100 Gbps Compact Integrated EML-TOSA

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1. Introduction

Along with the increase in speed and capacity of optical transmission devices, the use of 100 Gbps optical networks is rapidly expanding. To cope with the increase in traffic, 100 Gbps optical transceivers need to be downsized and able to operate with less power. We have developed a compactly integrated 100 Gbps electroabsorption modulator laser (EML) diode transmitter optical subassembly (TOSA) that is small in size and capable of low power consumption operation. This has been achieved by using four lenses precisely fixed in a close-packed manner for the respective four EMLs, and by embedding the laser in each EML to increase the efficiency.

2. Device Specifications

The compactly integrated 100 Gbps EML-TOSA that we developed complies with 100GBASE-LR4 specifications defining transmission at a distance of 10 km standardized by IEEE, 100GBASE-ER4 specifications defining transmission at a distance of 40 km, and application code 4I1-9D1F recommended by the ITU-T. The EML-TOSA operates within a case temperature range of −5°C to 80°C, up to a maximum bit rate of 27.95 Gbps.

3. Device Design

Figure 1 is a photo of the device. For the package, metal and ceramic are used in an integrated manner. For the electrical signal interface, two flexible printed circuits (FPCs) for radio frequency (RF) connection to allow modulating signals to pass through and for DC connection to supply power to the laser diode (LD), photodiode (PD), and thermoelectric cooler (TEC) are provided for connection to the package. The FPCs are directly connected to the metal pattern, the pitch of which has been narrowed on the ceramic to make the package compact. The FPC for RF connection has a three-layered structure; ideal impedance matching has been achieved by placing signal wires at an FPC inner layer to be free from constraints related to the electrode interval required to prevent short circuits at the connection. The size of the package is 15.0×6.5×5.4 mm, which is approximately two-thirds the volume of our conventional products.

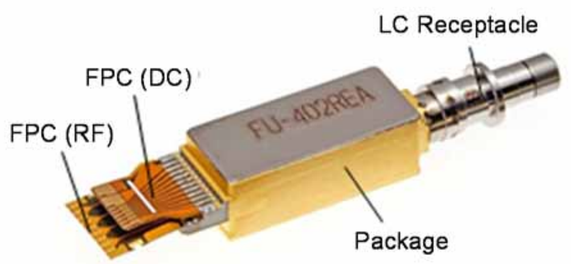

Fig. 1 100 Gbps compact integrated EML-TOSA

4. EML Design

Figure 2 shows schematic views of the EML device structure. The laser is embedded to ensure excellent efficiency and operation at high temperatures. The electroabsorption (EA) modulator is extended in length and reduced in width to achieve a balance between low modulation voltage and high-speed operation. The EA modulator is a high mesa type, which can keep the optical confinement coefficient high regardless of the narrowed width.[1] As described above, the laser and EA modulator are provided with separate waveguide structures, allowing them to individually exert excellent properties.

5. Optical System and Mechanism Design

Figure 3 shows a conceptual diagram of the optical system in the TOSA. In the package, four EMLs, four lenses, and a special optical system multiplexer are integrated. The optical multiplexer consists of three bandpass filters (BPFs) and a mirror, and is fixed to a block member. The product uses a double-lens optical system. The first lens is mounted inside the package, and the second lens is arranged outside the package. Collimated light passing through the first lens enters the special optical system multiplexer. The light is multiply reflected between the BPFs and mirror, thereby multiplexing four wavelengths of lanes 0, 1, 2 and 3.[2] Furthermore, as it is essential for downsizing the package to mount the four lenses in the package in a close-packed and highly precise manner, we have developed a technology to align and fix lenses to submicron order; this has allowed the lens spacing to be reduced to approximately two-thirds that of conventional products.

6. Evaluation Results

Figure 4 shows optical waveforms at a modulation speed of 27.95 Gbps. The EMLs modulated all lanes at the same time. The test pattern used was an optical waveform of NRZ PRBS 231-1 before transmission after passing through a fourth Bessel-Thomson filter. Under the condition of EA modulator voltage magnitude of

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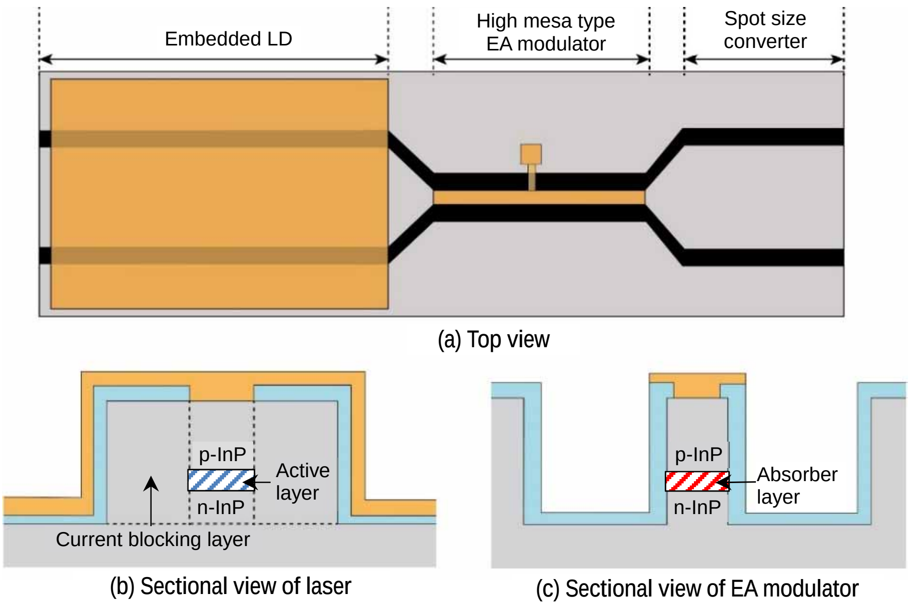

