Қазақстан Республикасы Тәуелсіздігінің 30 жылдығына арналған «Сейфуллин оқулары – 17: «Қазіргі аграрлық ғылым: цифрлық трансформация» атты халықаралық ғылыми – тәжірибелік конференцияға материалдар = Материалы международной научно – теоретической конференции «Сейфуллинские чтения – 17: «Современная аграрная наука: цифровая трансформация», посвященной 30 – летию Независимости Республики Казахстан.- 2021.- Т.1, Ч.3 - С. 75 - 78

INVESTIGATION OF THE DEPENDENCE OF THE WAVELENGTH OF TILTED FIBER BRAGG GRATINGS ON TEMPERATURE CHANGES

Kabibulatov A.A.
Kussainova K.T.
Khamzina B.E.

In the work "Experimental determination of the characteristics of a transmission spectrum of tilted fiber bragg gratings" A. Tolegenova, A. Zhetpisbaeva and others study the dependence of the width of the transmission spectrum of an tilted Bragg grating on the refractive index of the medium. Bragg gratings can be used to measure the refractive index of a medium [1].

Nowadays, fiber-optic sensors are often used for temperature measurement due to their advantages over competitive technologies such as fast data transfer, measurement accuracy, scalability, etc. Sensors made using fiber Bragg gratings offer the advantages of fiber optic sensors while improving the competitive edge over other technologies.

Tilted fiber Bragg grating sensors are the newest type of fiber sensors that are becoming increasingly important in the field of monitoring the state of civil infrastructure structures [2] and in the oil and gas industry [3].

The interest in tilted Bragg gratings is currently extremely high. This can be confirmed by numerous studies that are carried out around the world. For example, Ma, K.P., Wu C. and others conducted an experiment with a tilted Bragg grating that was placed in carbon fiber-reinforced plastic to obtain solidification data. Based on the result, they concluded that the refractive index of the Bragg grating sensor changed due to the anisotropic polarization of the ellipse caused by the residual stress of the isotropic laminate. Also, they noted that tilted Bragg gratings can be used to control the quality of manufacture and control damage to aerospace composites [4].

Another group of researchers (Xin Tian, Xiaofan Zhao and others) studied the potential of using Bragg gratings in high-power fiber laser systems. Experimental results have shown that if the Bragg wavelength is in the range of the Romanov gain spectrum with a relatively high gain, very weak Bragg reflection can be significantly enhanced at high power, which will seriously affect the laser output power, efficiency and beam quality [5].

In the course of our study, in order to determine the dependence of the wavelength of the Bragg grating on temperature, we carried out an experiment. We used two optical light-sensitive fibers with tilted Bragg gratings (TFBG) applied to them by the phase mask method with a grating period of 540 nm and a length of 10 mm. One fiber was covered with a grating with an inclination angle of 3 degrees, and on the other - with an inclination angle of 5 degrees. Both fibers were connected to a light source on one side and an optical analyzer on the other. The areas close to the middle of the cables were stripped and the cable sheathing was removed. This section was placed in a container with a 10% cane sugar water solution, and a medium refractive index of 1.3479. The container with the solution and fibers was placed in a climate chamber.

In this study, the signal was sent to a tilted Bragg grating from a light source that was connected to the grating using a single-mode optical fiber. The cable was placed in a container with a solution, the container was placed in a climatic chamber, the temperature varied from 0 to 500C with a step of 5 degrees. The transmission spectra of the grating entered the optical analyzer, after which it was possible to work with the data, to analyze the transmission spectra of the grating. An experiment to study the effect of ambient temperature on inclined Bragg gratings was carried out in the optical fiber laboratory at the Lublin University of Technology online.

A schematic of the experimental setup is shown in Figure 1, where an inclined Bragg grating with an inclination angle of 3 degrees is considered. After the experiment, the obtained data was used to construct the normalized spectrum of the lattice in the Matlab environment. This spectrum is shown in Figure 2 for a grating with an inclination angle of 3 degrees for temperatures from 0 to 50 ° C with a step of 5 degrees.

