8-Channel CWDM TOSA for CPO External Laser Sources Employing a Blind Mate Optical Connector

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Abstract: We report an 8-channel CWDM TOSA designed for CPO ELS modules adopted with a blind mate optical connector. The mechanical size of the TOSA is as small as 22.5 mm × 13.0 mm × 4.0 mm to be built in a standard QSFP housing. The pigtailed PMF cables are 180-degree turned to draw back to the card edge. The length of pigtailed PMF cables is as short as 95 mm. The fiber-coupled power is >20 dBm over the case temperature range of 25 °C to 55 °C. The polarization orientation of PMFs attached to a standard 12-lane MT ferrule is set to the horizontal slow axis and the measured PER is >20 dB for all channels.

1. Introduction

The adoption of Co-Packaged Optics (CPO) to data center and high-performance computing interconnects has been demanded to expand the bandwidths and save the power consumption. CPO has a unique packaging structure where high-density silicon photonics (SiPh) transceivers are mounted together with a switch application specific integrated circuit (ASIC) on the same substrate. A wide bandwidth switch ASIC generates a large amount of heat and hence it derives the temperature increase of SiPh transceivers. Silicon integrated circuits (ICs) can be operated at a high temperature of ~100 °C, but it is difficult for compound semiconductor lasers to realize the required characteristics and guarantee the reliability in such a high temperature. Hence, it is preferable to adopt an external laser source (ELS) placed at a front panel in an environmental condition of lower ambient temperature. The CPO collaboration ELS guidance document [1] describes to adopt QSFP-DD, OSFP and OBO for the small form factor (SFF). So far, an 8-channel CWDM ELS using SFP+ housing with a blind mate polarization-maintaining fiber (PMF) connector using a standard MT ferule was reported [2]. The SFP+ ELS has 8-channel optical outputs in compliant with 400GBASE-FR4. A thermo-electrical cooler (TEC) was built in the SFP+ housing. An 8-channel CWDM ELS using a double-height QSFP-DD housing with a blind mate PMF MPO connector was also reported [3]. The fiber-coupled power was 20 dBm at a case temperature up to 50°C. We have reported a high power 8-channel CWDM uncooled TOSA which can be built in a standard QSFP housing [4]. The TOSA can achieve a fiber-coupled power of >20 dBm for all channels over the case temperature ranging from 25 °C to 55 °C. We also assembled a pigtailed-QSFP ELS that integrates the TOSA and the driving circuitry-mounted PCB assembly (PCBA). The temperature difference between the case of TOSA and the top of housing was suppressed as low as 0.7 °C. Therefore, the QSFP ELS can maintain the same characteristics with the TOSA. On the other hand, a blind mate optical connector is preferable in terms of eye safety. In this paper, we report an 8-channel CWDM TOSA designed for CPO ELS modules adopted with a blind mate optical connector. The pigtailed PMF is as short as 95 mm for wiring inside the housing without excess length. We also demonstrate the characteristics of the TOSA when operating all 8 channels simultaneously.

2. Structure of the 8-channel CWDM TOSA

Fig. 1 shows a schematic illustration for the 8-channel CWDM TOSA structure. Wavelength-selected 8-channel semiconductor optical amplifier (SOA)-integrated distributed feedback (DFB) laser diodes (LDs) are mounted on a substrate. The 8-channel TOSA is compliant with the 400GBASE-FR4 wavelength allocation (i.e., 1271 nm, 1291 nm, 1311 nm, and 1331 nm). To monitor the output power, photodiodes (PDs) are located at the back side of SOA-integrated DFB-LDs. The each launched laser beam at the front facet is coupled to a PMF cable by a focusing lens through an optical isolator. The footprint of the TOSA is as small as 22.5 mm × 13.0 mm which is small enough to be built in a standard QSFP housing. The length of the TOSA is 1.0-mm shorter than previously reported [4], allowing a wider space to accommodate the PMF fiber cables. Fig. 2 shows an illustration for a QSFP ELS which employs a blind mate optical connector. The top view of the structure in the housing is shown in Fig. 2 (a) where the 8-channel TOSA adopts a flexible printed circuit (FPC) for electrical connections with the PCBA. Since a blind mate optical

connector is placed at the same face with the electrical connector, a standard 12-lane MT ferrule is located above the electrical pads at the card edge. In order to make 180-degree turn for the pigtailed PMF cables in the QSFP housing, the length of pigtailed PMF cables should be as short as 95 mm and the bent radius of the PMF cable should be 6.0 mm and longer to prevent the increase of bending loss and the degradation of polarization extinction ratio (PER). Fig. 2 (b) shows the optical interface where four consecutive channels in left and right have wavelength-selected optical outputs and 4 channels in the middle are blank. The polarization orientation of PMFs is set to the horizontal slow axis.

