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Fiber Optic Humidity Sensor Based on Polymer Optical Fiber Coated with Silver Nanoparticles

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Abstract. There has been a study of changes in the intensity of light output on fiber optic polymer (POF) against humidity changes. This study uses silver nanoparticles (AgNP) instead of cladding on fiber optics. AgNP synthesis method itself by using the reduction method with reductor Sodium citrate (Na3C6H5O7). The resulting AgNP solution with 4 mM concentration was used for clearing coating on POV. Coating itself with coating method is done on fiber optic that has been in his cladding peel along the 10 cm. Fiber optic used is Optical Polymer Fiber (POF) type SH-4001-1.3 with core refractive index of 1.49 and cladding refractive index of 1.41. The intensity of the obtained light output is measured using an optical power meter (OPM). The light source used is the Helium-Neon (He-Ne) laser with a wavelength of 623.8 nm. The analysis used is the ratio of the output intensity between fiber optic in coated by AgNP and without coating. The results obtained showed an increase in sensitivity and also linearity due to the addition of AgNP layer on fiber optic. Graph obtained shows if the linearity level of the coating done reached 0.990. In addition to the sensitivity level obtained at -0.02 dBm /%.

Keywords: fiber optic sensors, polymer optical fiber, humidity, silver nanoparticles.

INTRODUCTION

Humidity is a percentage of water vapor in air. In various applications such as industries, meteorology, health science and civil engineering humidity is very influential. If the humidity has high or low level, it can dangerous for environment[1,2]. Therefore, the humidity sensor is very important for many things. In other hand, development of humidity sensor is also still continues. Development of low cost humidity sensors with better performance is of prime importance. Commercial humidity sensors are mainly comprised of porous ceramics, polymer films etc. These sensors are based on the principle of change in electrical resistance as a function of relative humidity [1]. In addition is now developed humidity sensor based on polymer optical fiber (POF).

Polymer optical fiber is fiber optic based on polymer material. It means, POF has good structure for sensor because it has strength and high flexibility[3]. It's meas, the shap of probe sensor can be variety. Because, the shap or probe sensor will affect to intensity output in fiber optic. So, the shape of probe is very important in fiber optic sensor. However, still any problem in fiber optic sensor, that is sensitivity. We need more variation POF to increase sensitivity of sensor.

Basiclly, fiber optic sensor designed by varying cladding with another material. Recently, application of nanoparticle for sensor is still developed. One of them is used nanoparticle to replace cladding of fiber optic[1]. Nanoparticle has special and unique properties could be attributed to their small sizes and large specific surface area[4]. For these reasons nanoparticle has good properties to make sensitive sensor, such as humidity sensor.

METHODS

Synthesis of silver nanoparticle

Material for synthesis silver nanoparticle is $AgNO_3$ 4M and citrate of sodium. Chemicals reduction method used to generate of silver nanoparticle (AgNP). Citrate of sodium were used as a reducing agents. Citrate of sodium was also used as stabilizing agent at room temperature. The transparent colourless solution was converted to the characteristic pale yellow and pale red colour, when citrate of sodium was used as stabilizing agent. The occurrence of colour was indicated the formation of silver nanoparticles[]. The analysis of Uv-Vis spectroscopy for find the absorbance of nanoparticle silver solution.

Coating Proses

In this experiment used polymer optical fiber tipe SH-4001-1.3 with refractive index of core is 1,49 and refractive index of cladding is 1,41. Buffer and cladding of POF remove to replace with AgNP 4mM for probe sensor of humidity. After removing buffer and cladding AgNP coated with method thermal. POF soaked in AgNP solution and then heat in oven until solution gone.

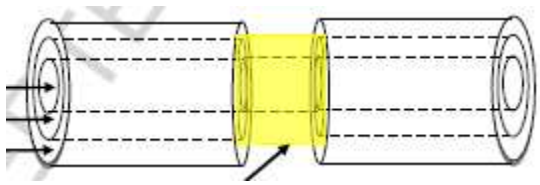


Figure 1. POF coated with AgNP

Humidity Sensor Experiment

Laser Helium-Neon (He-Ne) with a wavelength of 623.8 nm and power 5mW used to light source in fiber optic. Optical power meter (OPM) used to detect light output from fiber optic. Shap of probe sensor in this experiment created 2 tipe. First tipe of probe sensor is straight probe and the second is curve probe. That is the variation in this experiment.

