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Study of a silica glass SiO_2-Na_2O refractive index to fabrication of fiber optic with the Brewster method

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Abstract: One of the critical parameters in the fabrication of fiber optic is refractive index value from the fiber optic material. That is because the main requirement phase of critical angle on the fiber optic waveguide is a core refractive index higher than the cladding. Therefore, refractive index values must be calculated first. The research aim is to study refractive index value of fiber optic material on the fiber optic fabrication. Refractive index value determined by using the Brewster method. For this aim, the first step is an establish glass silica to a thin plate. Then thin plate inserts to the sketch of Brewster experiment. The Brewster method has the aim to determine the reflectance value of the light on transfer magnetic (TM) polarization. The Brewster angle determined by searching the minimum reflectance value of the light on this TM polarization. In this research, the Brewster angle obtained by 55.333 degrees. This Brewster angle used to calculate the refractive index value from the fiber optic material glass silica. The result of refractive index value at 1.446.

Keywords: Fiber Optic, Brewster method, Refractive Index

1. Introduction

The communication technology is widely used by humans lately. On progress, that shows many alternatives in the communication media. One of them is the utilization of fiber optic. Fiber optic is the transmission of information as light pulses along with a glass or plastic strand. Fiber optic can transmission of the light signal from the place to another place (Ghatak & Thyagarajan, 1997). Fiber optic is used long-distance and high-performance data networking. Transmission of light signal utilizing optical properties, that is data modulated with wavelength in the fiber optic. So, it produces data distribution quickly and in accordance with consumer expectations. The light signal in the fiber optic difficult to get out because of the refractive index value of fiber optic higher than the refractive index of air. Fiber optic also has resistance to electromagnetic interference (Baek, Jeong, Hak-Rin, Sin-Do, & Lee, 2003).

Fiber optic not only used to a connector in the communication system, but also has been developed to the sensor. Fiber optic for sensors must be made in the particular specification (Yu & Yin, 2002). Because the sensor needs fiber optic that matches the sensors function. The examples of fiber optic sensor are Fiber Bragg Grating (FBG) (Poli, Cucinotta, & Selleri, 2007), Long-Period Fiber Grating (LPG), Fiber Optic

Gyroscopes, etc. (Gaston, 2003). Accordingly, research about fabrication fiber optic with the particular specification has done.
Fabrication of fiber optic from material science involves the fiber optic material characterization, Fabrication, and fiber optic characterization (Maddu, 2007). Discussion in this paper restricted to fiber optic material characterization only. Fiber optic material characterization that is determined the refractive index value with the Brewster method. Refractive index of a material is a dimensionless number that describes how fast light travels through the material. Refractive value of a material influenced by electron density and polarizability, glass density, and thermal expansion (Saito & Kikuchi, 1997).

2. Research Method

The materials used in this research are fiber optic material from the silica glass SiO_2 mixed with Na_2O (Arciniega, 2009). The election of fiber optic material based on the theory that fiber optic will be good if it is made from the transparent material. The fiber optic material shape of the powder. So, first the material is melted and then shaped into a thin plate. After that, thin plate smoothed its surface with the polishing machine tools. It is called the sample of fiber optic material, which as measured optical properties can be seen at figure 1.

Figure 1. Thin plate of the fiber optic material

While, the equipment used in this research are: weighing tool, polish, saw, press, and a set of the Brewster methods (Look at the figure 2).

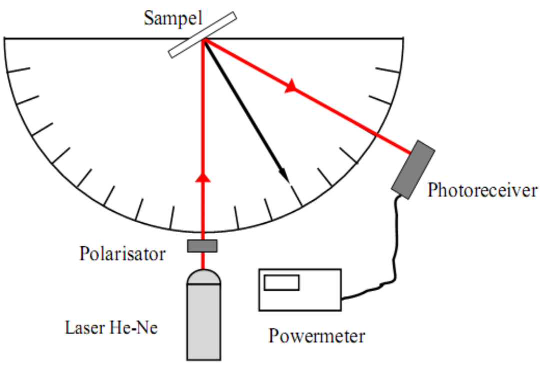

Figure 2. Set of Brewster method

The sample of the fiber optic material then included in a set of Brewster method (Kaercher, Hong, & Mobius). The Brewster method generates data of the reflectance values. Varying angles conducted this research from 10-70 degrees with an increase every 5 degrees. Moreover, This research, too the varying of He-Ne laser position. That are He-Ne laser beam polarized Transfer Magnetic (TM), and He-Ne laser beam polarized Transfer Electric (TE).

