Design and Analysis of Fiber Bragg Grating Tunable Filter Utilizing Thermal Technique

Ayad Z. Mohammed[1], A. K. Abass[1, a)], Samar K. Ibrahim[1]

[1]*Laser Engineering Branch, Laser and Optoelectronics Department, University of Technology, Baghdad, Iraq.*

[a)]*Corresponding author: 140042@uotechnology.edu.iq*

Abstract. In this paper a tunable filter based on fiber Bragg grating (TF-FBG) utilizing a thermal technique is theoretically investigated and experimentally validated. According to the results, a tuning range is achieved about 0.6 nm in C-band region. While, for L-band region the wavelength shift is slightly greater than in the C-band region about 0.7 nm. This shifting is due to changing in thermo-optic and thermal expansion of fiber, which causes changing in n_{eff} and Λ, respectively, which affects ther Bragg wavelength. The experimental validation is done at wavelength 1543.8 nm; the tunability is about 0.519 nm when the temperature is varied from 20°C to 70°C.

INTRODUCTION

Fiber Bragg gratings (FBGs) have been investigated in many published works during recent decades and up to the present. This is due to their applications as attractive optical sensors for different measurement purposes [1-4]. At the same time the FBGs based on tunable optical filters are widely used for semiconductor and doped fiber lasers [5-7], gain equalizer in a fiber amplifier [8], as well as add/drop multiplexer for wavelength division multiplexing systems [9-10]. In this context, the FBG center wavelength can be tuned by adjusting the refractive index of the fiber or by modifying the grating period. These modifications can be achieved by different ways, such as thermal effects [11-14], electromagnetic force [15], mechanical effect [16] and pressure technique [17].

To the best of our knowledge, there are a few published works regarding to TF-FBG based on thermal technique [13]. The authors were presented an innovative automated TF-FBG controlled by temperature to be used in temperature compensating schemes in FBG sensing setups. Mechanical and electronic aspects are discussed, and the implemented TF-FBG viability and reliability in sensing systems are showed. The system was employed to demodulate a high voltage AC signal applied to a FBG-PZT sensor, showing good linearity and sensitivity. In this paper a TF-FBG utilizing a thermal technique is theoretically investigated and experimentally validated.

THEORETICAL MODEL

A fiber Bragg grating is a piece of optical fiber with a periodic variation of the index of refraction along the fiber axis. Such a phase grating acts as a band rejection filter reflecting wavelengths that satisfy the Bragg condition and transmitting the others. FBGs act like tiny mirrors in a fiber that reflect specific wavelengths due to periodic changes in the index of the fiber core. In a uniform FBG the period length of refractive index change Λ is fixed and usually Λ is around 0.5 μm. Coherent reflection is achieved where the period is half the wavelength of the light in the fiber, giving an Equation (1) known as the Bragg condition:

$$N \, . \, \lambda_B = 2 \, n_{eff} \, \Lambda_g \tag{1}$$

where $N \geq 1$ is an integer indicating the order of the grating period, λB is Bragg wavelength, and Λg is Grating period, neff is Effective refractive index of the transmitting medium. Using the coupled-mode theory, theoretically the normalized reflection produced by an FBG is given by Equation (2):

4th Electronic and Green Materials International Conference 2018 (EGM 2018)
AIP Conf. Proc. 2045, 020012-1–020012-6; https://doi.org/10.1063/1.5080825
Published by AIP Publishing. 978-0-7354-1771-7/$30.00