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A STUDY OF LENGTH SCRATCH VARIATIONS ON MULTIMODE OPTICAL FIBER (FOM) FOR TEMPERATURE SENSOR

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Abstract

The research has done by using length scratch variations on the fiber optic multimode (FOM) with the intention of temperature sensor. The length scratch variations which have conducted were 5 centimeter and 7 centimeter. Some variations such length scratches would be seen by using FOM sensitivity which have sufficed temperature sensor specification. This experiment was began thought applying voltage of 12 volt from power supply to the sensor BF5RD-1-N Fiber Optic Amplifier. As per the sensor which has been resulted by laser beam. It would be transmitted to the FOM and it would be accepted again by the certain sensor which has a function as a receiver such voltage ration (dB). According to the voltage ratio, it would be calibrated with the specific temperature by using thermometer. As per the experiment, the research pointed out that there is a correlation between dB which has received by sensor and temperature's alterations from FOM. The result of the experiment found out that if scratches become bigger from the FOM, it would make voltage ratio becomes fewer. The FOM's linearity which has pointed out such as 0,996 and 0,989 for 5 centimeter and 0,996 and 0,965 for 7 centimeter. It can be concluded that the FOM's sensitivity which compatible with temperature sensor is scratch along 5 centimeter.

Keywords: multimode optical fiber, the ratio of the voltage, temperature sensor

Background

Optical fiber or optical fiber is transmission line which is made from pure glass, or plastic length and its diameter is micrometer size. Fiber optic is used to transmit light signals from one place to another. Optical fiber is a dielectric wave guides which is operated though a frequency/ optical wavelengths. The wavelength of the optical fiber ranges revolve from 600nm-1550 nm. Fiber optics insulate the electromagnetic energy such light on its surfaces and it guides the certain light to the parallel reactions.

Since the invention of fiber optic, it used specifically for communication systems. However, due to technological advances, the fiber optics widespread immediately. Take one sample from the use of optical fiber as the sensor is in the measurement system. The system has many advantages when it compares with the other measurement instruments. Fiber optics has the advantage in terms of high sensitivity, is not affected by the electric field and magnetic field, no direct contact with the object of measurement, practical and relatively inexpensive, and can be controlled remotely. In general, the optical fiber is divided into

two kinds of fiber optic single mode and multimode types. Single mode optical fiber is only able to transmit one beam mode only. Nucleus (core) of the optical fiber types are very small with diameters ranging from 8 to 10 micrometers. The advantages of single mode optical fiber is its ability to transmit light up to tens of kilometers so with the ability to single mode optical fiber is widely used in communication systems. The second type of optical fiber is a multimode optical fiber capable of transmitting 100 beam mode with a core diameter of 50 to 100 micro metres. The number of modes that can result from this type of optical fiber depends on the size of the size of the core of the optical

fiber and a parameter called the Numerical Aperture (NA). The greater the NA core will also increase and result in the number of modes that pass through the fiber.

During the research on optical fiber sensors have been carried out, among others, fiber optic sensors to measure the pH of the solution, as the optical fiber displacement sensor, a fiber optic temperature sensors, material deformation and other physical parameter measurements. Special to the temperature parameter has been some research that uses fiber optics including optical fiber coupler (Samian, 2010), the temperature transducer design for optical fiber transmission (Misto, 2004), the use of fiber Bragg Grating sensors as temperature sensors (Mohd Afiq Ismail, 2011), and thermal stress analysis in fiber optic sensors (Shiuh-Chuan Her, 2013).

The working principle of optical fiber as the sensor is to utilize losses incurred at the time of the macro bending (Mohtar Yunianto, 2002 and Fatimah Nur Hidayah, 2013) and micro bending on optical fiber. It also utilizes the wavelength and frequency modulation. In the course of a study previously conducted studies have losses in an optical fiber with a look at the depth of vertical strokes (Mohtar Yunianto, 2002). And on this research, the length variation in the transverse scratches on multimode optical fiber and the effect of these variations will be seen against losses arising from multimode optical fiber with changes in temperature on the thermometer reads.

Method

The main study of this research is to measure the length of the scratches on the FOM variation and its influence on the resulting losses later seen its influence on temperature. More details, as shown in Figure 1 and Figure 2.
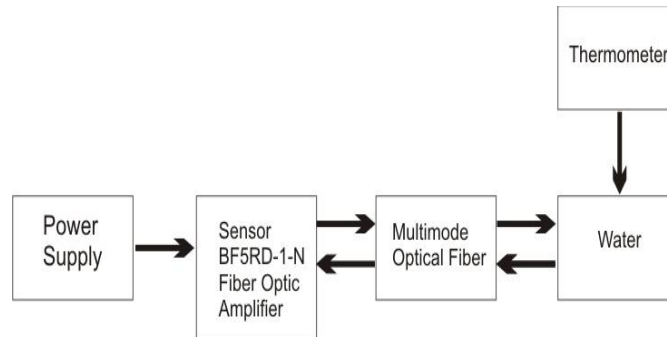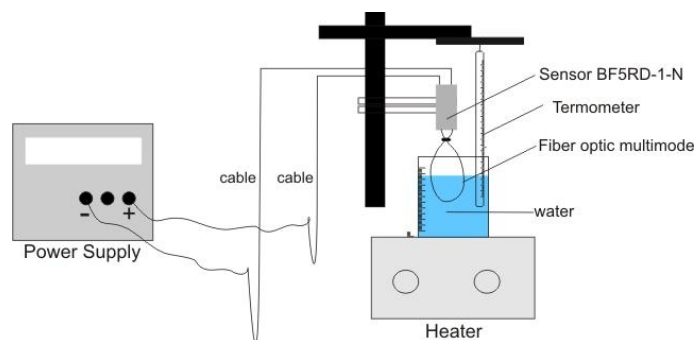