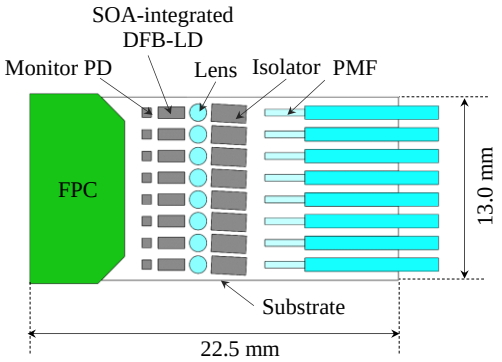


Fig. 1 Schematic illustration for the 8-channel CWDM TOSA structure.

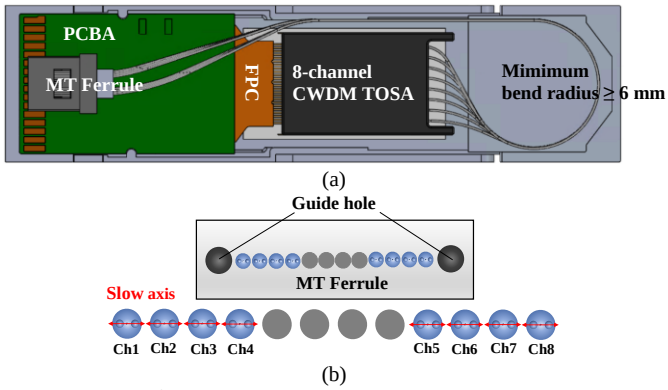


Fig. 2 Illustration for a QSFP ELS adopted with a blind optical connector. (a) Top view of the structure in the housing. (b) Optical interface.

3. Characteristics of the 8-channel CWDM TOSA

Fig. 3 shows a photograph of the 8-channel CWDM TOSA bult in a QSFP housing with a PCBA. The mechanical size of TOSA is as small as 22.5 mm (length) × 13.0 mm (width) × 4.0 mm (height) without the pigtailed PMF cables. The length of pigtailed PMF cables is as short as 95 mm. The PMF cables are turned with a bend radius of 7.5 mm to draw back to the card edge. A standard 12-lane MT ferrule is attached at the fiber end to be connected to a blind mate optical connector, where the polarization orientation of PMFs is adjusted to the horizontal slow axis. Fig. 4 shows the fiber-coupled power as a function of LD bias current and the optical spectra. As can be seen from Fig. 2 (a), the LD bias

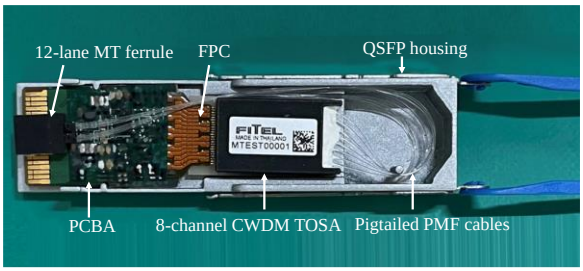


Fig. 3 Photograph of the 8-channel CWDM TOSA built in a QSFP housing with a PCBA. The PMF cables are turned with a bend radius of 7.5 mm to draw back to the card edge.

