iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL
FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: I Month of publication: January 2023

DOI: https://doi.org/10.22214/ijraset.2023.48180

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue I Jan 2023- Available at www.ijraset.com

Simulation of Fiber Bragg Grating Using Different Physical Parameters for Investigating the Effectiveness on Strain Sensor Measurements

Muhammad Arif Bin Jalil
Physics Department, Faculty of Science, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia

Abstract: This microstructure can be etched into the core of the single mode fibre by photo-inscribing it, and it has a length of a few millimetres. By illuminating the fibre with a UV laser beam and employing a phase mask to create an interference pattern in its core, this is achieved. For a variety of engineering measurements, including temperature, strain, pressure, tilt, displacement, acceleration, load, and the presence of numerous chemical and biological compounds in static and dynamic modes using Fiber Bragg Gratings (FBGs), these sensor elements are deemed outstanding. Mostly, researchers uses FBG to investigate its effectiveness in detecting physical parameters. Some people conduct research using applications and some people conduct research with simulation. For this project, the strain response of the optical FBG sensor is measured using Optiwave software with different parameters. It is shown that the various parameters represent one of the critical parameters in contributing to a high-performance fiber Bragg grating sensor. The simulated fiber gratings with different parameters were analysed and designed by calculating reflection and transmission spectra. Such simulations are based on solving coupled mode equations that describe the interaction of guided modes. It is affirmed that this model system can be used as the simulation results satisfy the previous research.
Keywords Strain sensor; Bragg wavelength shift, Temperature sensor, Poisson ratio

I. INTRODUCTION

Optical fiber sensors are gaining popularity due to their numerous benefits, including: immunity to electromagnetic interference, intrinsic fire safety, low invasiveness, and the ability to send data remotely via the same sensing fiber. One of several varieties of FOSs is the Fiber Bragg Grating (FBG) [1]. After that, the development of fiber Bragg grating has been steadily rising over the past three decades [2]. Fiber grating sensors play a key role in the development of new technologies for optical communication and sensing [3].

There are numerous applications for which the fiber Grating can be extremely efficient and low-loss at the same time [2].A fiber Bragg grating, for example, is required to detect leaks in underground pipelines. Hydraulic piping systems in vital industries require performance testing and condition monitoring. Fiber Bragg Grating (FBGs) are the most commonly utilized technique for this purpose.

The purpose of this research is to use OptiWave to simulate the strain in an FBG system and to vary parameters in an FBG system using Optiwave. The third purpose of this research is to determine the reflection and transmission of FBG. Scope study of this research FBG was created to detect parameters such as strain, temperatures, pressure, acceleration and others. Many simulations have been used and created for FBG to facilitate research. In this study, the simulation of the optical FBG strain response is by using Optiwave. In this study, fiber Bragg Grating is used as a strain sensor in the model system. The study will help to understand the applications of FBG and be able to initiate various research.

II. METHODOLOGY

A. Simulation Tools

Modeling and simulation approaches employed in this work will be presented. The study's methodology is based on a simulation. Details of the software used to imitate the optical sensor, OptiWave, are provided in this chapter. After that, Bragg grating is the key structure of grating coupler which consists of a rectangular grating cell to diffract the light coming from a single mode fiber into a dielectric SOI waveguide. Optical Spectrum Analyzer (OSA) is used to measure the Bragg wavelength shift.

B. Parameters Setting

Fiber Bragg gratings (FBGs) are the most important parameter in this simulation since they illustrate the sensor effect after detecting changes in strain. In this simulation, the settings of the default parameters were utilised to provide a basic description of the model system.

Parameter	Symbols	Values
Bragg wavelength	λ_B	1550nm
Photoelastic coefficient	Pe_{11}	0.121
Photoelastic coefficient	Pe_{12}	0.27
Poisson ratio	v	0.17
Temperature	T	25
Period	Λ	0.55381599

Table 2.1 The main parameters used in the Fiber Bragg Grating simulation

C. Simulation Tools

The Coupled Mode Theory of optical gratings is implemented in OptiGrating. Coupling and reflection in optical waveguides and fibres has been studied with this sophisticated instrument. There are also modules for simulating physical factors like temperature and strain on the grating in OptiGrating's simulation software programme. An effort has been made to simulate an FBG sensor with the lowest possible attenuation. A software tool can be used to construct an FBG sensor from the core notions. Fiber Bragg grating sensors for strain measurement can be designed using simulation tools by first estimating approximately the grating pitch for maximum reflective power for a given interrogating wavelength and then characterizing the sensor by varying the grating pitch as it changes under strain and noting the decrease in reflected power for the chosen wavelength [1].

