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Effect of Initial Phase in Wavelength Tunable DFB Laser with High Coupling Coefficient Gratings

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Abstract

We achieved a mode-hop-free tuning range of more than 5 nm for phase controlled wavelength tunable DFB lasers with high coupling coefficient gratings by changing the initial phase between their two DFB sections.

Introduction

In future optical network systems and optical sensing systems, it will be necessary for wavelength tunable lasers to change wavelength quickly. Carrier variation in a semiconductor induces a large and fast change in refractive index. Many types of wavelength tunable lasers operated by current injection have been reported including short cavity distributed Bragg reflector (DBR) lasers [1], super structure grating (SSG) [2] and sampled grating (SG) [3] DBR lasers and tunable twin guide (TTG) lasers [4].

We have studied wavelength tunable DFB lasers with high coupling coefficient (κ) gratings that can be controlled easily because they have only a single electrode for tuning. Moreover, they can be integrated with other optical components such as semiconductor optical amplifiers (SOA) and multi-mode interferometer (MMI) couplers to form a tunable laser array [5].

We have reported a continuous tuning range of 4.6 nm for a tunable wavelength DFB laser with high κ gratings of about 390 cm^{-1} [6]. In this work, we investigate the relationship between the two gratings in our lasers. As a result, we achieved a continuous wavelength tuning range of over 5 nm.

Experiment

Figure 1 shows a schematic diagram of our wavelength tunable DFB laser, which consists of two DFB sections (high κ gratings with gain) and one phase shift section. The lasing wavelength changes within a wide reflection band (stop band) according to the phase shift. The amount of phase shift can be changed smoothly and quickly by injecting current into the phase shift section. A grating with a κ as high as 390 cm^{-1} yields a stop band more than 10 nm wide.

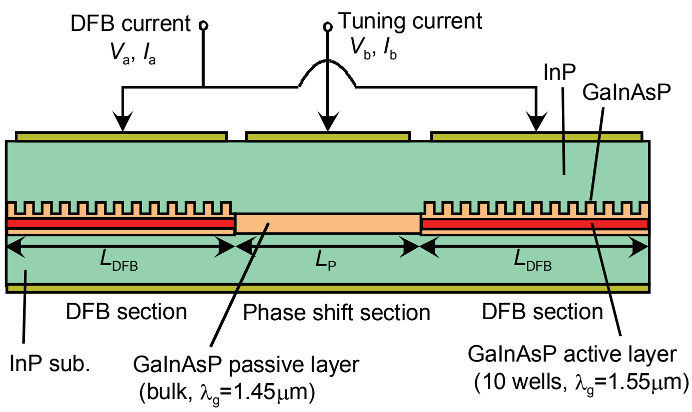

Fig. 1 Wavelength tunable DFB laser

We fabricated wavelength tunable DFB lasers with four kinds of grating patterns providing different initial phase shift (0, λ/8, λ/4, 3/8λ), as shown in Fig. 2. The actual optical phases are determined by both the initial grating position and the optical length of the phase shift section.

