Development of New Ceramic Package for Cooled TOSA

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The authors have successfully developed a new ceramic package that features high heat dissipation for a cooled TOSA (Transmitter Optical Sub-Assembly) used for transmissions over 10 Gbit/s. This package enables a laser diode to emit light without a costly glass window.

Keywords: ceramic package, cooled TOSA, laser diode

1. Introduction

With the rapid increase of data traffic in recent years, the networks of data transmission at more than 10 Gbit/s have been expanded. The optical transmitting unit of an optical transceiver mounted on the transmission apparatus is composed of TOSA (transmitter optical sub-assembly), which can be divided into two categories depending on the transmission distance. TOSA for data transmission within 10 km uses a coaxial package that has roundshaped metal parts and lead terminals sealed by glass. On the other hand, TOSA for data transmission over 40 km uses a ceramic package that has a multilayer ceramic substrate and high heat dissipation plate for mounting a TEC (thermoelectric cooler) in order to stabilize the transmission characteristics. However, the structure of a ceramic package has become more complex as compared to a coaxial package.

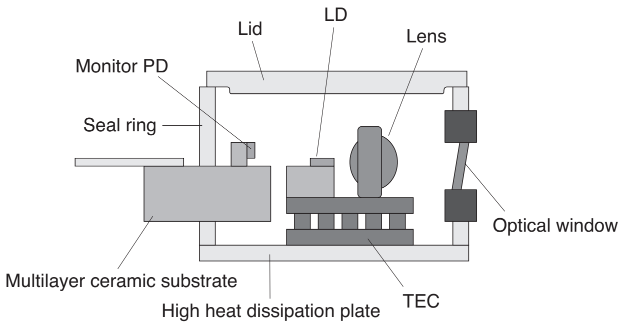
This time, we have developed a new ceramic package for cooled TOSA. The new ceramic package has a simplified structure and can be equipped with a TEC. In this paper, we report on the structure and characteristics of the ceramic package.

2. Structure of Ceramic Package for Cooled TOSA

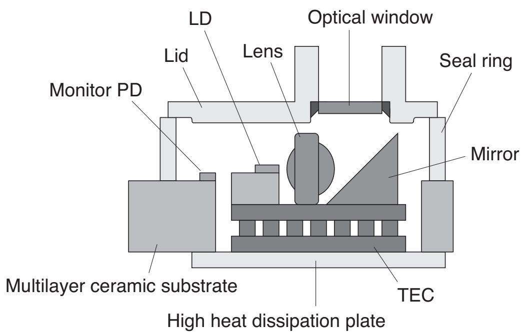
Figure 1 (a) shows the structure of a conventional ceramic package with a TEC for temperature control of an LD (laser diode). The conventional structure is composed of a seal ring, a multilayer ceramic substrate with an electrical interface, a high heat dissipation plate, and an optical window. The TEC is mounted on the high heat dissipation plate placed on the bottom of the package, and the LD and a collimator lens are mounted on the TEC. The LD emits light toward the side of the package, which necessitates an optical window located at a seal ring on the side of the package. As a result, the manufacturing process of the seal ring becomes more complex. In addition, the package size and the optical axis have been specified by the XMD-MSA (10 Gbit/s Miniature Device Multi Source Agreement), and there is a problem that the thickness of the high heat dissipation plate can't be ensured sufficiently.

On the other hand, some packages consist of a ceramic substrate and metal parts, as optical communication packages do. One of them is a crystal oscillator package for mobile phones and watches. We applied the design technology of the crystal oscillator package to our new package development, and modified the design and structure of optical communication packages.

Figure 1 (b) shows the basic structure of the newly developed ceramic package for cooled TOSA. We simplified the structure by using components with openings as the exit of light. In general, the opening is sealed by welding a single metal plate. In the new design, however, the opening is sealed by a lid that has a flat window fixed with low-melting point glass to transmit light. The TEC is mounted on the high heat dissipation plate on the bottom of the pack-



(a) Conventional structure



(b) Newly developed structure

Fig. 1. Structure for cooled TOSA

age. The LD, aspherical lens and mirror are mounted on the TEC, and the aspherical lens and mirror are fixed with UV curing resin. As the positional accuracy of the LD and aspherical lens is important in order to obtain high light output, it is adjusted to the three-axis optimum position and fixed by UV curing.

Figure 2 shows the characteristics of the coupling efficiency to SMF (single mode fiber) for the new structure. A high coupling efficiency of more than 70% was achieved.

