First Demonstration of 850 nm Transverse Coupled Cavity Vertical Cavity Surface-Emitting Laser

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Abstract We for the first time demonstrated an 850 nm-band transverse coupled cavity vertical cavity surface-emitting laser, which shows a record-breaking modulation bandwidth of over 30GHz.

Introduction

Ultra-fast and energy-efficiency 850nm vertical cavity surface-emitting laser (VCSEL) is the core component in recent optical interconnection systems such as datacenters and supercomputers [1]. Direct modulation has been the main choice regarding its compact size and good coupling to optical fibers. However, there is a bottleneck in further increase the device frequency response, limited by the relaxation oscillation frequency and paracitics. In this paper, we present the first demonstration of an ultra-fast 850 nm-band VCSEL using a transverse coupled cavity structure.

Device Structure and Principles

The proposed modulator is fabricated on a VCSEL epitaxial wafer. Top-view of the fabricated device is shown in Fig. 1. An external cavity is attached to the VCSEL on the right. Some of the VCSEL output will be laterally coupled, and reflected back to the cavity. This feedback cavity can provide significant bandwidth enhancement for the VCSEL [2]. In this device, the feedback section is as short as 15 μm and the isolation width is 3 μm, thus strong feedback is obtained even without current injection to the external cavity.

Device Characteristics and Power consumption

We measured the device frequency response, as shown in Fig. 2. A device with the same VCSEL structure but long (90 μm) external cavity is used for measuring the no-feedback case for comparison. The response of our device is very flat and the 3dB bandwidth exceeds 29 GHz, almost tripled that of the device without feedback. This value already exceeds the photodetector response limit (Newport 1414-50, f_{3dB} = 25GHz). After calibration, we can see that our device actually performed a 3dB frequency response over 30GHz. The bias current here is only 4.3 mA, which is much smaller than that of normal directly modulated VCSELs for high-speed modulations.

Large-signal transmission experiment was also carried out on another device with shorter isolation width (3 μm), which has larger optical output. The results are shown in Fig. 3 using a non-return-to-zero (NRZ) data with bitrate of 32 and 40 Gbps. The VCSEL current is 6.2 mA with a passive external cavity. Clear eye-opening can be observed for 32 Gbps signal. For 40 Gbps input, the eye-pattern shape is nice but relatively larger noise degrades the eye-opening. The noise, considered to be from the optical mode instability, can be removed after optimizing the device structure for mode selection.

Conclusions

We fabricated the first 850 nm-band transverse coupled cavity VCSEL, with strong feedback from the external cavity. Measurement results show the device has an intrinsic 3dB frequency response over 30GHz, and requires low bias current and small voltage swing.

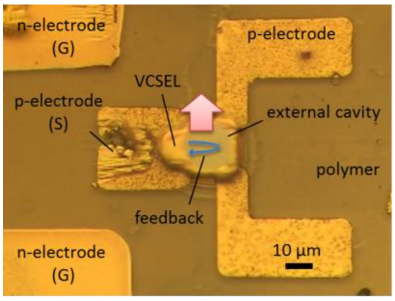

Fig. 1: Top-view of one fabricated device, with a mesa footprint of only 14×24 μm^2

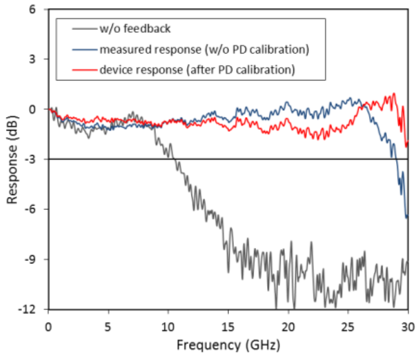

Fig. 2: Measured small-signal frequency response of the devices with and without feedback. Actual device response after PD calibration is also shown.

Fig. 3: Measured large single response with data rate of 32 Gb/s and 40 Gb/s (NRZ, PRBS 2^{31}-1, V_{pp}=500mV). VCSEL current is 6.2 mA with a passive external cavity. The isolation width is 3 μm.

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References

[1] A. Larsson, IEEE J. Sel. Topics Quantum Electron., vol. **17**, no. 6, p. 1552 (2011).
[2] H. Dalir and F. Koyama, Appl. Phys. Lett., vol. **103**, no. 9, p. 091109-1 (2013).