Dual-wavelength erbium-doped fiber laser with asymmetric fiber Bragg grating Fabry-Perot cavity*

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A novel dual-wavelength fiber laser with asymmetric fiber Bragg grating (FBG) Fabry-Perot (FP) cavity is proposed and experimentally demonstrated. A couple of uniform FBGs are used as the cavity mirrors, and the third FBG is used as intracavity wavelength selector by changing its operation temperature. Experimental results show that by adjusting the operation temperature of the intracavity wavelength selector, a tunable dual-wavelength laser emission can be achieved. The results demonstrate the new concept of dual-wavelength lasing with asymmetric FBG FP resonator and its technical feasibility.

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Dual-wavelength erbium-doped fiber (EDF) laser has attracted considerable interest for its potential applications in wavelength division multiplexing (WDM) optical communication systems, spectroscopy, fiber optic sensing, optical generation of microwave and millimeter waves and other fields[1-4]. Till now, many possibilities have been proposed to generate dual-wavelength lasing, such as optical parametric oscillator[5], Brillouin scattering[6], cascaded Sagnac loop interferometer[7], fiber loop cavity with cascaded fiber Bragg gratings (FBGs) and birefringent fiber filter[8], passively Q-switched loop cavity with grapheme and single-wall nanotube saturable absorber[9-11], actively Q-switched linear cavity[12], dual-loop cavity[13,14], symmetric linear FBG Fabry-Perot (FP) cavity[15], fiber loop cavity[16-19], phase-shift Bragg gratings[20,21] and linear overlapping cavity[22]. However, FBG is used as external wavelength selector in the loop structure, and a polarization maintaining (PM) chirped FBG and a PM FBG are used as the resonator cavity mirrors in the linear cavity structure, which lead to complicated cavity structures.

In this paper, we propose and demonstrate a simple dual-wavelength fiber laser with asymmetric FBG FP resonator. The dual-wavelength lasing is flexibly controlled by adjusting the operation temperature of intracavity wavelength selector, and the output spectra of dual-wavelength fiber laser with different wavelength spacings are observed.

The schematic diagram of the proposed dual-wavelength fiber laser with asymmetric FBG FP resonator is shown in Fig.1. A couple of identical uniform FBGs (FBG1 and FBG3) are used as the cavity mirrors, and the third uniform FBG (FBG2) is used as intracavity wavelength selector by changing its operation temperature. A piece of highly EDF with length of ~25 cm is placed between FBG2 and FBG3, which is served as the gain medium. A 980 nm laser diode (LD) with the maximum power of 500 mW is used for pumping the highly erbium-ytterbium (Er-Yb) co-doped fiber via a WDM coupler of 980 nm/1 550 nm. The doped fiber (Er110- 4/125, nLIGHT Corporation) has a numerical aperture (NA) of 0.19, and the used undoped fiber is G652B standard fiber. A spectrum analyzer (MS9710C, Anritsu) with resolution of 0.05 nm is used for measuring the output spectrum.

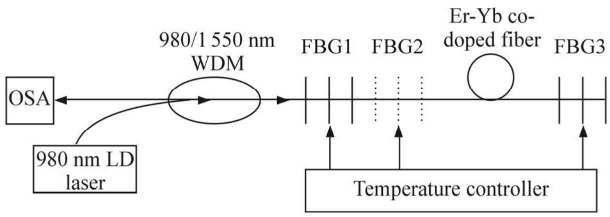

Fig.1 Schematic diagram of the proposed dual-wavelength fiber laser with asymmetric FBG FP resonator

When the operation temperatures of FBG1 and FBG2 are 25 °C and 0 °C, respectively, the transmission spectrum of the two cascaded FBGs is shown in Fig.2. Two reflection wavelengths corresponding to the Bragg wavelength λ_B of FBG1 and FBG2, i.e., 1 550.044 nm and 1 549.208 nm, are obtained. The Bragg wavelength

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λ_B is a function of the operation temperature of FBG, $\Delta\lambda = K\lambda_B\Delta T$, where $\Delta\lambda$ and ΔT are the changes of the reflection wavelength and operation temperature of FBG, respectively, K is the temperature coefficient of FBG, and the temperature coefficient of the FBGs used in our experiment is 1.27×10^{-5} °C^{-1}[23].

