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Multi-wavelength fiber laser sources with an elliptical core side-hole fiber Sagnac loop filter

Dae Seung Moon[1], Bok Hyeon Kim[1], Guoyong Sun[1], Young-Geun Han[2], Won-Taek Han[1] and Youngjoo Chung[1]
[1]Department of Information and Communications, Gwangju Institute of Science and Technology (GIST)
1 Oryong-dong, Buk-gu, Gwangju 500-712, Korea
Tel: +82-62-970-2214, Fax: +82-62-970-3137, Email: ychung@gist.ac.kr
[2] Hanyang University, Department of Physics
17 Haengdang-dong, Seongdong-gu, Seoul 133-791, Korea

Abstract

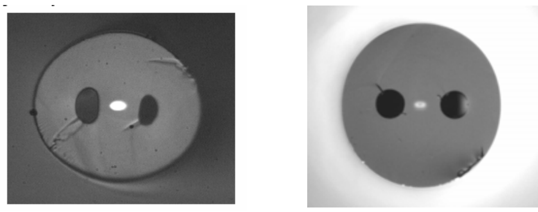
We propose and experimentally demonstrate a multi-wavelength fiber laser based on the Sagnac loop filter using elliptical core side-hole fiber with elliptical or circular cladding shape. We could obtain 18 discrete channels with SNR over 30 dB and channel spacing of 0.8 nm.

1 Introduction

Multi-wavelength fiber lasers are cost-effective sources in wavelength division multiplexed (WDM) optical communication systems, fiber sensors, and optical instrument testing. Semiconductor optical amplifier (SOA)-based multi-wavelength fiber lasers exhibit stable operation because the SOA has the property of inhomogeneous broadening and thus can support simultaneous oscillation of many lasing wavelengths. Several techniques have been proposed to achieve multi-wavelength fiber lasers. Among them, the use of a fiber Fabry-Perot filter increases the insertion loss of the cavity, and a Mach-Zehnder filter is sensitive to environmental changes due to the difference in the optical path lengths of the two arms [1]. The Sagnac loop filter incorporating high birefringence fiber has advantages of simple configuration and better stability compared with the filters based on Fabry-Perot and Mach-Zehnder interferometers. In this paper, we propose and experimentally demonstrate a multi-wavelength fiber laser based on Sagnac filter using the elliptical core side-hole fiber with elliptical or circular shape.

2 Experiment

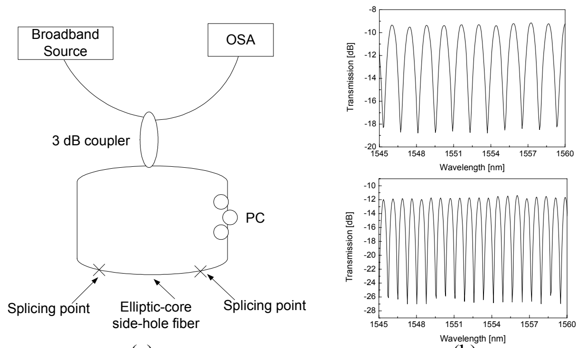
To fabricate the elliptical core side-hole fiber, we used the MCVD process. Figure 1 shows the cross section of



(a) (b)

Fig.1. The cross-section of fabricated elliptic-core side-hole fiber with (a) an elliptical shape, (b) a circular shape

the fabricated side-hole fiber with an elliptical core. The elliptic-shape fiber with elliptical core (Fig. 1(a)) was fabricated by over-jacketing (19 X 25 tube) and collapsing after cutting both sides of the preform. The fiber was drawn at the temperature of 1930℃. The relative index difference Δn (peak) was 0.02. The major/minor axes of the core and the side-hole diameter were 12 μm/6.6 μm and 20 ~ 25 μm, respectively [2]. To fabricate the circular-shape fiber with elliptical core (Fig. 1(b)), two holes with the diameter of 5 mm were drilled at both sides of the core in the preform [3]. The core with elliptical shape was made by partially collapsing the holes during fiber drawing at 2000℃. The major/minor axes of the core and the side-hole diameter were 8.6 μm/3.8 μm and 23 μm, respectively. The relative index difference Δn (peak) was 0.018. Generally, the wavelength separation between two transmission peaks of the Sagnac loop filter's output is given by $\Delta\lambda=\lambda^2/BL$ (where B is the modal birefringence, L is the length of the Hi-Bi fiber, and λ is the operation wavelength) [4]. From the transmission spectrum of Sagnac loop filter as shown in Fig. 2(a), the modal birefringence of the fabricated elliptical core side-hole fiber was 1.7×10^{-4} (elliptical shape) and 1.16×10^{-4} (circular shape), respectively.



