Journal of Physics: Conference Series

PAPER • OPEN ACCESS

The effect of fbg grating lengths for temperature sensing

To cite this article: N S Sahidan *et al* 2020 *J. Phys.: Conf. Ser.* **1484** 012015

Journal of Physics: Conference Series **1484** (2020) 012015 doi:10.1088/1742-6596/1484/1/012015

The effect of fbg grating lengths for temperature sensing

N S Sahidan[1], M A M Salim[1,2], S S Osman[1], H Bakhtiar[1], N Bidin[1], G Krishnan[1], M H D Othman[3], M A. Rahman[3], A F Ismail[3] and N Yahya[4]

[1] Laser Center, Ibnu Sina Institute for Scientific and Industrial Research, Universiti Teknologi Malaysia. 81310 Johor Bahru, Johor. Malaysia
[2] T05 Research Cluster, Faculty of Science Laboratory Management Centre, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor. Malaysia.
[3] Advanced Membrane Technology Research Centre (AMTEC), Universiti Teknologi Malaysia. 81310 Johor Bahru, Johor. Malaysia.
[4] Fundamental and Applied Science Department, Universiti Teknologi Petronas, Bandar Seri Iskandar, 31750 Tronoh Perak, Malaysia.

Corresponding author: hazri@utm.my

Abstract. In this work, we have successfully fabricated the fiber Bragg grating (FBG) with 1 cm and 3 cm grating length, respectively. The different grating length fabricated by adjusting the slit aperture in order to control UV light transmission while inscribing on the single mode fiber. Then the FBG was demonstrated through different grating length over temperature sensor to determine the differences for temperature sensing. The range for temperature The measured sensitivity of 1 cm and 3 cm grating length is 0.0103 nm/°C and 0.0132 nm/°C respectively at the same value of applied temperature. As a results, the shorter grating length, 1 cm has higher sensitivity response compared to 3 cm grating length over temperature sensing.

1. Introduction

A fiber Bragg grating (FBG) is significantly known and employed in the communications and sensing applications. FBG plays an essential role for dense wavelength-division multiplexing (WDM), optical add drop multiplexer and as erbium-doped fiber amplifier pump laser stabilizer [1] in communication whereas in sensing, FBG commonly used as temperature, refractive index, and strain sensor. FBG sensors have been used in various fields such as aircraft, electric power industry, railway system, bridges, and oil and gas reservoir monitoring [2-6].

Furthermore, FBG sensors have been widely known due to its advantages such as corrosion resistance, immune to the radio frequency and electromagnetic interference (EMI), ability to operate in the harsh environment where the conventional sensors cannot operate [7]. Nowadays, many methods including Sagnac, Mach-Zender, Fabry-Perot (FP) configuration, have been proposed for temperature sensing application. [8-10].

In this paper, we demonstrated the fabrication of FBG by using 248 nm KrF excimer laser. The FBG was fabricated by using phase mask technique with different grating length of the FBG have been described, 1 cm and 3 cm respectively. After the fabrication process, the FBG have been applied for temperature sensitivity. The response of the FBG to the temperature have been observed and discussed in this work.

2. Experimental setup

The experiment setup for FBG fabrication is shown in figure 1. KrF excimer laser (Optosystem, CL5100) was used as the UV source for grating inscription with linewidth of ~1.5 nm and pulse duration of ~10 ns. In this experiment, uniform grating structure was opted for grating inscription. A Keplerian expander that constructed from two cylindrical lenses was used to expand the laser beam horizontally. A tunable vertical slit was used to block both tails of the Gaussian beam to form a small (0.5 – 3.0 cm) beam. The fiber was placed closed near to the phase mask to receive the optimum interference visibility as shown in figure 2. Using the phase mask, Bragg gratings inscribed in fiber with diameter of 125 um and effective core index, (n_{eff}) = 1.4474. In this experiment, two different grating length have been fabricated, which is 1cm and 3 cm. The broadband light source was propagating into the fiber core of FBG and optical spectrum analyzer (OSA) was used for Bragg wavelength detection. The FBG transmission spectra is monitored using an optical spectrum analyser (OSA, Ando AQ6331) controlled by a Labview program via GPIB. Figure 2 shows the different grating length of FBG during fabrication process.

