Gain Study of an Edge Emitting Laser for Optical Fiber Communication System

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Abstract: In this work, an optical gain around 1 dB of an edge emitting laser (EEL) has been obtained applying threshold current of 22 mA. The conventional device lased at around 1.3 μm with 0.3 nm stripe width at room temperature. The device was also characterised through output light-voltage-current using current-temperature (I-T) controllers and optical spectrum analyser (OSA). Conventional EEL is actually a form of semiconductor lasers that propagates the light in a direction along the wafer surface of laser chip and their emitted light is reflected at a cleaved edge. The cleaved facets of the device acts as mirrors, reflecting photons back into the resonator and the stimulated emission occurs within cavity region for gain achievement.

Keywords: Conventional laser, band width, optical fiber, threshold current, tunable laser.

1. INTRODUCTION

Edge-emitting laser is typically used in many approaches to improve their vertical beam divergence as multi active region [1], double barrier separate confinement heterostructure [2] and inserting anti-guiding layers [3, 4]. The low divergence and circular beam emission from the edge-emitting diode lasers modified Bragg-like waveguide (MBW) was demonstrated previously [5]. With double heterostructure, the carriers are generated within a narrow region and at the same time serves as a waveguide for the optical field. When the device is forward biased, the carriers flow into the active layer and recombines with each other to enhance emitting light. In general, the active region material of any laser depends upon important properties such as emission wavelength, output power, excitation of laser using either optical pumping or electrical current injection, wavelength tunability, laser power consumption, output beam quality and device size [6].

Therefore, the active region that made of quantum well (QW) has been successfully utilized to optical fiber communication applications. However, their performance is not ideal [7]. For instance, the threshold current (I_{th}) of semiconductor lasers is often sensitive to temperature owing to the operating wavelength [8, 9]. As a result, their power can be wasted in the laser chip as a heat, so the cooler is usually used to control the laser temperature. The threshold current (I_{th}) of semiconductor lasers can be increased with increasing temperature, which some time causes broadening of the gain spectrum. For example, I_{th} at various temperature ranges in 1.5 *μ*m GaInAsP/InP edge emitting lasers been extensively characterised as indicated in references [10, 11].

In this paper, optical gain from conventional EEL device has been achieved with a low threshold current. The peak wavelength emission is 1331.4 nm, and the FWHM is 0.3 nm.

2. MATERIAL AND METHOD

In this experiment, the NI PXI-1033 tunable laser diode is used as an input signal source. The tunable laser wavelengths are change from 1265 to 1345 nm, while the output power varies from 1 to 6 mW. The laser output power is controlled by the means of an optical variable attenuator. A multimode fibre patchcord is used to connect one end of the isolator, and the other end is connected *via* an FC/APC adaptor to the port of an optical coupler. The laser signal passes through an isolator to prevent reflections and into optical variable attenuator. The output power is then connected to 10:90 coupler and instabilities is connected to the commercial available EEL device, optical power meter and into the optical spectrum analyser (OSA) as shown in Figure **1**.

The OSA is particularly useful for analysing light sources for optical telecommunications. Thus, the light intensity is as a function of wavelength over a fixed wavelength range. The amplified signal can be also detected using an optical power meter. A tunable laser, along with the OSA is employed to investigate the EEL spectrum and peak optical gain under low output power.

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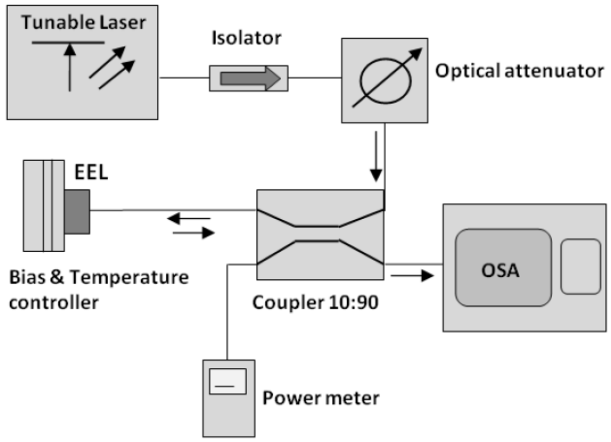

Figure 1: Schematic of the EEL experimental setup under continues wavelength (CW) operation.

