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

## Development of lithium tantalite ( $\text{LiTaO}_3$ ) for automatic switch on LAPAN-IPB Satellite infra-red sensor

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### Abstract

1 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 ( $\text{LiTaO}_3$ ) that will capture a moment as a response in temperature changes. In this research, we synthesized a thin film of lithium tantalite ( $\text{LiTaO}_3$ ) 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  $\text{LiTaO}_3$  film has a large number of photon energy. This research obtained the energy band-gap film  $\text{LiTaO}_3$  in the range 3.41-4.56 eV. This result concludes that annealed temperatures affects the optical properties of the  $\text{LiTaO}_3$  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.

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**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

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that uses sensors to detect movement, or body temperature changes. The Sensor employs a PIR (Passive Infra-Red Receiver) by using material of  $\text{LiTaO}_3$  that possesses a momentary response to changes in body temperature.

Lithium tantalite ( $\text{LiTaO}_3$ ) 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].  $\text{LiTaO}_3$  has the constant high dielectrics, and storage capacity for charging [7].  $\text{LiTaO}_3$  is crystalline ferroelectric which subjected to the process of temperature Currie higher by  $(601 \pm 5,5)^\circ\text{C}$  [8].

This research developed a film lithium tantalite ( $\text{LiTaO}_3$ ) 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 cleaned 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  $100^\circ\text{C}$  in temperature for 1 hour. A film was made by the  $\text{LiTaO}_3$  powder (tantalum oxide of lithium acetic) and 2.5 ml dissolved 2-metoxiethanol [18]. After that, grow this  $\text{LiTaO}_3$  film on the surface of reactor using CSD spin coater methods at the speed of 3000 rpm [9, 11]. The development of  $\text{LiTaO}_3$  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  $\text{LiTaO}_3$  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  $\text{LiTaO}_3$  solution to the silicon substrate. The process of annealing was done gradually using 3-130 Vulcanite™ furnace [20]. Warming starts from room temperature and then raised gradually to the desired temperature annealing such as  $550^\circ\text{C}$ ,  $600^\circ\text{C}$ ,  $650^\circ\text{C}$ ,  $700^\circ\text{C}$ ,  $750^\circ\text{C}$  and  $800^\circ\text{C}$  for eight hours.  $\text{LiTaO}_3$  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]

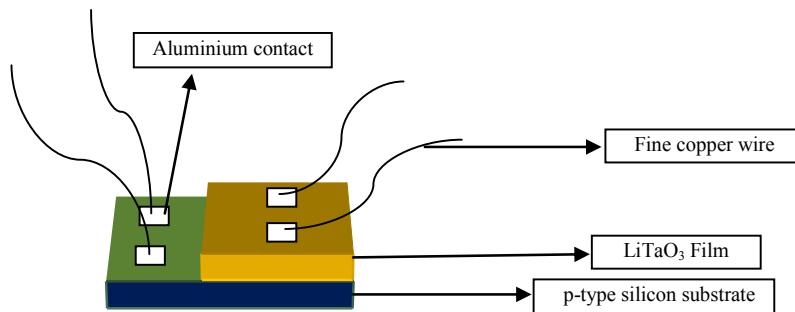


Fig. 1 The design of  $\text{LiTaO}_3$  ferroelectric

## 3. Result And Discussion

### 3.1. The Thickness of Film

The thickness of  $\text{LiTaO}_3$  film after the annealing process of an annealing is showed in Table 1. The thickness of volumetric film was calculated by the equation (1):

$$d = \frac{m_2 - m_1}{\rho \text{ film} \cdot A} \quad (1)$$

Table 1 LiTaO<sub>3</sub> during the annealing process

No	Sample film Temperature (°C)	Thickness d (cm)
1	550	1.34 x 10 <sup>-4</sup>
2	600	6.97 x 10 <sup>-4</sup>
3	650	5.36 x 10 <sup>-4</sup>
4	700	1.74 x 10 <sup>-4</sup>
5	750	4.29 x 10 <sup>-4</sup>
6	800	6.17 x 10 <sup>-4</sup>

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<sub>3</sub> film absorbs energy of photons and. Figure 1 shows the relationship between absorbance and wave length of LiTaO<sub>3</sub> film during the annealing process.

