A tunable dual-wavelength fiber Bragg grating laser using an external-injected DFB laser*

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A tunable dual-wavelength fiber Bragg grating (FBG) laser based on a distributed feedback (DFB) laser injection is proposed and experimentally demonstrated. The wavelength spacing can be tuned by adjusting the operation temperature of the DFB laser. When the DFB works at 25 ℃, a dual-wavelength simultaneous oscillation at 1 549.67 nm and 1 553.44 nm with wavelength spacing of 3.77 nm is achieved. Our experimental results demonstrate the new concept of dual-wavelength lasing with a DFB laser injection and the technical feasibility.

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Dual-wavelength lasers have been of great interest for their potential applications in remote sensing instruments, optical communication system, optical generation of microwave/millimeter waves and THz wave, fiber optic sensing, military as well as differential absorption spectroscopy measurements[1-7]. Until now, many different methods have been demonstrated to achieve stable and tunable dual-wavelength lasing at room temperature, such as cascaded fiber Bragg gratings (FBGs) in the laser cavity[8], symmetric and asymmetric linear fiber Bragg grating Fabry-Perot (F-P) cavity[9,10], passively Q-switched fiber laser based on different saturable absorbers[11-13], phase-shifted gratings and sampled FBGs[14-16], and single fiber loop and dual-loop cavity[17-20]. However, the mode-competition is a very common phenomenon for dual-wavelength lasers, which leads single mode oscillation, and the mode-competition can be eliminated by using the injection structure. Lee et al[21] proposed tunable dual-wavelength picosecond optical pulses by using self-injection seeded gain-switched laser diode (LD). Peng et al[22] reported a tunable dual-wavelength erbium-doped fiber ring laser using a self-seeded Fabry-Perot laser diode. In our previous work, we reported dual-wavelength FBG lasers with SESAM and asymmetric linear fiber Bragg grating Fabry-Perot (F-P) cavity[23,24].

In this paper, we propose and experimentally demonstrate a tunable dual-wavelength fiber Bragg grating laser based on a DFB laser injection, and a tunable dual-wavelength lasing is achieved. The wavelength spacing can be tuned by changing the operation temperature of the injected DFB laser.

The configuration of the proposed tunable dual-wavelength fiber Bragg grating laser based on a DFB laser injection is shown in Fig.1. A DFB laser with threshold current of 20 mA is used as the injection laser. A couple of identical uniform FBGs (FBG1 and FBG2) are used as the cavity mirrors of the FBG laser and connected by a piece of highly Er-doped fiber (EDF) with length of ~25 cm, which serves as gain medium. A 980 nm LD with the maximum power of 500 mW is used to pump the EDF through a wavelength division multiplexing (WDM) coupler of 980 nm/1 550 nm. An optical spectrum analyzer (MS9710C, Anritsu) with a resolution of 0.05 nm is used for measuring output spectrum.

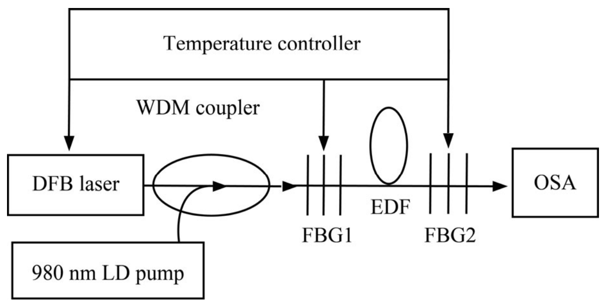

Fig.1 Experimental setup of dual-wavelength fiber Bragg grating laser based on a DFB laser injection

Keeping the operation temperatures of FBG1 and FBG2 at 10 ℃ and the DFB laser at 25 ℃, the pump power is 0, and the output spectrum of the FBG laser is shown in Fig.2. It demonstrates that the center wavelength of output laser is 1 553.44 nm with the full-width at half-maximum (FWHM) bandwidth of 0.18 nm, which

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is the output wavelength of the injected DFB laser. We gradually add the pump power, the effect of the pump power on the output of the FBG laser is shown in Fig.3. It shows that the lasing at 1 549.67 nm wavelength is not oscillated below the pump power of 210 mW, and a dual-wavelength simultaneous lasing at 1 549.67 nm and 1 553.44 nm with wavelength spacing of 3.77 nm is achieved with the pump power up to 210 mW.

