1060nm Single-mode Intra-cavity Metal-aperture VCSEL for over 2km Standard 1300nm SMF Transmission

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1. Introduction

Vertical-cavity surface-emitting lasers (VCSELs) [1] have been widely used for optical interconnects in datacenters. High-speed VCSELs of over 30GHz have been developed [2]. However, the MMF link length is limited below 100m. The use of a longer wavelength band of >1060nm could be an attractive choice for extending the link length thanks to lower fiber losses and dispersions [3, 4]. In this paper, we demonstrate a 1060nm intra-cavity metal-aperture VCSEL with an optimized surface relief structure for pushing the modulation bandwidth up to 29GHz.

2. Device Structure

The structure of the intra-cavity metal-aperture VCSEL is shown in Fig.1. Surface relief process is formed by shallow-wet etching with 30nm depth at the surface of a half-cavity VCSEL which includes 6-pair top semiconductor DBR and 30-pair bottom DBR. A ring-shaped p-contact metal with 7μm of diameter and 3μm of width is formed on the surface and under a 5-pair top dielectric DBR. A polyimide layer is inserted below the p-contact pad to reduce the parasitic capacitance.

3. Results

Figure 2(a) shows the L/I of the fabricated metal aperture VCSEL. The single-mode power is 2.5mW at 6mA. Stable single mode operations can be seen with SMSR over 50dB in the entire current range as shown in Fig. 2(b). The small signal modulation of the fabricated VCSEL with back-to-back, 2km, 5km, and 10km transmission through standard 1300nm-SMF (G652) are shown in Fig. 3. The modulation bandwidth is 29GHz, which is the record modulation speed of 1060nm VCSELs. Thanks to the frequency chirp and negative dispersion of the fiber, the modulation bandwidth can be increased to 36GHz and 32GHz through 2km and 5km SMF, respectively. Figure 3(b) shows the transfer function of different fiber lengths, which is in agreement with the calculated transfer function with a chirp parameter of 2.5. The result shows a potential of 50Gbps (NRZ) and 100Gbps (PAM4) transmission up to 5km.

Large signal modulations (PRBS) were measured as shown in Fig.4. We observed eye opening up to 50Gbps (NRZ) and 80Gbps (PAM4) under back-to-back, 65Gbps (NRZ) and 90Gbps (PAM4) through 2km, and 50Gbps (NRZ) through 5km SMF transmission.

4. Conclusion

We demonstrate a 1060nm single-mode intra-cavity metal-aperture VCSEL, exhibiting the record modulation bandwidth of 29GHz for 1060nm VCSELs. 65Gbps (NRZ) and 90Gbps (PAM4) transmissions were successfully demonstrated through 2km 1300nm-SMF. Further extensions on link lengths and bit rates could be expected by chirp reduction and bandwidth enhancement in transverse coupled cavity VCSELs.

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References

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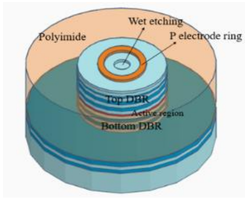

Fig. 1. Schematic structure of 1060nm intra-cavity metal aperture VCSEL.

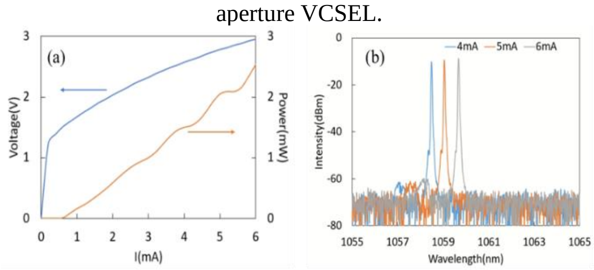

Fig. 2. (a) Measured V/I & L/I, (b) lasing spectra

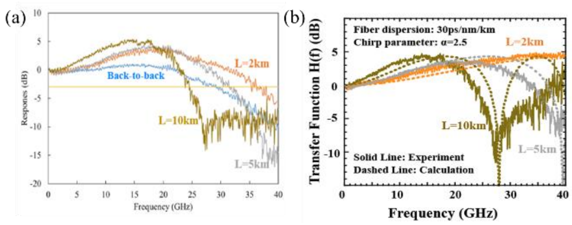

Fig. 3. (a) Small signal modulation response through different lengths of SMF, (b) Transfer function of SMF transmission with different fiber lengths in comparison with the calculation

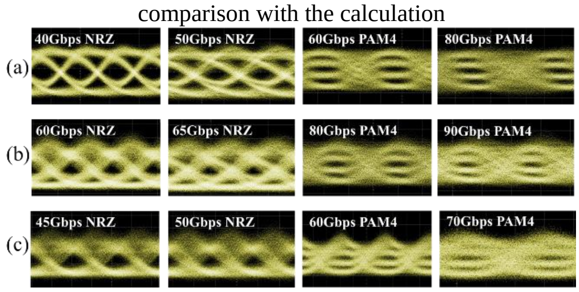

Fig. 4. Eye diagrams with different bit rates through (a) back-to-back, (b) 2km SMF, and (c) 5km SMF.