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INFLUENCE OF TEMPERATURE CHANGE ON THE SPECTRAL CHARACTERISTIC OF BRAGG GRATINGS

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In the modern world, people work with a huge amount of information, various gadgets from phones to computers help them in this. Each such device is used for specific purposes, be it information processing, distribution or transmission. Due to the rapid development of automated systems in various industries, the need for the use of fiber optic sensors in increasing. Their use lies in the measurement of physical quantities such as: temperature, pressure, deformation, angle of inclination, vibration. They serve as an integral part of the monitoring system, in which the transmission of information passes through the movement of light in the sensor itself. There are many different types of fiber optic sensors. Each of them has unique properties that are designed to perform a specific task. The study of fiber-optic sensors with the aim of improving their operation, increasing reliability and quality, efficiency is still relevant today.

The most popular and promising are fiber-optic sensors based on fiber bragg gratings, due to a number of advantages: compact size, low weight, no nedd for electrical connections, immunity to electromagnetic interference, ease of communication and multiplexing. External influence on sensors with Bragg gratings affects its wavelength and leads to its change, which means a change in the parameters of the grating itself. These changes can be used to judge the required characteristics.

For a conventional fiber Bragg grating, the frequency of modulation of the refractive index has a physical interval equal to half the wavelength of light propagating in the waveguide (phase synchronization between the grating planes and the incident light leads to coherent back reflection). Reflectance coefficients approaching 100% are possible, while the lattice bandwidth is usually from 0.1 nm to more than tens of nanometers. These characteristics make Bragg gratings suitable for telecommunications where they are used to reflect, filter or diffuse light. [1]

Fiber lasers, capable of emitting light in telecommunication windows, use Bragg gratings to form both a high reflectance end mirror and an output coupler to the laser cavity, resulting in an inherently efficient and stable source. In addition, the ability of gratings with non-uniform periodicity to compress or expand pulses is especially important for high-speed long-distance communication systems. Tunable grating-based dispersion compensation devices can be used to reduce harmonic distortion in the signal due to changes in optical power. Many grating-based transmission experiments have been reported [2], including 10 Gbps per 400 km of non-dispersion-shifted fiber with fixed dispersion compensation using chirped fiber Bragg gratings [3]. Systems using Bragg gratings have demonstrated transmission rates in excess of 100 km - 40 Gbps [2]. Given that future systems will operate at 160 Gbps data rates, accurate dispersion maps are required for the fiber network, furthermore, there are no electronic alternatives at this transfer rate, and dispersion compensation must be fully optical and customizable in nature. There are demonstrations up to 100 km at this repetition rate using tunable chirped gratings [4].

Fiber optic light sensitivity has truly ushered in a new era in fiber optic devices, with innovative new Bragg grating structures finding their way into telecommunications and sensor applications. Devices such as Fiber Bragg Fabry - Perot gratings for bandpass filters, chirped gratings for dispersion compensation and ultrashort operation pulse shaping, and luminous gratings for mode converters are becoming common applications. Fiber optic sensing is an area where Bragg gratings have been used since the early days of their discovery, and most fiber optic sensor systems today use Bragg grating technology. In the years since its initial development, fiber Bragg gratings have moved from laboratory interest and curiosity to applications in optical communication and sensor systems. In a few years, it will be as difficult to think of fiber optic systems without fiber Bragg gratings as it would be bulk optics without the familiar laboratory mirror [5].

The features of fiber Bragg gratings exhibit high sensitivity, high resolution and wide dynamic range, as well as their intrinsic immunity to radio frequency interference (RFI) and electromagnetic interference (EMI) and their interoperability. Communication systems have facilitated their widespread use in many sensor applications. Due to their high sensitivity to various environmental parameters, including physical, chemical, biomedical and electrical parameters, they are used for structural health monitoring in civil infrastructure, aerospace, energy and marine areas, where information associated with measured quantities is usually encoded by wavelength shift Bragg [6]

In the course of our study, in order to study the change in the minimum of the spectrum with a change in temperature, we carried out an experiment in which the phase mask method was used as a recording of an inclined fiber-optic Bragg grating with tilt angles of 3° and 5° C, as well as an excimer laser. One fiber was coated with a grating with a tilt angle of 3° C, and the other with a tilt angle of 5° C. Both fibers were connected to a light source on one side and to 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 ten percent solution of water with cane sugar, the refractive index of the medium was 1.3479. The container with the solution and fibers was placed in a climate chamber. The temperature in the climatic chamber was varied from 0° to 50° C with a step of 5° C. Ultraviolet light was applied to a light-sensitive single-mode optical fiber by the phase mask method. The light of the laser beam fell on the TFBG, which was immersed in an aqueous solution of cane sugar. The transmission spectra of the TFBG were measured using an optical spectrum analyzer. The diagram of our experimental setup is shown in Figure 1. Based on the obtained experimental data, the normalized spectra of the fiber Bragg grating in the Matlab environment with tilt angle of 3° C were found, the minima of these spectra were found (Figure 2). The minimum of the spectrum was obtained for inclined Bragg gratings with an increase in temperature from 5 ° to 50 ° C. An experiment to obtain the spectral characteristics of tilted Bragg gratings was carried out in the optical fiber laboratory at the Lublin Technical University online.

