ISSN : 0974 - 7524 Volume 9 Issue 7

Physical CHEMISTRY
An Indian Journal

Full Paper

PCAIJ, 9(7), 2014 [239-246]

Simulation of uniform and apodized fiber bragg grating

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ABSTRACT

This paper presents thesimulation of an optical fiber Bragg grating for maximum reflectivity, minimum side lobe. The reflection spectra, side lobes strength and bandwidth were simulated with different lengths. The side lobes have been suppressed using raised cosine apodization while maintaining the peak reflectivity. The simulations are based on using Optigratingsoftware.

KEYWORDS

Fiber Bragg grating;
Reflection;
Apodization;
Simulation
Optigratingsoftware.

INTRODUCTION

Optical fiber gratings are important components in fiber communication and fiber sensing fields. For normal fiber gratings, by properly choosing the period, length, index modulation amplitude, chirp and apodization function, one can flexibly design and optimize grating reflection ortransmission spectra to satisfy many applications[1]. FBGs take the advantages of a simple structure, low insertion loss, high wavelength selectivity, polarization insensitivity and full compatibility with general single mode communication optical fibers. Properly manufactured FBGs offer high reflectances and narrow bandwidths at the Bragg wavelength. All this makes them suitable forapplications in fiber optical communications, e.g. as WDM demultiplexers, fiber laser technique and fibersensor system[2]. FBG is a periodic or aperiodic perturbation of the effective absorption coefficient and/or the effective refractive index of an optical waveguide. They typically reflect light over a narrow wavelength range which satisfy the Bragg condition and transmit all other wavelengths, but they also can be designed to havemore complex spectral responses[3].

There are a number of parameters on which the spectra of FBG has shown dependency such as change in refractive index, bending of fiber, grating period, mode excitation conditions, temperature and fiber Bragggrating length[4-6].

THEORY

In this paper we perform a simulation of fiber Bragg grating with different length of grating. The simulated was analyzed and designed by calculating length of grating, Such simulations are based on solving Bragg condition equations that describe the changing Bragg wavelength with changing effective index of refraction of the fiber and length of grating.

The Bragg grating wavelength equation describe by$\lambda_{Bragg} = 2n\Lambda$, where n and Λ are the effective index of thefiber and the grating period in the fiber respectively. The results and discussion about the simulation work done on FBGs at typical specifications using Optigrating software.