Fig. 2 Structure of EML

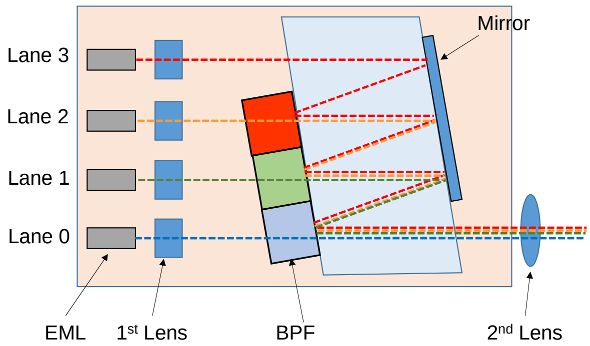

Fig. 3 Conceptual diagram of the optical system

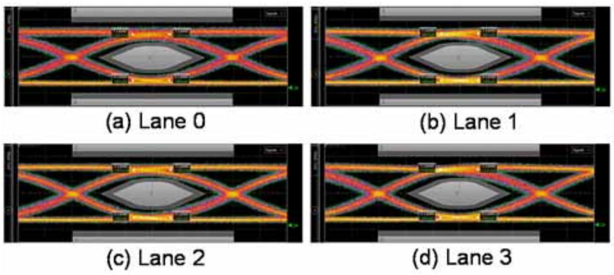

Fig. 4 Optical waveform

1.75 V for all lanes, we obtained results consisting of an extinction ratio not less than 9 dB, and desirable eye-opening characteristics with the mask margin not less than 20% for the eye mask specified by the ITU-T. The average optical output for each lane was 0.36 to 0.43 dBm, indicating that the obtained optical output had less variation between lanes. The case temperature variation (tracking error properties) of the average optical output did not exceed 0.5 dB for any of the lanes at any temperatures in the operating temperature range (−5°C to 80°C), showing that the optical output properties were very stable.

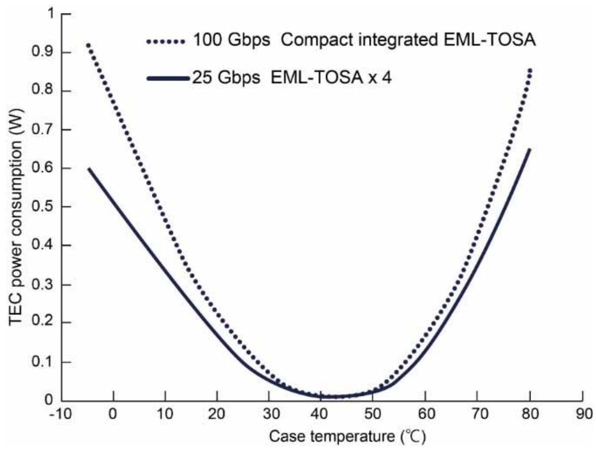

Fig. 5 TEC power consumption

Figure 5 shows the power consumption of the TEC. The operating temperature of the EMLs is set between 50°C and 60°C to be adjusted to the wavelength of the LAN-WDM standard. If the operating temperature of EMLs is set low, the temperature difference increases when the environment temperature is high, causing the TEC power consumption to increase. By setting the operating temperature of EMLs to 50°C or more, the product can keep the TEC power consumption at 0.8 W or less within the operating temperature range of −5°C to 80°C, at a level that allows its use in a small transceiver (QSFP + platform). For comparison, Fig. 5 also shows the power consumption when using four 25 Gbps TOSAs manufactured by Mitsubishi Electric Corporation. With the compactly integrated 100 Gbps EML-TOSA, power consumption was reduced by approximately 0.2 W when the case temperature was 80°C, and by approximately 0.3 W when the case temperature was −5°C.

7. Conslusion

We have commercialized a new 100 Gbps EML-TOSA that is compactly integrated to downsize the package and that operates with less power than conventional products. We will continuously strive to satisfy the ever-growing need for higher-speed operation, lower power consumption and smaller size of optical transmission devices, using and reinforcing the developed product technology.

References

(1) Yamatoya, T., et al.: Low-Voltage and High-Temperature Operation of 28 Gb/s EMLs with Hybrid Waveguide Structure for Next-Generation 100GbE Transceivers, IEICE GENERAL Conference C-4-18 (2013)

(2) Tadashi, M., et al.: Integrated Spatial Optical System for Compact 100GbE Transmitter Optical Sub-Assemblies Using Lens Positional Control by Laser Irradiation, Proceedings of the IEICE(LQE) (2015)