A 130-channel Optical Demultiplexer based on Cascaded Holographic Volume Gratings

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The demultiplexer based on the holographic volume grating represents the simplicity and cost-attraction[1, 2].For the large-scale dense wavelength-division multiplexing system, it is desirable that the demultiplexer can operate with as more channel as possible. In this paper, we describe the experimental demonstration of a demultiplexer with double wavelength selectivity due to the use of two cascaded gratings. The gratings are designed such that they have different center wavelengths and angles of grating vectors. When the multi-wavelength beam impinges on the grating system, the diffracted beam will be spatially and spectrally separated into two groups, i.e. each beam has different propagating direction and wavelength range.

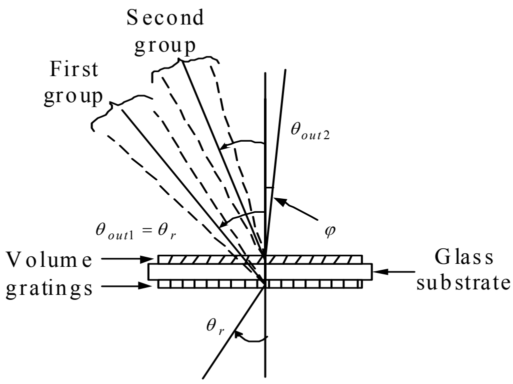

Fig. 1 The structure of two cascaded gratings with the output of diffraction beams

Figure 1 shows the structure and the diffraction angles of the cascaded gratings. The grating period of the first grating is $\Lambda_1 = 1.028\mu m$, where as that of the second grating is $\Lambda_2 = 1.1\mu m$. The second grating plane is tilted by an angle of 1.5° compared with that of the first one, which coincides with the normal plane of the surface. If the incident angle of the readout beam in the medium is chosen equal to $\theta_r = 29.7°$, the Bragg angles corresponding to each grating are $\theta_{B1} = 29.7°$ and $\theta_{B2} = 28.2°$. With this circumstance, the center wavelengths of two gratings, which are obeyed the Bragg condition $\lambda_{ci} = 2\Lambda_i \sin\theta_{Bi}$ where $i = 1,2$, are $1.53\mu m$ and $1.56\mu m$, respectively. The wavelength selectivity of a volume grating is given by[3] $\Delta\lambda_{sel} = \Lambda\lambda_c \cot\theta_B / L$, where L is the grating thickness. In our demonstration, the gratings are made of the photopolymer with the thickness of $100\mu m$. Therefore, the wavelength selectivity of each grating is $\Delta\lambda_1 = 27.5\mu m$ and $\Delta\lambda_1 = 32\mu m$, respectively. At the output, the first diffraction beam is going out at the angle similar to that of the input beam. However, since the second grating is slanted, the second diffraction beam has the angle $\theta_{out2} = \theta_r - 2\phi = 27.46^\circ$ to the normal direction of the film surface. The difference in the output angles of two diffraction beams ensures that the crosstalk between two gratings is avoided completely.

Figure 2 shows the experimental setup for testing the spectral response of the grating system. It consists of a collimating lens, volume holographic gratings, and an output-focusing lens. The output-focusing lens transforms the angularly dispersed diffraction beams into the spatial separation on the focal plane, where a single mode fiber is placed. This output fiber is held and moved along the horizontal direction by a motorized fiber alignment unit. At each position, the diffraction beam is coupled to the fiber and its spectrum is examined by an optical spectral analyzer. Figure 3 shows the spectra characteristics of all 130 channels ranging from 1520 nm to 1572 nm of the EDFA source. The highest loss measured is about 5.5 dB at the wavelength region of 1543 nm, where as the lowest loss is 2 dB at two center wavelength of two gratings. The uniformity of overall system, therefore, is 3.5 dB. It is necessary to design more carefully such as choosing two center wavelengths closer to improve the uniformity. By inserting more gratings with suitable design in series, it will be able to expand more working range of the demultiplexer based on free-space gratings.

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Reference

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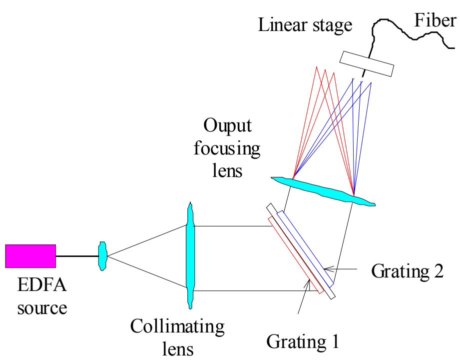

Fig. 2 The experimental setup for testing the spectral characteristics of the two cascaded grating system

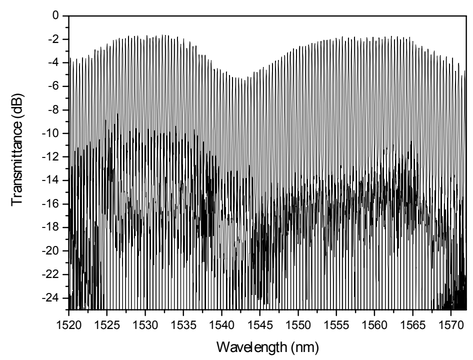

Fig. 3 The spectral characteristics of the demultiplexer based on the cascaded grating system