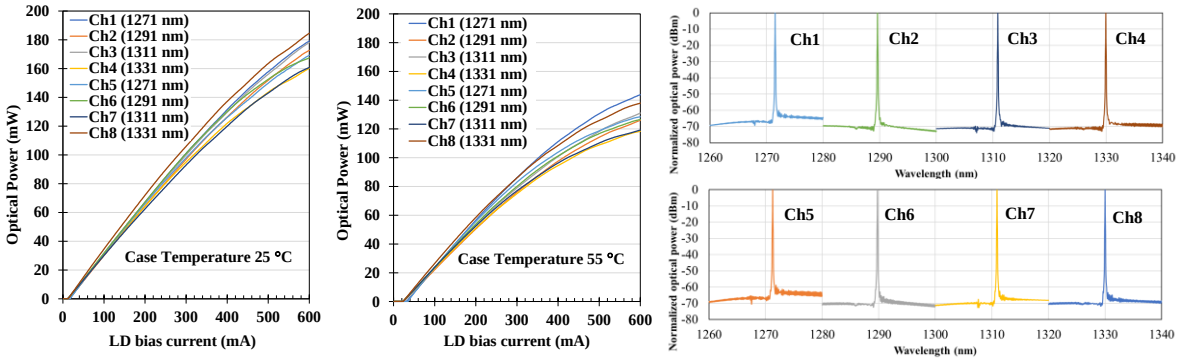
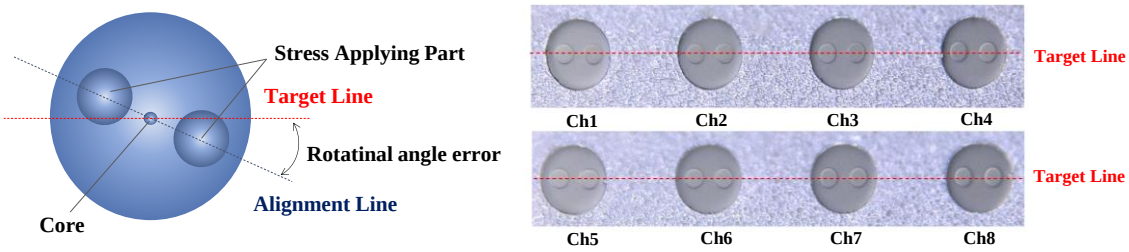


Fig. 4 Fiber-coupled power as a function of LD bias current and optical spectra. (a) L-I curves at the case temperature of 25 °C and 55 °C. (b) Optical spectra at the case temperature of 25 °C.

current to obtain the fiber-coupled power of 100 mW (i.e., 20 dBm) is ~300 mA for all channels at the case temperature of 25 °C. At the LD bias current of 500 mA, the lowest fiber-coupled power of 143 mW (i.e., 21.6 dBm) is measured at channel 7. At the case temperature of 55 °C, the LD bias current at the fiber-coupled power of 100 mW is ~400 mA. At the LD bias current of 500 mA, the fiber-coupled power is 110 mW (i.e., 20.4 dBm) and higher. Fig. 2 (b) shows the optical spectra for all channels at the case temperature of 25 °C. The measured side-mode suppression ratio

(SMSR) is larger than 50 dB for all channels. Fig. 5 shows a schematic illustration for a definition of rotational angle error and photographs of the PMF end face. To evaluate the rotational angle error, the target line is set horizontally through the center of core. Then, the alignment line is set to pass through the individual center of two stress applying parts and the center of core. By rotating PMFs, the alignment line overlaps the target line by a visual observation and then fix the PMF cables. A rotational angle error is defined as an angular difference between the alignment line and the target line. In the optical connector assembly process, the rotational angle error is targeted within ±3 degree. As can be seen from Fig. 5 (b), all the center positions of stress applying part are aligned on target line well. Table 1 shows measured polarization extinction ratio (PER) numbers for all channels. All channels have the PER number of > 20 dB.



(a) (b)

Fig. 5 Schematic illustration for the definition of rotational angle error and photographs of the PMF end face. (a) Definition of rotational angle error. (b) Photographs of the PMF end face.

Table 1 Measured PER for each channel

Ch No	1	2	3	4	5	6	7	8
PER (dB)	23.0	22.0	21.9	25.4	23.0	21.3	24.5	24.2

4. Conclusion

We designed and fabricated the 8-channel CWDM TOSA oriented for CPO ELS modules employing a blind mate optical connector. The mechanical size of the TOSA is as small as 22.5 mm × 13.0 mm × 4.0 mm which can be built in a standard QSFP housing. Inside the housing, the pigtailed PMF cables are 180-degree turned to draw back to the card edge. The length of pigtailed PMF cables is as short as 95 mm and the bending radius can be 7.5 mm and longer to ensure the reliability of the PMF cables. The LD bias current to obtain the fiber-couple power of 20 dBm is ~300 mA and ~400 mA at the case temperature of 25 °C and 55 °C, respectively. At the LD bias current of 500 mA, the fiber-coupled power is 20.3 dBm at the case temperature of 55 °C as the worst case. All lasing wavelengths are compliant with the 400GBASE-FR4 wavelength allocation and the SMSR numbers are higher than 50 dB for all channels. The polarization orientation of PMFs is set to the horizontal slow axis and the rotational angle error is within ±3 degree. The measured PER numbers are >20 dB for all channels. This small 8-channle can be adopted not only in QSFP but also in any SFF such as OSFP.

5. References

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