25-Gbps Can-type EML for 5G Mobile Base Stations

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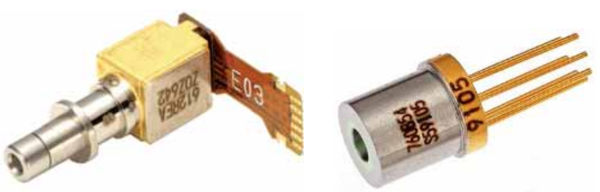
To meet the demand for rapidly increasing communication data volumes, the fifth-generation mobile communication system (5G) is planned to be introduced from 2020. Large-capacity optical communication systems will be used at mobile base stations, and so an electro-absorption modulated laser diode (EML) which operates at 25 Gbps is required for the fronthaul optical module. In the present work, the transmission speed of 25 Gbps, the first in the industry, was achieved by a can-type EML.

1. Introduction

With the shift to 5G, the optical module used for each layer of the mobile base station network must also be high speed. The distributed feedback laser diode (DFB), which operates at 10 Gbps, has traditionally been used for the fronthaul for 4G. However, for 5G, EML operating at 25 Gbps is required. The system is configured to transmit and receive the optical signal with one optical fiber, for which two types of EML with the wavelengths of 1,270 nm and 1,310 nm are required. In addition, regarding the configuration of the EML package, the can-type package which facilitates assembly for the bi-directional (BIDI) module is required.

Popular EML products which operate at 25 Gbps use the box-type package (Fig. 1 (a)) which integrates ceramics and metal. However, with the can-type package (Fig. 1 (b)), band limitation due to impedance mismatch occurs, and it is difficult to obtain a satisfactory band for operation at 25 Gbps [1].



(a) 25-Gbps box-type EML (b) 25-Gbps box-type EML

Fig. 1 25-Gbps Box- and can-type EML

In this study, to increase the band of the can-type package, the 3-dB bandwidth of the frequency response characteristics was improved by controlling multiple reflection arising from impedance mismatch in the package. The EML device is designed to achieve both high output and high speed, and an extinction ratio of 6 dB or more and good optical output waveform were obtained. In addition, the low power consumption of the conventional box-type was achieved by using a compact Peltier cooler and by reducing heat flow to the EML under temperature control. In this way, operation at I-temp (−40 to 95°C) was achieved.

2. Package Outline

The outline dimension of the can-type package is Φ5.6 mm which is the industry standard, and each pin layout is compatible with our 10-Gbps conventional products. Since the EML has large characteristic fluctuation due to temperature variation, it is necessary to control the EML temperature to a constant level using a Peltier cooler and thermistor. To control the current in the laser diode of the EML to a constant level, a photo diode which monitors the backlight output is also built into the unit. The lens cap is a general cylindrical shape and is designed to facilitate the BIDI module, using welding technology.

3. Design Result of EML Device

The waveguide at the laser diode of the EML is designed to be an embedded type which is excellent in efficiency and high-temperature operation. The electro-absorption (EA) modulation unit is designed to have a large length and narrow width so that both low modulation voltage and high-speed operation can be satisfied. The high-mesa waveguide, which can maintain a high optical confinement factor in a narrow width design, is used [2]. As described above, the different waveguide designs between the laser diode and the EA modulation unit provide excellent characteristics of both designs. In addition, a spot-size converter at the end of the device widens the spot size of the beam emitted from the EML and improves the coupling efficiency with an optical fiber through the lens.

4. Design Result of Can-type Package

The band degradation of the can-type package is attributed to impedance mismatch between the driver IC operating the EML and the EML device mounted on the package. In particular, since band degradation tends to occur due to electric multiple reflection generated between the glass penetration area of the package lead and the EML device, the bandwidth was improved by

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reducing the impedance mismatch including the transmission channel inside the can-type package. If 50Ω match is configured inside the can-type package, the 3-dB bandwidth of the frequency response characteristic stays at 14 GHz. In contrast, the 3-dB bandwidth was improved to 19 GHz by controlling multiple reflection after improving the impedance matching.

5. Evaluation Results

Table 1 shows the product specifications and evaluation results of the 25-Gbps can-type EML. Figure 2 shows the evaluation results of the frequency response characteristics. The 3-dB bandwidth of the pass characteristic was 19.2 GHz. Figure 3 shows the back-to-back optical output waveform with the wavelength of 1,270 nm. The operating conditions were: bit rate 25.8 Gbps, case temperature (T_c) 25°C, EML setting temperature (T_{ld}) 55°C, LD operation current (I_{op}) 100 mA, modulation voltage swing of EA (V_{pp}) 2 V, and bias voltage of EA (V_{off}) −1.3 V. For the evaluation, a flexible printed circuit was connected to the can-type package. After evaluating the can-type EML with the wavelength of 1,270 nm, a good optical waveform with the extinction ratio of 6.8 dB, mask margin @ CWDM4 of 37% and jitter (RMS) of 1.5 ps was obtained. The evaluation results of the can-type EML with the wavelength of 1,310 nm are shown in Table 1.

