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Novel Bandwidth Control Mechanism in Fiber Based Tunable Filters

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Abstract

Recently developed mechanisms to control the bandwidth of all-fiber filters, are introduced, 1) rotational control in helicoidal LPG pair 2) bending loss edge shifts in a HOF-MSF composite. Their tuning optical characteristics will be explained.

1 Introduction

Periodic grating structures in optical fibers could be equipped with flexible wavelength tuning capability using fundamental natures of mode coupling 1) acousto-optic undulation[1] 2) mechanical strain[2], and 3) thermo-optic effects[3]. In filter applications, it would be highly desirable to provide tunability in two aspects; spectral position of resonance, and bandwidth of the filter window.

Tunable band rejection filter has been recently achieved by thermo-optical tuning and corrugated long-period fiber grating over silica single mode fiber (SMF), as well as classical SMF acousto-optic tunable filter (AOTF)[4]. Thus far, most of interests and efforts have been concentrated in the spectral position tunability and possibility to tune the bandwidth has not been fully investigated.

In this review, two novel schemes are introduces, where bandwidth tuning was successfully demonstrated. Firstly a helicoidal long period fiber grating (LPFG) pair was inscribed by CO_2 laser and its bandwidth was made tunable by applying torsional stress. Secondly, the opposite cut-off shift behaviors of hollow optical fiber (HOF) and micro structure fiber (MSF) has been utilized to result in bandwidth tuning by macro-bending.

2 Helicoidal LPG pair band rejection filter

The proposed fiber filter is schematically illustrated in Fig. 1. The device consists of two helicoidal LPG with opposite helicities, clockwise, and counter clockwise direction.

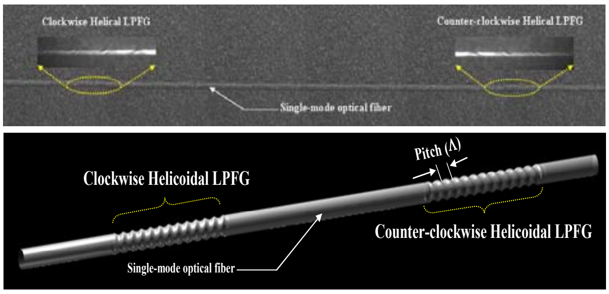

Fig. 1. Configuration of the proposed interferometer.

LPG with a helical index modulation was obtained by releasing the residual stress of a pristine fiber while it rotating under a continuous single side CO_2 laser beam exposure. In the helical LPFGs novel peak shift was observed so that co-directional and contra-directional torsions resulted in spectral shift to shorter and longer wavelength, respectively.

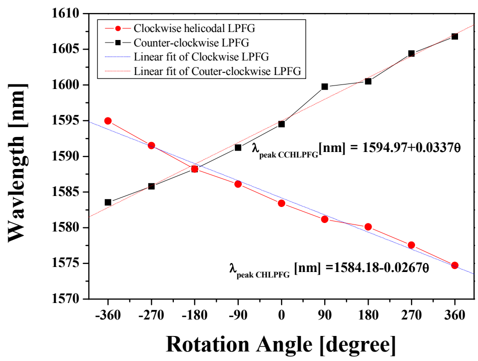

Fig. 2 Resonance peak shifts in helicoidal LPFGs

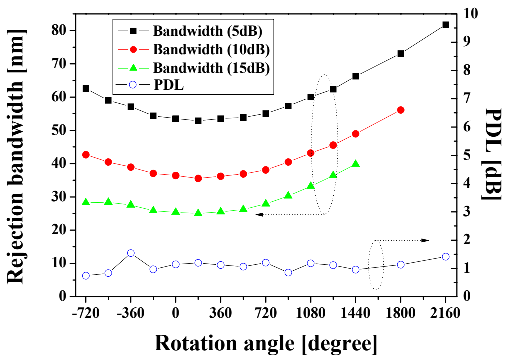

Fig. 3 Bandwidth Tuning in the proposed device.

