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Sampled Grating DBR Lasers with 35nm Quasi-Continuous Tuning Range*

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Abstract: We demonstrate a ridge waveguide sampled-grating distributed-feedback laser with quasi-continuous wavelength coverage over a 35nm range. The design is based on a 320nm-thick butt jointed passive waveguide optimized for carrier injection tuning. The butt-joint technology enable optimize the passive waveguide as well as active section. By tuning mirror sections, the laser provides 35nm tuning while maintaining >30dB sidemode suppression ratio.

Key words: SGDBR diode laser; tunable laser; butt-joint regrowth
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1 Introduction

Widely tunable lasers will be essential components for high capacity wavelength-division-multiplexed (WDM) transmission and photonic switching systems [1,2]. For these optical fiber communication systems, they offer several opportunities to increase the capacity, the functionality and the flexibility of WDM networks.

Among various type of tunable lasers, a principle advantage of sampled grating distributed Bragg reflector (SGDBR) laser over other widely tunable lasers is that it can be monolithically integrated with different devices such as semiconductor optical amplifiers (SOA) [3] and electro-absorption modulators [4] to create complex photonic integrated circuits. The prevail obstacle to achieve such devices lies on the manufacturing a different band edge energy from gain medium. There are currently several widely used methods to accomplish this type of variation. Such methods include but are not limited to butt-joint regrowth[5], quantum well intermixing (QWI) [6], and the use of offset quantum wells [7]. The butt-joint regrowth is an ideal technology for different materials can be optimized independently.

In this paper, we propose a tunable SGDBR laser fabricated by three steps of metal organic vapor phase epitaxy (MOVPE) growth. The threshold current of the devices is 26mA, and output power is more than 9mW at 100mA. By tuning two SGDBR sections and the phase control section, we obtain 35nm-tuning range and a high side mode suppression ratio (SMSR >30dB).

2 Experiment

The laser has four independently biased sections as illustrated in Fig. 1: two SGDBR sections, a passive phase section and an active section. This sampling of the grating results in a comb-like reflection spectrum with periodic maxima. The two SGDBR sections have slightly different sample period, resulting in the peaks of the reflection spectrum of both SGDBRs being slightly mismatched. When biased above threshold, lasing occurs at the wavelength where the reflection maximum for the front and back sampled-grating sections is coincident. Independent tuning of each SGDBR section's reflection spectrum is performed via

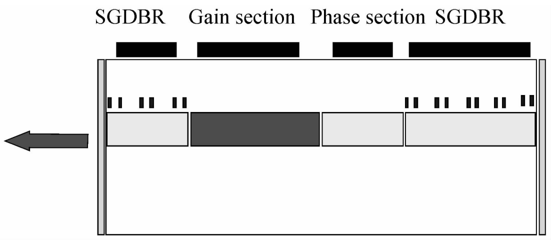

Fig.1 Schematic diagram of an SGDBR laser

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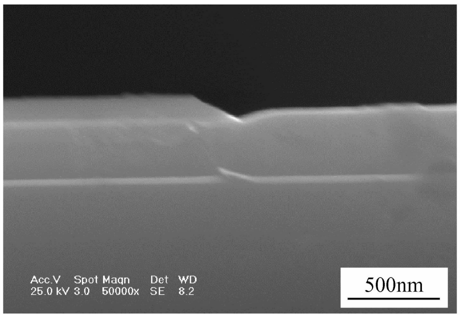

Fig. 2 SEM image of butt-joint regrowth

separately controlled current injection into each SGDBR section, where plasma and band-filling effects mediate the tuning behavior.

The devices are epitaxially grown using a Thomas Swan CCS MOVPE reactor on an n-type InP substrate. The epitaxial structure consists of six 5nm-thick compressively strained (0.8%) quantum wells and five 10nm-thick barriers. The quantum wells were sandwiched between 100nm InGaAsP (λ_g = 1240nm) waveguide layers. The active and passive regions were patterned selectively with a SiO_2 mask, the quantum wells in the region other than the active regions were removed by wet chemical etching, and stopped on the n-InP buffer layer. Following this, passive waveguide was regrown by butt-joint growth, as shown in Fig. 2. The passive waveguide is composed of 320nm InGaAsP (λ_g = 1420nm) and 50nm grating layer (λ_g = 1240nm). The sampled grating was formed on grating layer using a combination of holographic and masked lithography. A p-InP upper cladding and p^+-InGaAs contact layer were then regrown using again LP-MOVPE. After regrowth, the remaining fabrication steps are the same as the processing of a ridge waveguide laser except that the InGaAs contact layer was etched away for electrical isolation among electrode.

After metallization, film was evaporated using an e-beam evaporator on two facets to serve as the antireflection (AR) coating. The integrated devices were soldered on copper heat sinks for good electrical and thermal contact.

3 Results and discussion

The current versus light output for these devices is shown in Fig. 3. Locking the current of the SGDBR section and phase section at 0mA, the threshold current was 26mA, and the output power reached 9mW at 100mA. These indicate that a low couple loss between active and passive waveguide was achieved.

