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Lateral Mode Interference Observation in Emission Spectrum on Mode Selective Active-Multimode Interferometer Laser Diode

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Abstract
We newly showed lateral mode interference in the emission spectrum between 0th and 1st order modes on mode selective active multi-mode-interference laser diode that leads to single wavelength emission (SMSR=25dB).

1. Introduction

Mode division multiplexing (MDM) system has been widely researched recently to enhance the transmission capability of optical fiber [1]. Active-Multimode Interferometer Laser Diode (active-MMI LD) has various impressing properties [2], especially it permits individual higher order mode propagation path. Mode selective active multi-mode interference laser diode (active-MMI LD) was proposed [3] for such that MDM system so far as it offers a possibility of low cost MDM light source. The emission spectrum of it was, however, multi wavelength for the both modes. Although it was needed to improve the spectral characteristics, we newly report single wavelength emission (SMSR = 25 dB at λ = 1563 nm) based on lateral mode interference between 0th and 1st order modes.

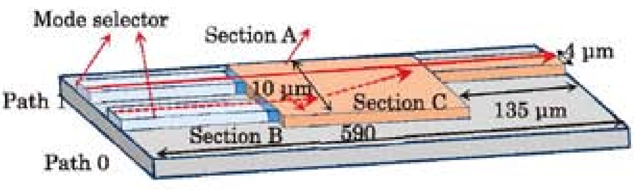


Figure 1. (a) Schematic view

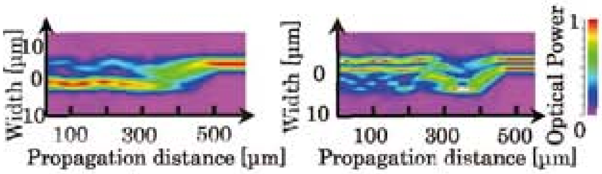


Figure 1. Propagation of (b)0[th] (c)1[st] mode

2. DEVICE CONCEPT

Figure 1 shows a schematic of the mode selective active-MMI LD. A 1x2 MMI configuration realizes two identical propagation path (cross path for 0th mode and straight path for 1st mode) into a single device [4, 5]. The electrodes are separated into three sections as shown in Fig. 1 (a). Section A lies along 0th mode propagation path, therefore, it works as 0th mode selector while section B works 1st mode selector. As section C lies along a path for the both modes, it works as power amplifier for the both modes. Actually implemented device was designed with the total device length of 590 µm. The width and length of the MMI section was set to be 10 µm and 180 µm,

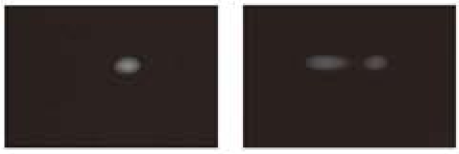
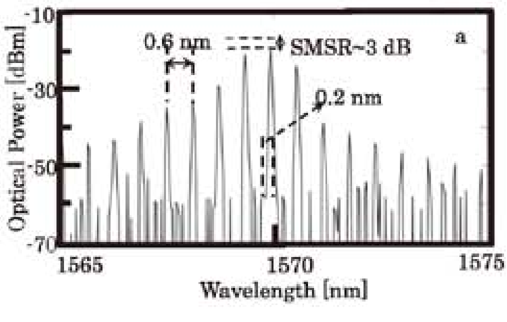


Figure 2. Near field pattern of (a)0[th] mode (b)1[st] mode



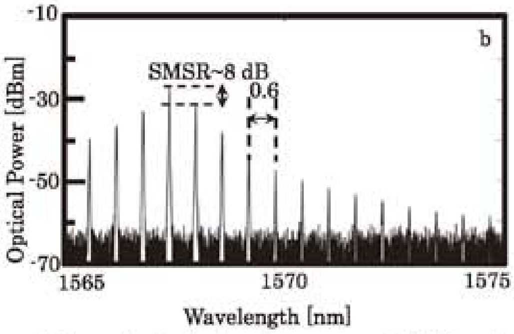


Figure 3. Emission Spectrum of (a)0[th] mode (b)1[st] mode

respectively. A ridge waveguide structure was used. 0th and 1st mode propagation in the waveguide configuration are shown in Fig.1 (b) and Fig. 1 (c) respectively. As is already explained in the above, 0th mode propagates toward cross path while 1st mode propagates toward straight path. Note that the simulation was carried on passive waveguide (not on gain medium) to verify the possibility of mode selective configuration. Regular InGaAsP/InGaAsP multiple quantum well (MQW) was used for the active layer.

