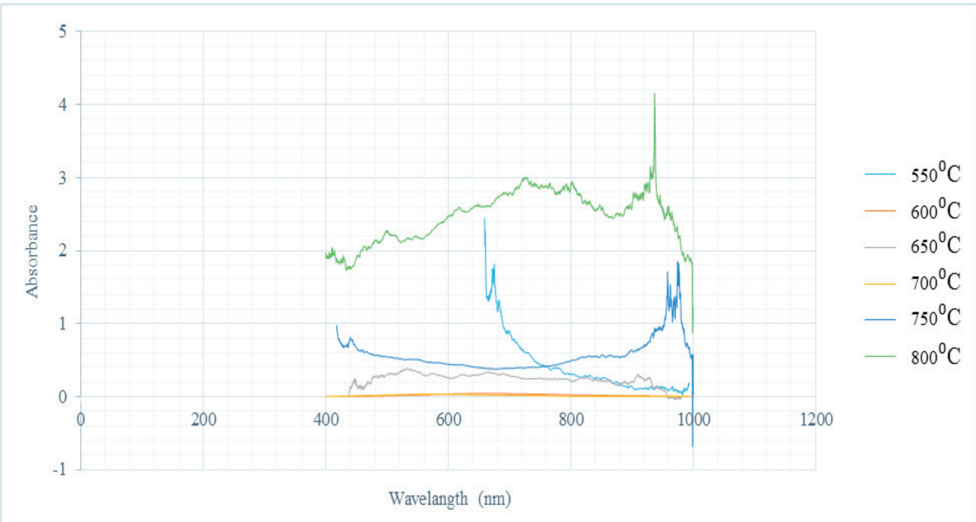

Fig. 2 Absorbance relations and wavelength $LiTaO_3$ film after the annealing process

The absorption of photons by materials could occur by sundry. The process of absorption against wavelength gives the possibility to degrade chemical information in the material through reflected light. The value of high absorbent showed that $LiTaO_3$ film could reach the temperature of 800°C. The absorbent wavelength range is 400-1000 nm. Indigo medium absorbed by $LiTaO_3$ on infra-red wavelengths.

3.3. Reflectance Characterization

The maximum and minimum value of a reflectance produced different layers for each with the annealed thickness according the variations of temperature. Figure3. Showed the wave fluctuation from each annealed-temperature and showed a declining value of the annealed-temperature at 550°C. The lower reflectance can be caused by the size of large granules .The large granules have large internal absorption of photons following the law of beer-Lambert. The higher reflectance value is shown at temperature 500^0C. Reflectant is the opposite of absorbent showed in Figure 3.The relationship between reflectance and wavelength is shown in range 400-1000 nm.

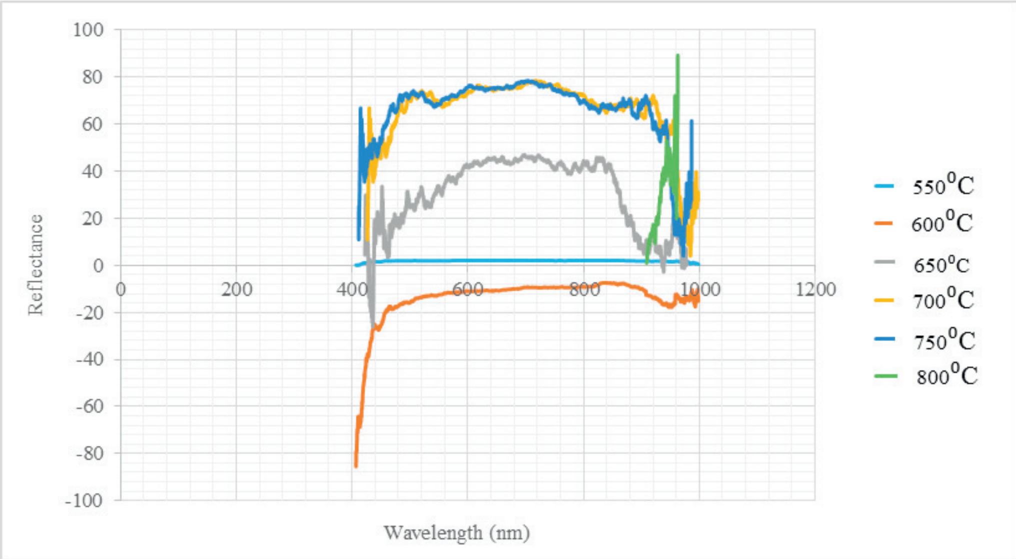

Fig. 3 Reflectance relations and wavelength film-business $LiTaO_3$

3.4. Energy Band-gap

Band-gap energy is able to calculate using a reflectance calculator using following equation (2) [17].

