서로 다른 방향성을 가지는 나선형 장주기 격자쌍을 이용한 차단대역 가변형 필터

Bandwidth Tunable Band Rejection Filter based on Helicoidal Fiber Grating Pair of Opposite Hellicity

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A helically structured long-period fiber grating (LPFG) was firstly demonstrated with the wiring technique for a two-mode fiber spatial-mode coupler(1). Recently, the helical LPFG whose helical index modulation was obtained by releasing the residual stress of a pristine fiber, was fabricated by rotating the fiber under a continuous single side CO_2 laser beam exposure and showed relatively low polarization dependent loss compared with that of a conventional LPFGs. Novel peak shift was also demonstrated so that co-directional and contra-directional torsions resulted in spectral shift to shorter and longer wavelength, respectively(2). These novel characteristics of helical LPFGs can be used for a torque sensor and tunable filters. In this paper, a bandwidth tunable all-fiber band rejection filter (BRF) is proposed with serially cascaded helicoidal LPFGs (HLPFG) with opposite rotation directions by using new fabrication technique and characteristics of the proposed device are experimentally investigated. Compared with conventional optical fiber gratings, helically structured optical fiber gratings are characterized by the refractive index modulation of a helical structure such as a screw. HLPFGs are based on asymmetric refractive index modulation induced by the eccentricity between the fiber core and the cladding in the helicoidal structure.(3)(4) When a standard single-mode optical fiber is twisted, its core follows a helicoidal path inside the cladding which produces a significant periodic index change along the fiber, which results in LPFG with a certain grating period.

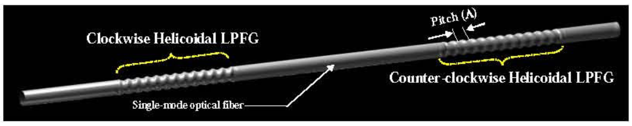
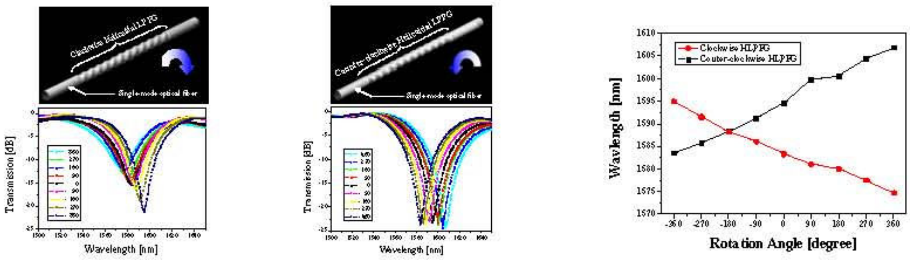


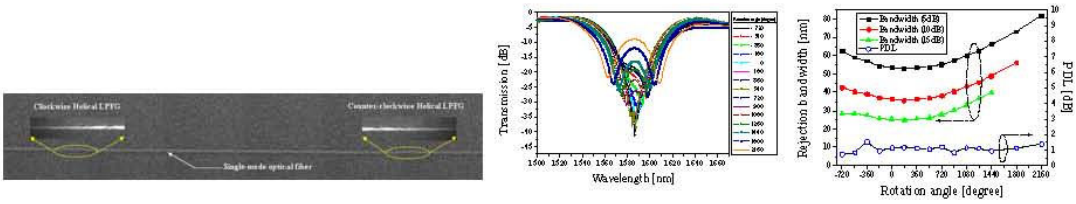
Fig. 1. Schematic of the proposed bandwidth tunable all-fiber BRF based on HLPFG pair.

