포토폴리머 부피형 회절격자를 이용한 홀로그래픽 역다중화기의 가우시안 아포다이징

Gaussian apodization technique in holographic demultiplexer based on photopolymer volume grating

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In recent years, soaring traffic volumes over optical communications networks lead to the rapid advances in information communications equipments. In backbone communications networks, there has been an advance in high-density transmission through DWDM, which can simultaneously transmit numerous signals with different wavelengths. When the channel spacing is narrower, the cross-talk between channels an important parameter that guarantees to the high performance of a whole system, becomes critical. In this paper, we present theanalysis and simulation of the Gaussian apodization applied into the demultiplexer based on photopolymer volume grating.

Apodization can be understood by simple Fourier analysis: A grating limited in space by the volume of the recording medium can be viewed as a superposition of infinite-size sinusoidal gratings, each having a different spatial frequency vector **K** and a respective amplitude. The grating vector spectrum can be found by Fourier transform[1].

$$FT\{[1+m\cos(K_g r+\phi_0)]rect\frac{x}{X}\,rect\frac{y}{Y}\,rect\frac{z}{Z}\}=$$

$$[\delta(K)+\frac{1}{2}\delta(K-K_g)+\frac{1}{2}\delta(K+K_g)]\otimes XYZ sinc\frac{Xk_x}{2\pi}sinc\frac{Yk_y}{2\pi}sinc\frac{Zk_z}{2\pi} \tag{1}$$

Here the recording volume is a parallelepiped of dimensions X, Y, and Z, $\mathbf{K}_g$ is the grating vector, and ϕ_0 is an arbitrary phase factor. If a planar polychromatic beam incidents on the grating, light of a certainwavelength is diffracted in different directions, making the divergence of a monochromatic diffracted beam. On the other hand, several wavelengths that have an equal dephasing factor go out of grating at the same angle. Consequently, the output comprises of many planar polychromatic beams that diverge into different directions, as shown in Fig. 1.

In the demultiplexer scheme[2] shown in Fig. 2, by using a lens, output beams are focused into different points on the back focal plane where the output fibers are located. The spectrum of a channel, which closely similar to sinc2function, simulated by using coupled wave theory are shown in Fig. 3. It is evident to realize that the sidelobe of the spectrum is large. This leads to high cross-talk between the adjacent channels. If the uniform function is replaced by one that vanishes smoothly at the edges of the grating, the slowly decaying sidelobes of the sinc2 curve is eliminated, i.e. the cross-talk will be significantly reduced. In this paper, Gaussian function is chose as apodization profile because it is easily created by making an interference of two Gaussian beams on photopolymer. Fig. 3 shows that the sidelobe is largely dropped when the Gaussian profile is applied. This improvement reduces the cross-talk between channels significantly. As shown in Fig. 4, two channels, that have same bandwidth, make the cross-talk of 15 dB and 31 dB in case of using uniform grating and Gaussian apodized grating, respectively. The result of the evaluation opens a capability of the apodization technique to improve the channel cross-talk - an important parameter, in DWDM system.

(a) (b)

Fig. 1: (a) Divergence of diffracted beam, (b) Bandwidth of diffracted beam

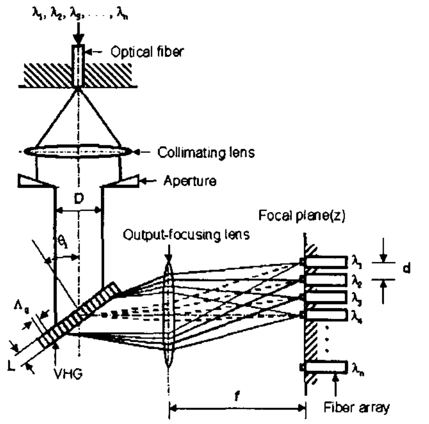


Fig. 2: Basic structure of a demultiplexer

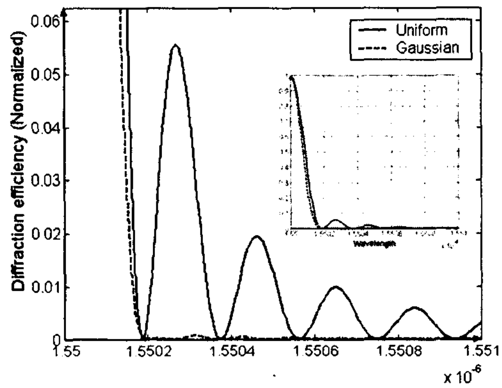
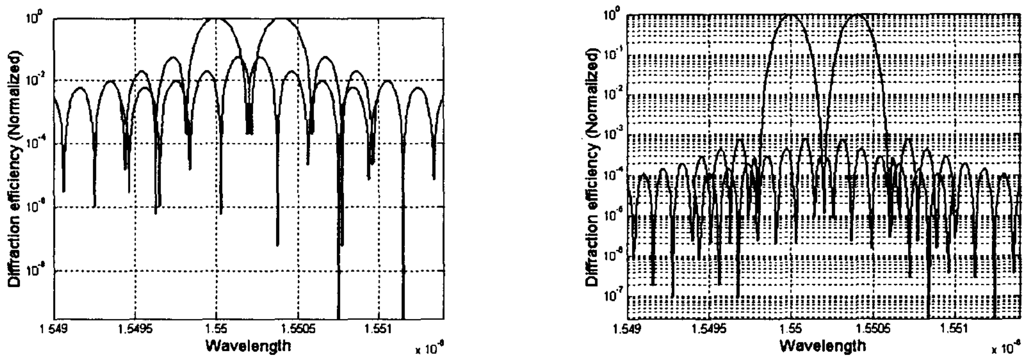


Fig. 3: Normalized diffraction efficiency



(a) (b)

Fig. 4: Cross talk between two channels. (a) Uniform grating, (b) Gaussian grating.

This work was supported by grant No.(R01-2001-000-00324(2002)) from the Korea Science & Engineering Foundation.

References:

1) J. Goodman, *Introduction to Fourier Optics*, 2nd ed. McGraw-Hill, New York, pp. 333-336., 1996
2) Jun-Won An, Nam Kim, and Kwon-Yeon Lee, JJAP, vol. 41,no. 6B, 2002.