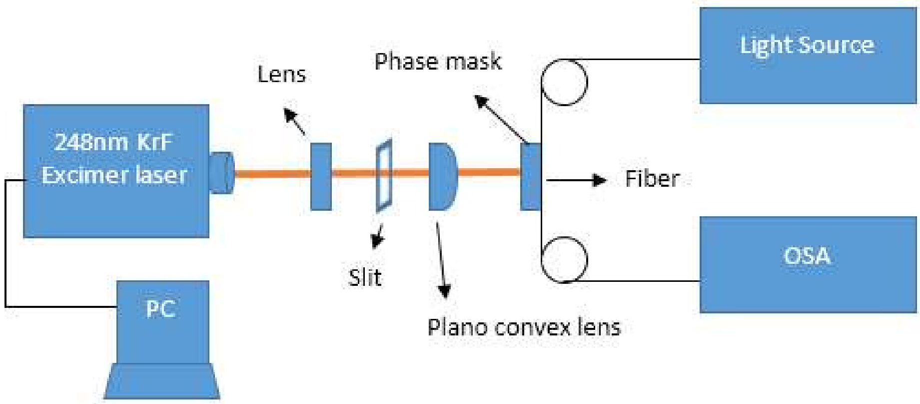
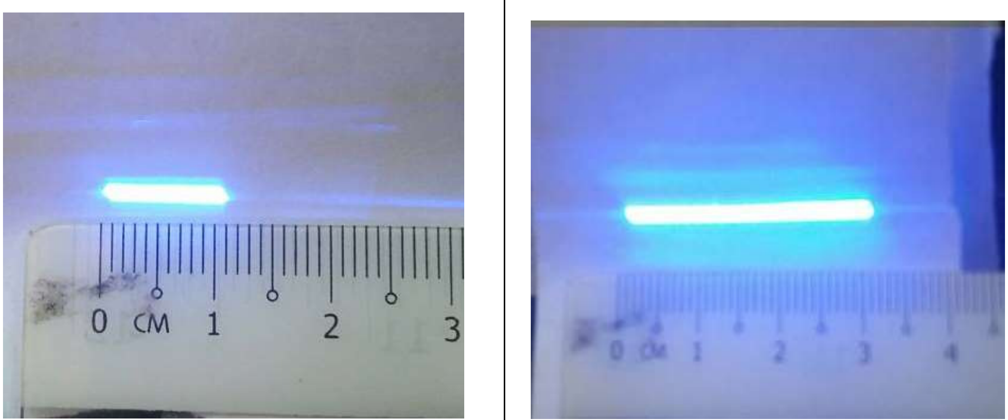


Figure 1. Experimental setup for FBG fabrication.



(a) (b)

Figure 2. The variation of grating length (a) 1 cm ; (b) 3 cm.

3. Temperature sensitivity

The response of the FBG on the temperature sensitivity have been demonstrated for grating length of 1 cm and 3 cm. The FBG was located inside the temperature controlled oven. The effect of temperature changes from 25 °C to 120 °C was observed by monitoring the Bragg wavelength (λ_B) shift on an optical spectrum analyzer. Once the temperature was applied, the reflected spectrum was observed and recorded. Light from the broadband light source was initiated into the FBG and go through the oven and traveled to the optical spectrum analyzer for Bragg wavelength (λ_B) measurement. The setup for this experiment is shown in figure 3.