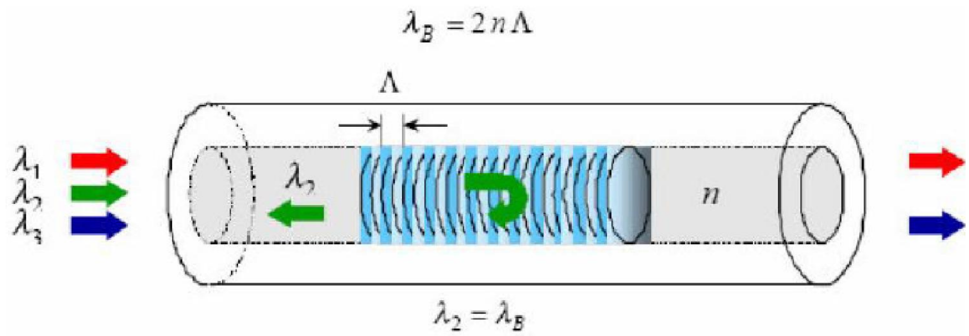

Figure 1 : Principle of operation of a fiber bragg grating

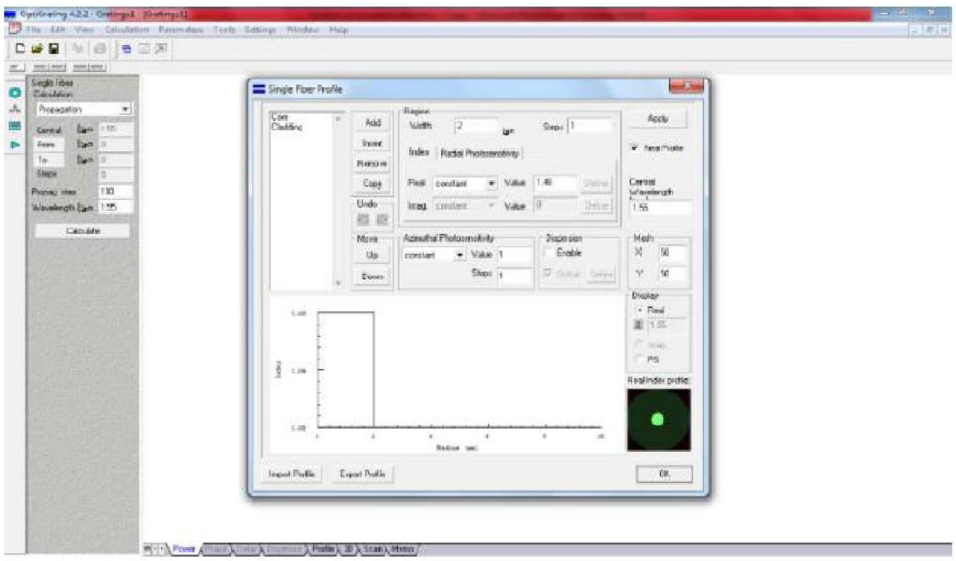

Figure 2 : The dialog box of waveguide profile

TABLE 1: The Parameters of the designed FBG

Parameters	Setting
Grating shape	sine
Average index	Uniform
Period chirp	No chirp
Apodization	No apodization
Length (L)	05 to 45 mm
Index modulation amplitude (Δn)	0.0001
Grating period	0.52762870μm
Waveguide width	9 μm
Waveguide thickness	9 μm
Core index	1.47
Cladding index	1.457

SIMULATION RESULTS AND DISCUSSION

The reflectance spectra of the reflection FBGs were simulated by using Optigratingsoftware Figure 2 show the dialog box of waveguide profile to design FBG.

The basic parameters of uniform FBG, is shown in TABLE 1 and the dialog box in Figure 3.

Reflection spectra was obtained and analyzed for different values of grating length (TABLE 2). It was confirmed that the spectral properties ofuniform gratings comes out to be similar to *sinc*function. The reflection spectra for different grating length 5mm,7mm, 10mm, 15mm and25mm is shown below in (Figure 4,5,6,7,8). At L=05mm, 07mm, 10mm,15 mm and 25mm. successively the maximum reflectivity is 58.15%,78.51%, 92.99%, 99.03%. At L=25 mm, thereflectivity reached 99.98% but increase in thereflectivity of sides lobes. After that, if the length isincremented further, it is observed that maximumreflectivitymaintains the same value of99.99%. Alsoe we noted that the bandwidth decreases with increasing of grating length.

As shown in Figure 9, itwas confirmed that the simulated uniform FBG showedbetter performance as the

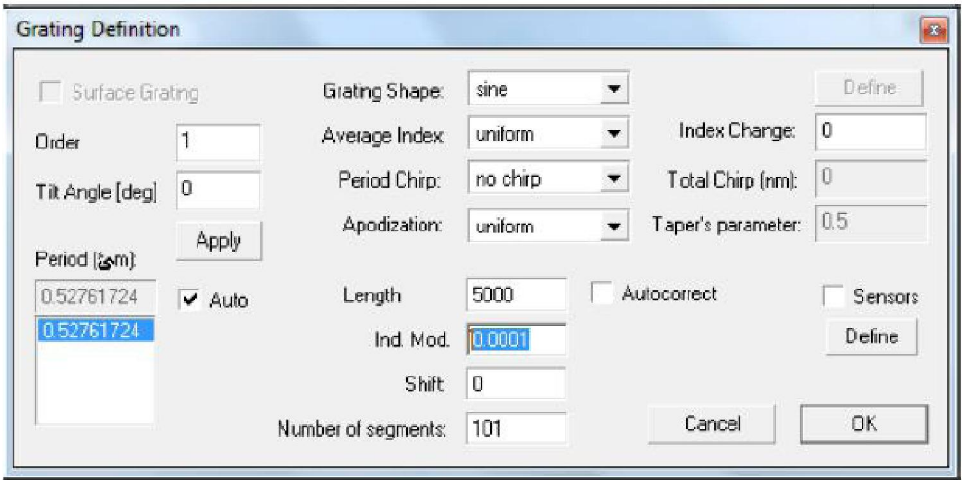

Figure 3 : The dialog box of the FBG

TABLE 2 : Reflectivity and bandwidth of uniform FBG for different grating lengths

