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Optimization of Polymer Coated Fiber Grating for Dispersion Compensation

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Abstract

This study presents the designing and simulation of polymer coated fiber Bragg grating as dispersion compensator for maximum reflectivity and lower dispersion. Dispersion is a very critical issue in optical systems like WDM and DWDM systems. As the demand of bandwidth is increasing day by day, it is very essential to resolve this problem. In this paper an analytical model is proposed, to reduce the dispersion using polymer coated fiber Bragg grating for different length, index profile and different polymers (Refractive index change). Polymer has better sensing properties than simple fiber (uncoated). An investigation and comparison is made for coated and uncoated fiber with different lengths and index profile. Output characteristics of fiber Bragg grating greatly depends on physical parameters so as the length and outer coating is changed there is a significant change in dispersion also. It is seen here that as the length plays an important role in dispersion reduction. Results also depicts that index profile also affects the dispersion notably.

Keywords: Polymer coating, fiber Bragg grating, dispersion compensation, reflectivity, length.

1. Introduction

Fiber Bragg grating was first demonstrated by K. O. Hill *et al.* in 1978[1]. Fiber grating is also known as reflection grating as it reflects a particular wavelength. This reflection of a single wavelength is the main characteristics of grating,as it is very useful for sensing purpose. It is widely used for health monitoring, environmental condition change like temperature, pressure, humidity etc. Reflected wavelength directly depends on pitch of grating and effective refractive index of core as given below,

(1)

Where is the Bragg wavelength, is effective refractive index of core and is the pitch of grating. Fig. 1 shows the basic fiber Bragg grating structure,

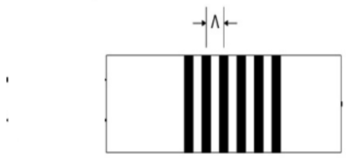

Figure 1: Basic fiber Grating structure.

Some basic parameters such as length, strain on fiber, pitch of grating greatly affects the output reflection pattern. In today's world everyone needs more and more space, in communication language bandwidth is the parameter represented as space. Bandwidth is significantly affected by some critical issues ofoptical fiber. Dispersion is one of the issue which critically effects usable bandwidth of communication link. Dispersion is the broadening of optical pulse and broadening is increased with the distance[2]. WDM and DWDM systems are commonly used optical networking systems in which this issue is more intense. To compensate this problem a lot of methods has been proposed as dispersion compensating fiber, use of narrow beam width laser and fiber Bragg grating also. In fiber grating itself there are a number of ways to reduce this problem. Chirped grating one of that ways. It is very effective method but it also have some limitation like this can not be employed everywhere because its reflectivity is very low. Also if we stitch two or more grating together it will give reflection peaks in between the spectrum which is highly undesirable[3].

In this study, polymer coating is employed on uniform fiber grating to make it more appropriate for dispersion compensation. As polymer have higher refractive index then core effective refractive index and also it have high negative temperature coefficient which significantly affects system dispersion. Here dispersion is seen for different grating length which also affects it. In the next section, theoretical modelling of polymer coated fiber grating has been done.

2. Theoritical Model

Dispersion is one of critical issue in optical networking. Fiber grating experiences chromatic dispersion because of single mode fiber. Dispersion has direct relation to group delay (Δt). D(w) is chromatic dispersion coefficient, is given by[4],

$$D(w) = \Delta t / \Delta\lambda_{bw} \quad (2)$$

Where Δt is group delay and $\Delta\lambda_{bw}$ is reflection bandwidth. Due to coating there is a change in Bragg wavelength and effective length which is given by [5],

$$\delta\lambda_{Br}/\lambda_{Br} = \alpha\Delta T + (1-Pe)\,\delta l/l + \delta n_{eff}/n_{eff} \quad (3)$$

Where $\delta\lambda_{Br}$shift in bragg wavelength, α is thermal expansion coefficient, Pe photo elastic constant of fiber, $\delta n_{eff}/n_{eff}$and$\delta l/l$ are the change in length and period due to thermal and strain expansion. From Eq. 3 it is clear that Bragg wavelength, length of grating and effective index of core is changed as a result of coating. From grating basic equation it is clear that $\Delta\lambda_{bw}$is also changed with the effective refractive index and period of grating and these depends on coating characteristics. From that one can say, D(w) also get changed due to polymer coating.

3. Result and Discussion

In this paper modelling of fiber grating has been done with different polymer differentiate by their refractive indexes. Index profile and length of fiber grating is also varied to optimize its performance as dispersion compensator. Tab. 1 having the list of basic grating parameters,

Table 1: Fixed Grating Parameters.