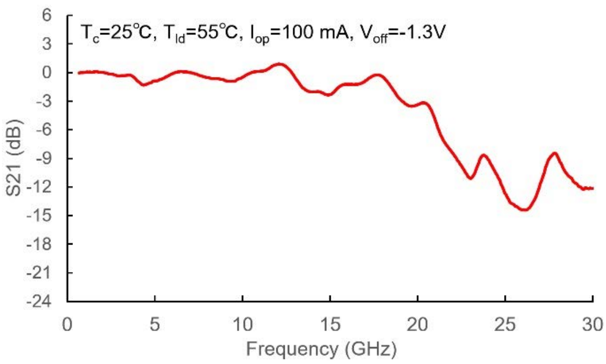

Fig. 2 Experimental results of frequency response

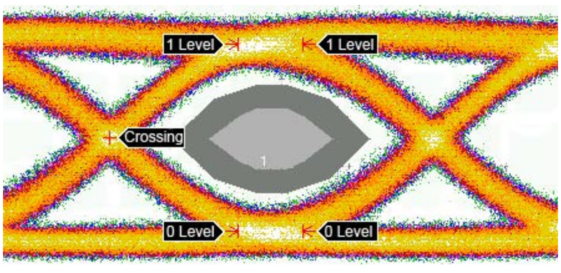

Fig. 3 25.8-Gbps eye diagram at 1,270 nm

Extinction ratio: 6.8 dB, Mask margin: 37%, Jitter (RMS): 1.5 ps

Figure 4 shows the power consumption of the Peltier cooler when the case temperature was changed from −40°C to 95°C. For comparison, the power consumption of the box-type package product mounted with the same EML device is also shown. Tld is 55°C and Iop is 100 mA. The power consumption of the Peltier cooler at the case temperature of 95°C was 0.32 W and the power consumption at −40°C was 0.52 W. This shows that both power consumptions decreased by about 30 to 40% in comparison with the box-type package products, indicating the effect of reducing the thermal input to the Peltier cooler.

6. Conclusion

We developed a 25-Gbps EML mounted on a can-type package for 5G. By improving the impedance matching inside the can-type package, the bandwidth was widened, and 19.2 GHz was achieved in the 3-dB bandwidth. The optical waveform of this newly-developed product was evaluated. With both the can-type EML having the wavelength of 1,270 nm and

Table 1 Specifications and experimental results of 25-Gbps can-type EML

Item	Product specification	Evaluation result
Emission wavelength	1,270 ± 10 nm 1,310 ± 10 nm	1,274 nm 1,309 nm
Optical output (CW) @ Iop = 100 mA	≥ 10 dBm	12.4 dBm
3 dB cutoff frequency	–	19.2 GHz
Extinction ratio	≥ 5 dB	6.8 dB @ 1,270 nm 7.8 dB @ 1,310 nm
Mask margin @ CWDM4	–	37% @ 1,270 nm 29% @ 1,310 nm
Jitter (RMS)	–	1.5 ps @ 1,270 nm 1.5 ps @ 1,310 nm
Power consumption of Peltier cooler	≤ 0.7 W @ −40°C ≤ 0.42 W @ 95°C	0.52 W @ −40°C 0.32 W @ 95°C

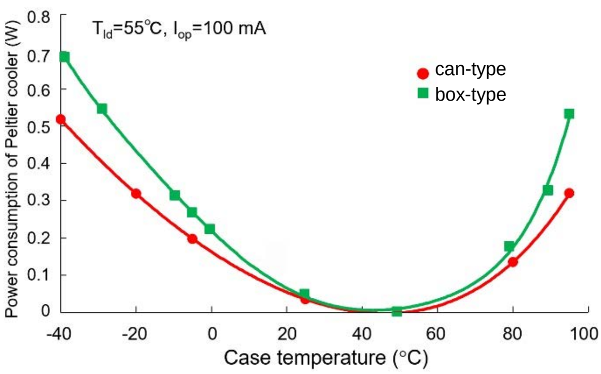

Fig. 4 Experimental results of power consumption of Peltier cooler

1,310 nm, the back-to-back values were: extinction ratio was 6 dB or more, mask margin @ CWDM4 was 29% or more and jitter (RMS) was 1.5 ps. In addition, the compact Peltier cooler and reduced thermal input lowered the power consumption by about 30 to 40% compared to conventional products. The power consumption of the Peltier cooler at the case temperature of +95°C is 0.32 W, which allows for operation at I-temp (−40 to +95°C).

7. References

(1) Okada, N., et al.: Cost-Effective 10.7 Gbit/s Cooled TOSA Employing Rectangular TO-CAN Package Operating up to 90 °C, Optical Fiber Communication Conference, JWA38 (2010)

(2) Yamatoya, T., et al.: Novel Hybrid-Waveguide EMLs for 100 Gb/s CFP2 Transceivers, 18th OECC/PS, MK1-2 (2013)