3. Results and Discussion

To obtain mode selectivity, we have controlled current injected into each electrode. Near Field Pattern (NFP) results are shown in Fig. 2. As shown in Fig. 2, mode selectivity weas clearly observed for the both modes in the following conditions. The current injection plan were as followed:

For 0th mode: Current A = 42 mA, current B = 0mA, and current C = 42 mA.

For 1st mode: Current A = 0 mA, Current B = 7 mA, andCurrent C = 100 mA

Figure 3 shows the emission spectrum of the both cases. As seen here, the obtained spectrum for the both modes were not regular Fabry-Perot modes, however, these were multi wavelength emission (not single wavelength emission) unfortunately. The mode distance in spectrum were 0.60 nm in case A. In case A, another 0.20 nm mode difference were also observed. As the length of A section (260 μm), and C section (330 μm) correspond to the longitudinal interferences of these mode distances. Similarly, the mode distance in spectrum were also 0.6 nm in case B. As the length of B section (260 μm) and MMI section (330 μm) corresponds to the longitudinal interference of the mode distance. As explained here, we observed complex longitudinal interference for each mode at least. To achieve single-wavelength emission requires another lateral interference into each cavity.

However, interestingly, we observed single wavelength emission in both modes oscillation case, as shown in Fig. 4 (Current A = 83 mA, Current B = 27 mA, and Current C = 42). Different from previous reported single wavelength emission active-MMI LD, which is caused from interference between different longitudinal modes [5], this result is considered to be a lateral mode interference between 0th and 1st modes. As the both modes were operated by suing separated electrodes, it implies a possibility of wavelength tuning using section A and B. In order to confirmed the wavelength tenability, we tried to adjust the current injection plan to shift the main lasing peak in another case (Current A = 83 mA, Current B =

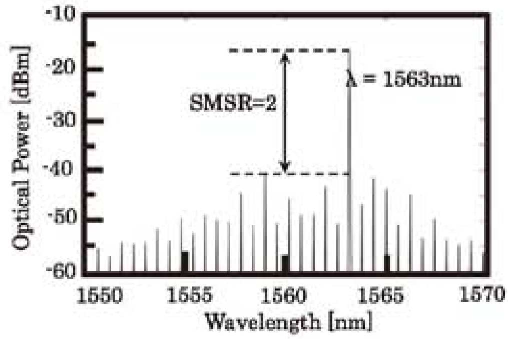


Figure 4. Emission Spectrum when both modes are oscillating

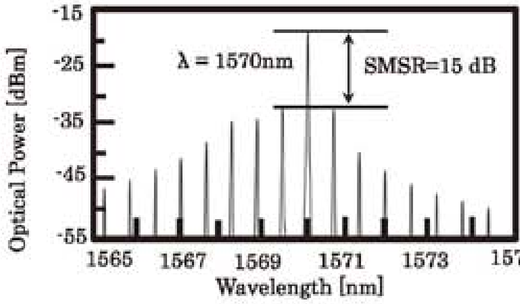


Figure 5. Emission Spectrum of Case D

43 mA, and Current C = 82 mA). Although the achieved SMSR in Fig. 5 degraded (15 dB), peak wavelength was shifted to 1570.0 nm in this case that corresponds to 7 nm wavelength shift. Therefore, lateral interference may be one wavelength-selectable principle in the future.

4. Conclusion

We reported a single wavelength emission avtive-MMI LD (SMSR = 25 dB at λ = 1563.2 nm) on lateral mode interference. Peak wavelength shift of 7 nm has been also confirmed on this device.

Acknowledgment

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