Switchable dual-wavelength erbium-doped fiber laser based on polarization-maintaining fiber Sagnac loop mirror and fiber Bragg gratings

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Abstract:
A switchable dual-wavelength erbium-doped fiber laser is proposed and experimentally demonstrated, which is constructed by a polarization-maintaining fiber Sagnac loop mirror (PMF-SLM) and two FBGs with different wavelengths. Wavelength switching operation is achieved by properly adjusting the polarization controller (PC) in the PMF-SLM. Stable single- or dual-wavelength lasing output can be realized. The maximum amplitude variation for every lasing wavelength is less than 1 dB, and the signal-to-amplified spontaneous emission (ASE) ratio is about 35 dB.

Keywords: erbium-doped fiber laser, polarization-maintaining fiber, fiber Bragg grating, wavelength-switchable, dual-wavelength.
hydrogen loaded SMF were fabricated through the phase mask scanning method using KrF eximer laser. The central wavelengths of the FBG1 and FBG2 are 1543.61, 1544.91 nm, with a 3-dB bandwidth of 0.06, 0.062 nm, and 95.5%, 96% reflectivity, respectively. The transmission spectrum of the FBGs is shown in Fig. 3.

Firstly, by appropriately adjusting the states of the PC in PMF-SLM, switchable single-wavelength lasing operation can be easily obtained. Two separate single-wavelength lasing lines at 1543.61 and 1544.91 nm, with corresponding output power of –8.7 and –12.1 dBm, respectively, are illustrated in Figs. 4(a) and (b). In these situations, the pump power works at about 100 mW. Figures 4(c) and (d) show the 16 times repeated scan of the single-wavelength lasing at these two wavelengths with a 5-s interval. The maximum power fluctuation of the lasing lines is less than 0.5 dB. By monitoring the laser spectra over about 10 min, the results indicate stable operations of the single-wavelength lasing.

The mechanism of realizing the switchable single-wavelength lasing operations is based on the proper control of the cavity losses experienced by the two wavelengths, through adjusting the PC. Figure 5 presents the reflection spectrum of the PMF-SLM (dotted lines) and corresponding lasing operation (solid lines). Since the reflection spectrum is a periodic cosine function of wavelength, the PMF-SLM has a comb like filter characteristic. In the Fig. 5(a), the Bragg wavelength of the FBG2 just falls into the dip region of the PMF-SLM, while the Bragg wavelength of FBG1 lies in the peak region. Therefore, the light with the Bragg wavelength of FBG2 cannot oscillate due to the more cavity loss, while that of FBG1 can. By adjusting the PC in PMF-SLM, its reflection spectrum shifts towards long wavelength region about half of the period, i.e. 1 nm. Since the spacing between Bragg wavelengths of FBG1 and FBG2 is about 1.3 nm, the Bragg wavelength of FBG2 can oscillate, but FBG1 cannot, as shown in Fig. 5(b). It is expected that the larger separation between switching wavelengths can be obtained as long as the Bragg wavelengths of the FBGs are varied and the spacing between two Bragg wavelengths is about the odd times of half period of the PMF-SLM. Furthermore, if the length or birefringence parameter of the PMF is changed, the separation between switching wavelengths can be made even smaller than 1.3 nm, by choosing the corresponding FBGs.

Additionally, the stable dual-wavelength laser can also be achieved by carefully adjusting the PC. Figure 6(a) shows two lasing lines at 1543.61 and 1544.91 nm, respectively, with corresponding output powers of –12.34 and –13.20 dBm. The wavelength separation is about 1.3 nm. To study the stability, the dual-wavelength lasing were monitored in about 20 min, and stable operation can be found. As shown in Fig. 6(b), the wavelengths remain stable, and the output power stability at each lasing line is within 1 dB. In all, no significant drifts in the wavelengths and the amplitudes are detected, indicating that the dual-wavelength operation of the laser is stable.
When operating at the stable dual-wavelength lasing condition, Fig. 7 presents the reflection spectrum of the PMF-SLM (dotted line) and corresponding lasing operation (solid line). It is obvious that, by adjusting the PC, the peak-to-notch contrast of the PMF-SLM reflection spectrum is greatly reduced. Thus, the gain obtained from the EDF can be made compensate the cavity loss for both Bragg wavelengths of the FBGs. When the spatial interference pattern is generated by the counterpropagation optical fields, absorption coefficient with periodic variation which leads to spatial hole burning is formed. So, the dual-wavelength oscillation is operated steadily.

In conclusion, we demonstrate that single- or dual-wavelength laser output is obtained by the proposed fiber laser, which consists of a PMF-SLM and two FBGs. Wavelength-switching operation is accomplished by appropriately adjusting the PC in the PMF-SLM. The amplitude variation of laser lines in both single and dual operation is measured to be less than 1 dB, and signal-to-ASE ratio is about 35 dB.

References