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Monitoring of Environment Pollutants (Gaseous) by Advanced Technique Optical Fiber Bragg Grating

PK Singh, Rajni Singh

Abstract

This paper reveal about global warming due to rapid industrialization, population growth deforestation, cutting of tree etc. These factor increase the amount of CO_2 in environment, the other pollutant also emit from industry, factory and vehicle etc. The paper restricts their study only on the recent advance technique based on optical fiber grating methodology for measuring toxic gas carbon monoxide emitting from sealed, abandoned wells, oil wells, caves etc.

Keywords: Optical Fiber Bragg Grating, IPCC, Optical Filter, Fresnel Reflection.

Introduction

A fiber Bragg grating (FBG) is a type of distributed Bragg reflector constructed in a short segment of optical fiber that reflects particular wavelengths of light and transmits all others. This is achieved by adding a periodic variation to the refractive index of the fiber core, which generates a wavelength specific dielectric mirror. A fiber Bragg grating can therefore be used as an inline optical filter to block certain wavelengths, or as a wavelength-specific reflector (fig. 1).

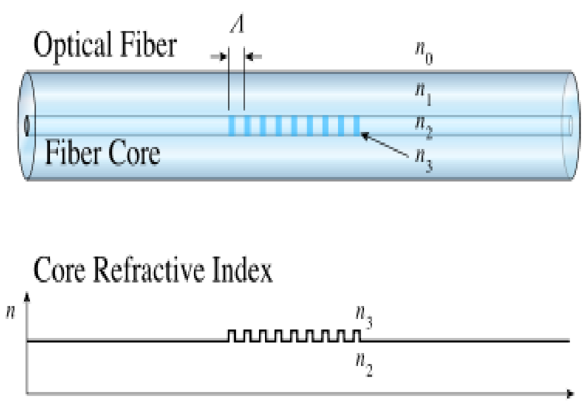

Figure 1.Fiber Bragg Grating structure

Theory

The fundamental principle behind the operation of a FBG, is Fresnel reflection. Where light traveling between media of different refractive indices may both reflect and refract at the

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interface. The grating will typically have a sinusoidal refractive index variation over a defined length. The reflected wavelength (λ_B), called the Bragg wavelength, is defined by the relationship,

$$\lambda_B = 2n_{eff}\Lambda \qquad (1)$$

where n is the effective refractive index of the grating in the fiber core and Λ is the grating period. The wavelength spacing between the first minima (nulls), or the bandwidth ($\Delta\lambda$), is given by,

$$\Delta\lambda = (2\delta_{n0}\ \eta)\ \lambda_B/\pi \qquad (2)$$

where δ_{n0} is the variation in the refractive index ($n_1 - n_2$), and η is the fraction of power in the core.

The Bragg wavelength is sensitive to Strain as well as temperature. This means that fiber Bragg gratings can be used as sensing elements in optical fiber sensors. In a FBG sensor, the measurand causes a shift in the Bragg wavelength, $\Delta\lambda_B$. The relative shift in the Bragg wavelength, $\Delta\lambda_B / \lambda_B$, due to an applied strain (ε) and a change in temperature (ΔT) is approximately given by,

$$\Delta\lambda_B / \lambda_B = C_S€ + C_T\,\Delta T \qquad (3)$$

$$\Delta\lambda_B / \lambda_B = (1 - p_e)\,\varepsilon + (\alpha_\Lambda + \alpha_n) \qquad (4)$$

Here, C_S is the coefficient of strain, which is related to the strain optic coefficient p_e. Also, C_T is the coefficient of temperature, which is made up of the thermal expansion coefficient of the optical fiber, α_Λ, and the thermo-optic coefficient, α_n.

Principle of Measurement

Optical Fiber Bragg gratings could be used as direct sensing elements for strain and temperature. They could also be used as transduction elements, converting the output of another sensor, which generates a strain or temperature change from the measurand.For example the optical fiber Bragg grating gas sensors use an absorbent coating, which in the presence of a gas expands generating a strain, which is measurable by the grating.Technically the absorbent material is the sensing element which show the effect on OFBG as strain as per amount of gas.The Bragg grating then get strained and correspondingly change in wavelength occurs. In the case of measurement of CO, thin film of SnO_2 (Tin oxide) is used an absorbent coating which reacts with subject gas and resistivity changes significantly. Change in the resistivity leads to change in strain of fiber so the refractive index of the cladding. The Bragg grating then transduces the strain to the change in wavelength.

Experimental Setup

The long optical fiber grating is dipped into (laid down) the abandoned well and one end of the fiber is coupled to infra red source for generating infrared in wavelength range. The other end of the fiber on the surface has detector followed by portable optical spectrum analyzer to record the changes in wavelengths according to changes in strain of the cladding (fig.2).

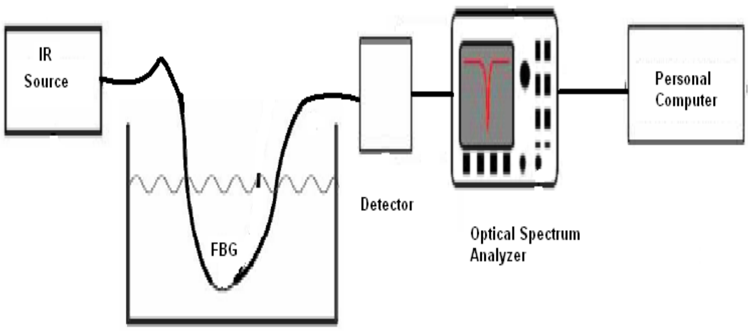

Figure 2.Experimental setup

Results

This increase temperature change the value of refractive index and grating period, due to which Bragg wavelength $\lambda_B = 2n_{eff}\Lambda$ change as per the value of n_{eff} and Λ.These changes can be shown on spectrum analyzer. At the Bragg wavelength the reflection is highest and before and after the reflection decrease in the form of sinc function and similar the transmission is highest at other than Bragg wavelength. At Bragg wavelength the transmission loss is highest as shown in fig.3.

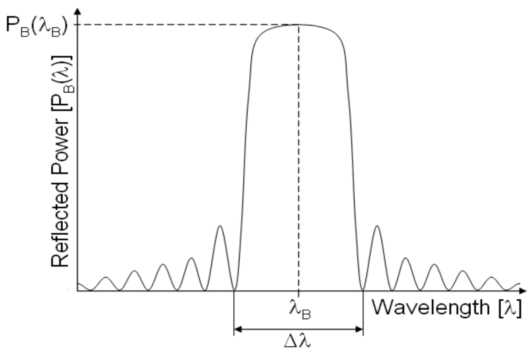

Figure 3.Reflection spectrum

These plots show the different reflectivity at different loss and Bragg wavelength.

Conclusion

There are a nos. of techniques available for measuring Toxic pollutant gas Carbon Monoxide. However for measurement of CO presence inside abandoned well, oil well, underneath waste disposal, cave. Tunnel, Goof area in underground coal & other metal mines etc. the fiber optics Bragg grating sensor and associated monitoring circuitry (instrumentation) is appropriate technology.

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