Wavelength Control in a Double Contact FP-LD
Ah-Hyun Kim, Ju-Hee Park, Ho-Sung Jo*, and Chang-Hee Lee

Dept. of Electrical Engineering and Computer Science, Korea Advanced Institute of Science and Technology
373-1 Guseong-dong Youseong-gu, Daejeon, 305-701, Korea
(Tel) +82-42-869-5463, (Fax) +82-42-869-3410, (e-mail) chl@ee.kaist.ac.kr

Abstract: We propose a double contact Fabry-Perot laser diode (DCLD) to have a constant lasing wavelength regardless of operating temperature.

The passive optical network based on wavelength division multiple access (WDM-PON) can provide almost unlimited bandwidth to the subscribers with protocol transparency. To realize WDM-PON, a low cost WDM source is essential. The wavelength-locked Fabry-Perot transparency. To realize WDM-PON, a low cost WDM unlimited bandwidth to the subscribers with protocol division multiple access (WDM-PON) can provide almost increases. This temperature dependency of the FP-LD decreases, while the current I1 also decreases to maintain the constant output power. Then, the net effects on the center wavelength variation in- decreases, while the current I1 also decreases to maintain the constant output power. Then, the net effects on the center wavelength variation.

However, the wavelength of the FP-LD changes as temperature varies. It is well known that the bandgap of the semiconductor strongly depends on the temperature. It brings about shift of the center wavelength of the laser by 0.6nm/°C. Thus the large temperature variation induces the wavelength locking at gain edge of the laser for a given injection wavelength. Then, the wavelength locking efficiency decreases, i.e., the noise of the output light increases and the output power of the FP-LD decreases. This temperature dependency of the FP-LD degrades system’s performance. Therefore, we may need TEC (thermoelectric cooler) or a heater to reduce the center wavelength variation. However, the TEC and the heater have problems in size and cost.

In this paper, we propose a new WDM source, a double contact FP-LD, to control the center wavelength shift electrically. We demonstrate the considerable reduction of the center wavelength shift by controlling injection currents into the laser, while maintain a constant output power.

![Fig. 1. (a) The simple structure of DCLD, (b) the experimental setup, (c) the measured L-I DCLD](image)

A Simplified structure of the DCLD is shown in Fig. 1(a). It has a common electrode and two separate electrodes at the other side. The length the two electrodes are the same. The current to flow through the two electrodes can be controlled independently. Fig. 1(b) shows the experimental setup to investigate the center wavelength control characteristics of the DCLD. The laser was mounted on a TEC to change the operating temperature. The measured L-I curve at different values of the injection current I2 is shown in Fig. 1(c). We use the current through the electrode 2 (I2) as the control current, while the other I1 as the injection current for lasing. The L-I curve looks like typical L-I curve of a conventional FP-LD, when the I2 is positive. However, it changes considerably, when I2 is close to zero or negative. Eventually, we observed optical bistability [2].

![Fig. 2. The center wavelength as a function of the control current I2 at different temperature](image)

We measured the center wavelength of the output spectrum as a function of the control current I2 at a constant output power of –3 dBm. The results are shown in Fig. 2. The center wavelength was referred to Telcordia GR-468-CORE, Section 5.1. When the operating temperature increases, the center wavelength increases at the same control current. It can be explained as the decrease of the band-gap with temperature. As shown in Fig.2, the center wavelength decreases as we increase the control current I2.

The round trip gain of the laser should be equal to the total cavity loss to have laser oscillation. If the control current is negative, the area under the contact 2 acts like an absorber, instead of a gain medium. The current through the contact 1 should be sufficiently high to have the gain for lasing and to maintain the constant output power. It is expected that the lasing wavelength is long wavelength side, since the absorption increases as we decrease the wavelength (increase the energy).

As we increase the control current I2, the absorption decreases, while the current I1 also decreases to maintain the constant output power. Then, the net effects on the
gain spectrum is shift of the gain peak or the center wavelength to the shorter wavelength side, since the absorption change with respect to the wavelength is a dominant factor to determine lasing wavelength. This behavior continues until the current I1 and I2 are equal. After that the center wavelength rule of I1 and I2 are exchanged, provided by a constant output power. On average, the measured center wavelength variation at same temperature is 1.3–4 nm/mA.

By considering the temperature tuning coefficient of 0.6nm/°C and the current tuning one, it may be possible to hold the center wavelength at a fixed value within reasonable temperature range. In other words, we can change the current through I1 and I2 with respect to the temperature to keep the center wavelength as a desired value.

As shown in Fig. 3, the center wavelength was fixed at 1587 nm, when the temperature varies from 20 °C to 45 °C. To keep the center wavelength, the current I2 increases, while I1 decreases as temperature increases. For this case, the maximum current through the laser was less than 70 mA. It may be noted that the lower temperature of 20°C was limited by the TEC capacity used in the experiment.

The above experimental results imply that the center wavelength can be maintained at a constant value within limited range of the temperature. It may be noted that it is limited by the capacity of the TEC in our experiment. However, the high temperature operation can be limited by the amount of the blue shift to compensate the red shift induced by temperature change.

Based on the experimental results, we estimate the center wavelength variation 0 °C to 50 °C as shown in Fig. 4. It is about 30 nm for a conventional FP-LD. For the DCLD with the center wavelength control, the variation can be reduced as shown in blue curve. Here we assume that the same tuning coefficient outside of the demonstrated temperature range. The total variation was reduced from 30 nm to 15 nm. Since the low temperature operation is limited by the TEC capacity, we expect that the suppression of the center wavelength variation at low temperature region. That is, if roughly I1=100mA and I2=15mA are injected which are determined by the linear approximation based on Fig. 3(a) at 0 °C, the center wavelength can be fixed at 1587nm. Then, the total variation can be reduced to 3 nm as shown in dashed line.

In conclusion, we proposed a double contact FP-LD to maintain the lasing center wavelength as a constant regardless of the temperature. By controlling the current through the two contacts, we demonstrated a feasibility of temperature independent center wavelength within a limited temperature range of 25°C. The proposed laser can be used as a WDM source based on wavelength locking to externally be injected to broadband light. Then, we can minimize temperature effects on system performance without the TEC cooler or heater. Thus, the proposed double contact FP-LD will be very useful to realize a cost effective WDM-PON source.

Acknowledgment

This work was supported by National Research Laboratory project of Korea.

References