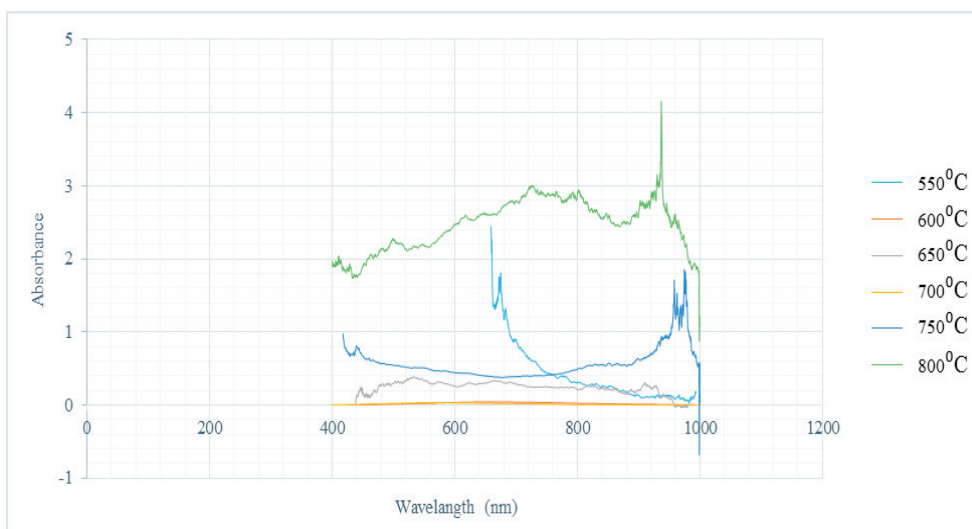


Fig. 2 Absorbance relations and wavelength LiTaO<sub>3</sub> film after the annealing process

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<sub>3</sub> film could reach the temperature of 800°C. The absorbent wavelength range is 400-1000 nm. Indigo medium absorbed by LiTaO<sub>3</sub> 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<sup>0</sup>C. Reflectant is the opposite of absorbent showed in Figure 3. The relationship between reflectance and wavelength is shown in range 400-1000 nm.

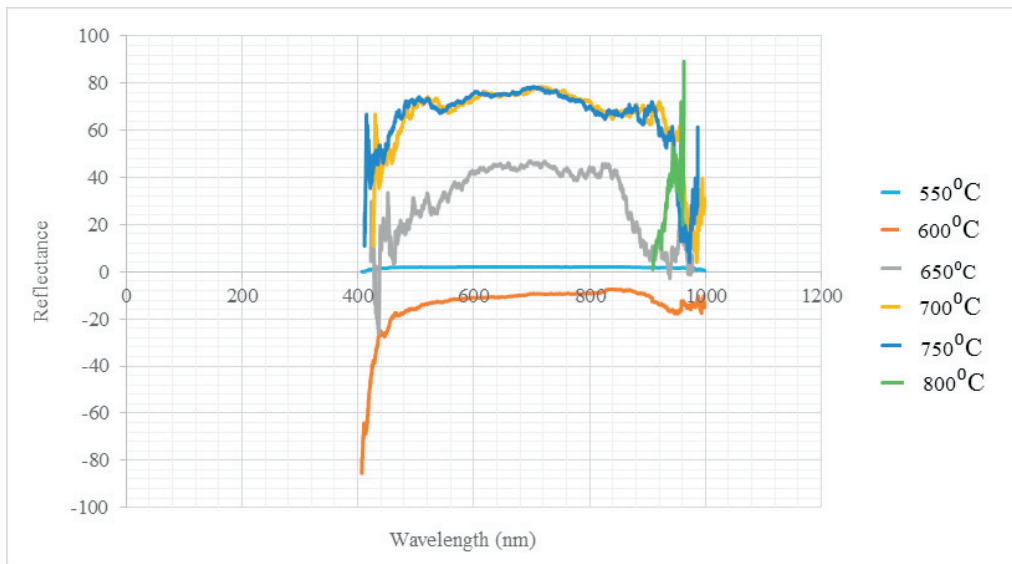


Fig. 3 Reflectance relations and wavelength film-business LiTaO<sub>3</sub>

3.4. Energy Band-gap

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

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

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

Table 2. Energy band-gap LiTaO<sub>3</sub>

No	Sample film Temperature (°C)	Energy band-gap (eV)	Band-gap LiTaO <sub>3</sub> (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	

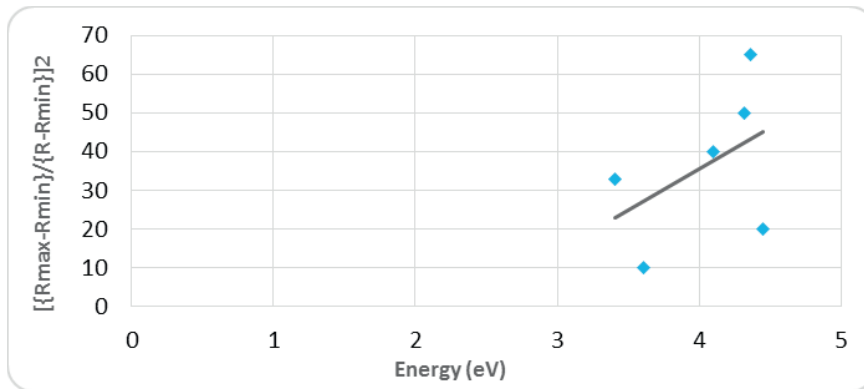


Fig. 4. Energy band-gap film LiTaO<sub>3</sub> after the process of annealing

The previous research obtained band-gap value between 3-4.6 eV [18]. while, band-gap energy from LiTaO<sub>3</sub> was obtained higher range 3.41-4.56 eV as showed in Table 1. Based on the band-gap energy obtained, LiTaO<sub>3</sub> 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<sub>3</sub> film using Si (100) p-type semiconductor substrate. This research obtained the band-gap energy of LiTaO<sub>3</sub> 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.

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