Extended Temperature (-40/+90°C) Ultra Low Power Consumption with High Average Output Power (>+3 dBm) 1.55µm TOSA Module for up to 11.3 Gb/s 100 km Dispersion Compensation Free Transmission Metro Applications

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Abstract: We first report on a high average output power (>3dBm) 1.55µm EML TOSA able to address industrial environment temperature range [-40/+90°C] with Ultra-Low Power consumption (0.8W) and power penalty <2dB over 100km SMF fiber transmission.

OCIS codes: (250.0250) Optoelectronics; (250.5960) Semiconductor Lasers; (250.4110) Modulators

1. Introduction

Although TOSA modules are available for 100km Metro applications in the commercial case temperature range [0;+75°C], none is presented today for the industrial temperature environment range [–40;+90°C]. Several papers have been already presented to reduce power consumption in a large temperature range while keeping a high average output Power. For instance 1.7 dBm average power & 0,5W @ 80°C TOSA temperature has been reported [1]. Using un-cooled EML a TOSA module performing 0dBm in [–5;+75 °C] range has been reported as well [2]. To our knowledge, none have been presented to deal with the industrial temperature environment with a large average power supporting 100km transmission span on single mode fiber link without dispersion compensation. Indeed, in order to sustain the high temperature of 90°C, the EML chip temperature has to be set in the [50;60°C] range. The challenge is then to offer sufficient output power while maintaining good transmissions characteristics over a 100km SMF fiber link.

Thanks to the development of a new Electro-Modulated Laser (EML) chip, we present here results of a TOSA reaching an average output power greater than +3 dBm, while allowing in the same time a total electrical power consumption below 1W while operating under an environmental temperature of +90°C.

2. Technology

The EML is composed of a compressively strained MQWs DFB laser connected via a butt-joint to a compressively strained MQWs Electro Absorption Modulator modulator. The modulator has been specifically designed such as to allow good transmission characteristics with very low additional losses. In addition, great attention has been paid to the modulator saturation characteristics in order to maintain high bandwidth at both high temperature and high input power. Both laser and modulator have a ridge structure. The output facet has an anti-reflection coating and the rear facet a high reflection one. To reduce the modulator capacity, BCB is used under the modulator bond pad.

The TOSA comprises the EML chip, Peltier cooler and XMD compliant flex output. Care has been taken in the overall product design to obtain a good average coupling ratio (~70%).

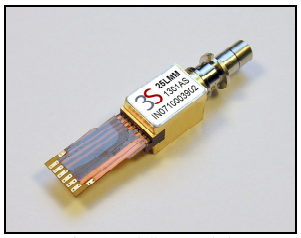


Fig. 1. TOSA module

3. EML Chip Results

The figures 2 and 3 present the L(I) curves and P(V) curves obtained on the chip on submount at different temperatures. It can be seen that 10 mW output power is obtained at a current as low as 105 mA at 45°C and that at

120 mA, output power greater than 5 mW is obtained up to 60°C. SMSR is better than 40 dB and extinction ratio of 14 dB is obtained with voltage below 2V at temperature higher than 45°C. Thanks to the advanced modulator design, bandwidth better than 13 GHz are obtained up to 55°C at 120 mA, which exceeds required bandwidth for 10Gbit/s transmission and allows the use of all errors correcting codes to support bit rates up to 11.3 Gb/s.