By the opposite shift of resonance peaks as shown in Fig.2, the helicoidal pair of opposite helicity can provide bandwidth tuning ability as in Fig. 3. Note that the bandwidth could be almost linearly increased from 0 to 2160^0 rotational stress over the device.

3. Tunable bandpass filter using HOF-MSF bending

One of notable features of MSF is the existence of short-wavelength bend-loss edges (BLEs). In conventional MSFs, the long-wavelength BLEs are usually located at mid-IR irrespective of bending radii and only the short-wavelength BLEs have been experimentally accounted. This peculiar short-wavelength BLE limits the operation bandwidth of the single mode guidance of MSFs but enables us to implement a tunable high pass filter as shown in Fig. 4.

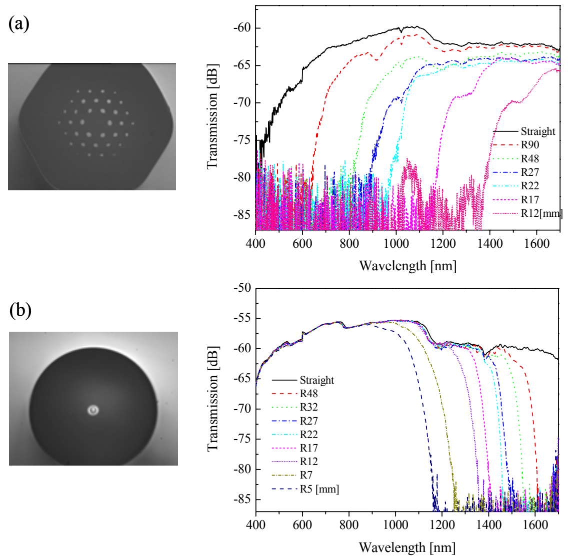

Fig. 4 Transmission spectra in MSF and HOF for various bend radii

In contrast HOF has a further extended distribution of optical field into the cladding region, which provides HOF with a bend-sensitive long-wavelength BLE in the longer wavelength. The fundamental cutoff wavelength can be easily shifted by increasing the central air hole size in HOF and air-hole periodicity for MSF. Therefore, the HOF show a bend-sensitive long-wavelength BLE, which can be utilized for implementing a low pass filter as depicted in Fig. 4(b). The low pass filtering function of the HOF is a clear contrast to the high pass one of the MSF. Furthermore, by cascading MSF and HOF and individually controlling the bending curvatures, we could easily realize a tunable bandpass filter as shown in Fig.5. The bandwidth could be widely tuned from 1000 to 300nm with a high extinction ratio over than 20dB.

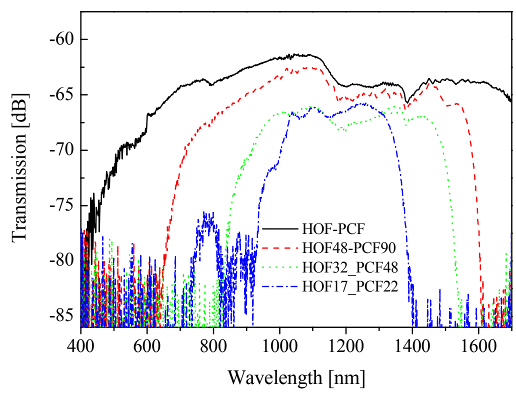

Fig. 5 Transmission spectra with short- and long bend edge.

We expect that the proposed leading mechanism to control the bandwidth of all-fiber filter would find applications in the realization of fiber laser, fiber sensors, and optical tomographic systems.

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4. References

[1] E. Udd, Ed., *Fiber Optic Sensors: An Introduction for Engineers and Scientiests*, New York: Wiley, 1991.

[2] K.Oh, et. al., *J. Lightwave Technol.*, vol. 23, pp. 524, 2005.

[3] Yan Zhang, et. al., *IEEE Photon. Technol. Lett.*, vol. 17, pp. 2712, 2005.

[4] R. Feced, et. al., *IEEE J. Quantum Electron.*, **5**, 1278