Grating Parameter	**Values**
Period	0.5µm
Mod Delta	0.00044
Delta	0.008
Grating Type	Volume Index

Reflectivity, FWHM and dispersion graph has been plotted in the following figures which are very useful to characterize fiber grating as dispersion compensator. With different index profiling: Step index and Gaussian index,

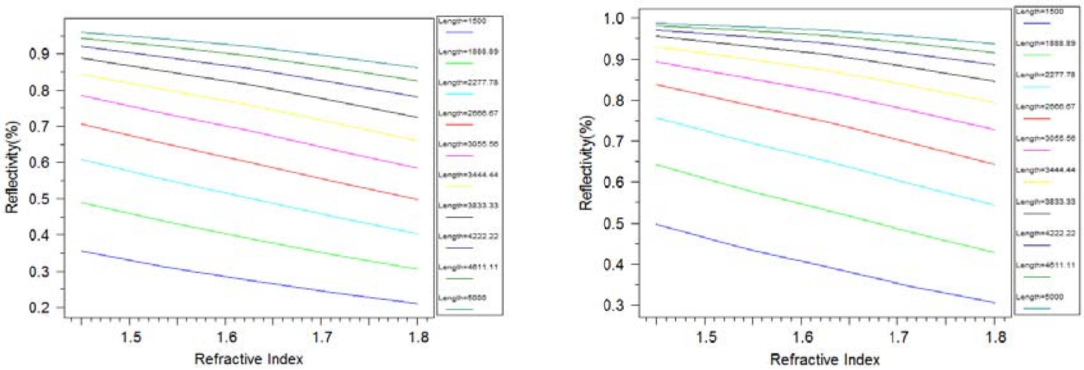

Figure 2: (A) Reflectivity for Gaussian index Profile (B) Reflectivity for Step index Profile

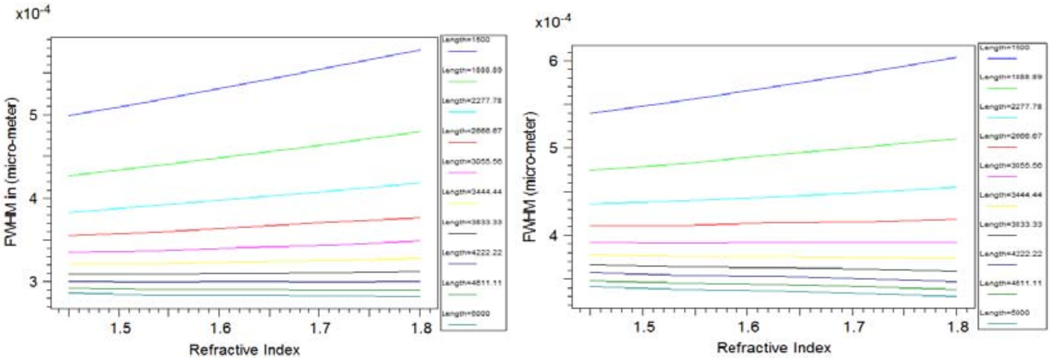

Figure 3: (A) FWHM for Gaussian index Profile (B) FWHM for Step index Profile

Fig. 2 and Fig. 3 shows reflectivity spectrum and FWHM spectrum of fiber grating with different lengths. From the figures it is clear that for Step index profile grating length ranges from 5000µm to 3000µm give good results. Whereas for Gaussian index profile grating length ranges only from 5000µm to 3800µm. Fig. 4 shows the dispersion for these two grating profiles,

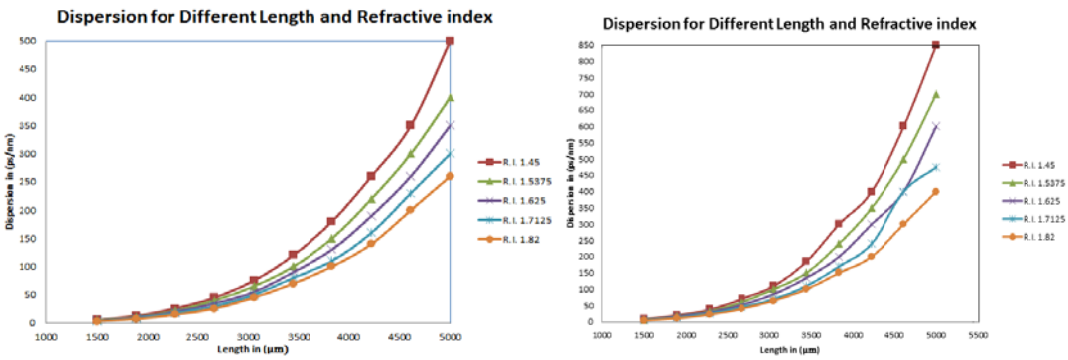

Figure 4: (A) Dispersion for Gaussian index Profile **(B)** Dispersion for Step index Profile.

It is clear from above graphs as the refractive index of polymer coating increased dispersion of the grating is decreased and also for different length grating output experiences different dispersion. From the Fig.4 it is clear that as length is increased dispersion is also increased.

4. Conclusion

From the simulation results it is depicted that polymer coating with higher refractive index reduces the dispersion in optical fiber grating significantly. As in this study we have considered two types of index profile and in comparison to step index profile Gaussian profile gives better results. So that one can say that for chromatic dispersion compensation Gaussian index profile with higher refractive index coating gives very effective results without changing the grating type. As the main objective of this study is that to optimize the grating performance for dispersion compensation. Grating length plays the most important role. From results it is clear that grating length must be as small as possible. Length up to 3000µm gives dispersion less than 100ps/nm dispersion. At the end of discussion we can say grating of length less than 300µm with polymer coating can be used as dispersion compensator effectively.

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