$$2\alpha d = [(R_{max}-R_{min})/(R-R_{min})]^2 \quad (2)$$

Reflectance calculation of band-gap energy was obtained by extrapolating $[\ln(R_{max}-R_{min})/(R-R_{min})]^2$ to 0, with hv in the x-axis and $[\ln(R_{max}-R_{min})/(R-R_{min})]^2$ in the y-axis.

Table 2. Energy *band-gap* $LiTaO_3$

No	Sample film Temperature (°C)	Energy *band-gap* (eV)	*Band-gap* $LiTaO_3$ (eV) [18]
1	550	3.61	4,6
2	600	4.45	
3	650	3.41	
4	700	4.10	
5	750	4.32	
6	800	4.56	

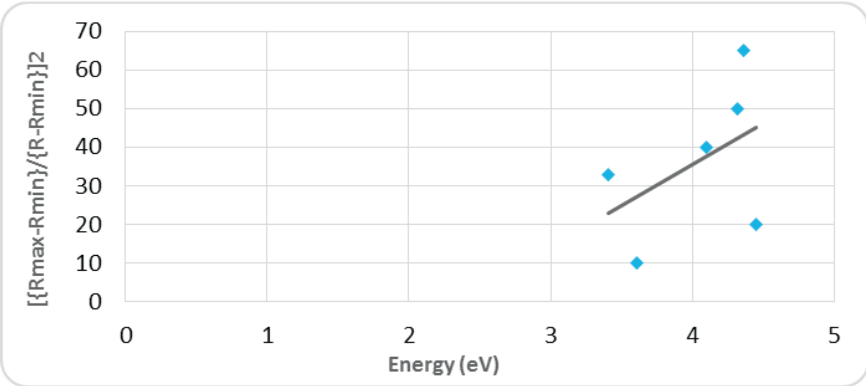

Fig. 4. Energy band-gap film $LiTaO_3$ after the process of annealing

The previous research obtained band-gap value between 3-4.6 eV [18]. while, band-gap energy from $LiTaO_3$ was obtained higher range 3.41-4.56 eV as showed in Table 1. Based on the band-gap energy obtained, $LiTaO_3$ film could be use as a semiconductor (1-6 eV) [20].

Conclusion

Based on the results, this study concludes that temperature annealed affects the optical properties of $LiTaO_3$ film using Si (100) p-type semiconductor substrate. This research obtained the band-gap energy of $LiTaO_3$ film in the range of 3.41-4.56 eV. The sensitivity of this high absorbent obtained high value of energy is great and potential to be used for the automatic switch sensor on the satellite.

Acknowledgements

This work was supported by Incentive Grant of SINAS KMNRT, Republic of Indonesia under contract No. 38/SEK/INSINAS/PPK/I/2014, and National Strategic Research of Directorate General of Higher Education, Ministry of National Education, Republic of Indonesia under contract No. 134/SP2H/PL/Dit.Litabmas/V/2014.