Grating Length (mm)	Reflectivity Obtained (%)	Bandwidth (nm)
05	58.15	0.1896
07	78.51	0.1632
10	92.99	0.144
15	99.03	0.1272
16	99.35	0.1272
18	99.71	0.1224
20	99.86	0.1201
22	99.94	0.1176
25	99.98	0.1124
28	99.99	0.1062
30	99.99	0.1062
35	99.99	0.1062
40	99.99	0.1062

grating length increased andachieved 99.98 % reflection at the grating length of 25 mm. A very effective method for eliminating the side-lobes of an FBG isapodization. Apodization is achieved by a contoured inscription of thegrating in order to reduce the refractive index changetowards the ends of the grating. Other apodization functions that are used in thecommunications industry include pure cosine, Gaussian, sinc and Kaiser profils[7-10].

Figure 10, 11,12,13,14 illustrates the reflectance spectrumresponse of an apodized FBG for different grating length. At L=10mm,20mm,30mm,40mm and 50mm the maximum reflectivity is 60.94%, 94.10%, 99.25%, 99.86% and 99.99% as shown in TABLE 3.

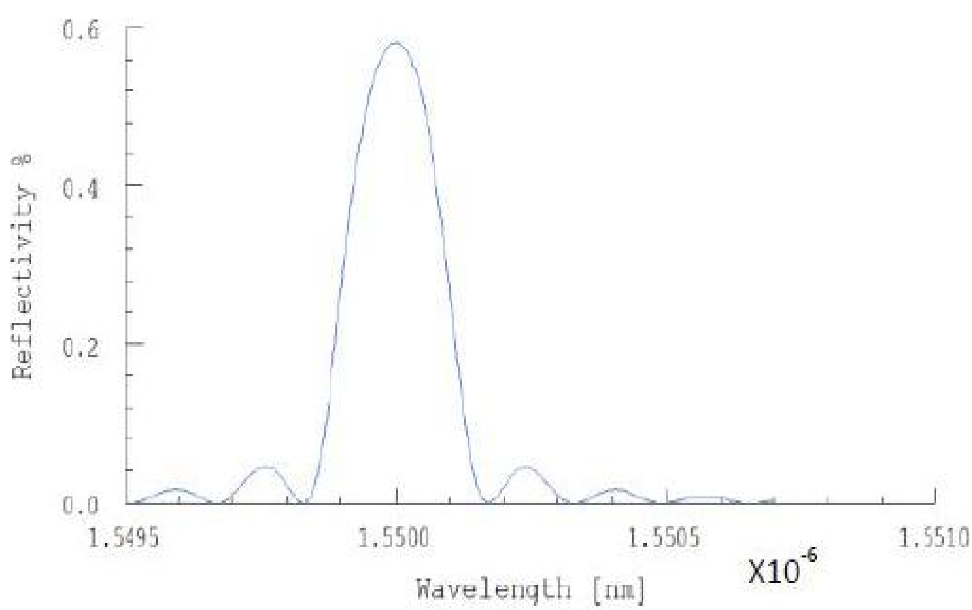

Figure 4 : Reflection spectrum at L=05mm

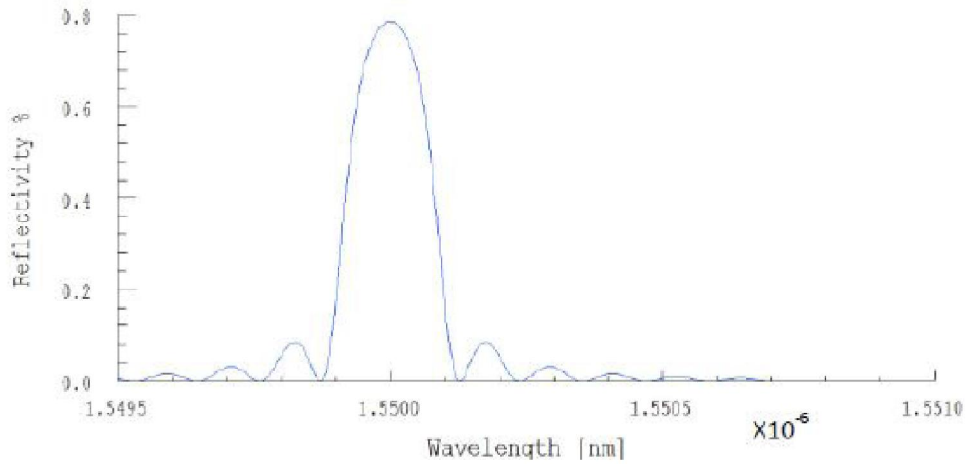

Figure 5 : Reflection spectrum at L=07mm

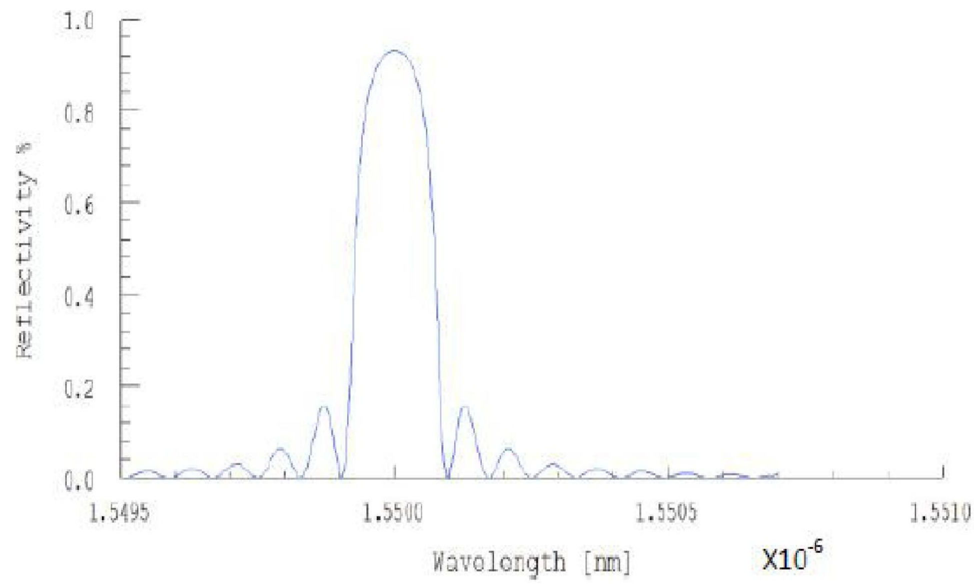

Figure 6 : Reflection spectrum at L=10mm

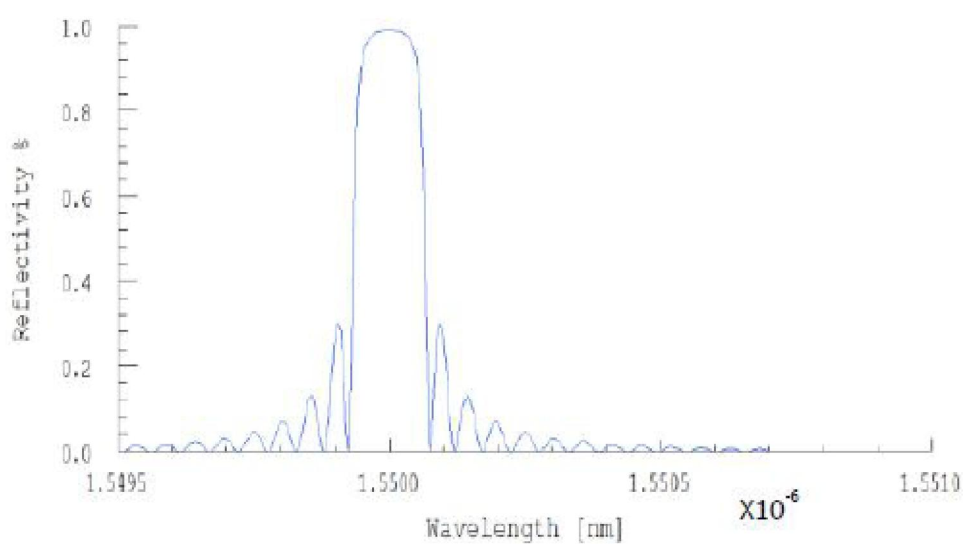

