High Power CW Laser for Co-Packaged Optics

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Abstract: A high-power, Continuous-Wave (CW) laser prototype for External Laser Sources (ELSs) used in Co-Packaged Optics (CPO) applications is demonstrated at over 500mW ex-fiber, more than 10% efficiency.

1. Introduction

The amount of annual global data center traffic has tripled in the last five years, and nearly three-fourths of it resides inside data centers thanks to drivers such as video, AI, and HPC [1]. Power consumption of next-generation switches such as 51T and 102T switches might exceed cooling facility limits if traditional switch construction techniques with pluggable optics are used. CPO is one of the key initiatives to reduce power consumption in next-generation datacenter networking systems. CPO-based switch designs utilizing ELSs provide the advantages of serviceability of the laser sources, separation of the temperature-sensitive lasers from the switch IC, and easing space limitations on Silicon-Photonic (SiPho) die by eliminating the integrated lasers. For CPO-based, 51T switches, each laser would need to provide approximately 22 to 25dBm of optical power. In addition to the high-power output, it is necessary for the ELS to provide high Power Conversion Efficiency (PCE) for CPO systems to achieve the power reduction sought. Preliminary PCE target of 10% should achieve this goal.

2. Laser Structure, Device Fabrication and Characterization

The distributed feedback (DFB) laser structure is similar to the one used in [2]. Multiple quantum well (MQW) structure in InGaAsP/InP material system features a low QW confinement factor, which provides a low cavity loss, high saturation power, and large spot size. The far-field divergence angle is small, which makes high-efficiency fiber coupling possible. A large optical cavity design with a cavity length of 4mm is used, which reduces thermal and series resistances and therefore leads to high output power and high PCE. The quantum well is strained, and its composition is adjusted to target photoluminescence wavelength that aligns the gain peak with the DFB wavelength at 45°C. The barrier height is chosen to make the lasers relatively temperature insensitive. An in-house simulator, based on the coupled-wave method, is used to simulate the single-mode selectivity of the grating and the electric field distribution within the cavity for various grating coupling strengths. The optimal grating coupling strength is selected based on the simulation results. First-order DFB grating is patterned by holographic photolithography. After waveguide formation, surface passivation, VIA opening, metal contact formation, wafer thinning, polishing, and cleaving, laser fabrication completes with <0.1% front fact AR-coating and >95% back facet HR-coating.

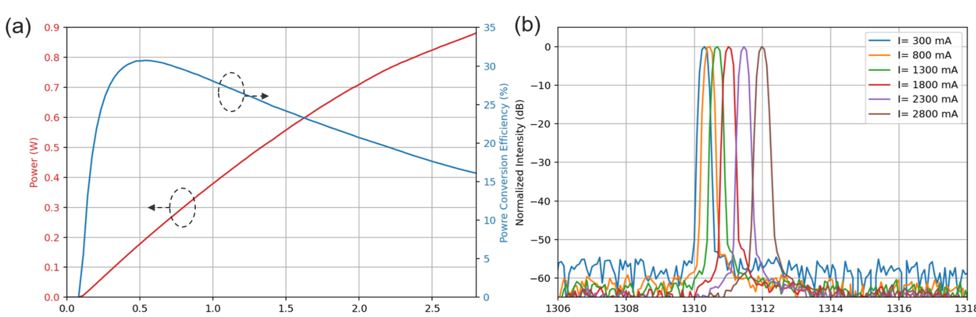

Fig. 1. 25°C CW mode COS characterization results showing (a) Power-Current and PCE-Current, (b) spectrum

The lasers are mounted p-side down on AlN submounts for chip-on-submount (COS) testing. 25°C CW COS testing results of one device are shown in Fig. 1. The maximum output power reaches 880mW, the same as the power level recently demonstrated near 1550nm in [3]. However, the SCOW structure used in [3] has poor manufacturability since the structure is sensitive to waveguide etching conditions. On the other hand, our structure has proven manufacturability, as demonstrated by our high-power Raman pump lasers. The threshold current is 99 mA, and the slope efficiency is 0.45 W/A. The emission wavelength peaks around 1310 nm. The spectrum, measured with 0.1 nm resolution, is single-mode during the entire operating current range. The side mode suppression ratio (SMSR) is more than 50 dB. The far-field full width at half maximum is 6.0° and 20.1° in the lateral and vertical directions.

The COS device was packaged into a 14-pin butterfly (BTF) module. The power output from the COS device is coupled to a lensed polarization-maintaining fiber with a high coupling efficiency of 86%. The polarization extinction ratio (PER) is more than 16 dB. Fig. 2 shows characterization results of the module tested at 25°C, 40°C and 50°C laser diode temperatures at 50°C and 70°C case temperatures. The maximum output powers are 720mW, 640mW, and 580mW at 25°C, 40°C, and 50°C laser diode temperatures, respectively, independent of the case temperature. At 50°C, the threshold current is 150mA, and the slope efficiency is 0.35W/A. At 50°C and 500mW ex-fiber output power, operating current and voltage are 2.0 A and 1.8V, respectively. At 400mW ex-fiber power, the module PCE is at least 10% at all the testing conditions. SMSR of the spectrum, measured with 0.02nm resolution, is higher than 45dB. RINc measured without a reflector is lower than -156dBc over the output power range of 200-500mW with laser temperature at both 40 and 50°C.

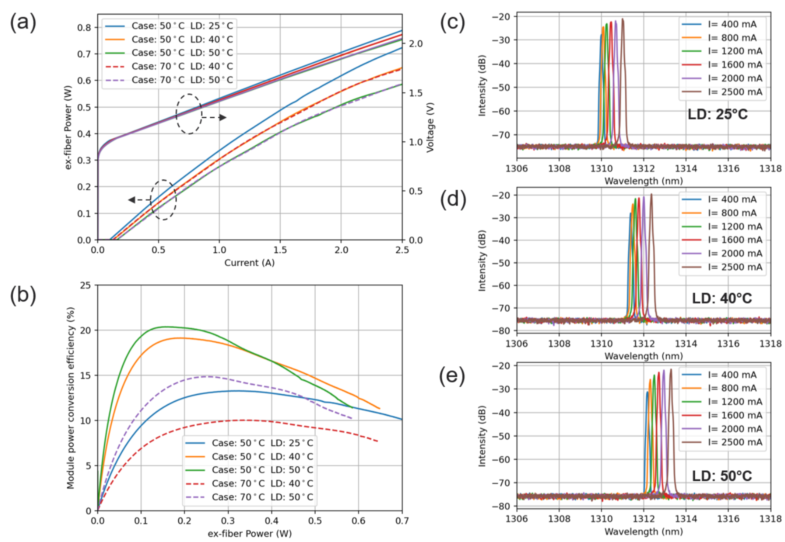

Fig. 2. Module characterization results showing (a) Power-Current-Voltage, (b) module PCE vs. ex-fiber power, and emission spectrum at (c) 25°C, (d) 40°C, and (e) 50°C laser diode temperatures at 50°C case temperature

3. Conclusions

We have demonstrated high power CW 1310nm DFB lasers with a maximum out-of-facet power of 880mW at 25°C. When packaged in a 14-BTF module, ex-fiber output power reaches 580mW at 50°C laser diode temperature.

4. References

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