For the search of refractive index value, the data were used is the reflectance data at the TM polarized. This data than searching the polarization angle. The polarization angle used to calculate the refractive index the material value. The refractive index value calculates which the Snellius law (Keiser, 2000):

$$\sin\theta_p n_1 = \sin\theta_r n_2 \tag{1}$$

This equation holds if

$$\theta_p + \theta_r = 90^0 \tag{2}$$

$$\theta_r = \left(90^0 - \theta_p\right) \tag{3}$$

Equation (3) submit to equation (1), so

$$\sin\theta_p n_1 = \sin\left(90^0 - \theta_p\right) n_2 \tag{4}$$

$$\sin\theta_p n_1 = \cos\theta_p n_2 \tag{5}$$

With n_1 is refractive index of air ($n_1 = 1$), so

$$n_2 = tg\theta_p \tag{6}$$

n_2 is a refractive index of material, with θ_p is a polarization angle.

3. Results and Discussion

The theory of fiber optic says that the excellent fabrication of fiber optic is the material of fiber optic has the ability to high beam transmission. It is indicated by a small reflectance value, or close to zero. The angle in which the lowest reflectance value is the polarization angle. The polarization angle too called the Brewster angle. Based on this research, the result data obtained can be seen at figure 3.

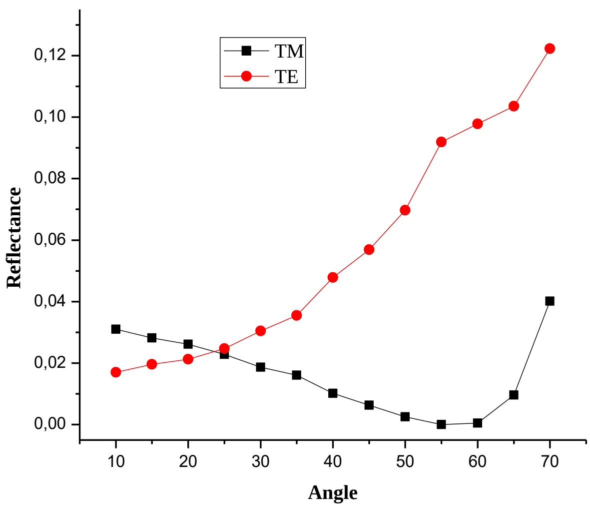

Figure 3. Result of the Reflectance value at TE and TM Polarized

The result of the reflectance value with the TE Polarized method shown by the red graph, and with the TM polarized method showed by the black graph. At the TM polarized from 10 to 60 degrees angle, the greater of the reflection angle resulting in a smaller the reflectance value. However, the reflectance value reverses the greater at a 60 degrees angle or above. This data can be concluded that the polarization angle at the 50 to 60 degrees. Therefore, the research was repeated by changing the interval of the angle. The result of repetition obtained data at figure 4.

