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Comparison of Fabry – Perot Filter of Fiber Bragg Grating for Visible and Ultraviolet Spectra

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Abstract
The use of Fiber Bragg Grating (FBG) as Fabry – Perot filter has been successfully developed for visible light and ultraviolet spectra. The characteristic of FBG is analyzed by using computational model with Transfer Matrix Method by order 2 with the coupled mode theory. The reflectivity, length of grating and bandwidth are parameters to determine the performance of FGB with laser source of 1 mW for 250 – 350 nm, ultraviolet and 380 – 780 nm, visible light. The simulation is also carried out by various grating from 0.5 cm – 9.5 cm with increment step of 1 cm. The simulation result showed that there is the filter discrepancy for maximum peak. This design of FGB can be used as a filter. Only selected wavelength is allowed to transmit the signal until the end of the optical fiber.

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1. Introduction

Configurations Fabry-Perot interferometers recently have been applied in telecommunications system scheme based on optical fiber. One of the application as optic resonator is by inserting Fiber Bragg Grating, (FBG) functioning as mirror. The grille placed separates at distance which have been determined, creating grille ante-room. Characteristic transmission wave propagation can be determined by passing Grille Bragg structure. Experiments which have been developed in general require costly expense and time relative longer. One of the solutions is by using method analyzed simulation with computer simulation. A method which is often used for the specifications of Grille Bragg is mode theory hold mutually (Coupled Mode Theory) and method of is transfer of matrix (Transfer of Matrix Method) capable to analyze periodic structure from grille found on single mode optical fiber [5].

FBG component has good benefit since it can be used as a sensor for nano and micro scale. It is computable to the solution of length scale by measuring the transmitted and reflected patterns, and then it can indirectly calculate the mechanical magnitudes. Although FBG can measure the mechanical magnitudes, it is also necessary to compare and characterize the effect of the visible and ultra violet wavelength source to FBG. This comparison will show the influence of the coupling amongst the source, fiber and grating to FBG as the result of interference and disturbance between the photon source and the FBG refractive indices parameters. In this report, we present the application of FBG for range visible and ultra violet spectra as a source by using FBG and a detector to investigate the transmission and reflection pattern of wave output. This will allow describing the effect of the various spectra in FBG characteristics.

2. Methodology

FBG basically has to fulfill the change of momentum and energy. The first order is simple condition of Bragg:

$$\lambda_b = 2n_{eff}\Lambda \tag{1}$$

where λ_b is the Bragg Grating wavelength. At an empty space between wavelength grille centers from incident ray will be re-bounced from Bragg grille, and n_{eff} is effective refractive index from core of fiber. FBG performance is influenced by reflected peak, wide *R* of ribbon $\Delta\lambda$ and Bragg grille length L, the third parameter can be written as:

$$R = tanh^2\kappa. \tag{2}$$

and

$$\Delta\lambda \approx \frac{\lambda_b^2}{n_{eff}L}\left(1+\frac{\kappa^2L^2}{\pi^2}\right)^{1/2} \tag{3}$$

where

$$\kappa \approx \frac{\pi\Delta nI}{\lambda_b} \tag{4}$$

Δn the change of refractive index in I given by

$$I = 1 - exp\left(-\frac{2a^2}{w^2}\right) \tag{5}$$

where a is the radius core and the fiber depicts Gaussian dot size measure from fundamental mode. The difference of refractive index is immeasurable in fiber type, as in general it is defined as follows:

$$n_{eff} = \frac{\lambda_b}{2\Lambda} \tag{6}$$

where λ_b Bragg is wavelength and Λ is grille period.

The length of grille is a wide ribbon at reflected spectrum. The wide ribbon can go up or alight from long degradation and increase of grille during time constant nL. The Equation of grille is formulated.

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$$L=\frac{\lambda_B^2}{\pi n_{eff}\Delta\lambda}\sqrt{\left(tanh^{-1}\left(\sqrt{R}\right)\right)^2+\pi^2} \tag{7}$$

According to [3] the ideal modes at Equation of mode are hold mutually. Consider it is imposed by electrical field transverse component written down as ideal mode superposes which is symbolized with j (mode at an ideal wave guide without a hitch grille).

$$\vec{E}_t\left(x.y.z.t\right)=\sum_j\left[A_j\left(z\right)exp\left(j\beta_j z\right)\ +B_j\left(z\right)exp\left(-j\beta_j z\right)\ \right]\cdot\vec{e_{jt}}\left(x.y\right)exp\left(-i\omega t\right) \tag{8}$$

where A_j (z) and B_j (z) represent amplitude which creep slow at mode allowed of j at tinder direction + and z - z. A mode of electric field $\vec{e_{jt}}\left(x.y\right)$ describes as a boundary.