The transmission spectrum of a HLPFG displays several dips that correspond to coupling of light from the core mode to the cladding modes, similarly to conventional LPFGs. The schematic of the proposed bandwidth tunable all-fiber BRF is shown in Fig. 1. The proposed device is composed of two serially formed HLPFGs which have almost same resonance with opposite hellicity; one in the clockwise direction and the other in the counter-clockwise, As a torsional stress is applied to the HLPFG pair, the helical pitch can be effectively reduced or enlarged.. Therefore, the overlap of the rejection bands of the cascaded HLPG can be adjusted by applying appropriate directional torsions. For example, rotating the cascaded device in the clockwise direction, the resonances of the clockwise and the counter-clockwise HLPFG move to a shorter and a longer wavelength, respectively. In a counter-clockwise direction rotation, the resonances of HLPFGs move conversely. We realized bandwidth tunable all-fiber BRF using this novel resonant peak shifts of HLPFG pair against the applied co-directional and contra-directional torsions. The helicoidal structures with the clear periodic index change were built up by CO_2 laser beam irradiation onto an single-mode optical fiber while the fiber twisted and moved with a constant speedalong the optical fiber axis. For precise control of the spectral characteristics and reduction of the transmission loss of HLPFGs, all fabrication parameters such as the rotation speed of fiber, moving speed of base stage, and the power of CO_2 laser were optimized. 10 W of a stabilized CO_2 laser beam was focused on the fiber.. While two rotating fiber holders simultaneously rotated in opposite directions at a speed of 1.4 °/sec, the actuator translated the fiber along its axis with a speed of 10 mm/sec. Ten helical pitches were formed in two section of a conventional single mode fiber (SMF-28, Corning) with opposite direction of helix in period of about 1300 mm. The measured spectral responses of theindividual clockwise and counter-clockwise HLPFG depending on the co-directional and contra-directional torsions are shown in Fig. 2(a) and Fig. 2(b), with the rotation angle of the fiber holder varied from -360 to 360 ° with 90 degrees intervals. The initial resonance peaks of clockwise HLPFG (cHLPFG) and counter-clockwise HLPFG (ccHLPFG) were at 1583.4 nm and 1594.5 nm, respectively. In cHLPFG, the clockwise rotation resulted in the resonance peak shift to a shorter wavelength while in the ccHLPFG red-shift was observed. The measured wavelength shifts of resonant peaks as a function of the rotation angle are shown in Fig. 2(c), where monotonic increase and decrease are manifested for cHLPFG and ccHLPFG, respectively. The magnified optical image and transmission characteristics of the fabricated bandwidth tunable all-fiber BRF are shown in Fig. 3. In Fig. 3(a), two helically formed periodic structures with different direction of helix are clearly shown. In order to investigate the tunable functionality of rejection bandwidth, torsional stress was deliverately applied to one of the ends of HLPFG pair. Now in the form of pair, the HLPGs with opposite hellicity will results in both red-shift and blue-shift to provide a broader bandwidth, if the spectral overalp between the two resonance is optimized. The measured spectral bandwidth changes of the proposed device are shown in Fig. 3(b), The rejection band of the proposed device was centered near 1585 nm. As the torsional stress is applied the center stayed near the initial position but the bandwidth changed proportionally. The bandwidth and polarization dependent loss (PDL)were measured for the rotation angle variations from -720 to 2160 ° with 180 degrees intervals, and the results are shown in Fig. 3(c). The bandwidth at the rejection level of 5, 10 and 20 dB were increased to 28.9 nm, 20.57 nm and 14.79 nm, respectively. The maximum insertion loss of proposed rejection bandwidth tunable filter was kept under 1.3 dB and showed a dramatically low PDL value less than ~ 1.5 dB. This significantly low PDL is originated from the azimuthally uniform index modulation of the overall helicoidal structure of the fabricated HLPFG.



(a) (b) (c)

Fig. 2. The spectral responses of HLPFGs according to the rotation angle. (a) The spectral response of cHLPFG. (b) The spectral response of ccHLPFG. (c) The measured resonant wavelength shifts of cHLPFG and ccHLPFG for clockwise rotation.



(a) (b) (c)

Fig. 3. (a) The image of the fabricated bandwidth tunable all-fiber BRF. (b) The spectral characteristic of the fabricated bandwidth tunable all-fiber BRF according to the rotation angle. (c) The trace of rejection bandwidth and polarization dependent loss of the bandwidth tunable all-fiber BRF along the rotation angle variations.

[참고문헌]

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