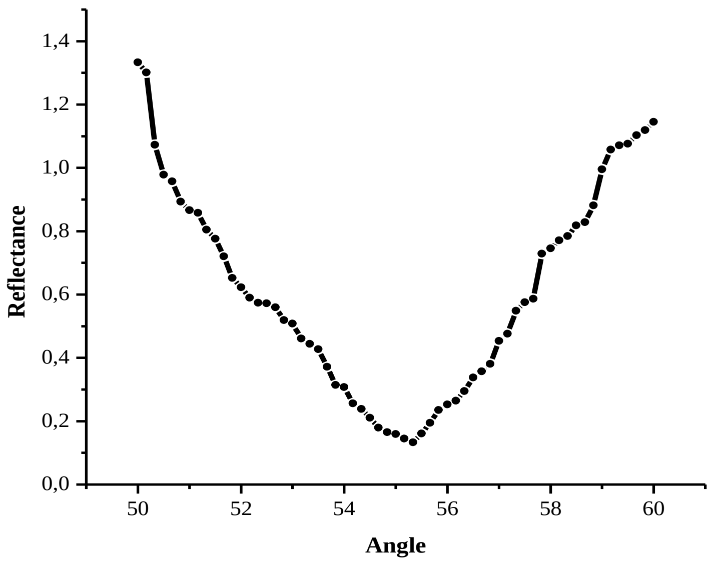

Figure 4. Result of the Reflectance value

From the figure 4, the angle of polarization can be known. Which is at the lowest angle. The lowest angle value at 55.333 degrees. The angle of polarization in the reflection beam depends on the angle of light. The theory says that the angle of polarization is called the Brewster angle. So, this angle of polarization used to calculate refractive index material with the equation 6. After the calculation, obtained a refractive index material value of 1.446.

The function of the study refractive index value from the material of fiber optic is to determine whether the uses are suitable from the fabrication of fiber optic. The usefulness of fiber optic can be seen by calculating the numerical aperture value. That is calculated with the equation 7.

$$NA = n_1\sqrt{2\Lambda} \tag{7}$$

With Λ is the relative of the refractive index value $|n_1 - n_2|$. After the calculation, it obtained a numerical aperture value of 0.944. A higher of numerical aperture value means that the fiber optic will be useful to fiber optic sensor which can be the transmission of the light at a high angle (US Patent No. 0104436, 2007).

4. Conclusion

Fiber optic has a function to the transmission by the light signal from one place to another place. Fiber optic is not disturbed of the electromagnetic disturbance. So, fiber optic can be used to various technologies. Every technology needs fiber optic with a special characterization. Fiber optic need to be characterized by the material of fiber optic as well as after the fabrication. One of the characterizations of fiber optic material is a calculation of a refractive index value. Refractive index value calculated by the Brewster method. Brewster angle is the angle in which the reflectance value is lowest. From this research, the Brewster angle obtained of 55.333 degrees. Brewster angle used to calculate of a refractive index value. A refractive index material value obtained of 1.446. This refractive index material value used to find out the function of fiber optic. That is by determining of a numerical aperture value. A numerical aperture value obtained of 0.944. So, fiber optic with a glass silica SiO_2-Na_2O can used to sensor fiber optic which can be transmission of the light signal at the high angle.

References

Arciniega, e. a. (2009). Crystallization Kinetics of a Sodalime Silica Glass with TiO2 Addition. *Revista Mexicana De Fisika 55*, 1, 32-37.

Baek, S., Jeong, Y., Hak-Rin, K., Sin-Do, L., & Lee, B. (2003). Electrically Controllable In-Line-Type Polarizer Using Polymer-Dispersed Liquid-Crystal Spliced Optical Fiber. *Applied Optics*, 42(25), 5033-5039.

Gaston, et al. (2003). Evanescent Wave Optical Fiber Sensing (Temperature, Humidity, and pH Sensors). *IEEE Sensors Journal*, 3(6).

Ghatak, A., & Thyagarajan, K. (1997). *Introduction to Fiber Optics.* USA: Cambridge University Press.

Kaercher, T., Hong, D., & Mobius, D. (n.d.). *Brewster Angle Microscopy a new Method of Visualizing the Spreading of Meibomian Lipids.* Germany: Augenklinik Ludswigshafen.

Keiser, G. (2000). *Optical Fiber Communications. 3rd Edition.* USA: McGraw-Hill Companies, Inc.

Li, M. J., & et al. (2007). *US Patent No. 0104436.*

Maddu, A. (2007). *Pengembangan Sensor Serat Optik dengan Cladding Termodifikasi Polianilin Nano Struktur untuk Mendeteksi Beberapa Uap Air.* Jakarta: Technology Faculty of Indonesia University.

Poli, F., Cucinotta, A., & Selleri, S. (2007). Photonic Crystal Fiber. *Springer Netherlands*, 40-87.

Saito, M., & Kikuchi, K. (1997). Infrared Optical Fiber Sensors. *Optical Review Journal*, 4(5), 527-538.

Yu, F. T., & Yin, S. (2002). *Fiber Optics Sensors.* New York: Marcel Decker, Inc.