Wideband tunable optical filter using a mechanically induced long-period fiber grating

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Abstract

We have developed a wideband tunable optical filter using a long-period fiber grating in which both resonance wavelength and its signal attenuation can be adjusted independently.

1. Introduction

A long-period fiber grating (LPFG) is a loss filter that uses mode coupling between the fundamental guided mode and forward-propagating cladding modes in an optical fiber[1]. Owing to its simple structure and excellent characteristics, the device is used for many applications, such as amplitude equalizing devices for optical amplifiers and various types of optical fiber sensor. Recently, in a search for flexibility in applications, interest has shifted to tunable LPFGs. For this purpose, a mechanical method of inducing refractive-index changes along the fiber was also proposed. Because the period is as large as several hundred micrometers, one can induce the index modulation mechanically, for example, by pressing the fiber between a periodically grooved plate and a flat plate[2] or by winding a nylon string around the fiber periodically[3].

A tunable optical filter requires control of the resonance wavelength and signal attenuation independently. The resonance wavelength should be adjustable without affecting the signal attenuation, and similarly the signal attenuation should be adjustable without affecting the resonance wavelength. In search of such a tunable LPFG device, we have developed a method of fabricating a mechanically tunable LPFG. The grating is created mechanically by pressing a spring coil to an optical fiber.

2. Discussion

Resonance wavelength λ_m of the LPFG is given by $\lambda_m=\Lambda(n_{core}-n_{clad}{}^{m})$, where Λ is the grating period of the LPFG, n_{core} is the refractive index of the LP_{01} fundamental mode, and $n_{clad}{}^{m}$ is the index of LP_{0m} (m=2,3,4.....) cladding modes. Resonance wavelength λ_m can be adjusted by proper selection of grating period Λ. And we can control the amount of signal attenuation by adjusting the impressing load to the fiber. The setup for mechanically tuning the LPFG by using a coiled spring is shown in Fig. 1. We can adjust the grating period Λ coarsely by expanding the length of the coiled spring. The effective grating period Λ is finely adjusted by the impressing position of the spring using screws, which gives distributed pressurization along the fiber, that is, in this LPFG, the whole spring is not pressurized uniformly. The effective grating period Λ changes with the pressurization position because the coil is not expanded uniformly. This is an interesting property of the spring coil.

The transmission spectra in the wavelength range 1400-1650 nm are shown in Fig. 2 for three different coil pitches of the spring, 0.60, 0.68 and 0.76 mm. The figure shows how the resonant wavelengths are proportional to the coil pitch of the spring, that is, to the grating period Λ.

Figure 3 shows transmission spectra of the LPFG with grating period Λ fixed at 0.66 mm and with several impressing weights from 1.00 to 2.05 kg on the fiber. The amount of attenuation increases as the impressing weight is increased. It should be noted that the central value of the resonance wavelength does not change for different weights. It is important to control the amount of attenuation without affecting the resonance wavelength. Figure 4 shows measured transmission spectra for different impressing positions with average grating period Λ = 0.66 mm. The figure shows that the resonance wavelength is finely controlled by adjusting the impressing position of the spring coil without affecting the signal attenuation. It indicates that the effective grating period Λ is changed finely by adjusting the impressing position, although the average pitch over the entire coil length is 0.66 mm.

Fig. 5 and Fig. 6 show the result of this LPFG applied to the equalization of an ASE light source. Fig. 5 shows the spectra before fine adjustment, and Fig. 6 well adjusted spectra suitable for the equalization of the ASE outputs.

Conclusion

Continuous fine tuning of wavelength and attenuation is achieved by adjusting the coil length, impressing position to the spring coil and the amount of impressing load. Adjustable ranges of the LPFG are over 200 nm in resonance wavelength and more than 10 dB in signal attenuation.

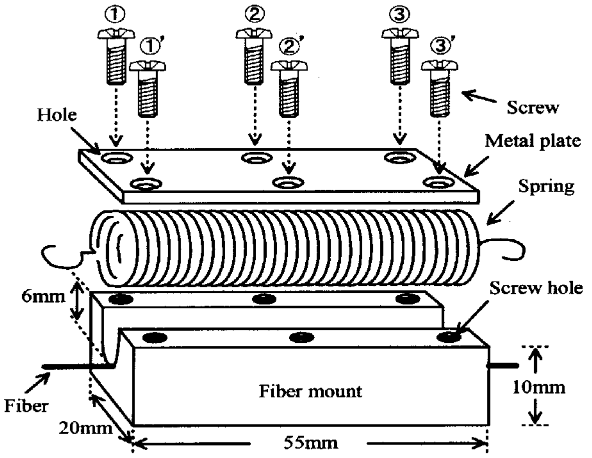

Fig. 1 Setup for mechanically tuning an LPFG using a coiled spring.