Figure 7 : Reflection spectrum at L=15mm

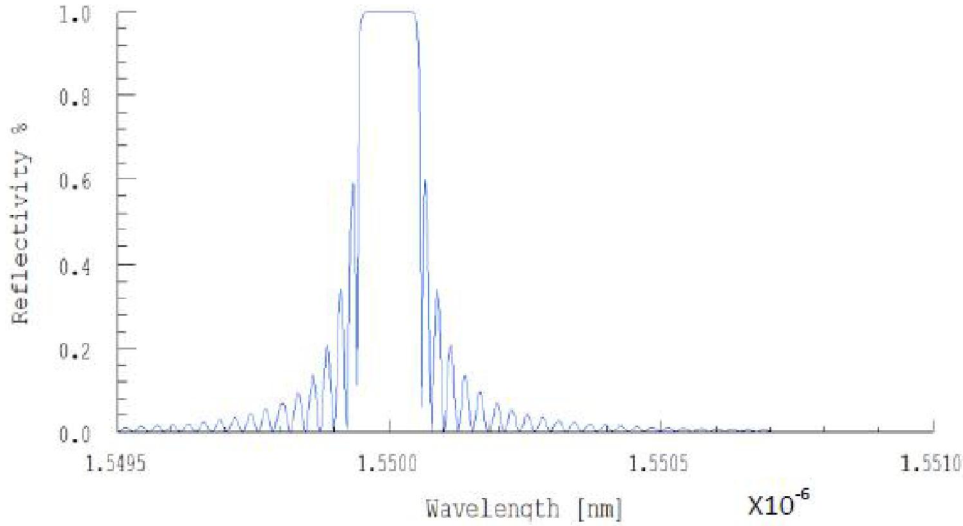

Figure 8 : Reflection spectrum at L=28mm

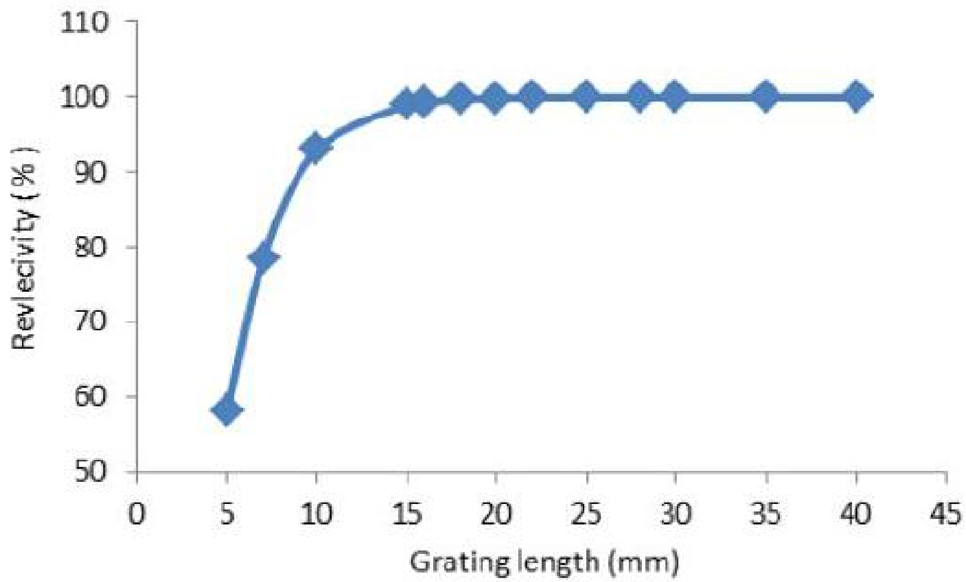

Figure 9 : Relation between uniform FBG reflectivity and grating length

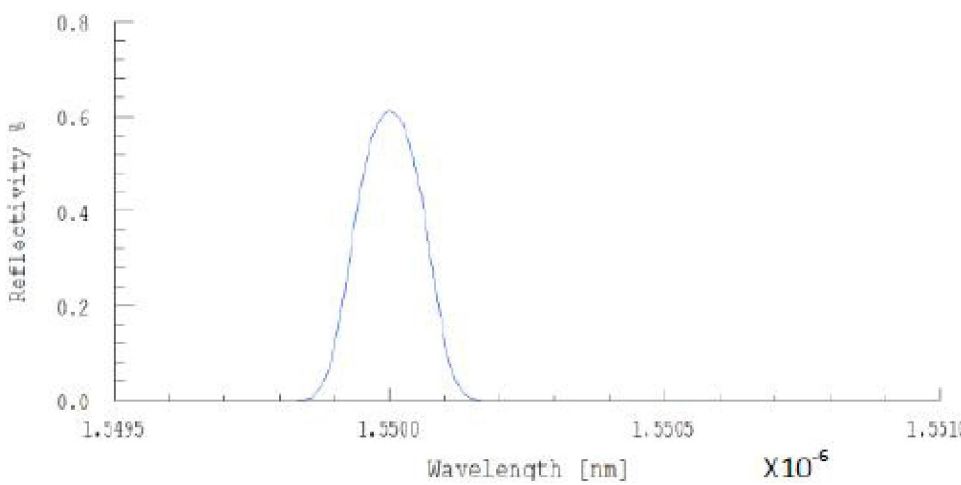

Figure 10 : Apodized reflectance rpectrum at L=10mm

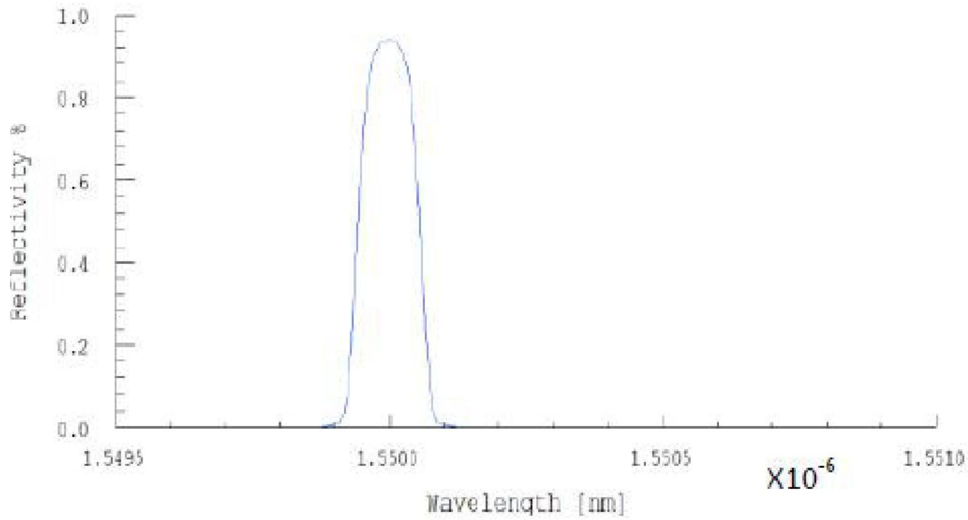

Figure 11 : Apodized reflectance spectrum at L=20mm

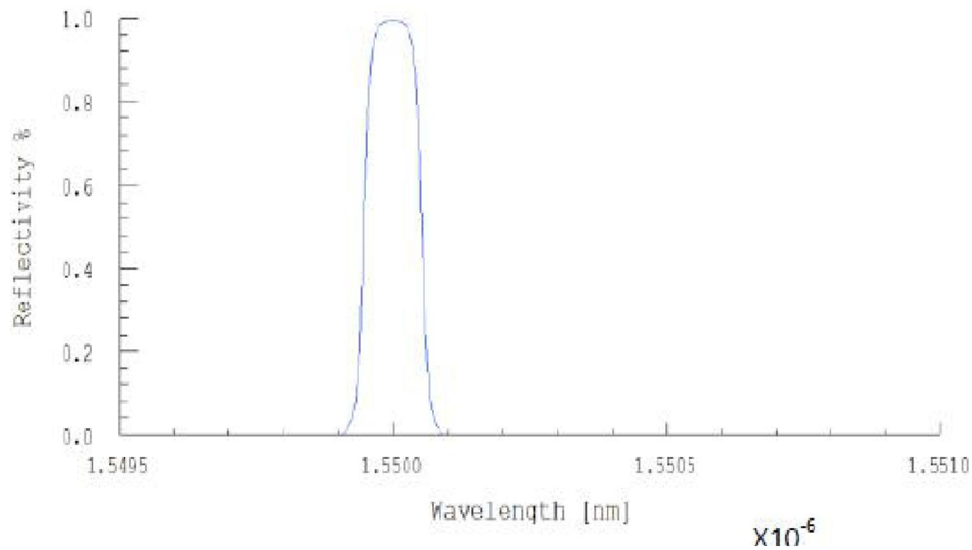

Figure 12 : Apodized reflectance spectrum at L=30mm

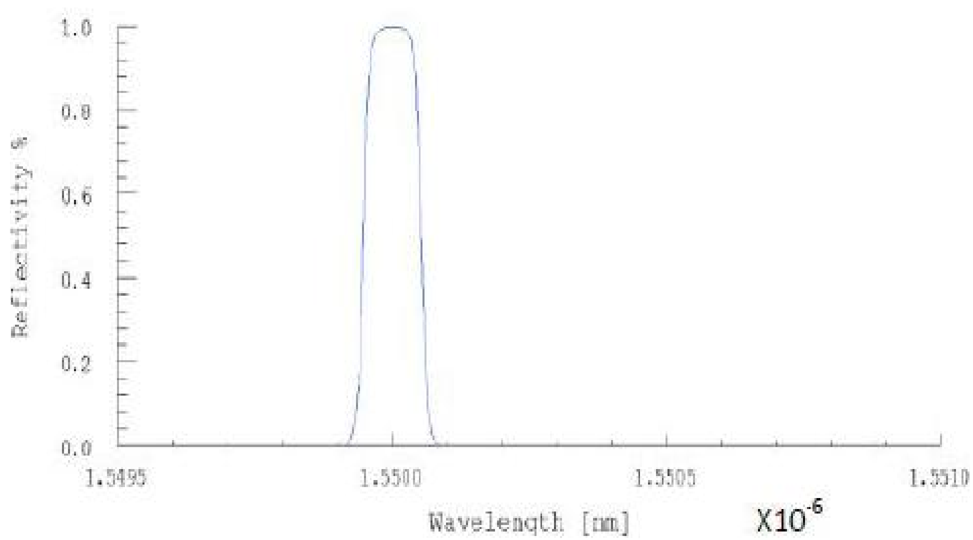

Figure 13 : Apodized reflectance spectrum at L=40mm