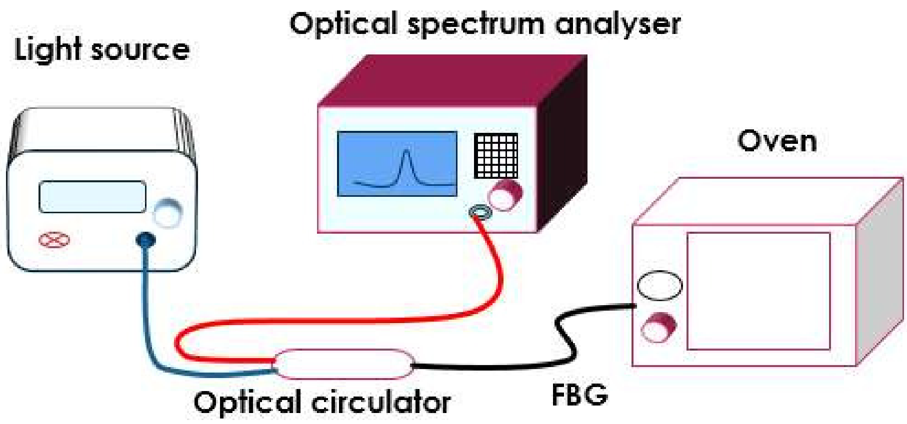


Figure 3. A schematic of experiment setup for temperature sensitivity.

4. Results

The signal of Bragg grating inscribed using 248 nm KrF excimer laser with a phase mask technique are shown in figure 4 with different grating length of the FBG. Perturbation of the grating leads to shifting in the Bragg wavelength on the device, which might be detected in either by the reflected or transmitted spectra. Figure 4 show the reflection spectrum of the fiber Bragg grating that have been fabricate for grating length of 1 cm and 3 cm. An optical spectrum analyzer measured the center wavelength of the grating transmission, 1540 and 1541 nm. Figure 5 shows the wavelength shift for the grating length of 1 cm and 3 cm on temperature sensitivity.

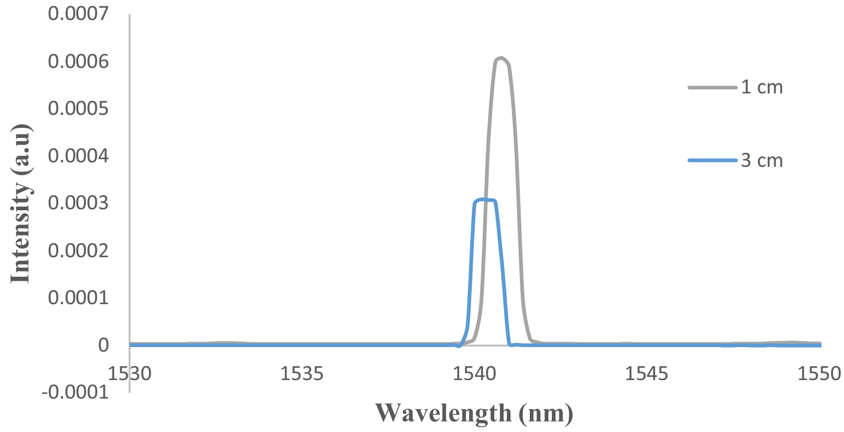
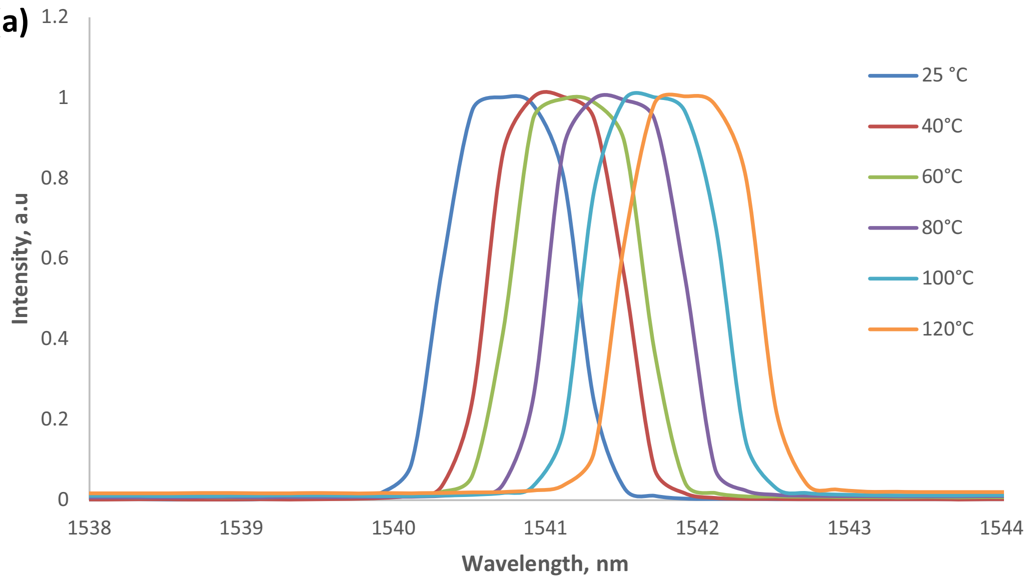