When orthogonal mode is at ideal wave guide [2], the attendance of dielectric trouble cause couple mode at A_j (z) and B_j (z) (j mode z) mount as long as z tinder, expressed with:

$$\frac{dA_j}{dz}=i\sum_k A_k\left(K_{kj}^t+K_{kj}^z\right)exp\left[i\left(\beta_k-\beta_j\right)z\right]+i\sum_k B_k\left(K_{kj}^t-K_{kj}^z\right)exp\left[-i\left(\beta_k+\beta_j\right)z\right] \tag{9}$$

$$\frac{dB_j}{dz}=-i\sum_k A_k\left(K_{kj}^t-K_{kj}^z\right)exp\left[i\left(\beta_k+\beta_j\right)z\right]-i\sum_k B_k\left(K_{kj}^t+K_{kj}^z\right)exp\left[-i\left(\beta_k-\beta_j\right)z\right] \tag{10}$$

Where $K_{kj}^t(z)$ is athwart coupling coefficient between j modus and passed to k equation:

$$K_{kj}^t\left(z\right)=\frac{\pi}{4}\iint_\infty dxdy\Delta\varepsilon\left(x.y.z\right)\vec{e}_{kt}\left(x.y\right)\cdot\vec{e}_{kt}^{\,*}(x.y) \tag{11}$$

Where $\Delta\varepsilon$ is the trouble, but in general $K_{kj}^z\left(z\right)\ll K_{kj}^t\left(z\right)$ for the modes of fiber, and that way this coefficient is generally disregarded, hence it is specified by two new coefficients:

$$\sigma_{kj}\left(z\right)=\frac{\omega n_{co}}{2}\delta n_{dc}\left(z\right)\iint_{core}dxdy\vec{e}_{kt}\left(x.y\right)\cdot\vec{e}_{kt}^{\,*}(x.y) \tag{12}$$

$$\kappa_{kj}\left(z\right)=\frac{\omega n_{co}}{4}\delta n_{ac}\left(z\right)\iint_{core}dxdy\vec{e}_{kt}\left(x.y\right)\cdot\vec{e}_{kt}^{\,*}(x.y) \tag{13}$$

Where σ is the coupling coefficient "dc" (period mean) and κ is coupling coefficient "ac". The coupling coefficient can be written down as:

$$K_{kj}^t\left(z\right)=\sigma_{kj}\left(z\right)+2\kappa_{kj}\left(z\right)cos\left[\frac{2\pi}{\Lambda}z+\phi(z)\right] \tag{14}$$

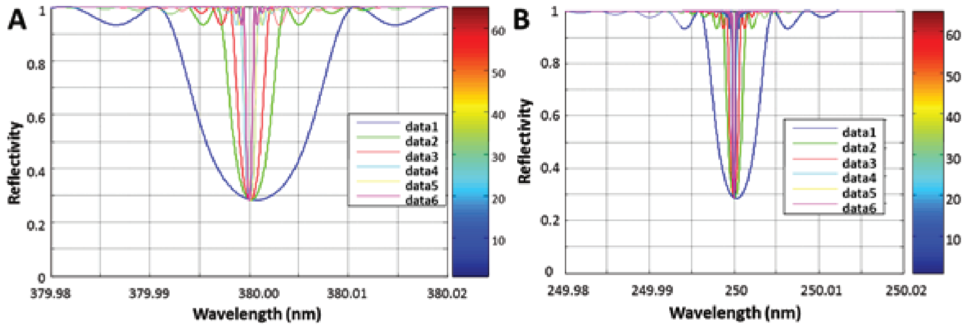

Figure 1: Characteristics for (A) 380 and (B) 250 nm each distance Fiber Brag Grating is from 0.458 cm until 9.458 cm for reflectivity of 0.715.

For the characteristics of light spectrum which creep at uniform grille, each grille deputizes order matrix two (matrix 2 X 2). With multiplying part of this matrix, it is obtained by matrix in general. The refractive index at one grille from Grille Bragg is assumed with:

$$n(z) = n_{eff} + \Delta n_i cos\left(\frac{2\pi}{\Lambda_i}\right) \quad (15)$$

n_{eff}_index deflects the amplitude modulation. and Δn_ii part of grille period.

The uniform grille to each part of grille is described with matrix, given by Ti:

$$\begin{bmatrix} R_i \\ S_i \end{bmatrix} = T_i \begin{bmatrix} R_i \\ S_i \end{bmatrix} \quad (16)$$

with Ti to one part of Bragg grille, given by Equation:

$$T_i = \begin{bmatrix} cosh\left(\Omega_i dz_i\right) - j\frac{\sigma_i}{\Omega_i} sinh(\Omega_i dz_i) & -j\frac{\kappa_i}{\Omega_i} sinh\left(\Omega_i dz_i\right) \\ j\frac{\kappa_i}{\Omega_i} sinh\left(\Omega_i dz_i\right) & cosh\left(\Omega_i dz_i\right) + j\frac{\sigma_i}{\Omega_i} sinh(\Omega_i dz_i) \end{bmatrix} \quad (17)$$

In this case. $j = \sqrt{-1}$, where the amplitude variation of the round of waving at + and z – z, dz is length part of uniform grille i, σ and κ are coupling parameters to part of i.