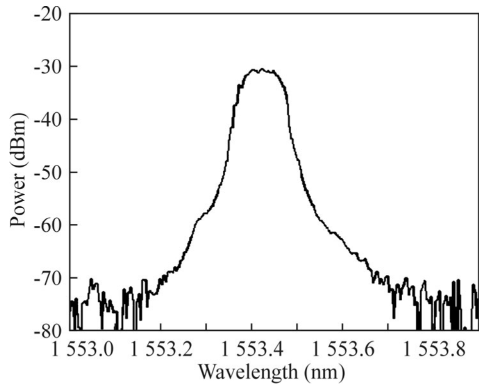

Fig.2 Output spectrum of the FBG laser without pump

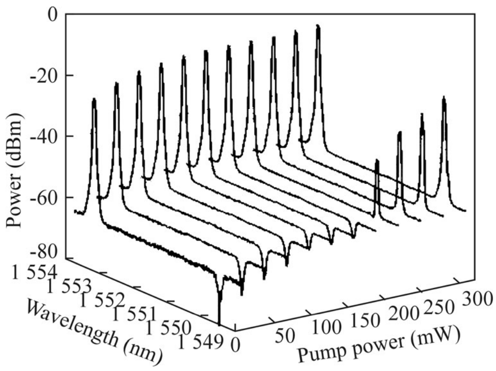

Fig.3 Effect of pump power on the output spectrum of FBG laser

Keeping the operation temperature of two FBGs at 10 ℃, the effect of the operation temperature of the injected DFB laser on output of the FBG laser is shown in Fig.4. It demonstrates that the output of the FBG laser is a function of the operation temperature of injected DFB laser. When the injected DFB laser works at 10 ℃, a dual-wavelength simultaneous lasing at 1 549.67 nm and 1 551.82 nm with signal-to-noise ratios of >30 dB is achieved with the pump power of 300 mW, as shown in Fig.4(a), and the wavelength spacing is 2.15 nm. When the injected DFB laser works at 5 ℃, a dual-wavelength simultaneous lasing at 1 549.67 nm and 1 551.24 nm with signal-to-noise ratios of >30 dB is achieved with the pump power of 300 mW, as shown in Fig.4(b), and the wavelength spacing is 1.57 nm. When the injected DFB laser works at 0 ℃, a dual-wavelength simultaneous lasing at 1 549.67 nm and 1 550.56 nm with signal-to-noise ratios of >30 dB is achieved with the pump power of 300 mW, as shown in Fig.4(c), and the wavelength spacing is 0.89 nm. When the injected DFB laser works at -5 ℃, a dual-wavelength simultaneous lasing at 1 549.67 nm and 1 550.12 nm with signal-to-noise ratios of >30 dB is achieved with the pump power of 300 mW, as shown in Fig.4(d), and the wavelength spacing is 0.45 nm.

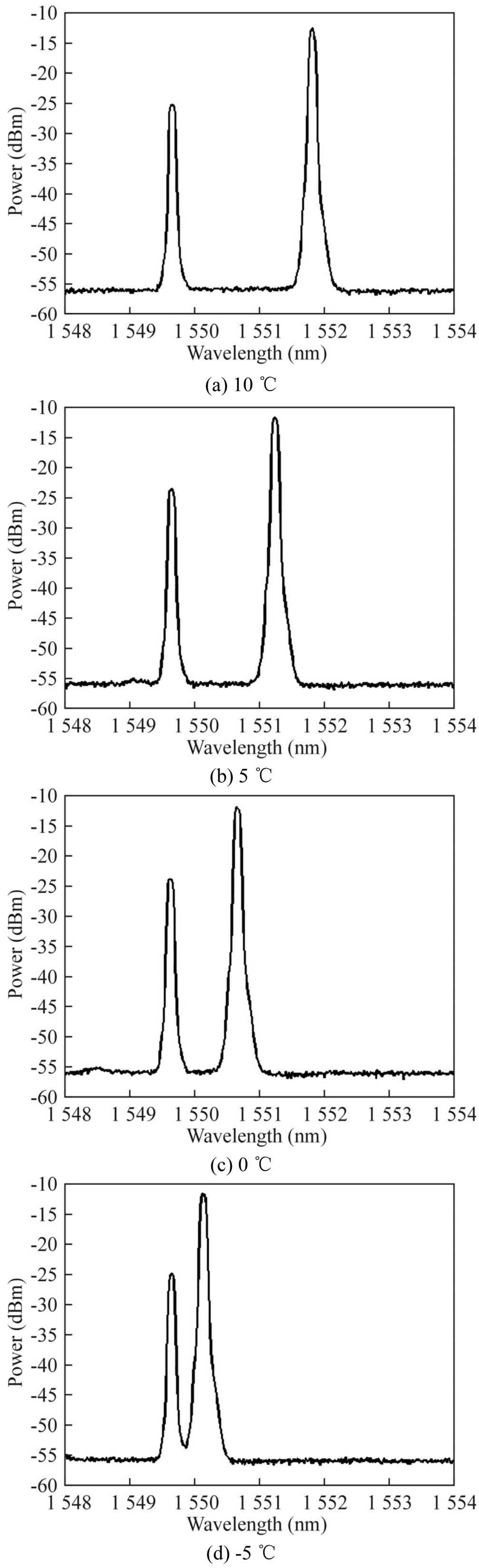

Fig.4 Output of the FBG laser as a function of the operation temperature of injected DFB laser

The effect of pump power on the lasing at 1 549.67 nm wavelength is shown in Fig.5. It demonstrates that the threshold pump power is almost 205 mW, and the maximum output power of 4.84 μW with a slope of 0.051 7% is achieved at the pump power of 300 mW. The slope is lower, because some separate elements are used and connected actively in our experiment, which leads to the power coupled into the EDF is much lower than the display value.

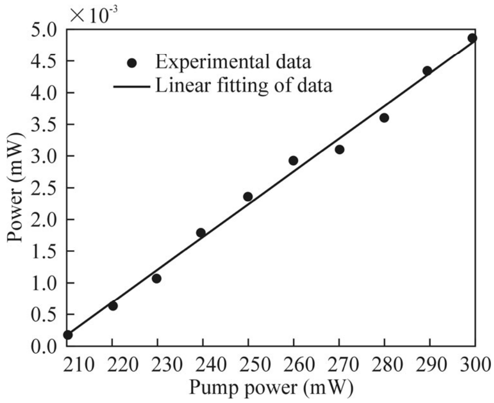

Fig.5 Output vs. input at 1 549.67 nm wavelength

In summary, we have proposed and experimentally demonstrated a dual-wavelength FBG laser based on injected FBG laser. When the two FBGs work at 10 ℃ and DFB laser at 25 ℃, a dual wavelength lasing at 1 549.67 nm and 1 553.44 nm is observed with wavelength separation of 3.77 nm, and the threshold pump power for the lasing at 1 549.67 nm wavelength is ~205 mW. The wavelength spacing can range from 0.45 nm to 3.77 nm when the operation temperature of the injected DFB laser varies from -5 ℃ to 25 ℃.

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