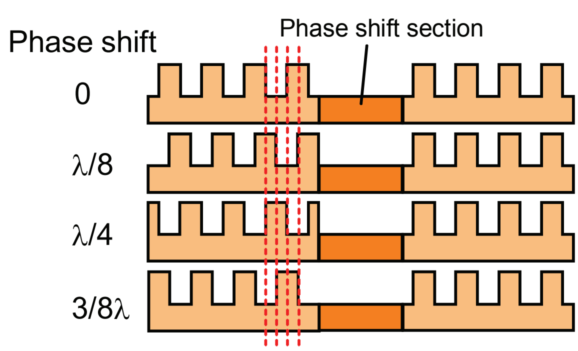

Fig. 2 Images of four grating patterns

Figure 3 shows the dependence of the lasing wavelength on the voltage supplied to the phase shift section for tunable DFB lasers with different initial phase shifts. All lasers consist of two 40-μm long DFB sections and a 15-μm long phase shift section. The DFB current (I_a) was fixed at 50 mA, and the tuning voltage (V_b) ranged from 0 to 1.8 V. The lasing wavelength can be tuned from the longer wavelength side to the shorter wavelength side. The initial lasing wavelength at V_b = 0 V depends on the initial phase. The tuning range is the largest (5 nm) for the laser with an initial phase of 0, where the lasing wavelength moves continuously from 1550.3 to 1545.3 nm. Whereas the laser with an initial phase of λ/8 exhibits mode hopping from a shorter to a longer wavelength during tuning, the tuning ranges for lasers with initial phases of λ/4 and 3λ/8 are 3.9 and 4.6 nm, respectively. The initial lasing wavelength should be set on the shorter wavelength side as long as there is no mode hopping during tuning.

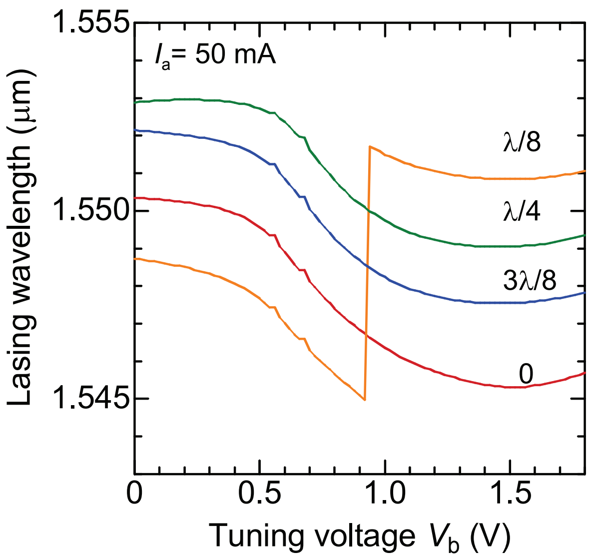

Fig. 3 Tuning characteristics of four lasers

Figure 4 shows the tuning spectrum of the laser with an initial phase of 0, which has a tuning range of 5 nm. We achieved an output power of more than 1 mW and a side mode suppression ratio (SMSR) of more than 35 dB during tuning. Although the output power decreases, a wider tuning range of more than 5 nm can be obtained with a small DFB current.

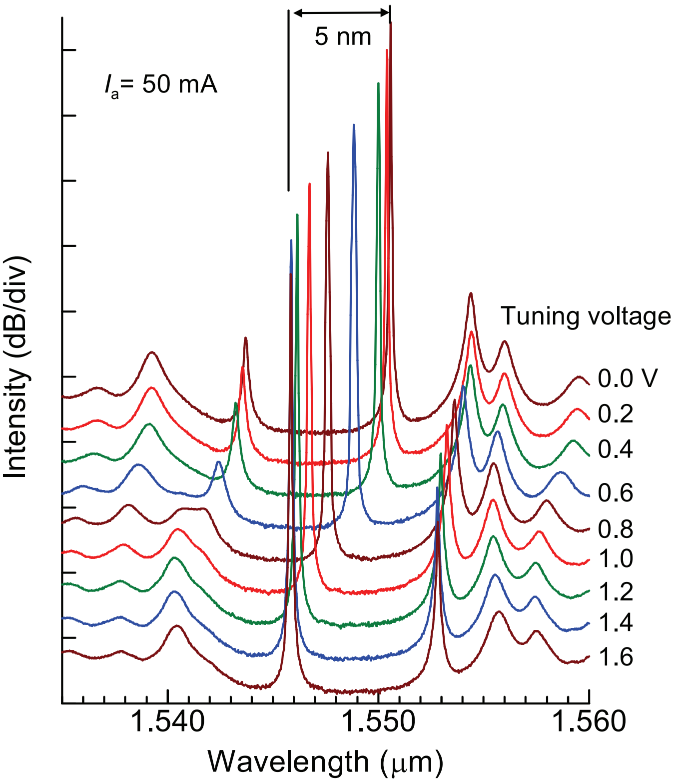

Fig 4. Tuning spectra

Conclusion

We achieved a mode-hop-free tuning range of 5 nm for wavelength tunable DFB lasers with optimized initial phase shifted gratings for a κ value of 390 cm^{-1}.

Acknowledgments

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