(a) (b)

Fig.2. (a) Configuration of the Sagnac loop filter, (b) transmission spectra of elliptical core side-hole fiber with an elliptical shape (L=10 m, $\Delta\lambda$=1.4 nm) and a circular shape (L=26 m, $\Delta\lambda$=0.8 m), respectively.

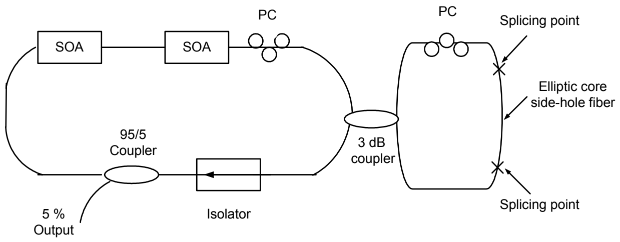
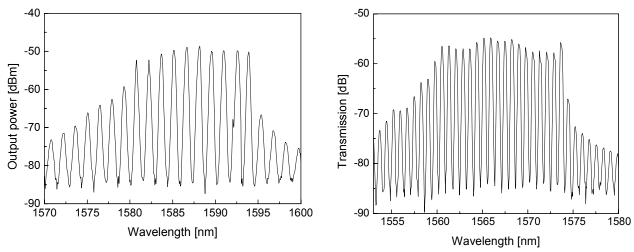


Fig.3. The experimental setup for multi-wavelength fiber laser.

Figure 3 shows the experimental setup of the proposed fiber laser. The input beam from two SOAs is split into two counter-propagating beams using the 3 dB coupler, which recombine at the coupler after travelling through the fiber loop. Due to the birefringence in the elliptical core side-hole fiber, the beams transmitted from the fast axis and slow axis suffer different optical path lengths. The channel spacing of the fiber laser is determined by the birefringent component, i.e., the elliptical core side-hole fiber within the Sagnac loop filter. We used two SOAs instead of one to increase the output power [5]. The laser output is taken from the 95:5 coupler, which provides 5 % for the output and 95 % for feedback to the cavity.



(a) (b)

Fig. 4. The output spectra of fiber laser using elliptical core side-hole fiber with (a) an elliptical shape (L=10 m, $\Delta\lambda$=1.4 nm) and (b) a circular shape (L=26 m, $\Delta\lambda$=0.8 nm).

By proper adjustment of the polarization inside the cavity, we could obtain the multi-wavelength output spectra of the proposed fiber laser when the two SOAs were driven with the injection current of 200 mA. Figure 4(a) shows the output spectrum composed of 10 discrete channels with less than 3 dB power variation among them. The channel spacing was ~1.4 nm and SNR was over 30 dB. Figure 4(b) shows the output spectrum with 18 discrete channels and less than 3 dB power variation. The channel spacing was ~0.8 nm (100 GHz at 1550 nm, i.e. WDM ITU-grid spacing) and the SNR was over 30 dB.

3 Conclusion

In this work, we proposed and experimentally demonstrated a multi-wavelength fiber laser based on the Sagnac loop filter using the elliptical core side-hole fiber with elliptical or circular cladding shape. By properly adjusting the polarization controller, we could obtain 18 discrete channels with SNR over 30 dB and channel spacing of 0.8 nm and 10 discrete channels with SNR over 30 dB and channel spacing of ~1.4 nm. The fiber laser proposed in this work is expected to find various applications as a tunable multi-wavelength light source for optical communication and sensing.

Acknowledgements

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4 References

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