

Influence of Coating Thickness of Polyimide for Moisture Sensing

Siti Nur Aizatti Rohizad¹, Suzairi Daud^{1,2} and Ahmad Fakhurrazi Ahmad Noorden³

¹ Department of Physics, Faculty of Science, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia.

² Laser Center, Ibnu Sina Institute for Scientific & Industrial Research, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia.

³ Department of Physics, Kulliyah of Science, International Islamic University Malaysia, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia.

Abstract. This work focused on the effect of existence of polyimide coated fibre Bragg grating (FBG) for moisture sensing in stingless bee. The moisture sensitive material namely polyimide (PI) was used to improve the sensitivity of the fibre optic sensor. By taking the benefits from amine groups in 3-(aminopropyl) triethoxysilane (APTES), PI is coated onto the segment of FBG through covalent interaction. Different thickness of PI coated FBG as well as determination and optimization of the designated sensor has been done. 3 layers of polyimide coating were used to improve the sensitivity of moisture sensing, and the sensitivity of coated fibre been analysed.

Keywords: Fibre Bragg grating, Bragg wavelength, moisture, sensor, honey

1. Introduction

Optical fibre has been used widely in communication system. However, it became popular in research area especially for sensing application due to their advantages such as electromagnetic immunity, allow monitoring with high multiplexing capacity, and reduce size and weight [1]. The diverse of sensing elements that has been explored including the measurement of temperature [2, 3, 4, 5], strain [6], displacement [7], pressure [8], surrounding refractive index (SRI) [9, 10] and curvature [11]. The common advantages of fibre optic sensors include high sensitivity, immune to electromagnetic interference (EMI), spark free, minimal intrusiveness due to their small size and lightweight [12].

In this work, the FBG sensor will be used for sensing of moisture and humidity of stingless bee honey.

2. Theory

Optical fibres are usually known for wide range applications, including optics and photonics fields. It works based on the principle of total internal reflection phenomenon which occurs at the interface between the core and the cladding. The core of the fibre is the most important component in optical fibres which is made from glass or plastic, depends on the types of the fibres. It is surrounded by another plastic layer called cladding which is categorized by a lower refractive index material compared to the core material [13]. There are two types of optical fibre commonly used in industry, which are single-mode fibre (SMF) and multi-mode fibre (MMF). SMF is typically used for longer communication distances which is suitable for the long-distance telephone and multi-channel TV transmission systems as examples. The core diameter of single-mode fibre is smaller than MMF, which



is between 5 to 10 μm . Due to the small size of its core diameter, the propagation of light occurs in the axis parallel to the fibre [14].