III. RESULTS AND DISCUSSION

A. Spectral Reflectivity

Grating Length, L(mm)	Strain (μm)	Bragg wavelength,λ_B (nm)	Reflectivity(dB)
10	20	1550.0232	-6.7506
10	40	1550.0496	-6.7506
10	60	1550.0736	-6.7506
10	80	1550.0976	-6.7506
10	100	1550.1216	-6.7506
10	120	1550.1456	-6.7506
10	140	1550.1696	-6.7506

Table 3.1 The spectral reflectivity of Bragg wavelength is dependent on grating length and strain changes.

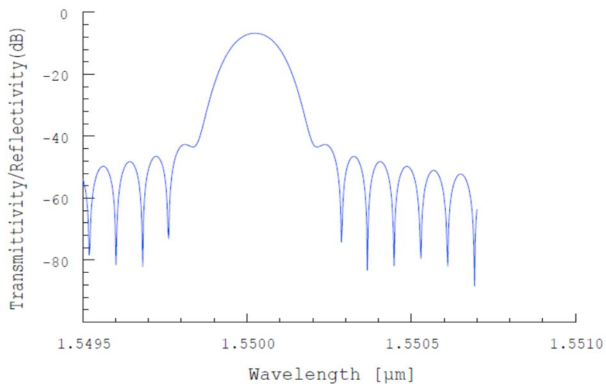

Figure 3.1 The reflection spectrum of FBG for strain 20µm at grating length of L=10 mm

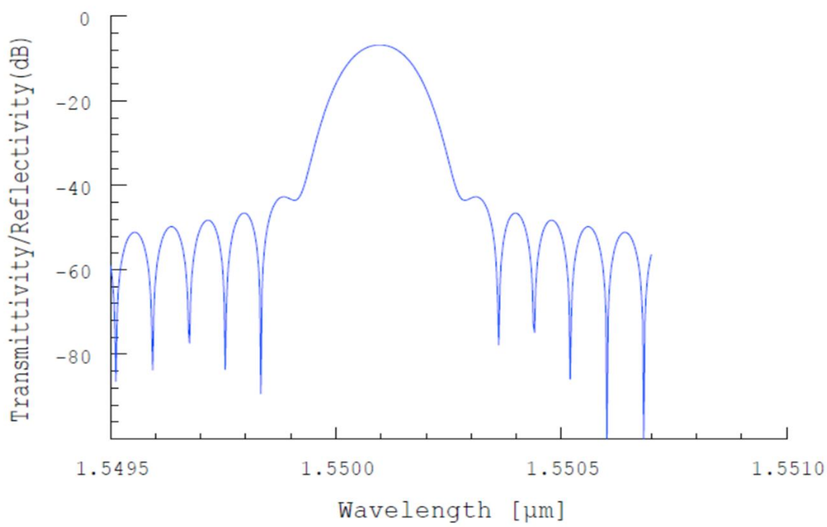

Figure 3.2 The reflection spectrum of FBG for strain 80µm at grating length of L=10 mm

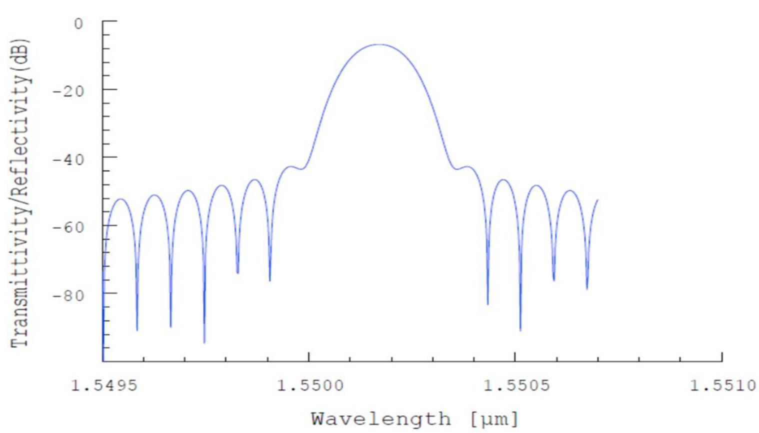

Figure 3.3 The reflection spectrum of FBG for strain 140µm at grating length of L=10 mm

B. Spectral Transmittivity

Grating Length, L(mm)	Strain (µm)	Bragg wavelength, λ_B (nm)	Transmittivity
10	20	1550.0232	-1.03099
10	40	1550.0496	-1.03099
10	60	1550.0736	-1.03099
10	80	1550.0976	-1.03099
10	100	1550.1216	-1.03099
10	120	1550.1456	-1.03099
10	140	1550.1696	-1.03099

Table 3.2 The spectral transmittivity of Bragg wavelength is dependent on grating length and strain changes.