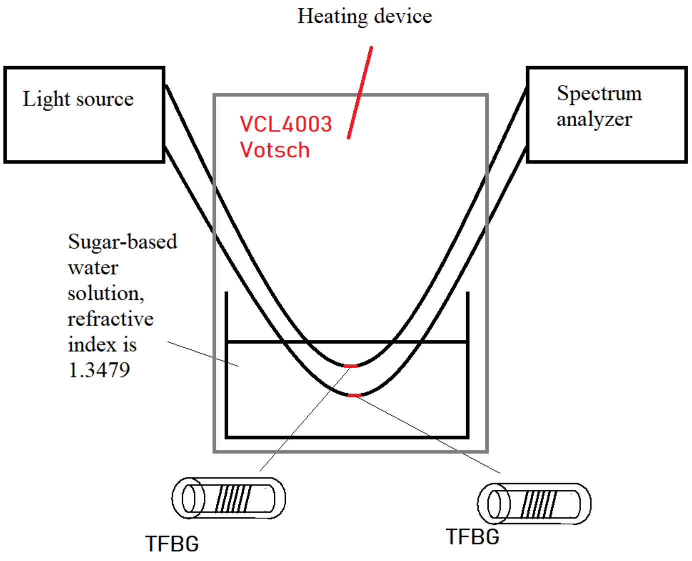

Figure 1. Experimental setup for investigating the temperature dependence of the wavelength of an inclined Bragg grating.

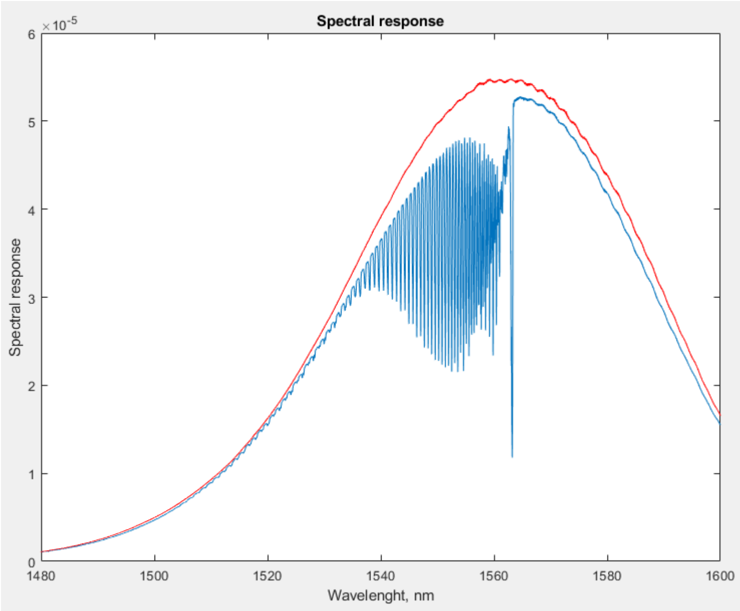

Figure 2.Tilted Bragg grating spectral response

The normalized spectrum was obtained by us by the ratio of the grating spectrum to the spectrum of the light source - the blue line to the red one (Figure 3). The wavelength of the tilted Bragg grating varies with the ambient temperature.

During the experiment, the dependence of 10 wavelength values on 10 temperature values for an inclined Bragg grating with an angle of inclination of 3 degrees (Table 1) was revealed, a graph was built (Figure 4).

