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10 Gbps/ch 1×10 VCSEL array at 850-nm wavelength

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Abstract: 10 Gbps/ch 1×10 850-nm VCSEL array was fabricated for 100 Gbps optical link module. It was found that static characteristics were uniform. In addition, good modulation characteristics of 10 Gbps for each device were realized over extensive environmental temperatures.

Internet traffic is increasing dramatically now and innovative technologic developments are demanded for long distance network, metropolitan area network, access network, and local area network. Especially, in short distance network, economic and scalable high-capacity optical link techniques are demanded. For this purpose, it is important to reduce the device size and its power consumption. As a light source to solve this issue, vertical-cavity surface-emitting laser (VCSEL) is attractive.

We developed 780-nm VCSEL for laser printer, and we have commercialized the world first VCSEL based high performance color laser printer [1]. By applying accumulated techniques in this development, we try to realize the 100 Gbps optical link module with 10 Gbps/ch 1×10 850-nm VCSEL array. In this paper, 10 Gbps/ch 1×10 VCSEL array aimed to improve the uniformity of the optical characteristics and to clarify technological issues for the 1×10 VCSEL array is reported.

Figure 1 shows the top view of the 1×10 VCSEL array. The channel spacing was 250 μm and the p-type contact pad size was 60 μmϕ.

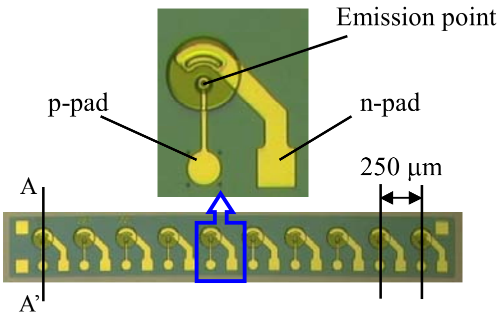


Fig. 1 Top view of 1×10 VCSEL array.

Figure 2 shows the cross section structure of fabricated selective oxide-confined VCSEL. We introduced the in-situ AlAs oxidation probing technique called OPTALO (Optical Probing Technique for AlAs Lateral Oxidation) [2]. The n-type and p-type

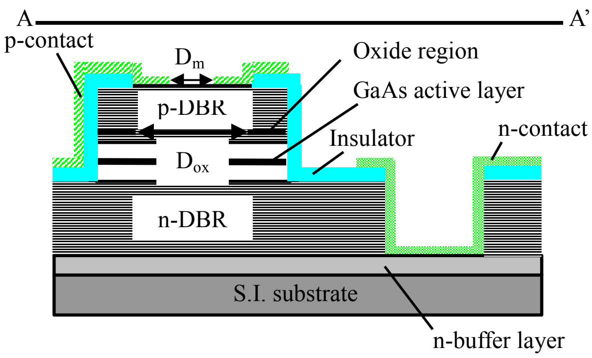


Fig. 2 Schematic cross section structure of selective oxide-confined VCSEL.

contacts were both fabricated on the surface. The n-type contact was fabricated by etching to the n-buffer layer. In addition, the lasing mode was controlled by optimizing the inner diameter of the p-type ring contact (D_m) with respect to the oxidation aperture size (D_{ox}) [3].

Figure 3 shows the LIV characteristics of the 1×10 VCSEL array at room temperature. Threshold current was approximately 0.5 mA for each chip, and the maximum light output exceeded 3 mW. Uniform static characteristics were realized.

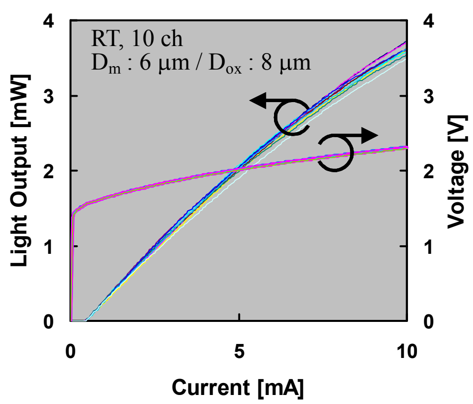


Fig. 3 LIV characteristics of 1×10 VCSEL

Figure 4 shows the small-signal responses of the 1×10 VCSEL array at 5 mA under room temperature. This result indicates that the high-speed modulation characteristics of more than 10 Gbps will be realized for each channel because f_{-3dB} exceeded 10 GHz. We have measured the 10.3125 Gbps modulation characteristics with the 10 Gbps Ethernet mask. The good characteristics of the mask margin of more than 20 % were realized for all of 10 channels at 25ºC.

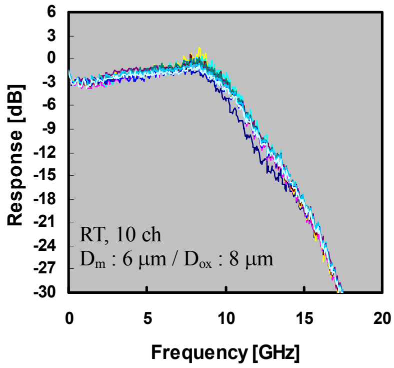
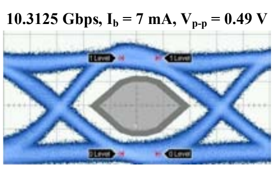
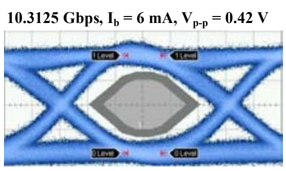


Fig. 4 Small-signal response of 1×10 VCSEL array.

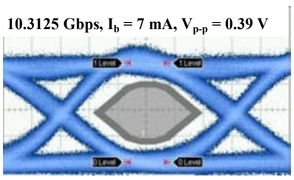
Figure 5 shows 10 Gbps eye diagrams at –20ºC, 25ºC, and 85ºC. Satisfactory mask margin of more than 20 % were obtained under all three temperatures. These results indicate that the high-speed modulation device without temperature control device could be fabricated.



(a) –20ºC



(b) 25ºC



(c) 85ºC

Fig. 5 10 Gbps eye diagram at –20ºC, 25ºC, and 85ºC.

Figure 6 shows the spectral width and the peak wavelength of the 1×10 VCSEL array. The devices were operated at 6 mA under room temperature. The spectral width below 0.5 nm was obtained for all VCSELs. In addition, the spectral width hardly changes regardless of the modulation.

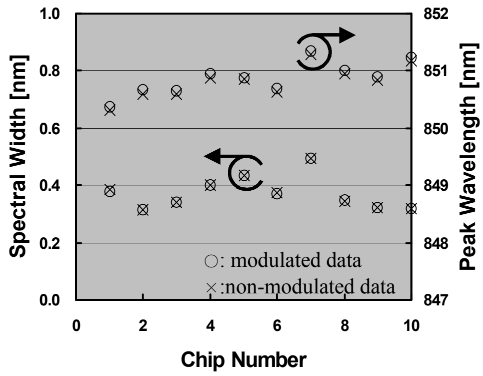


Fig. 6 Spectral width and peak wavelength of 1×10 VCSEL array.

In summary, we fabricated the 10 Gbps/ch 1×10 850-nm VCSEL array. Good characteristics were realized and we believe that this technology has potential for 100 Gbps VCSEL array module application. In the future, we will investigate the reliability of the 1×10 VCSEL array which is important when used as a VCSEL link module.

Acknowledgment

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