Figure 1. Block diagram of a research

Figure 2. Set up data retrieval research

The design of the experiment was divided into two phases. The first do a variation of etching with 5 cm and 7 cm at the FOM and the second stage is the set-up of fiber optic measurement system. Specification of the tools used in this measurement system is the power supply with a voltage of 12 volts, the sensor BF5RD-1-N Fiber Optic Amplifier which serves as a source of light once the receiver, multimode fiber optic, thermometer, heater, water containers, the cable clamp. The light source in the sensor BF5RD-1-N Fiber Optic Amplifier is a He-Ne laser beam with a wavelength of 632.8 nm. For FOM used fabricated from plastic optical fiber with a diameter of 1 mm, the value of the coupling ratio of 0.25, the coupling ratio of 7% tolerance, loss and directivity Exces respectively - each 1.4 dB and 24 dB.

This study begins with scraping multimode optical fiber with a length of scratches transversely 5 cm and 7 cm by using a razor blade and then smooth it with the paper pads wear. After designing the measurement system as shown in figure 2. The technique used in this study is the macro bending technique (macro bending).

The procedure of data collection in this research was initially missed the voltage 12 volts from the power supply to the sensor BF5RD-1-N Fiber Optic Amplifiers, these sensors will be generated from a laser beam that is passed to the multimode optical fiber and received back by the sensor also serves as a receiver output power/ voltage ratio in decibels (dB). From the results of the power loss will be calibrated with the measured temperature of the thermometer. Data collection was conducted on each of 1 ^{0}C temperature increase and decrease the temperature by 1 ^{0}C. The experimental results obtained by the data relationship between voltage ratio (dB) received by the sensor with temperature changes of multimode optical fiber.

Furthermore, after the data collection data processing and interpretation of data based on the relationship between the ratio of the voltage graph (dB) with temperature measured on the thermometer (^{0}C). Based on the graph will see a variety of parameters such as gradients, linearity and sensitivity of a multimode optical fiber. These parameters will show a close relationship between losses due to scratches on multimode optical fiber with temperature.

Discussion and Result

This section will discuss the results that have been obtained from measurements of the losses due to variations in the etching transversely multimode optical fiber will then be seen to do with the temperature reading on the thermometer. For measurement data variation along the 5 cm scratches can be seen in Table 1 and the results of the characterization of multimode optical fiber as a temperature sensor in the form of graphs the relationship between the voltage ratio (dB) with temperature (^{0}C) shown in Figure 3. As for the variation of the measured data scratches along the 7 cm can be seen in Table 2 with the graph the relationship between the voltage ratio (dB) and temperature (^{0}C) with a linear area of each is presented in Figure 4.

In this study the presence of losses arising from multimode optical fiber due to the occurrence of scratches and bending on multimode optical fiber. Loss multimode optical fiber is obtained from the equation dB= 20 log T, with T=V_2/V_1 is light transmission of multimode optical fiber. V_2 is the voltage magnitude of multimode optical fiber is scraped across, and V_1 is the magnitude of the reference voltage of the optical fiber.

Principle of optical fiber is used as a sensor due to changes in light transmission experienced by multimode optical fiber due to certain treatments. And in this case multimode optical fiber is treated with inscribed transversely to the length of certain scratches. In addition, multimode optical fiber is also bent (macro bending techniques). From Figure 3 and 4 will be visible image gradient and linearity of a multimode optical fiber that states the relationship between the loss/ voltage ratio with temperature. In this research will also be seen that the sensitivity of multimode optical fiber for use as a

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temperature sensor based on variations in the length of scratches transversely multimode optical fiber.

In theory, the change in the ratio of stress arising from temperature changes caused by changes in the refractive index of water is heated. When water is heated the particles in the water will move quickly at random and will emit energy in the form of GEM. As a result, the refractive index of the waters will also change. Changes in the refractive index of water will affect the light coming from the fiber optics and reflective.