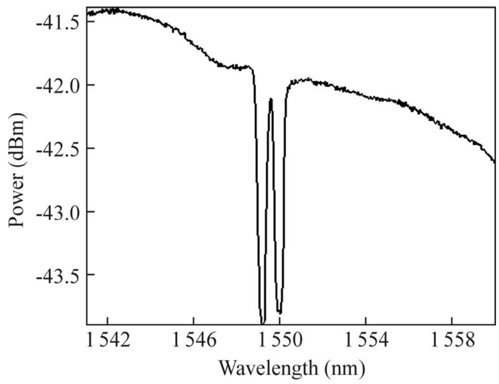
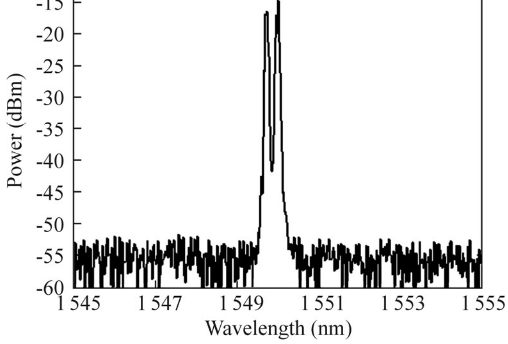
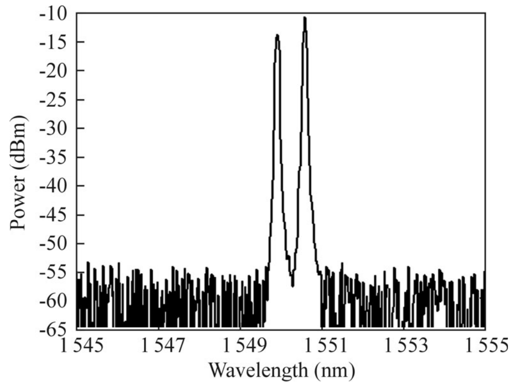


Fig.2 Transmission spectrum of the two cascaded FBGs

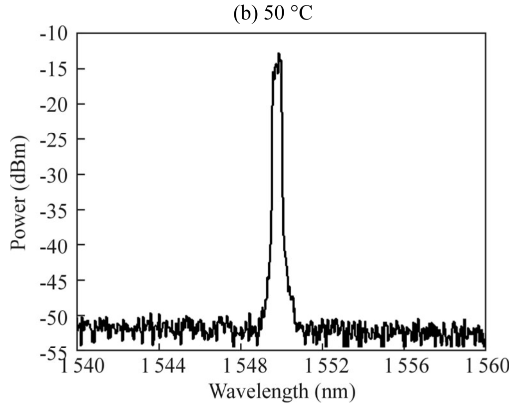
Keeping the identical uniform FBG1 and FBG3 at the same temperature of 25 °C, and changing the operation temperature of FBG2, a continuous wave (CW) dual-wavelength lasing is observed. When FBG2 works at 10 °C, a dual-wavelength simultaneous oscillation at 1 550.02 nm and 1 549.74 nm with signal-to-noise ratios (SNRs) larger than 40 dB is achieved with the pump power of 100 mW as shown in Fig.3(a), and the wavelength spacing is 0.28 nm. When FBG2 works at 50 °C, a dual-wavelength simultaneous oscillation at 1 549.92 nm and 1 550.66 nm with SNRs larger than 45 dB is achieved with the pump power of 140 mW as shown in Fig.3(b), and the wavelength spacing is 0.74 nm. When FBG2 works at 25 °C, a single-wavelength simultaneous oscillation at 1 549.866 nm with SNRs larger than 40 dB is achieved with the pump power of 100 mW as shown in Fig.3(c). In this case, the three identical FBGs (FBG1, FBG2 and FBG3) work at the same temperature of 25 °C, and their central wavelengths are the same approximately, which leads to a single-wavelength lasing. Here, there is a little difference which is caused by the error of temperature control.



(a) 10 °C



(b) 50 °C



(c) 25 °C

Fig.3 Output spectra of the dual-wavelength fiber laser with different operation temperatures of FBG2

We propose and experimentally demonstrate a dual-wavelength fiber laser with asymmetric FBG FP cavity. By controlling the operation temperature of intracavity FBG, a tunable dual-wavelength or single-wavelength lasing is achieved. When two identical uniform FBGs used as cavity mirrors work at 25 °C and the intracavity FBG works at 10 °C and 50 °C, dual-wavelength simultaneous oscillations at 1 550.02 nm/1 549.74 nm and 1 549.92 nm/1 550.66 nm are achieved, respectively.

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