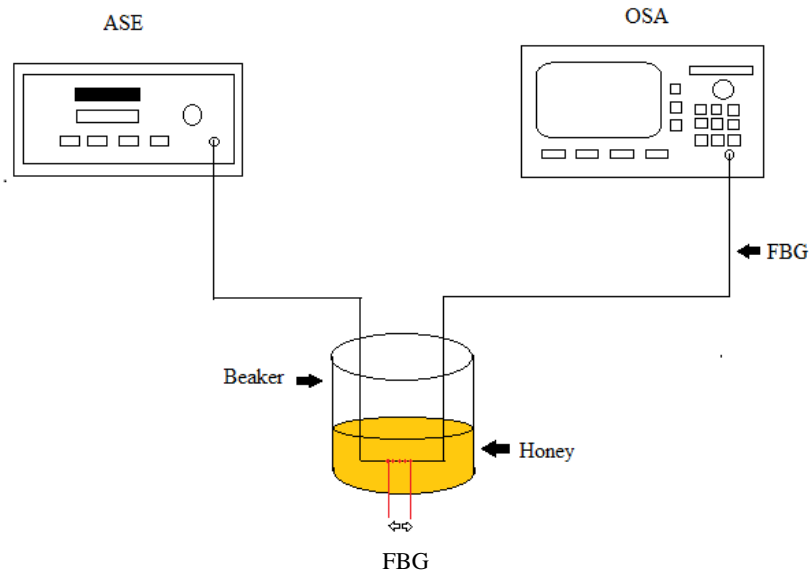


Figure 1. Setup of FBG sensor

3. Experimental set-up and discussion

The experimental set-up for this experiment is presented in Fig.1, which consists of the proposed FBG sensor, amplified spontaneous emission (ASE), and optical spectrum analyser (OSA). In this experiment, FBG with an initial wavelength of 1588.85 nm was used. Both end of the FBG sensor were connected with ASE and OSA. The distance of the grating used is 2.5 cm as it is experimentally optimized to achieve the desired sensitivity. The FBG sensor with different coating thickness were soaked in the beaker which contained honey solutions at room temperature. Before dipping the FBG grating, it was treated with 3-aminopropyltriethoxisilane (3-APTES) in order to increase the adhesion at polymer interface. Hence, polyimide was used as the coating layer of FBG to enhance the sensitivity of FBG for humidity sensor.

The thickness was measured using an optical microscope. Table 1 shows the thickness obtained from the experiment. It shows an increment in the coating thickness after 3 times repeated process.

Table 1. Measurement of sample polyimide coating

Sample	Thickness (± 0.01 nm)		
	Measurement 1	Measurement 2	Measurement 3
1	98.58	100.51	106.31
2	90.60	97.93	101.80
3	88.53	96.64	115.97

Fig. 2 shows the increase of thickness when the polyimide is coated on the fibre after repeating for 3 times. The measured thicknesses were 95.58 nm, 100.51 nm, and 106.31 nm, respectively. It witnessed the uniformity of polyimide coating adhered to the fibre.

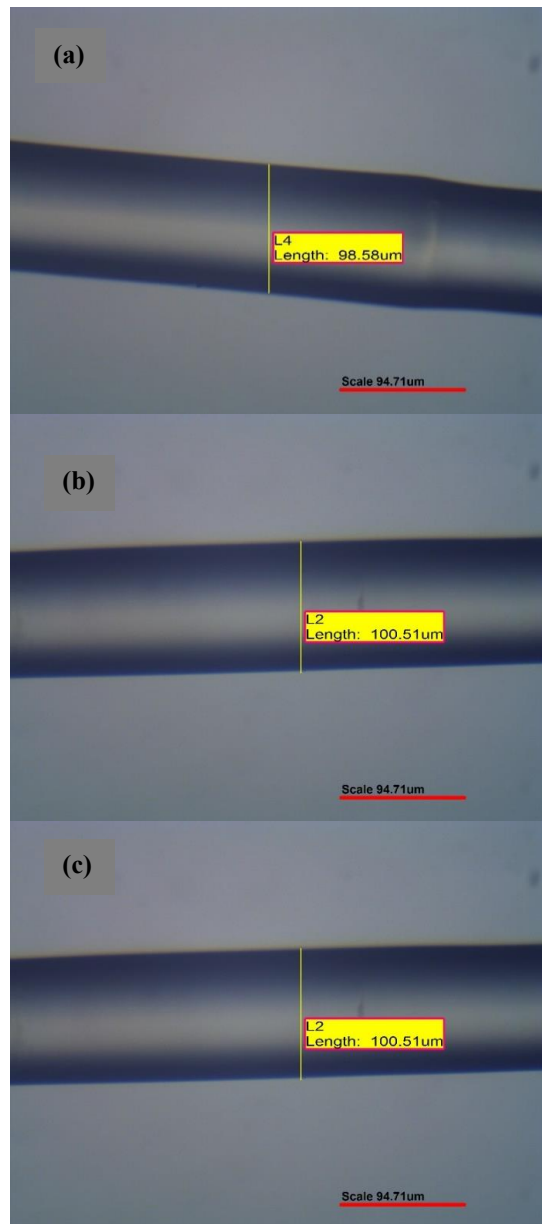


Figure 2. Different thickness of polyimide coating on fibre which is (a) 98.56 nm, (b) 100.51 nm, (c) 106.31 nm

4. Conclusion

In this work, a high feasibility FBG sensor was proposed to analyse which coating thickness is the most sensitive, and it shows that the higher thickness will enhance the sensitivity of the sensor. The proposed design consists of FBG which has a grating that can function to detect the moisture of stingless bee honey.

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