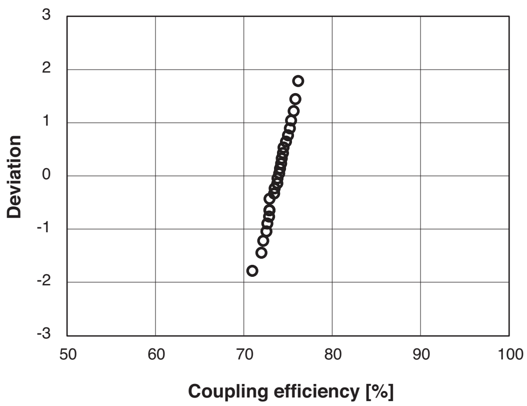


Fig. 2. Coupling efficiency

3. High-Frequency Property of the New Package

The conventional package for cooled TOSA consists of a metal frame, multilayerceramic substrate, and lead pins connected to an FPC (flexible print circuit). The AC signal to drive the LD is transmitted through the line on the FPC, lead pins and ceramic substrate, all of which are designed to be positioned at nearly the same level. On the other hand, the new package has no lead pins, and therefore, the FPC is directly attached to the multilayer ceramic substrate and AC signals are designed to be transmitted vertically, which is different from the design of the conventional package.

The transmission line is designed to go through the multilayer ceramic substrate to optimize the impedance properties of via holes that vertically connect the surface and the bottom of the 1.2 mm thick substrate, and surround the signal via with the ground pattern. This approach successfully made the new package comparable to the conventional one in the properties.

For the structure in which the FPC is directly soldered to the multilayer ceramic substrate, it is important that the signal pad is surrounded by the ground pattern and placed on the bottom of the package. This design can be achieved by connecting the pattern brazed with a high-radiation metal plate and the ground pattern surrounding the signal pad. However, the ground potential can be unstable if these patterns are connected. Therefore, by optimizing the size of the signal via and ground pattern around it, the package size of 6.5 mm x 5.7 mm was achieved without the connection of the pattern for the radiation plate.

Figures 3 and 4 show the simulation result and measurement result for electrical insertion loss properties, respectively. Both results show good coincidence, indicating that the new package has favorable properties as expected. In addition, the insertion loss shown in **Fig. 4** is more than -3 dB in the frequency range between 0 and 22 GHz, which suggests that this package can be used for transmission over 25 Gbit/s.

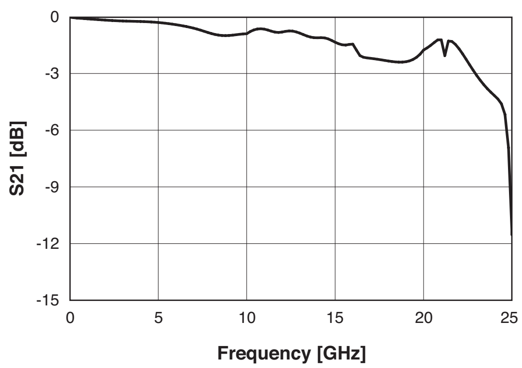


Fig. 3. Electrical insertion loss (Simulation)

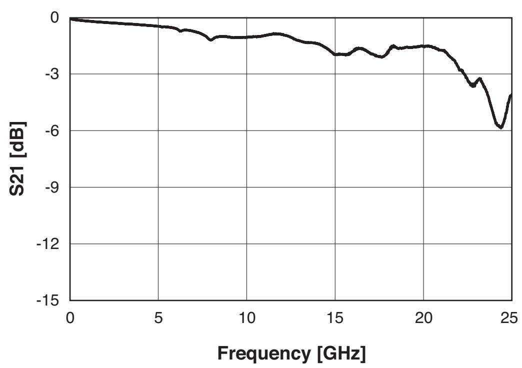


Fig. 4. Electrical insertion loss (Measurement)

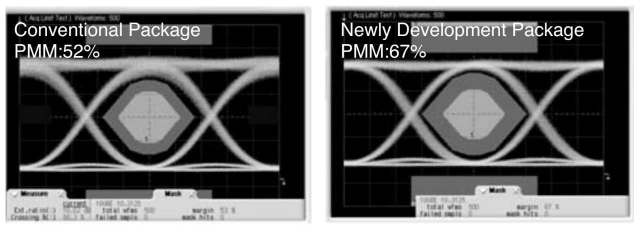


Fig. 5. Optical eye diagrams

In **Fig. 5**, the eye patterns of TOSAs with the conventional and new packages are shown. In the condition of the transmission rate of 10.3125 Gbit/s and the extinction rate of 10 dB, TOSA with the new package successfully achieved the PMM (pulse mask margin) of 60% or higher.