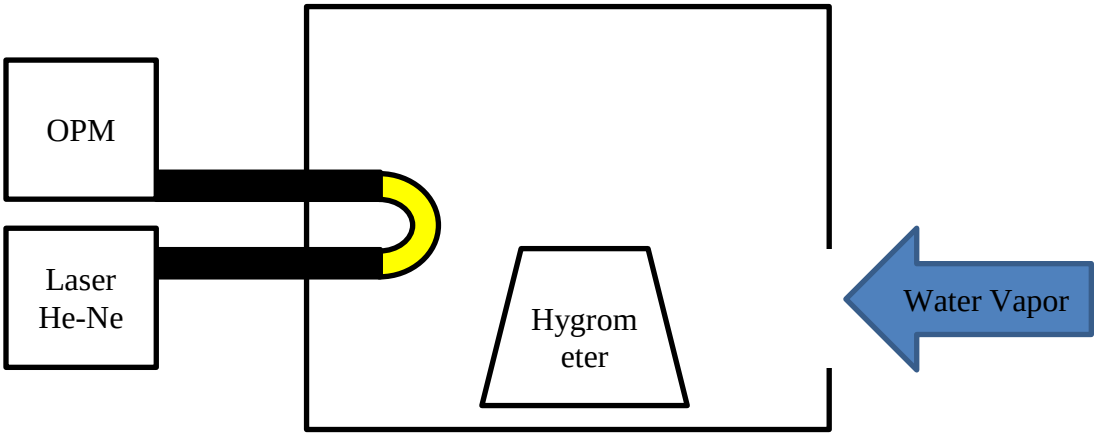


Figure 2. curve probe sensor

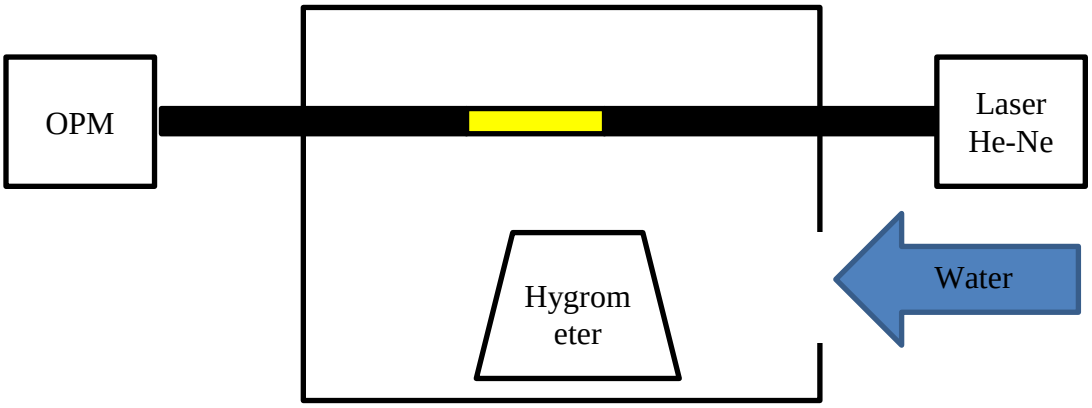
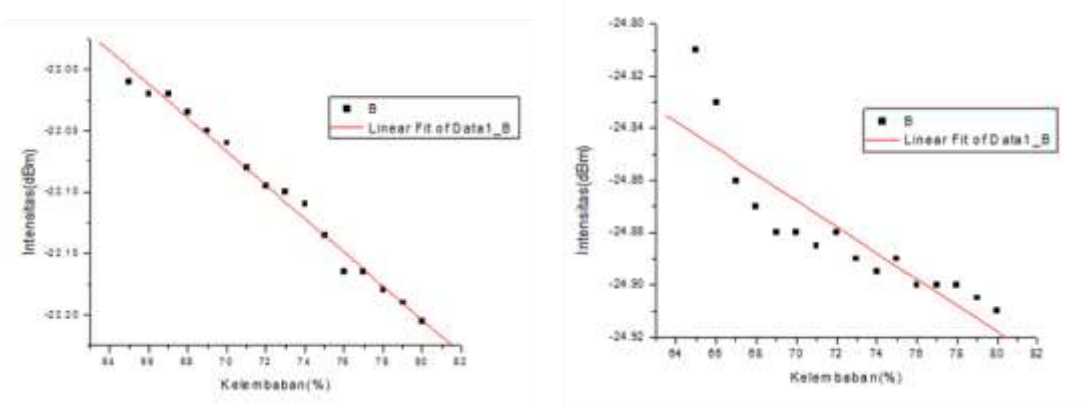