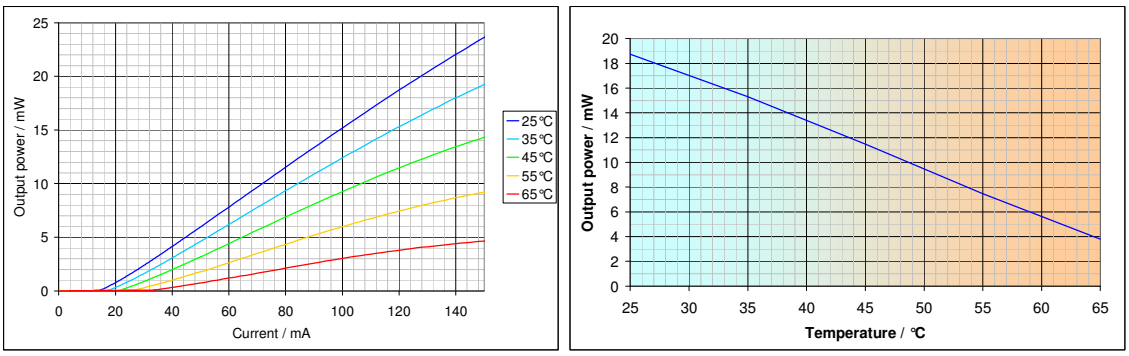


Fig. 2. L(I) and output power @ 120 mA versus temperature.

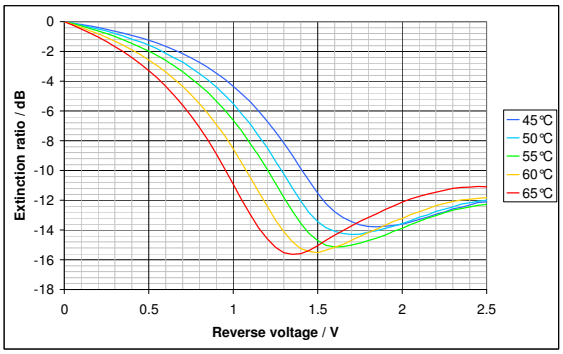


Fig. 3. extinction curve @ 120 mA versus temperature.

3. TOSA Module Results

Thanks to the good coupling ratio, CW +7 dBm TOSA output power is typically obtained at 120 mA and 55°C.

Figure 4 presents the back-to-back eye diagram obtained at 45°C and 100 mA. An extremely good margin is obtained using the STM64 Filter. Thanks to both modulator and packaging design improvement, the eye quality is maintained up to 70°C at 120 mA as can be seen in Figure 5. This result is performed with TOSA mounted on an XFP test board and driven by a commercial OKI 4145 driver.

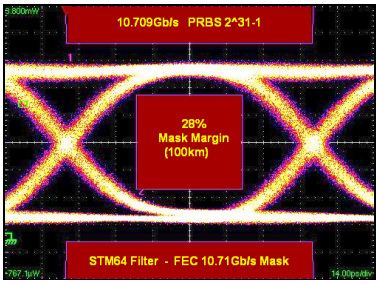
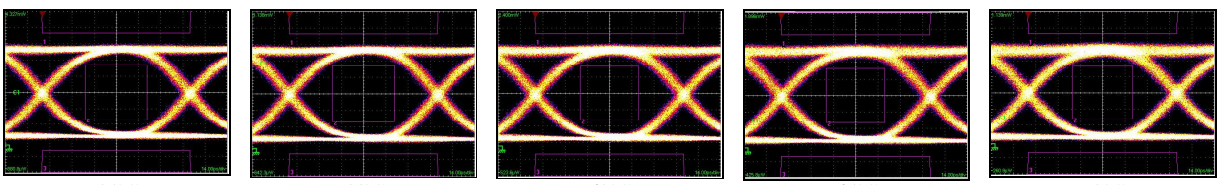


Fig. 4. TOSA eye diagram @ 45°C, 100mA driven by OKI 4145 driver



45°C 55°C 60°C 65°C 70°C

Fig. 5. Eye diagram @ 120mA vs chip temperature

At 55°C and 120 mA, a path penalty of 1.1 dB after 100 km fiber, has been obtained on assembled TOSA modules, with $2V_{pp}$, Dynamic Extinction Ratio (DER) of 10.3 dB and average output power of more than 3 dBm -Up to 4dBm-. Figure 6 shows typical BER curve and Figure 7 shows path penalty distribution (measured between 45°C-60°C) and average optical power distributions (measured at 55°C/ 120mA) achieved on a typical Design Verification Tests set of TOSA modules.