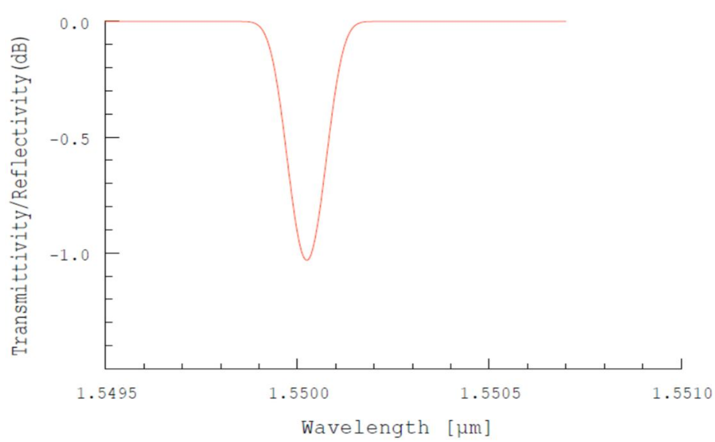

Figure 3.2 The transmission spectrum of FBG for strain 20µm at grating length of L=10 mm

IV. CONCLUSIONS

An optical system's fundamental requirements are determined by this study. Using a fibre Bragg grating, you may determine the damage to an application by running this simulation. Optiwave software can also be used to develop graphs and simulate the strain of the FBG sensing system.Reflection is generated when the length of the fiber changes from its original length. When the strain increases, the Bragg wavelength will also increase. With the increase in grating length, the reflectivity of FBG increases. The reflectivity is constant with the increase of strain.

V. ACKNOWLEDGEMENT

The author would like to thank the Ministry of Higher Education of Malaysia (MOHE) and Universiti Teknologi Malaysia, UTM for providing GUP TIER 2 grants (PY/2017/01792, Q.J130000.2626.15J57) in order to conduct this research and developing the paper. The author report no conflicts of interest in this work.

REFERENCES

[1] Palli Mishra, Kanhu Charan Bhuyan, Hemanta Kumar Sethi. (n.d.). Development of FBG Sensors using Optiwave system software for structural health monitoring. International Journal of Engineering Science Invention, 157-163.

[2] Othonos, A., Kalli, K., Pureur, D. and Mugnier, A. (n.d.). Fibre Bragg Gratings. Springer Series in Optical Sciences, pp.189–269. doi:10.1007/3-540-31770-8_6.

[3] Kori, T., Kori, A., Kori, A. and Nandi, S. (2019). A Study on Fiber Bragg Gratings and Its Recent Applications. Innovative Mobile and Internet Services in Ubiquitous Computing, pp.880–889. doi:10.1007/978-3-030-22263-5_84.

[4] Krishna Prasad, S., Talasila, V. and Mohana Kumar, S. (2020). Simulation and Modeling of Fiber Bragg Grating Sensors. 2020 International Conference on Recent Trends on Electronics, Information, Communication & Technology (RTEICT). doi:10.1109/rteict49044.2020.9315659.

[5] Hill, K. O., Fujii, Y., Johnson, D. C., & Kawasaki, B. S. (1978). Photosensitivity in optical fibre waveguides: Application to reflection filter fabrication. Applied Physics Letters, 32(10), 647–649.

[6] Department of Electrical Engineering, The Hong Kong Polytechnic University, Hong Kong, & Jin, W. (2007). Structural Strain and Temperature Measurements Using Fibre Bragg Grating Sensors.

[7] Yuan, L., & Yang, J. (2003). Multiplexed Mach–Zehnder and Fizeau tandem white light interferometric fibre optic strain/temperature sensing system. Sensors and Actuators A: Physical, 105(1), 40–46.

[8] A. D. Kersey, M. A. Davis, H. J. Patric, M. LeBlanc, K. P. Koo, C. G. Askins, M. A. Putnam, and E. J. Friebele, \"Fibre grating sensors,\" J. Lightwave Technol., 15, 1442-1462 (1997)

[9] A. Othonos and K. Kalli, \"Fibre Bragg Gratings: Fundamentals and Applications in Telecommunications and Sensing,\" Artech House, Norwood, pp. 301-396, (1999)