Figure 3. straight probe sensor

RESULTS AND DISCUSSION

Experiment show if intensity of laser in fiber optic change according to humidity changes. In figure 4 show if the intensity of laser has decreased while humidity is raised without AgNP coated. It's meas that in fiber optic has light loss from humidity changes. Other than, shap of probe sensor is also has impact to light changes. Graph (a) for straight probe has a linearity of 0.993 and sensitivity of -0.01dBm/%. In Graph (b) for curve probe has a linearity of 0.879 and sensitivity of 0.005dBm/%.

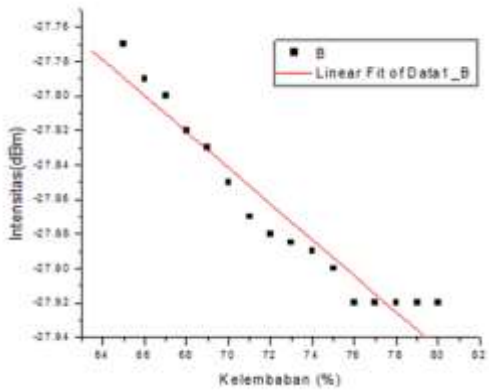


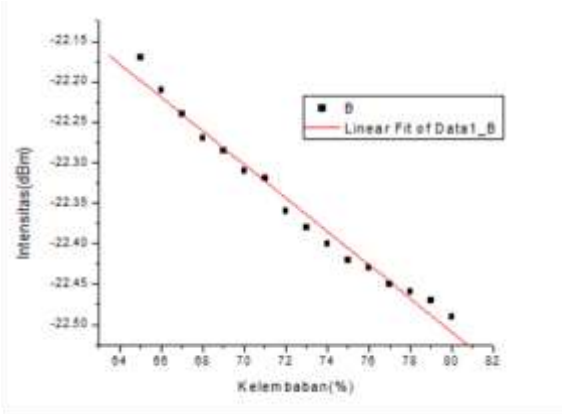
(a)

(b)

Figure 4. Without coating (a) graph of straight probe (b) graph of curve probe

Figure 5 is graph of fiber optic coated with AgNP 4mM. Same as before if the intensity of laser has decreased while humidity is raised. It's meas that fiber optic has light loss from humidity changes. Graph (a) for straight probe has a linearity of 0.965 and sensitivity of -0.01dBm/%. In Graph (b) for curve probe has a linearity of 0.990 and sensitivity of 0.02dBm/%.





(a)

(b)

Figure 5. Coating with AgNP (a) graph of straight probe (b) graph of curve probe

From the experiment we have done, AgNP successfully increase the humidity sensor performance. We focus in the range of humidity between 65% to 80% . Sensitivity of sensor has increase effect from AgNP coated. Other than, linearity of humidity sensor also increase be come more linear. We can compare with Ryuji Okimura research in 2015 [5]. In that research, Ryuji used TiO_2 to coatting fiber optic. In that research, the sensitivity of sensor is high, but the linearity of sensor is more good in this research using AgNP.

CONCLUSION

In this research we used AgNP nanoparticle to coting fiber optic for humidity sensor. From the experiment, AgNP success coated in fiber optic to be probe of humidity sensor. Other than shape of probe sensor is also influence the sensitivity and linearity. From the experiment, the curve shape have the good result for humidity sensor. The best results from this experiment is fiber optic coated with AgNP and the curved probe shape. That sensitivity is -0.02dBm/% and the linearity is 0.990. Therefore, we were able to confirm that AgNP has successfully increase sensitivity and linearity of humidity sensor.

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