References

1. Wen dong Z, Tan Qiu lin, Liu Jun, Xue Chen yang, Xiong Jijun, Chou Xiujian. Two channel IR gas sensor with two detectors based on $LiTaO_3$ single-crystal wafer. optics & laser technology. *The Journal of Applied Crystallography* 2010; **44**: 158–62.
2. Kostritskii SM, Sevostyanov OG, Bourson P, Aillerie M, Fontana MD, Kip D. Comparative study of composition dependences of photorefractive and related effects in $LiNbO_3$ and $LiTaO_3$ crystal. *Ferroelectrics* 2007; **352**: 61-71.
3. Plehnert C, Norkus V, Mo¨hling S, Hayes A. Reactive ion beam etching of lithium tantalate and its application for pyroelectric infrared detectors. *Surf Coat Technol* 1995; (74 – 75): 932– 6.
4. Gopalan V, Gupta M C. Origin of internal field and visualization of 180° domains in congruent $LiTaO_3$ crystal. *J. Appl. Phys* 80 1996; **11**: 6099-106.
5. Hikam M, Sarwono E, Irzaman. Perhitungan polarisasi spontan dan momen quadrupol potensial listrik bahan PIZT ($PbIn_xZr_yTi_{1-x-y}O_{3-x/2}$). *Makara, Sains* 2004; **8** (3): 108-15.
6. Tao Yan, Feifei Zheng, Yonggui Yu, Shubin Qin, Hong Liu, Jiyang Wang, Dehong Yu. Formation mechanism of black $LiTaO_3$ single crystal through chemical reduction. *J. Appl. Cryst* 2011;**44**: 158-62.
7. Uchino K. . *Ferroelectric Devices*. New York: Marcel Dekker, Inc; 2000
8. Irzaman, Darvina Y, Fuad A, Arifin P, Budiman M, Barmawi M. Physical and pyroelectric properties of tantalum oxide doped lead zirconium titanate [$Pb_{0.9950}(Zr_{0.525}Ti_{0.465}Ta_{0.010})O_3$] thin films and its applications for IR sensor. *Physical Status Solidi (a) Germany* 2003; **199** (3): 416-24.
9. Irzaman, Maddu A, Syafutra H, Ismangil A. Uji konduktivitas listrik dan dielektrik film tipis lithium tantalate ($LiTaO_3$) yang didadah niobium pentaoksida (Nb_2O_5) menggunakan metode chemical solution deposition. Di dalam : *Prosiding seminar nasional fisika*: pp. 175-83; 2010.
10. Effendi H. Konduktor film tebal pada rangkaian hybrid-IC. *Buletin IPT* 1 1996 ;(5-6): 39-43.
11. Bornand V, Huet I, Papet P, Philippot E. LiNbO3 and LiTaO3 thin films deposited by chemical and/or physical processes. *Ann Chim Sci*; 2001; **26**: 49 – 54.

12. Maissel LI, Glang R. Handbook of Thin Film Technology. New York: McGraw-Hill Book Company; 1970
13. Paula Maria Vilarinho, Nathalie Barroca, Sebastian Zlotnik, Pedro Félix, Maria Helena Fernandes. Are lithium niobate ($LiNbO_3$) and lithium tantalate ($LiTaO_3$) ferroelectrics bioactive. *Materials Science and Engineering* 2014: 395-402.
14. Valery V. Afanas'ev. *7 - Silicon–Insulator Interface Barriers. Internal Photoemission Spectroscopy* (Second Edition): pp. 255-299; 2014
15. Hariyanto S, Budianto A, Subarkah, Atmono T. *Penentuan Indeks Bias dan Reflektivitas Lapisan Tipis dengan Metode Serapan Optik.* Di dalam: *pertemuan dan presentasi ilmiah PPNY-BATAN Yogyakarta*; pp. 87-92; 2006.
16. Peng LH, Tseng YP, Lin KL, Huang ZX, Huang CT, Kung AH. *Depolarization Field Mitigated Domain Engineering In Nickel Diffused LithiumTentalate*.Applied Physics Letters 92, 092903; 2008.
17. Kumar V, Sharma SKr, Sharma TP, Singh V. Band gap determination in thick films from reflectance measurements. *Optical Materials* 1999; **12:** 115-9.
18. Cabuk S, Mamedov A. A study of the $LiNbO_3$ and $LiTaO_3$ absorption edge. *Tr. J. of Physics* 1998; **22**: 41-5.
19. Youssef S, Al Amar R, Podlecki J, Sorli B, Foucaran A. Structural and optical characterization of oriented $LiTaO_3$ thin films deposited by sol-gel technique [abstract]. *Eur. Phys. J. Appl. Phys*. 2008; **43** (1): 65-71.
20. Muktavat K, Upadhayaya A K. *Applied Physics*. New Delhi: L.K. International publishing House Pvt. Ltd; 2010.