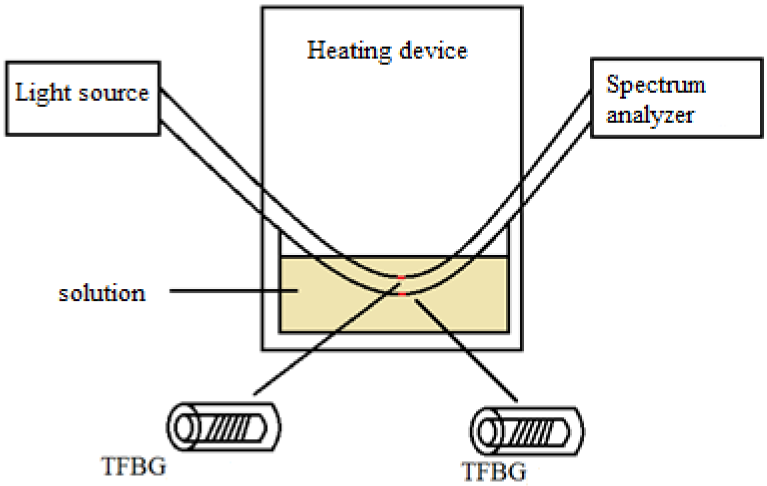

Figure 1. The diagram of experimental setup

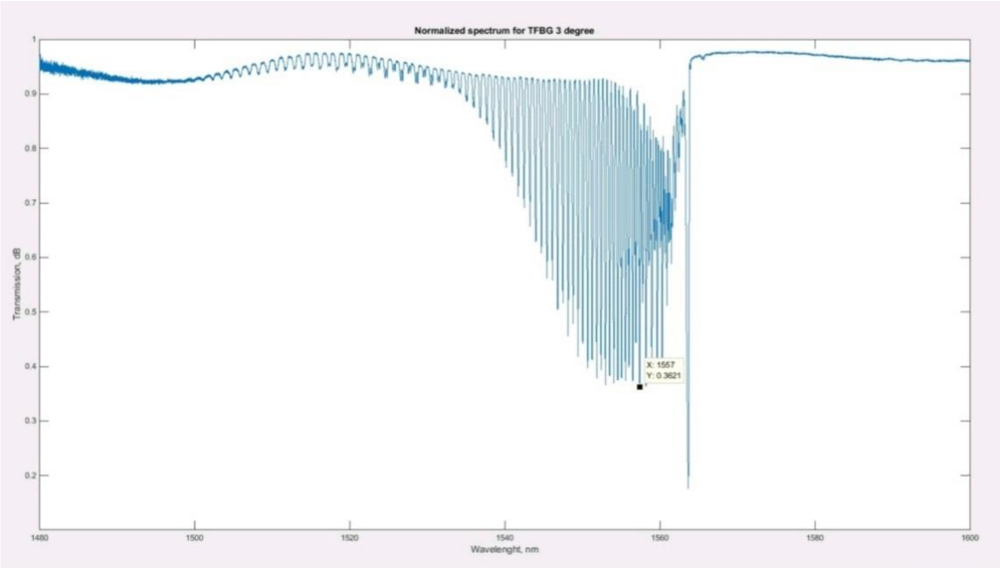

Figure 2. Titled grating spectrum minimum

During the experiment, the dependence of 10 spectrum minimum values on 10 temperature values for an inclined Bragg grating with an angle of inclination of 3 degrees a graph was built (Figure 3). With increasing temperature, the minimum of the spectrum decreases.

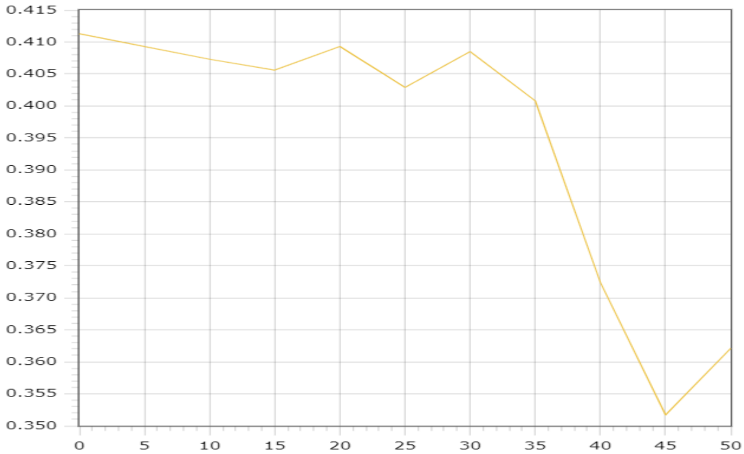

Figure 4. Graph of dependence of spectrum minimum on temperature

Thus, the dependence of the minimum of the inclined Bragg grating spectrum on the ambient temperature for an inclination angle of 3 ° C shows a linear dependence. Consequently, the minimum of the inclined Bragg grating spectrum can be used as an indicator of changes in the ambient temperature. The characteristic is of great interest in the context of the practical application of temperature control in chemical processes, power cables for optimizing industrial relations, ensuring fire safety in railway tunnels and in wagons, as well as for detecting leaks in pipelines.

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