Measurement of broadband gain spectrum of semiconductor optical amplifiers using a two-section technique

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Abstract: A two-section technique is used to measure gain spectrum of semiconductor optical amplifiers. Without other external setup, broadband gain spectrum is measured for a spectral range of 290nm with the gain of above 30 cm^{-1}.

OCIS codes: (250.5980) Semiconductor optical amplifier; (140.4480) optical amplifiers

1. Introduction

Broadband characteristics of semiconductor optical amplifiers (SOAs) are highly desired in modern optical communication and have been successfully demonstrated [1, 2]. The estimation of the SOA gain spectrum is important for the realization of its applications. So far, the ways to obtain the gain profile are mainly with external setup and quite complicated [3-5]. In this work, we introduce a simple way to measure the broadband gain spectrum of SOA by using a two-section monolithic device. The broad bandwidth of the SOA gain spectrum covers about 290nm.

2. The two-section technique

This method is implemented on a two-section tilted-stripe SOA, as schematically shown in Fig. 1. The gap between the two sections is etched to the above of the active layer and works as electrical isolation with the resistance of about 1 kilo-ohms. Therefore, I1 and I2 can be injected independently for the measurement of the gain profile. The spectrum $S_{tot}(I_1, I_2, \lambda)$ collected from the output facet near section 2 under certain I1 and I2 is

$$S_{tot}(I_1, I_2, \lambda) = C \cdot [S_1(I_1, \lambda)] \cdot e^{G_m(I_2,\lambda)\cdot L_2 - \alpha_i \cdot L_2} + S_2(I_2, \lambda) \qquad (1)$$

where the $S_1(I_1,\lambda)$ and $S_2(I_2,\lambda)$ are the spontaneous emission spectra of section 1 and 2, respectively, and $G_m(I_2,\lambda)$ and α_i are the modal gain and internal loss of the amplifier (section 2) at wavelength λ, respectively; L is the length of section 2. C is the coupling coefficient, which includes the coupling of light from the facet/air interface into the monochrometer and the coupling of light from section 1 to section 2. The estimation of C is given by guided-wave optics and can be verified with our results of former experiments. From (1), we can obtain the modal gain spectrum of section 2 as

$$Gm(I_2, \lambda) = \frac{1}{L_2} \ln\left[\frac{S_{tot}(I_1, I_2, \lambda) - S_2(I_1 = 0, I_2, \lambda)}{C \bullet [S_1(I_1, I_2 = 0, \lambda)]} \right] + \alpha_i \qquad (2)$$

where $S_1(I_1,I_2=0,\lambda)$ and $S_2(I_1=0, I_2,\lambda)$ are measured separately from the facets near section 1 and section 2, respectively.

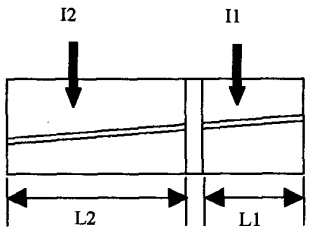

Fig.1 Schema of two-section structure

3. Experiment results and discussion

The SOA is 1mm long and is divided into two sections, L1=200μm and L2=800μm. $S_1(I_1,\lambda)$ is obtained from the facet near section 1 while I2 is set to zero. Then similar measurement was made at the other facet to get $S_2(I_2,\lambda)$. Those spectra are shown in Fig. 2. Because section 1 is very short, no amplification is observed in Fig. 2(a).

The SOA has two kinds of QWs with their first quantized energy levels corresponding to 1.3μm and 1.55μm, respectively. The emission moves toward 1.3μm as the injection current increases. Varying a series of injection current I2 of SOA, we obtained the total output spectrum $S_{tot}(I_1, I_2,\lambda)$ changing with the current I2 under the constant current level $I1$. In this measurement, section 1 works as the light source, while section2 is the amplifier. Even at the low current level 80 mA, section 1 has wide emission bandwidth, so the characteristics of broadband amplification can be measured.

Fig. 3 shows the broadband gain spectrum of SOA under different injection current I2 from 40mA to 640mA for I1=80mA. Using the monolithic integration of two devices, extremely broadband gain spectrum can be acquired immediately without any external setup of measurement. The result agrees with our QW gain simulation. Further discussion about broadband gain measurement of SOA will be discussed in the presentation.

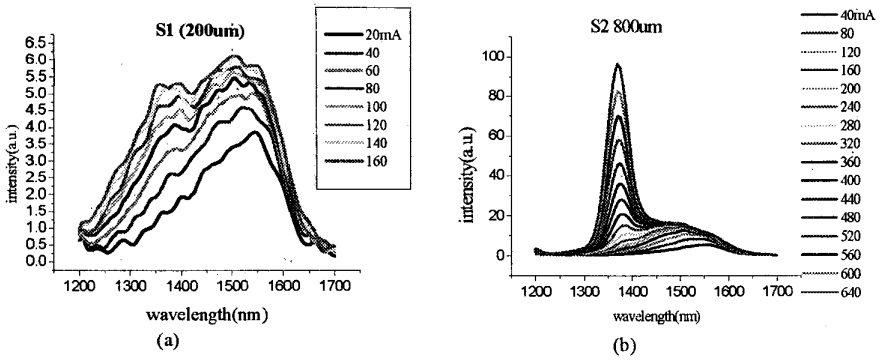

Fig.2 Spectra of (a) section 1 (200μm, with I2 = 0) and (b) section 2 (800μm, with I1 = 0)

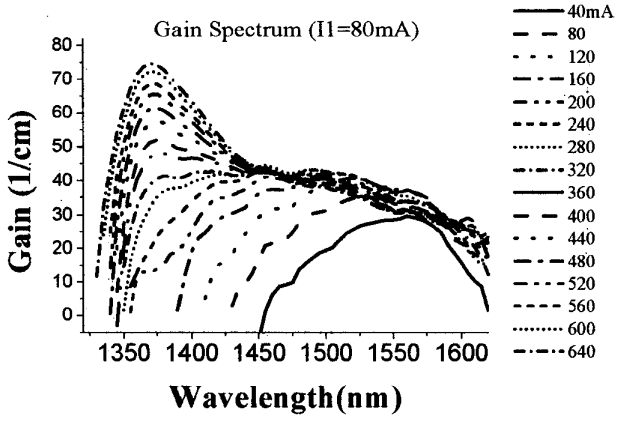

Fig. 3. Gain spectrum of different injection currents I2 from 40mA to 260mA.

4. References

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