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Compensation of the grating chromatic dispersion

Tien Viet Vu[a], Nam Kim[a], Eun Kyong Kim[b], and Kwon Yeon Lee[c]
[a] Department of Information and Communication Engineering, Chungbuk National University
[b] Department of Chemical Engineering, Yonsei University
[c] Department of Electronic Engineering, Sunchon National University
E-mail: tienvv@osp.chungbuk.ac.kr

Up to now, usage of diffraction gratings has been found in a number of applications, e.g. DWDM's [1], optical pickup heads, beam shapers for laser systems. In many cases, the grating is designed to work as multiple beamsplitters by which an impinging light beam will be split into several diffracted waves propagating along different directions. The deflection angle of each wave is always dependent on the incident wavelength. In some systems such as optical interconnection networks [2], this is undesired effect and cannot be compensated by the design of the grating, since there is no degree of freedom in grating equations. In this work, we design a lens system used in combination with the grating to compensate that wavelength dependence.

A typical interconnection network is shown in Fig. 1. Light beams behind the collimating lens are diffracted by the Dammann grating. Then, each individual diffracted wave is focused into a separated spot on the focal plane. For normal incidence, the sine of the deflection angle of the diffracted waves is given by

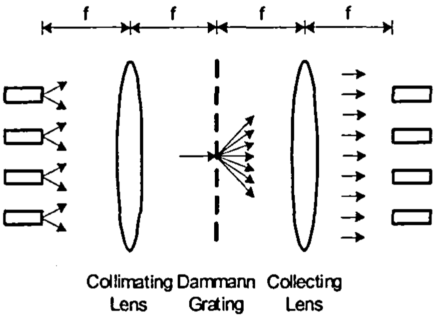
$$\sin\alpha = m\frac{\lambda}{\Lambda} \tag{1}$$

Where m is the diffraction order, λ is the wavelength, and Λ is the period of the grating. The lateral location x of the focus in the focal plane is approximately given by $x = f\alpha$, where f is the focal length of the collecting lens. If the collecting lens is in achromatic refractive type, then f is independent on λ. Consequently, as the wavelength changes, the lateral position of the focus will change. If a Fresnel zone lens (FZL) is used as a displacement of the achromatic lens, the focus shifts only axially and not laterally, since the focal length the FZL is inversely proportional to λ:

$$f = f_0\frac{\lambda_0}{\lambda} \tag{2}$$

where f_0 is the focal length at the wavelength λ_0.

For any combination of an achromatic lens and a FZL in contact, the wavelength-dependent positions of the foci are related by a linear combination of the two shifts. Therefore, no combination of thin refractive and diffractive lenses in contact can provide one with the possibility to compensate fully for these wavelength-dependent changes.



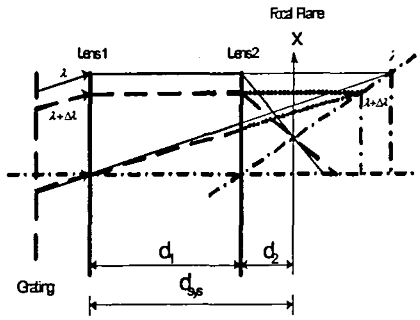


Figure 1. Interconnection network Figure 2. Compensation system

The chromatic problem can be handled with two approaches. In one approach, the wavelengths of all the transmitters must be held within a narrow range, which is difficult to achieve in practice, since commercially available laser diodes usually operate with the wavelengths in the range of about 20 nm. The second approach involves the introduction of an optical system to compensate for the wavelength dependence.

Figure 2 depicts the geometrical arrangement of the optical system. The system includes two lenses with different wavelength dependence. The wavelength dependence is characterized by the chromatic variation of the lens power at a specified wavelength:

$$t(\Delta\lambda) = \frac{c_{\lambda+\Delta\lambda} - c_{\lambda}}{c_{\lambda}} \tag{3}$$

where

$$c_{\lambda} = \frac{1}{f_{\lambda}} \tag{4}$$

is the lens power at the wavelength λ. In our design, lens 1 has a positive lens power variation that is achieved by the combination of a thin refractive and a thin diffractive lens. Lens 2 is a diffractive lens with a negative lens power variation. Lens 1 focuses different wavelengths to different axial and lateral positions. Since the lens power variation of lens 1 is positive. The larger wavelength λ is focused behind and with a larger axial distance than the shorter wavelength $\lambda + \Delta\lambda$ ($\Delta\lambda$ is assumed negative). The two virtual foci are imaged by lens 2 onto the same point in the focal plane.

Acknowledgement

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References

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