4. Heat Dissipation Characteristic

Cooled TOSA has a TEC for controlling a LD temperature. It is necessary for suppressing power consumption and maintaining optical characteristics to transport heat from the TEC to the package efficiently. We compared the heat dissipating efficiency of TOSA with the conventional package and TOSA with the new package.

Figure 6 shows conceptual diagrams of heat conducting paths from TOSA to the package; **Fig. 6 (a)** shows a conventional structure and **Fig. 6 (b)** shows a newly developed structure. The heat from TOSA of the conventional structure is transported to the package by a heat dissipating sheet. Contrary to the conventional structure, a radiation facet of the newly developed structure is perpendicularly to the package so that a heatdissipating block, in **Fig. 6 (b)**, takes on the function of radiating heat to the package, which is made of metal. The thickness of the heatdissipating sheet is extremely important because its thermal conductivities is one-tenth to one-hundredth smaller than that of metal (TOSA and the package are made of metal.). Then, we calculated tolerance of a gap between TOSA and the package. The tolerance of the gap is depended on two factors: the tolerance of aligning sleeves and dispersion thickness of parts. We estimated them at +/- 0.20 mm and +/- 0.05 mm on calculation. As the result of calculation, the tolerance of a gap in the conventional structure is +/- 0.21 mm and that of the newly developed structure is +/- 0.10 mm by square root of sum of squares. The tolerance of a gap of the newly developed structure is half smaller than that of the conventional structure because it is possible to neglect aligning sleeves. From this calculation, we can use thinner heat dissipating sheet by using the newly developed TOSA.

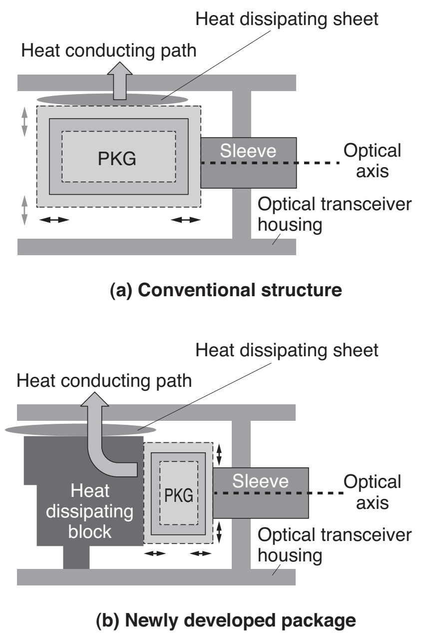


Fig. 6. Heat dissipation structure

Figure 7 is measurement and simulation results of the thermal resistance, which is calculated by dividing the temperature difference between TOSA and the transceiver by the power consumption of the TEC, which is depended on the thickness of the heat dissipating sheet. The thickness of the heat dissipating sheet is determined by the previous examinations. The experiment and simulation results show that the thermal resistance of the newly developed TOSA is about 60% smaller than that of the conventional TOSA. This enables the newly developed TOSA to expand its maximum operating temperature range by 6 degree Celsius and reduce the power consumption.

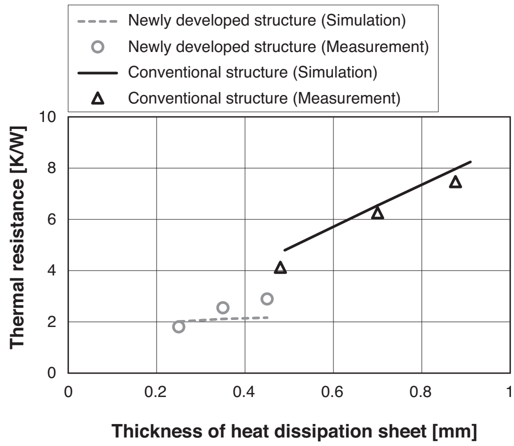


Fig. 7. Characteristics of heat dissipation

5. Conclusion

We have developed a new ceramic package that can be used for medium and long distance transmission of 10 Gbit/s. We have succeeded in the development of a next generation ceramic package with excellent high frequency characteristics and high heat dissipation characteristics by improving the package structure.

Reference

(1) Nakajima et al. "Development of low-cost cooled EML-TOSA for 10Gbit/s application," IEICE General Conference, C-3-62, March 2010

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