3. RESULTS AND DISCUSSION

Light-voltage-current (L-V-I) characterisation of the commercial EEL device is shown in Figure **2**. The device is tested under CW test conditions at various temperatures. The laser threshold currents were almost constant and it is vary from 1.2 mA to 1.7 mA at temperature from T=15°C to 40°C, respectively. The EEL device had spontaneously emitted at temperature of T=30 and 40 °C, while it remained lased at threshold voltages of V_{th}=19, 21 and 23 V at temperatures of T= 25, 20 and 15 °C, respectively. This is because the number of free carriers decreases at high temperatures, resulting less emission light. Varying the temperature also causes a wavelength shift, because the cavity is slightly altered. No output power saturation is observed. The maximum output power exceeded 0.05, 0.1 and 0.2 mW at temperatures of 25, 20 and 15 °C, respectively.

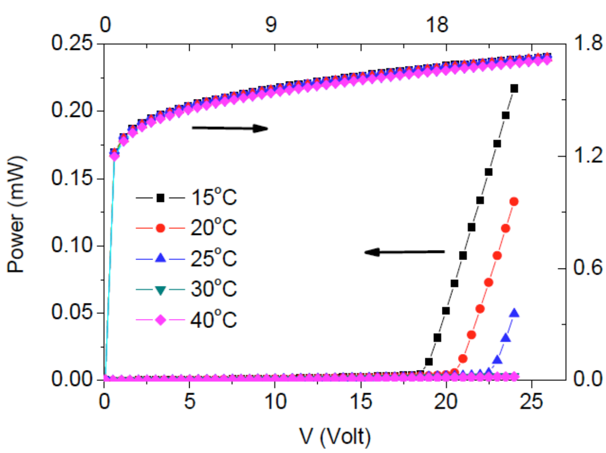

Figure 2: Light-Voltage-Current (L-V-I) characterisation of the EEL in C.W mode at different temperatures.

The EEL is biased with different threshold current at room temperature. Figure **3** shows the EEL optical spectra, which have two modes corresponding to the polarisations of the device. The first mode is called the fundamental mode that has a lasing mode, whereas the second mode is called the side mode. The EEL emits at a wavelength of around 1311.4 nm with broader width. The emission signals are in principal mode, and the emission of the side mode is ignored. The emission peak has increased from -55 to -29 dBm with an increase of injected current at I_{th}= 20 to 22 mA, respectively.

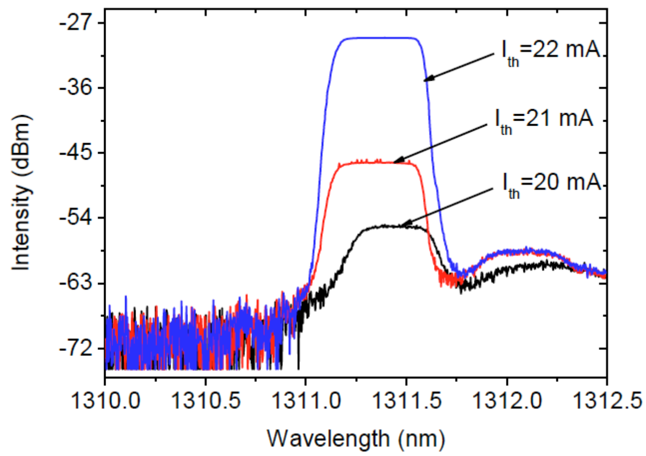

Figure 3: Spectra of EEL device for three different threshold current at room temperature.

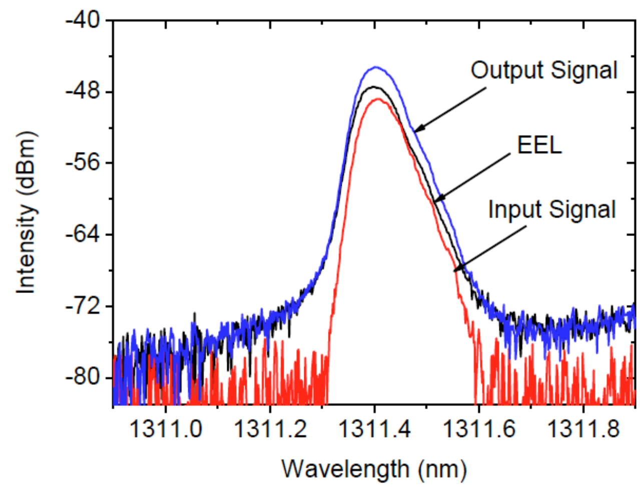

Figure 4: Emission spectra of input signal, output signal and EEL Signal gain, showing an optical gain around 1 dB at room temperature of T=20 °C.