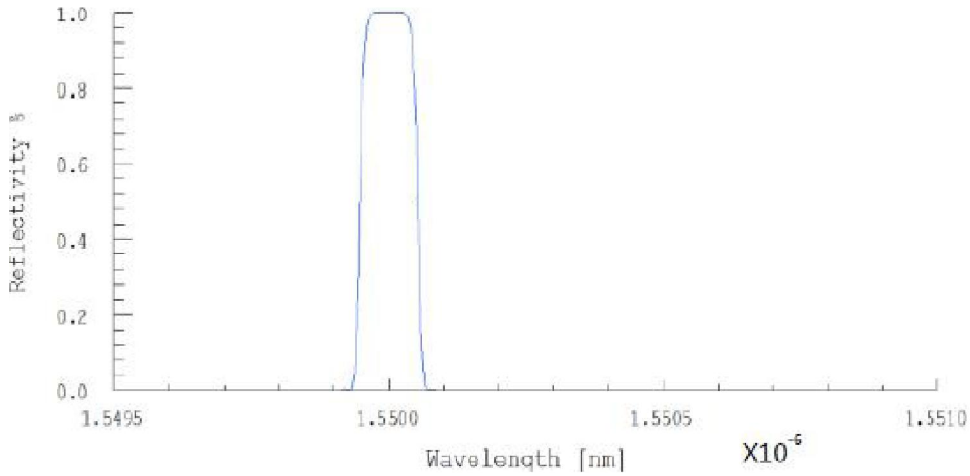

Figure 14 : Apodized reflectance spectrum at L=50m

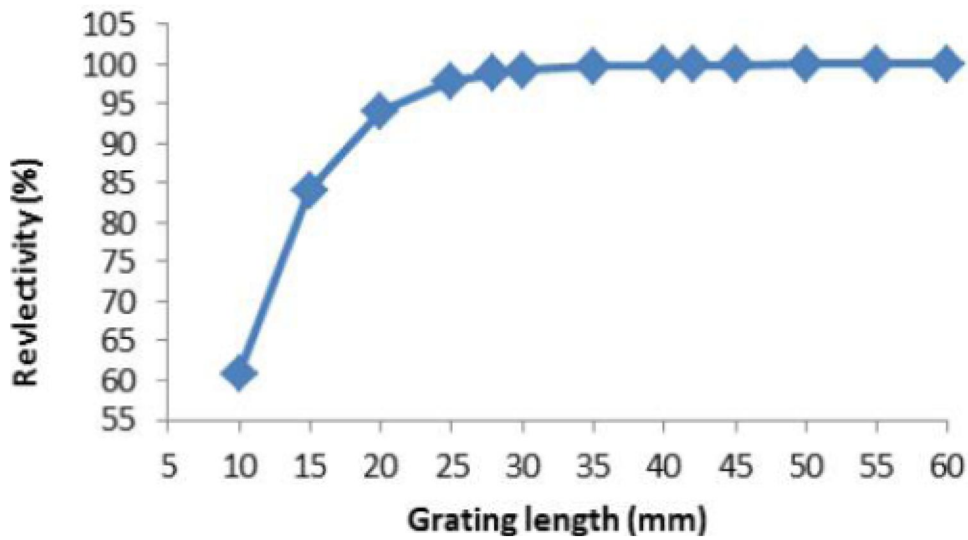

Figure 15 : Relation between apodized FBG reflectivity and grating length

TABLE 3 : Reflectivity and bandwidth of apodized FBG for different grating lengths

Grating Length (mm)	Reflectivity Obtained (%)	Bandwidth (nm)
10	60.94	0.1464
15	84.10	0.1224
20	94.10	0.1128
25	97.89	0.1082
28	98.87	0.1056
30	99.25	0.1032
35	99.74	0.1032
40	99.86	0.1032
42	99.94	0.1032
45	99.97	0.1032
50	99.99	0.1032
55	99.99	0.1032
60	99.99	0.1032

Note that all of side lobes have been completely eliminated but reflected power can be increased by increasing the length of apodized FBG, while bandwidth decrease.

As shown in Figure 15. upon consideration of the reflectivity elevation of apodized FBG, it was confirmed that the simulated apodized FBG showed better performance as the grating length increased and achieved 99.99 % reflection at the grating length of 50mm.

CONCLUSION

In this paper we have described the signal characteristics of FBG with various grating lengths using simulation software. The conclusions obtained from this study are as follows.

1. The reflectivity of fiber grating increases with the increase in grating length.
2. For uniform fiber Bragg grating the reflectivity increased with the elevation of grating length until reached 99.99% in reflection and maintained constant for this value for longer length.
3. For Raised cosine Apodizationthe reflected power increased by increasing the length of apodizedFBG. The reflectivity increased until reached 99.99% and maintained constant for this value for longer length.
4. The increase of the grating length for uniform and Apodized FBG causes the bandwidth decrease and maintained constant for longer length.

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