Table 1. The results of measurements of the ratio of voltage to FOM with a scratch length of 5 cm

Temperature (^{0}C)	Voltage ratio (dB) for each increase of 1 ^{0}C	Voltage ratio (dB) for each decrease of 1 ^{0}C
35	666	657
36	669	664
37	675	679
38	680	683
39	684	691
40	689	698
41	695	707
42	699	715
43	704	724
44	713	733
45	720	745
46	727	754
47	734	762

Table 2. The results of measurements of the ratio of voltage to FOM with a scratch length of 7 cm

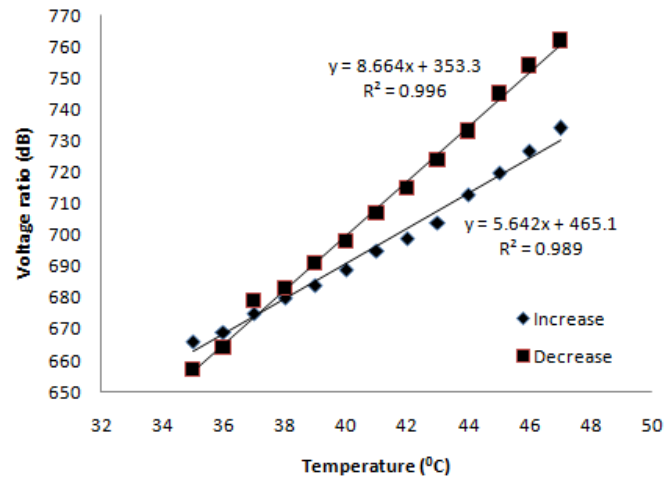| Temperature (^{0}C)	Voltage ratio (dB) for each increase of 1 ^{0}C	Voltage ratio (dB) for each decrease of 1 ^{0}C
35	218	206
36	221	207
37	224	208
38	227	209
39	231	211
40	236	213
41	239	215
42	241	216
43	244	217
44	248	221
45	250	223
46	254	226
47	257	230

Figure 3. Graph the linear voltage ratio (dB) with temperature (^{0}C) to FOM with scratches 5 cm.
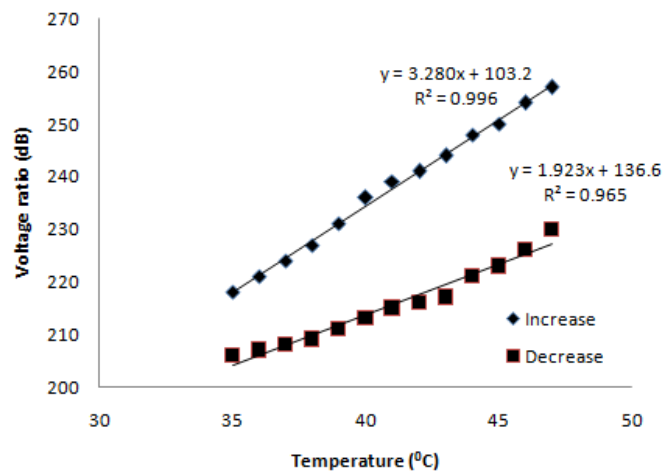

Figure 4. Graph the linear voltage ratio (dB) with temperature (^{0}C) to FOM with scratches 7 cm.

From the graph above the magnitude of the influence of temperature, slope/ gradient, and long scratches on losses in multimode optical fiber, at the same temperature indicates that the longer scratches the losses in multimode optical fiber will be smaller. This will affect the gradient of each length of multimode optical fiber scratches. At 5 cm scratch gradient of 8.664 was obtained for each increment for increment 1 ^{0}C and 5.642 for each 1 ^{0}C decrease. At 7 cm to scratch each gradient obtained for the increase and decrease of 1 ^{0}C is 3.280 and 1.923. These results demonstrate the greater transversely scratches on the optical fiber will be the lesser slope.

Based on the graph can also be seen that the linearity and sensitivity of each FOM. For FOM with scratches 5 cm linearity of the data obtained 0.996 for each increment 1 ^{0}C and 0.989 for each decrease 1 ^{0}C. While FOM with a length of 7 cm scratches on the rise and every 1 ^{0}C decrease have data linearity of 0.996 and 0.965. The results showed that

the highest linearity of data is in FOM with scratches 5 cm, thus it can be said that the FOM with a length of 5 cm scratches better suited to be used as a temperature sensor FOM compared with 7 cm long scratches.

Then from figure 3 and 4 shows that the ratio of the voltage (dB) is not exactly coincide between one point and another. This suggests that a comparison is not appropriate value when the temperature was increased with temperature when lowered. But the trend of increases and decreases in proportion to the temperature variation is given. It can be concluded that the multimode optical fiber sensors that meet the rules made relative stability of a sensor.

Conclusion

Research findings show that the multimode optical fiber temperature sensor can be applied as long streaks with variation across. Results of a study showed that the sensitivity of a multimode optical fiber suitable for the design of temperature sensor is used as a scratch along the 5 cm with a gradient of 8.664 for each increment for increment 1 ^{0}C and 5.642 for each 1 ^{0}C and decrease linearity of each by 0.996 for each increment 1 decrease ^{0}C and 0.989 for each 1 ^{0}C.

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