Figure **4** shows the spectra of the input signal (tunable laser), EEL mode and output signal (amplified signal). The device is biased with a fixed current threshold of I_{th}=22 mA and a temperature of T=20 °C. The lasing mode is located at around ƛ=1311.4 nm and shows a broad width of 0.3 nm in FWHM. Optical gain of 1 dB is obtained in which the amplified signal intensity was measured on a log scale and has a maximum peak of -45.3 dBm. Thus, optical gain was calculated from:

gain=amplified signal power−(EEL power+input signal power)

4. CONCLUSIONS

In summary, we had demonstrated a gain around 1 dB at fixed temperature of 20 ^{o}C *via* the edge-emitting laser. This is achieved using tunable laser as an excitation signal.

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REFERENCES

[1] Cui BF, Guo WL, Du XD, Li JJ, Zou S, Shen GD. A tunnel regenerated coupled multi-active-region large optical cavity laser with high quality beam. Chin Phys B 2012; 21: 094209-1-094209-4. http://dx.doi.org/10.1088/1674-1056/21/9/094209

[2] Hung CT, Lu TC. 830-nm AlGaAs-InGaAs graded index double barrier separate confinement heterostructures laser diodes with improved temperature and divergence characteristics. IEEE J Quantum Electron 2013; 49: 127-132. http://dx.doi.org/10.1109/JQE.2012.2231053

[3] Li WL, Su YK, Chang SJ, Tsai CY. A novel waveguide structure to reduce beam divergence and threshold current in GaInP/AlGaInP visible quantum-well lasers. Appl Phys Lett 1997; 71: 2245-2247. http://dx.doi.org/10.1063/1.120063

[4] Ma B, Cho S, Lee C, Kim Y, Park Y. High-power 660-nm GaInP-AlGaInP laser diodes with low vertical beam divergence angles. IEEE Photon Technol Lett 2005; 17: 1375-1377. http://dx.doi.org/10.1109/LPT.2005.849977

[5] Wang L, Tong C, Tian S, Shu S, Zeng Y, Rong J, Wu H, Xing E, Ning Y, Wang L. High-Power Ultralow Divergence Edge-Emitting Diode Laser With Circular Beam. IEEE Journal Of Selected Topics in Quantum Electronics 2015; 1501609. http://dx.doi.org/10.1109/JSTQE.2015.2420669

[6] Hunziker G, Knop W, Harder C. Gain Measurement on One, Two, and Three Strained GaInP Quantum Well Laser Diodes. Transactions of Quantum Electron 1994; 30: 652-658. http://dx.doi.org/10.1109/3.328605

[7] Marko IP, Sweeney SJ. Optical and electronic processes in semiconductor materials for device applications. In Excitonic and Photonic Processes in Materials 2015; 203: 253-297. http://dx.doi.org/10.1007/978-981-287-131-2_9

[8] Sweeney SJ, Phillips AF, Adams AR, O'Reilly EP, Thijs PJA. The effect of temperature dependent processes on the performance of 1.5-*μ*m compressively strained InGaAs(P) MQW semiconductor diode lasers. IEEE Photon Tech Lett 1998; 10: 1076-1078. http://dx.doi.org/10.1109/68.701507

[9] Marko IP, Adams AR, Sweeney SJ, Mowbray DJ, Skolnick, Maurice S, Liu HY, Groom KM. Recombination and loss mechanism in low-threshold InAs/GaAs 1.3 *μ*m quantum-dot lasers. IEEE J Sel Topics Quant Electron 2005; 11: 1041-1047. http://dx.doi.org/10.1109/JSTQE.2005.853847

[10] Phillips AF, Sweeney SJ, Adams AR, Thijs PJA. The temperature dependence of 1.3- and 1.5-*μ*m compressively strained InGaAs(P) MQW semiconductor lasers. IEEE J Sel Topics Quantum Electron 1999; 5: 401-412. http://dx.doi.org/10.1109/2944.788398

[11] Sweeney SJ, Thijs PJA. Origin of the high temperature performance degradation of 1.5 *μ*m InGaAs(P)/InP quantum well lasers. In Proc IEEE 16th Annu Meet Lasers Electro-Optics Soc 2003; 2: 977-978. http://dx.doi.org/10.1109/LEOS.2003.1253133

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http://dx.doi.org/10.6000/1927-5129.2016.12.33