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Modeling of Surface Grating-loaded VCSEL for Vertical Emission

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1. Introduction

Surface emission DFB lasers and DBR lasers by applying second-order gratings have been studied since 1970 [1-3]. Although the VCSELs are surface emitting lasers, they are limited to low power to enable single mode. Recently, a single-mode surface grating VCSEL with high-power operation is demonstrated [4]. By applying the surface grating, we could get stable single mode operations with long cavity length. However, the beam direction is tilted by an angle around 50° to the vertical direction which could be difficult for fiber alignment. In this paper, a 2nd order surface grating loaded VCSEL structure for vertical emission is introduced. The angle and intensity of every deflection mode are presented by using a Rigorous Coupled Wave method (GSolver).

2. Grating loaded VCSEL

The schematic of the 2nd order grating loaded VCSEL is shown in Fig. 1, where the 2nd order grating is formed on the surface of the conventional VCSEL. A 2nd order grating is formed on the surface of a conventional VCSEL with 6 pairs of top DBR, 30 pairs of bottom DBR. The 2nd order grating pitch Λ is as large as 1μm. Since light travels in VCSEL as “Zig-Zag” format, by changing wavelength of the slow light mode, the propagation angle θ can be adjusted which could adjust the transmission mode and the angle.

3. Results

By using GSolver, we can simulate the deflection modes of this structure. To simplify the simulation, we assume that the input light is the slow light mode propagate in the active region with angle of θ and to calculate the transmission and reflection mode. Fig.2 shows every deflection mode by changing the input angle θ. When the angle θ equals to 8°, two transmittance mode T_0 mode and T_{-1} mode are appeared. When we increase the angle θ to 17°, just T_{-1} mode with vertical emission is achieved. Therefore, by adjusting the angle which means change the lasing wavelength, we could get single mode and vertical emission.

Figure 3 shows the intensity of every deflection modes with the structure of 1μm grating pitch, 40% grating duty cycle, 120nm grating depth, and the lasing wavelength is 1030nm where the propagation angle θ is 17°. Through the Fig.3, there is a radiation dip at 1030nm which means lasing at 1030nm of this structure could be reasonable. Besides, the intensity of T_{-1} mode could be around 50% which is double of other high order reflection mode. Therefore, the vertical emission single mode VCSELs with long cavity length which enables high power operations could be possible.

4. Conclusion

The intensity of every deflection mode of the 2nd order grating loaded VCSEL have been presented. By changing the propagation angle θ to 17°, single mode with vertical emission can be achieved. Also, the intensity of transmission mode could be reasonable for lasing. We could expect vertical lasing for high-power and single-mode VCSELs.

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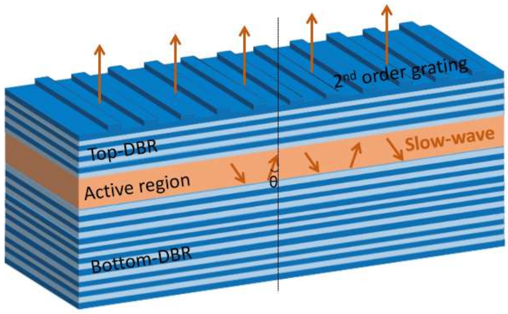
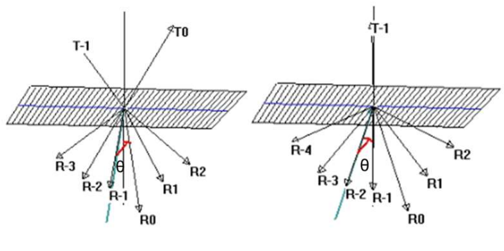


Fig. 1. Schematic structure of 2nd order grating loaded VCSEL.



(a) θ=8° (b) θ=17°

Fig. 2. Deflection modes at input angle (a) θ=8°, (b) θ=17°.

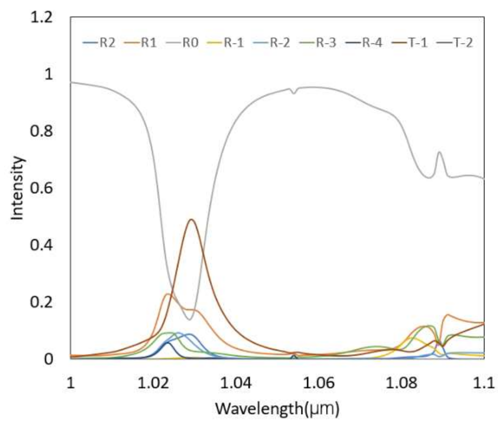


Fig. 3. Intensity of every deflection mode by changing the wavelength.