At 60°C and 120 mA, typical path penalties are of 0.9 dB after 100 km fiber, obtained with $2V_{pp}$, DER of 10.4 dB and average output power of 1.3 dBm.

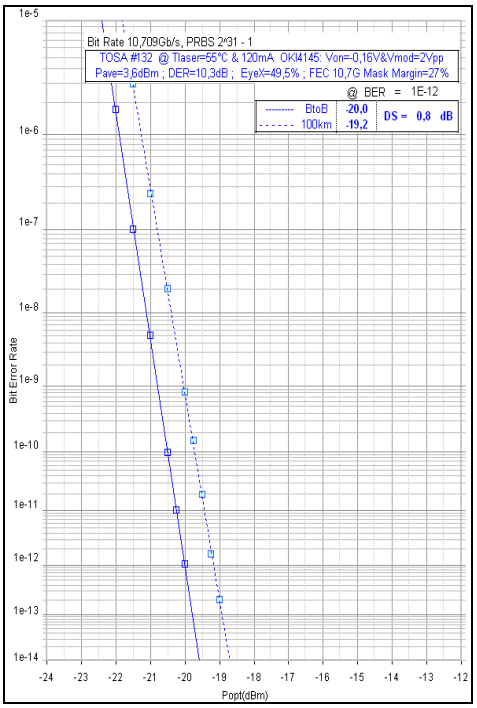


Fig. 6.TOSA BER curve

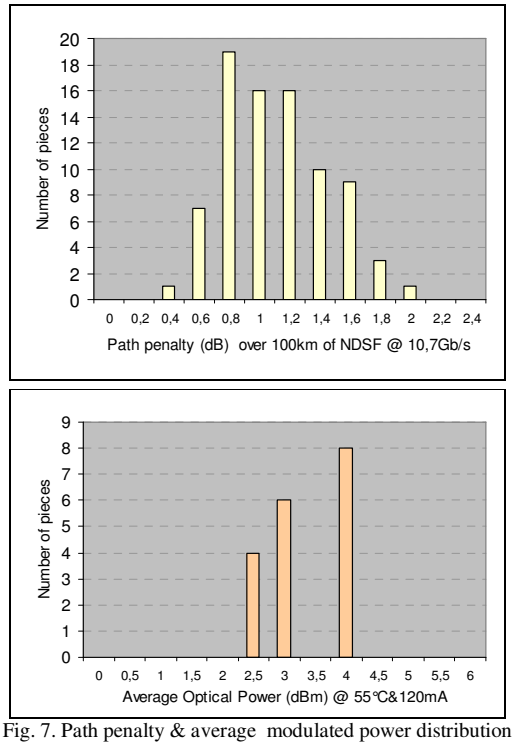


Fig. 7. Path penalty & average modulated power distribution

Consumption measurements were performed in the conditions used for the transmission experiments. At 55°C and 120 mA, the Peltier cooler consumption with a case temperature of 75°C is as low as 0.25W. When the external temperature is set to 90°C, the Peltier cooler consumption remains very low at 0.7 W. When the transmission conditions are set to 60°C and 120 mA, this consumption reduces to 0.5 W.

Considering reliability, more than 2000h ageing tests have been accumulated in accelerated conditions. Acquired data show that this EML chip is qualified up to 120mA 60°C.

3. Conclusion

The results of XMD TOSA for industrial environmental conditions are presented. Thanks to the development of a new EML chip and to a coupling design allowing 70% average coupling efficiency, + 3 dBm average modulated output power with path penalty better than 1.1 dB are obtained after 100 km of NDSF without dispersion compensation, with Peltier cooler consumption lower than 0.8 W at a case temperature of 90°C.

4. References

[1] Norio Okada & al, "10Gb/s Low Power Consumption & Low Jitter EML TOSA employing interdigital capacitor" ECOC 2006
[2] Hiroshi Yamamoto & al, "Compact and low power consumption 1.55 mm Electro-Absorption modulator integrated DFB-LD TOSA for 10Gb/s 40 km Transmission" OthT5, OFC 2009