3. Result and Discussion

The wavelength characteristics of 780 nm and 580 nm at grating distance 0.458 with reflectivity of 0.718 described two similar maximum peaks but it happen a long friction of wave that is in 780.025 nm and in 780.040 nm, and also in 580.0125 nm and 580.025 nm. In addition to the characteristics of the other wavelength there is only one maximum peak in good reflectivity upon the other grille distance.

Wavelength characteristics of 300 nm and 250 nm at Bragg grille distance of 6.458 cm and 9.456 cm with reflectivity of 0.518 shows the changes the maximum culminate which do not meet from low to high level. The other wavelength depicts regularly to maximum culminate from high level to the low one. The data implicitly describe that

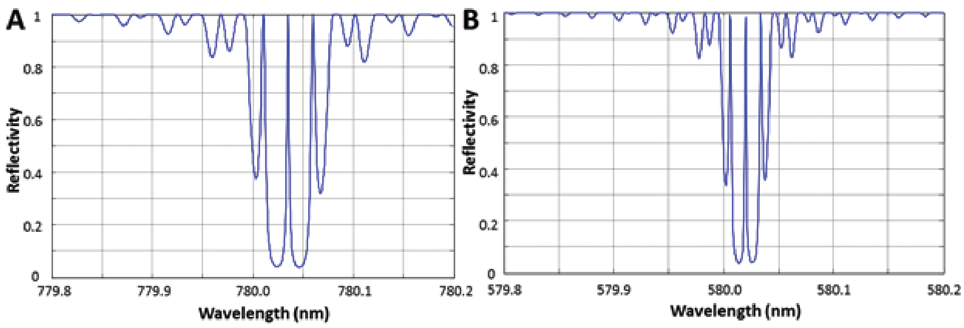

Figure 2: Characteristics for (A) 780 nm and (B) 580 nm with grating of 0.458 cm and reflectivity of 0.718.

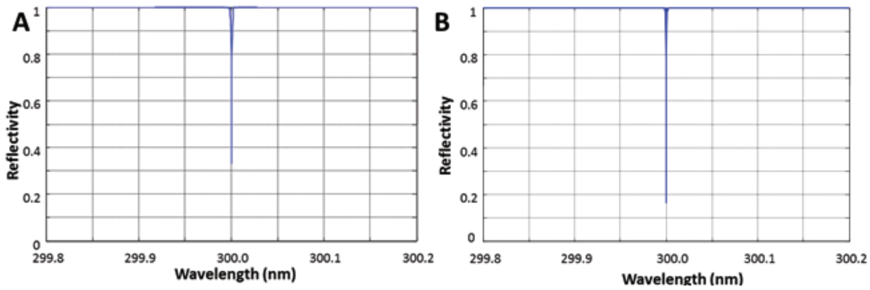

Figure 3: Characteristic for 300 nm with grating (A) 6.458 cm and (B) 9.458 cm and reflectivity of 0.518.

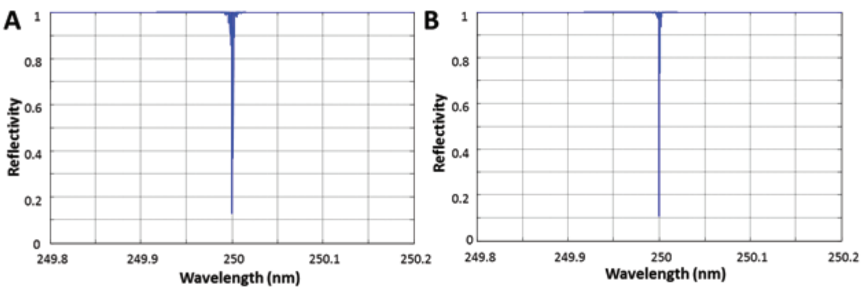

Figure 4: Characteristic for 250 nm with grating (A) 6.458 cm and (B) 9.458 cm and reflectivity of 0.518.

the wave pattern is relatively sharp and stable at peak beginning from the near grating to far one (9.5-0.5cm) either 380 nm or 780 nm wavelength source. The pattern change is due to the FBG adaptation of power source parameters.

4. Conclusion

The characteristics of FBG have been obtained at ultraviolet wavelength of 250 nm until 350 nm. and the visible light of 380 nm until 780 nm. When the wave propagates along the FBG several wavelengths is reflected and the others are transmitted by ignoring the losses. Several peaks are shown due to high transmission for the lower wavelength compared to the higher wavelength. This implicitly depicts that the higher energy corresponding to the lower wavelength can filter the wavelength well and vice versa.

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