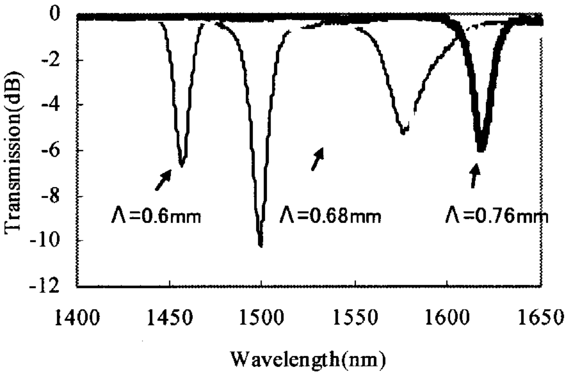

Fig. 2 Measured transmission spectra of LPFGs with grating periods Λ=0.6 , 0.68 and 0.76mm.

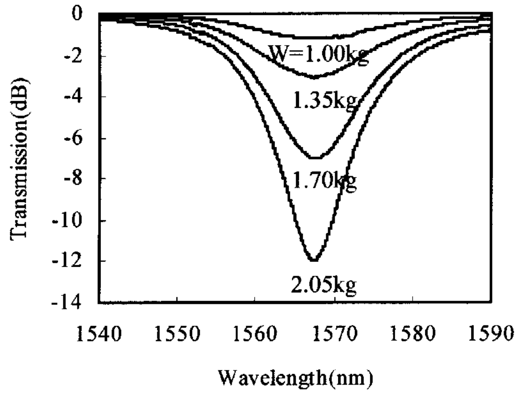

Fig. 3 Measured transmission spectra of LPFG with Λ=0.66 mm and different weights from 1.00 to 2.05 kg.

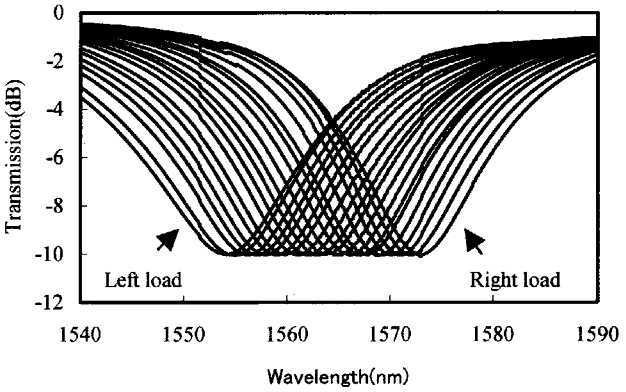

Fig. 4 Measured transmission spectra for different load positions with adjusting pressures.

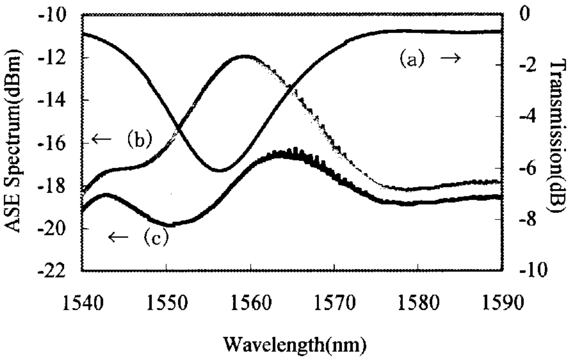

Fig. 5 An example of equalization for ASE light source before adjustments.
(a) : Sample LPFG transmission. (b) : ASE spectrum without the LPFG. (c) : ASE spectrum with the LPFG.

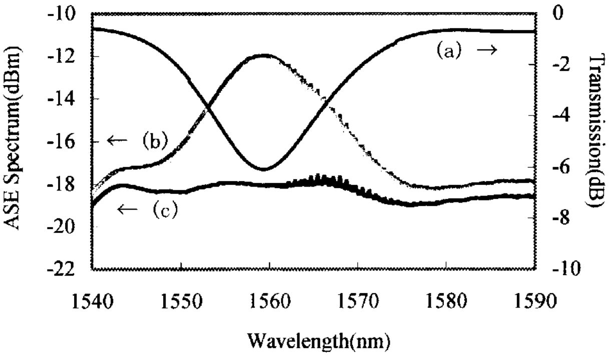

Fig. 6 An example of equalization for ASE light source using proposed LPFG.
(a) : Proposed LPFG transmission. (b) : ASE spectrum without the LPFG. (c) : ASE spectrum with the LPFG

References

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