Figure 4. The refelction spectrum of the FBG at 1 cm and 3 cm grating length.

(a)



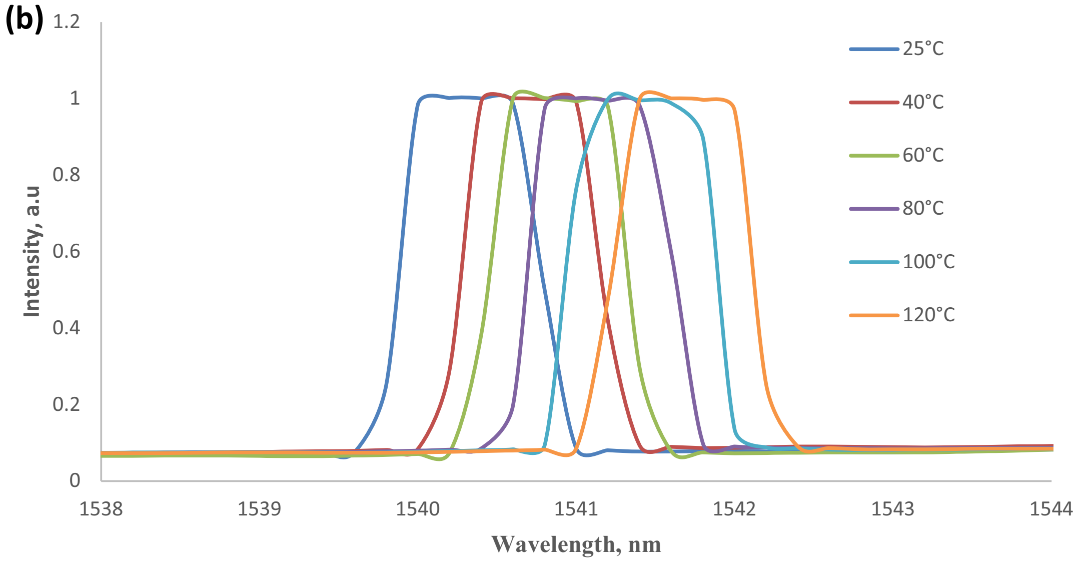


Figure 5. Wavelength shift for grating length (a) 1 cm (b) 3 cm.

Figure 6 shows the plot of the response of the FBG for 1 cm grating length and 3 cm grating length against temperature. As a results shows, the Bragg wavelength shifted to the longer wavelength with the increases of the temperature. The temperature response based on the Bragg wavelength is affected by two factors, which is the thermal expansion of the fiber and the thermo optic effect. A change in the grating spacing causes the thermal expansion of the fiber and the thermo optic effect leads to change in the effective refractive index of the fiber. Most material expand when the temperature increases. When the temperature increases, the fiber will expands and cause the grating spacing increases, then the Bragg wavelength will shift. Besides, the linear characteristic of the graph between Bragg wavelength versus temperature shows that the wavelength shifting is proportional to the temperature. The measured sensitivity of 1 cm and 3 cm grating length is 0.0103 nm/°C and 0.0132 nm/°C respectively at the same value of applied temperature. As a results, the shorter grating length, 1 cm has higher sensitivity response compared to 3 cm grating length over temperature sensing. This can be related with previous study that have been done on the sensitivity of the fiber grating sensor. The result show the smaller sensor length is more sensitive than larger sensor length [11].