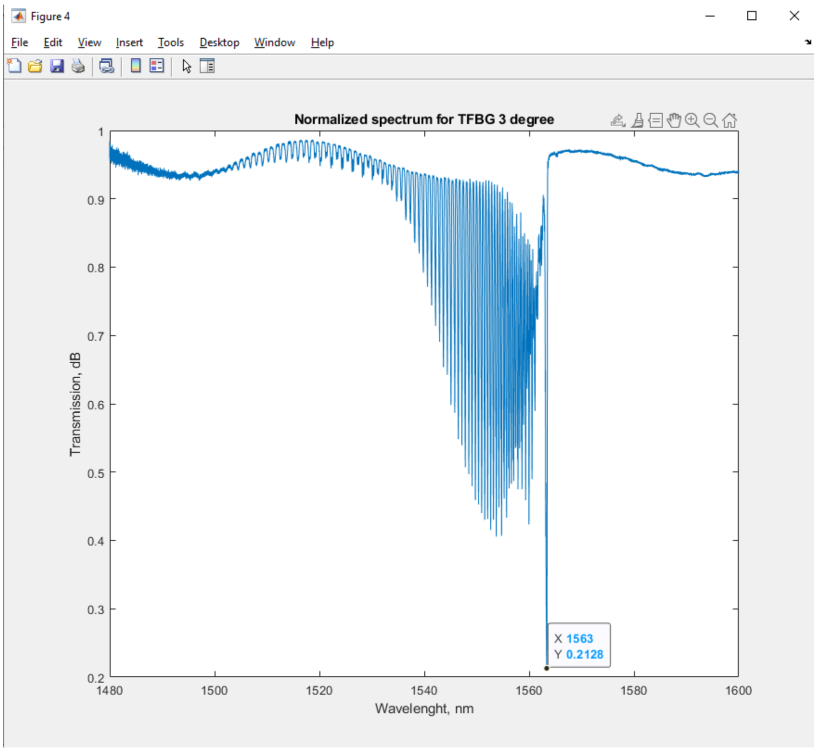

Figure 3. Tilted grating wavelength

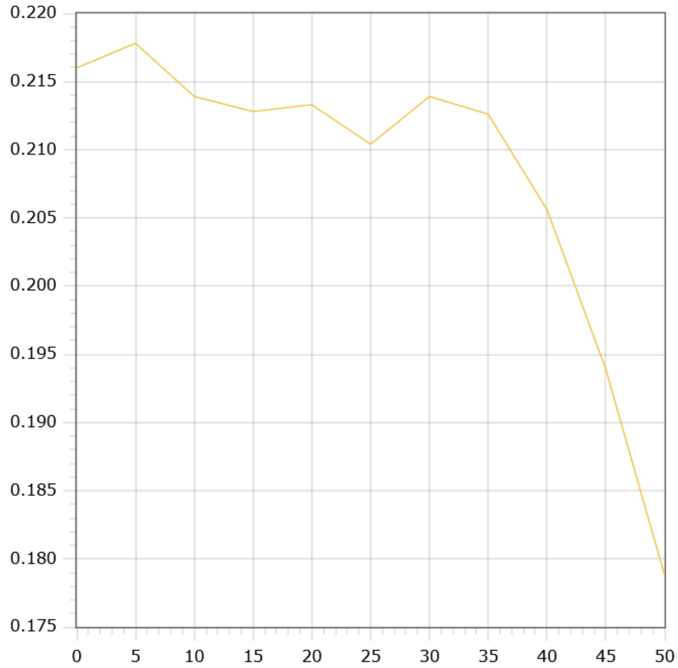

Figure 4. Graph of dependence of wavelength on temperature

Thus, the dependence of the wavelength of the tilted Bragg grating on the ambient temperature is linear. Therefore, the wavelength of the tilted Bragg grating can be used as an indicator of the change in ambient temperature. Wavelength characterization is of great interest in the context of practical industrial applications for temperature monitoring. To do this, we should repeat the same wavelength measurements for other tilt angles of inclined Bragg gratings.

List of references

1. Experimental determination of the characteristicsof a transmission spectrum of tilted fiber bragg gratings / AkmaralTolegenova, Piotr A. Kisała, AinurZhetpisbayeva, OrkenMamyrbayev, BekbolatMedetov. Metrol. Meas. Syst.,Vol. 26 (2019) No. 3, pp. 581–589. DOI: 10.24425/mms.2019.129585

2. Performance assessment of indigenously developed FBG strain sensors under short-term and long-term loadings K. Kesavan1, B. ArunSundaram, A. k. Farvaze Ahmed, S Parivallal, pbiswas, S bandyopadhyay, k ravisankar and umesh Tiwari. CSIR-Structural Engineering Research Centre, Council of Scientific and IndustrialResearch, Chennai 600 113, India 2 Central Glass and Ceramic Research Institute, Council of Scientific and IndustrialResearch, Kolkata 700 032, India3Central Scientific Instruments Organization, Council of Scientific and IndustrialResearch -2015. -Vol. 40, part 2. – pp. 577-590.

3. Modelling and Simulation of Fiber Bragg Grating Characterization for Oil and Gas Sensing Applications. Solomon Udoh, James Njuguma,

RadhakrishnaPrabhu, 2014 First International Conference on Systems Informatics, Modelling and Simulation

4. Ma, K.-P.; Wu, C.-W.; Tsai, Y.-T.; Hsu, Y.-C.; Chiang, C.-C. Internal Residual Strain Measurements in Carbon Fiber-Reinforced Polymer Laminates Curing Process Using Embedded Tilted Fiber Bragg Grating Sensor. Polymers 2020, 12, 1479. https://doi.org/10.3390/polym12071479

5. Influence of Bragg reflection of chirped tilted fiber Bragg grating on Raman suppression in high-power tandem pumping fiber amplifiers. Xin Tian, Xiaofan Zhao, Meng Wang, Qihao Hu, Hongye Li, Binyu Rao, Hu Xiao, Zefeng Wang. OpticsExpressVol. 28, Issue 13, pp. 19508-19517 (2020). https://doi.org/10.1364/OE.396250