Thermal Crosstalk Evaluation of Densely Packed 1.1 µm-band VCSEL Array for Multi-core Fiber Transmission

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1. Introduction

Edge data centers (EDCs) have been attracting much attention due to the rapid growth of big data, the Internet of Things (IoT) and 5G mobile networking. EDCs have a smaller scale. Existing optical transceivers are no longer good choices because of their larger module size and large power consumption. Co-package Optics (CPO) for a compact integration of optical transceivers could be a key technology in EDC. A VCSEL array could be a better light source to meet the requirement. VCSEL has many advantages such as small footprint, low power consumption and low cost. Also, VCSELs are easy to be fabricated into array to provide a high-density and high-speed transmission [1]. In this paper, we present a single-mode 16-ch VCSEL array for multi-core fiber (MCF) transmission, exhibiting a low thermal crosstalk.

2. Device structure

Figure 1 shows the schematic structure of the VCSEL and the photo of a fabricated 16-ch single mode VCSEL array. The spacing of each channel is 40 µm. The total chip size is as small as 900 µm. A single-transverse mode operation is realized thanks to the metal-aperture structure, which also offers the enhancement of the modulation bandwidth [2].

3. Results and discussions

The current-light (IL) characteristic and lasing spectra of the 16-ch VCSEL array are shown in Fig. 2. The device shows single mode operations for the entire current range. The temperature change caused by self-heating is estimated from the lasing wavelength shift as shown in Fig. 3(a), where the temperature dependence of lasing wavelength is assumed as 0.07 nm /K [3]. The thermal resistance R of VCSEL in the array is defined by the following equation [4]:

$$R = \frac{\Delta T}{I \cdot V - P_{light}}$$

where ΔT is the temperature change, $I \cdot V$ is the electrical power and P_{light} is the output power. From Fig. 3(a), the thermal resistance is estimated about 1900 K/W.

The operating current of all VCSELs in the array is set as 5.0 mA. We measured the wavelength shift and hence temperature change at different distances as shown in Fig. 3(b). The temperature change caused by self-heating is about 23 K. The temperature change caused by an adjacent VCSEL at the distance of 40 µm is less than 1 K. The total thermal crosstalk is estimated as 7 K which could be much smaller than the self-heating.

4. Conclusion

A 1060 nm-band 16-ch VCSEL array is fabricated for a high-density, high-speed MCF transmission. The pitch between adjacent VCSELs is 40 µm. When the operating current is set as 5 mA, the total thermal crosstalk caused by other 15 channels is as small as 7 K.

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References

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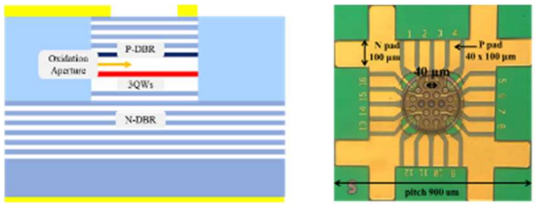
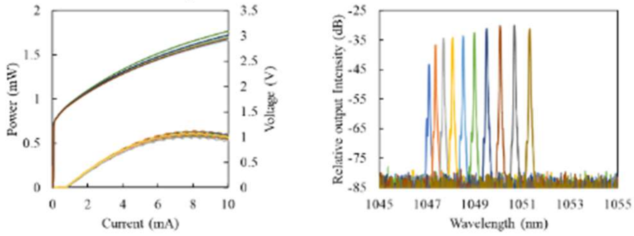
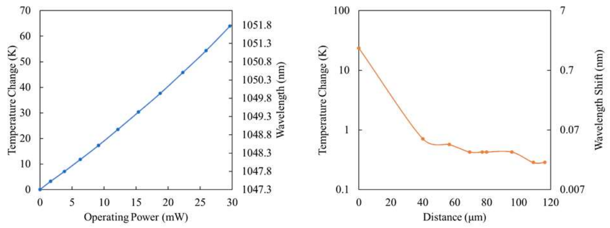


Fig. 1. Schematic structure of 1060nm VCSEL and photo of 16-ch VCSEL array.



(a) (b)

Fig. 2. (a) Current-output (IL) characteristics of 16-ch array and (b) lasing spectra with different currents from 2mA to 10mA.



(a) (b)

Fig. 3. (a) Wavelength shift and temperature change with operating power increasing, (b) wavelength shift and temperature change at difference distances when the injection current is fixed as 5 mA.