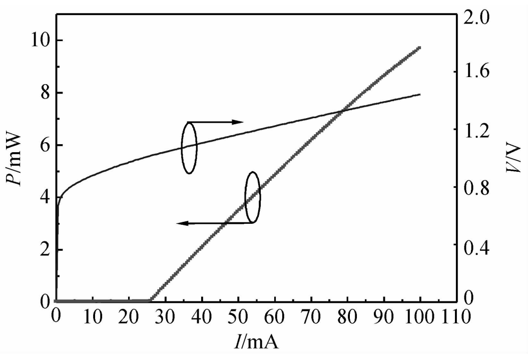

Fig. 3 *P-I-V* curves of the SGDBR laser

The SGDBR laser is wavelength tuned by shifting the front and back mirror reflectivity combs by current injection. The device can be continuous tuned over a short range by simultaneously tuning the front and back mirrors. Once the limit of the index tuning is reached, the front and back SGDBRs are tuned differently, aligning an adjacent set of reflectivity peaks, at which point the reflectivity combs are tuned simultaneously again. This principle is used to achieve any wavelength within the designed tuning range. The full tuning range of the SGDBR device can be demonstrated by sweeping the front and back SGDBR currents, creating a map of the wavelength for various combinations of mirror currents while keeping a constant of the active driving current of 100mA. Such an SMSR map is shown in Fig. 4(a), while a map of the wavelength is shown in Fig. 4(b).

Figure 5 shows the tuning curve for front and back mirror of SGDBR laser. Full wavelength coverage over 35nm can be achieved with tuning currents of

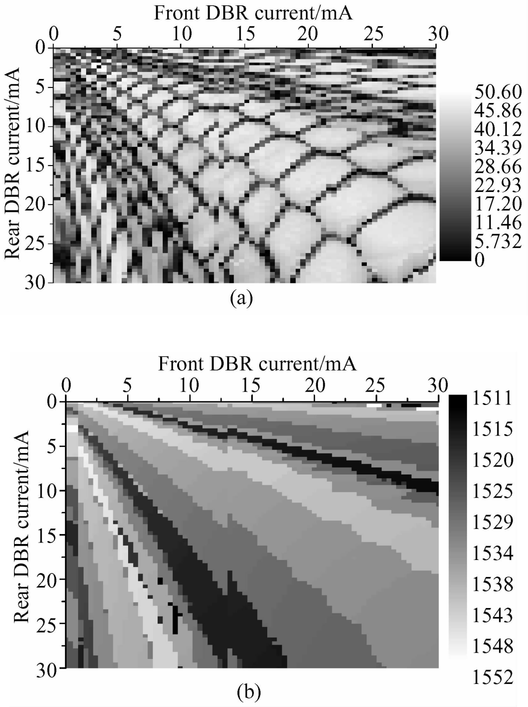

Fig. 4 (a) SMSR map of the SGDBR laser; (b) Wavelength map of the SGDBR laser

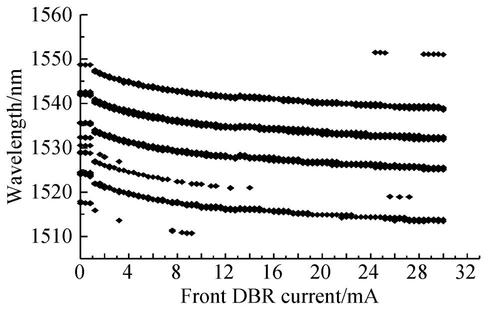

Fig. 5　Tuning range of SGDBR laser

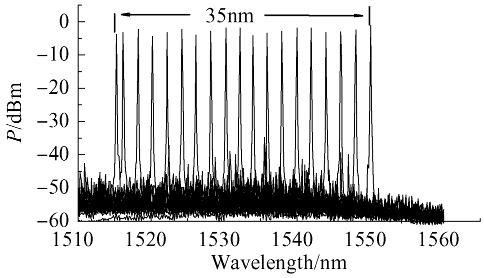

Fig. 6　Superimposed tuning spectra for the laser over a 35nm tuning range

30mA. The current into the phase section allowed all channels to be tuned in 0. 3nm and aligned precisely at WDM channels.

The SMSR is one of the most important characteristics of SGDBR laser, which is determined by both front and back mirror designs. The mismatch of peaks of reflection spectrum of both SGDBRs and width of the individual reflectivity peaks plays a role in the SMSR. Typical output spectra of SGDBR lasers are shown in Fig. 6. The spectra were taken at various wavelengths within the tuning range of the device. The SMSR for the typical SGDBR device is 30dB or greater except for the mode jump regions, which indicates that the high value of SMSR could be achieved by butt-joint technology. The output variation is due to the difference reflectivity among reflection peaks.

4　Summary

In conclusion, a ridge waveguide SGDBR lasers have been fabricated using butt-joint technology. In the case of the currents of the passive sections locking at 0mA, the threshold current was 26mA, and the output power reached over 9mW at 100mA. Tuning the injection currents of back and front SGDBR, quasi-continuous tuning range of more than 35nm is achieved with greater than 30dB of SMSR. This demonstrates the applicability of butt-joint technology to fabricate widely tunable lasers, and provides a powerful processing platform for integrating widely tunable lasers with other components on chip for future photonic integrated circuit.

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准连续调谐 35nm 的 SGDBR 激光器的研制*

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摘要：对接生长技术可以独立优化不同区域的波导结构，有利于制作高性能的半导体光电子集成器件. 文中采用 MOCVD 对接生长技术制作了 SGDBR 激光器，通过载流子注入，器件准连续调谐范围为 35nm，在调谐范围内边模抑制比大于 30dB.

关键词：SGDBR 半导体激光器；可调谐激光器；对接生长
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