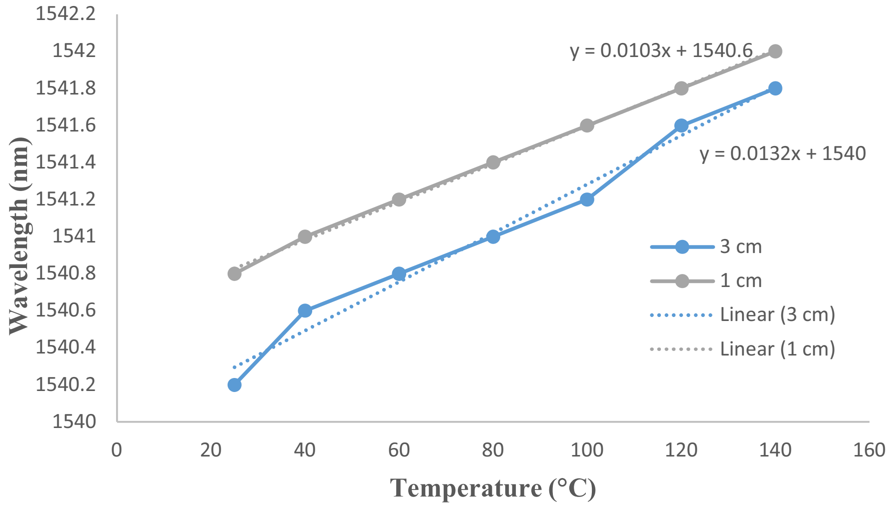


Figure 6. Bragg wavelength versus temperature for 1 cm and 3 cm FBG.

5. Conclusion

Fabrication of fiber Bragg grating using 248 nm KrF laser as UV laser source have been demonstrated. The FBG were written in the standard single mode fiber of 125 um diameter using phase mask technique. Different grating length of the FBG have been obtained in this experiment. As a results, Bragg wavelength increase with the increases of the temperature. The measured sensitivity of 1 cm and 3 cm grating length is 0.0103 nm/°C and 0.0132 nm/°C respectively at the same value of applied temperature. It can be conclude that smaller grating length is more sensitive of FBG which makes an ideal candidate to be used in sensing applications like strain sensing and temperature sensing.

Acknowledgement

The authors would like to thank Universiti Teknologi Malaysia for financial supported by research grant R.J130000.7609.4C112.

References

[1] Vikas S D and Grover A 2015 *Adv. Eng. Tech. Appl* **4** 15-25
[2] Tosi D, Olivero M, and Perrone G 2009 *Measurement Science and Technology* **20** 065203
[3] Chen Y, Chen L J, Liu H L and Wang K 2013 *Optik-International Journal for Light and Electron Optics* **124** 4802-4
[4] Lan C, Zhou Z, He J and Ou J 2008 *19th International Conference on Optical Fibre Sensors* **7004** 700463
[5] Lan C, Zhou Z, Sun S and Ou J 2008 *Smart Sensor Phenomena, Technology, Networks, and Systems 2008* **6933** 693312
[6] Pinet É 2011 *21st International Conference on Optical Fiber Sensors* **7753** 775304
[7] Lau K T, Yuan L, Zhou L M, Wu J and Woo C H 2001 *Composite structures* **51** 9-20
[8] Omar M, Cholan N, Mohd A, Azhan M, Talib R and Ngajikin N 2018 *International Journal of Engineering & Technology* **7** 126-30
[9] Deng M, Liu L, Zhao Y, Yin G and Zhu T 2017 *Optics letters* **42** 3549-52
[10] Domínguez-Flores E., Monzón-Hernández D, Moreno-Basulto J I, Rodríguez-Quiroz O,

Minkovich V P, López-Cortés D and Hernández-Romano I 2019 *Journal of Lightwave Technology* **37** 1084-90

[11] Tahir B A, Ali ., Rahman R A and Ahme A 2009 *Journal of Optoelectronics and Advanced Materials* **11** 1692