論文 / 著書情報
Article / Book Information

論題(和文)	
Title(English)	High-speed and Single mode 850nm Intracavity Metal Aperture VCSEL with Transverse Coupled Cavity Effect
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出典	第68回応用物理学会春季学術講演会 講演予稿集
講演番号	19p-Z22-4
発行日	2021, 3

High-speed and Single mode 850nm Intracavity Metal Aperture VCSEL with Transverse Coupled Cavity Effect

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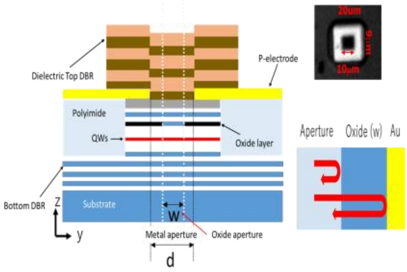
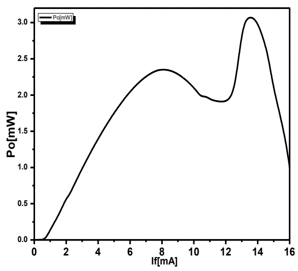
1. Introduction: Vertical cavity surface emitting lasers (VCSELs) have exhibited the advantages of low cost, ease of fabrication into arrays, small footprint, wafer-scale testing, and low power consumption [1, 2]. Therefore, VCSELs are attracting much attention for use in data center networks. The network traffic in data centers is increasing rapidly and hence the development of high speed VCSELs is a key issue. The modulation bandwidth of VCSELs is typically less than ~ 20 GHz due to the limited intrinsic carrier-photon resonance (CPR). We propose and demonstrate intracavity metal aperture VCSELs (MA-VCSEL) with a rectangular shaped oxide aperture. The fabrication process is exactly same as intracavity contact VCSELs. We found that the intracavity metal contact causes the transverse resonance [3] which provides the modulation bandwidth enhancement.

2. Device Structure: Figure 1 (a) illustrates the schematic structure of the fabricated single-mode MA-VCSEL. The size of an active region oxidation aperture is 9 x 10 μm^2, as shown in Fig.1(b) which is large enough for high reliabilities. We found that two lateral boundaries cause the transverse resonance as shown in Fig. 1(c).





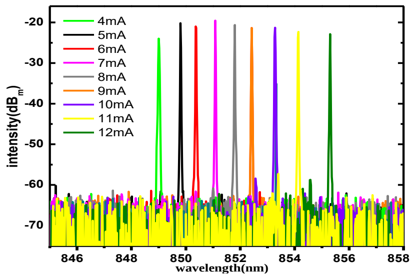
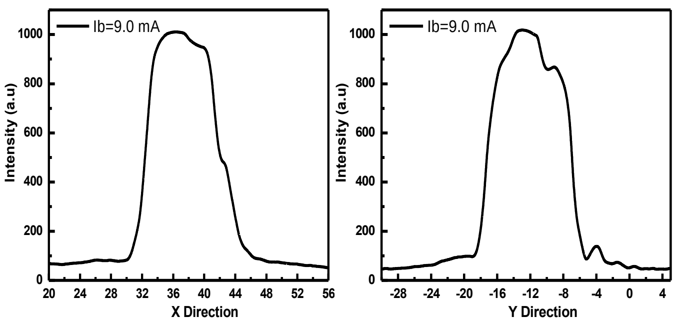


Fig.1. Schematic and top-view of infrared image of oxide aperture Fig.2. L-I curve for MA-VCSEL. Fig.3. Spectra measured

3. Results and discussions: The L-I curves of two fabricated devices were measured; one is for metal-aperture-VCSEL (MA-VCSEL) with a distance of less than 2um between the oxide aperture and metal aperture and the other one is conventional VCSEL (C-VCSEL) with a distance larger than 2um for comparison. Fig. 2 illustrates the L-I curve of MA-VCSEL with distance of 1.5 - 2 μm with oxide aperture size 9x10 μm^2. A kink appeared in the L-I curve as optical feedback induced from the metal boundary is coupled into the primary VCSEL cavity. The lasing spectra of the MA-VCSEL was measured a single-mode operation was obtained in the entire current range with SMSR of more than 40 dB as shown in Fig. 3.
Figure 4 shows the measured NFP at 9mA bias current. currents. The mode field diameter is as large as 10 μm which is equal to the oxide aperture size. The small signal modulation response in MA-VCSEL is shown in Fig.5 the modulation bandwidth is over 20 GHz while it is 10 GHz for conventional VCSELs.



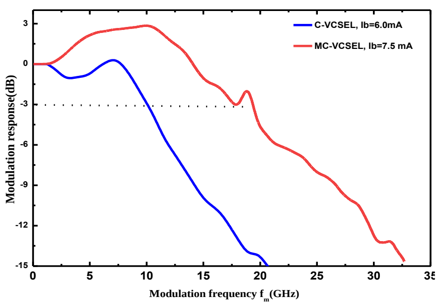


Fig. 4. NFP of MA-VCSEL in the X (a) and Y (b) directions Fig. 5. Small signal modulation response of MA-VCSEL

4. Conclusions: In conclusion, we proposed and demonstrated the novel concept of high-speed and single-mode VCSELs with a large mode-field diameter. The mode field diameter is as large as 10 μm for single mode operations in the entire current range. The bandwidth can be double thanks to the coupled cavity effect.

Acknowledgement: This work was supported by NICT.

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