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Transverse Coupled Cavity VCSELs for Push-Pull Modulation

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1. Introduction

A highly-efficient and ultra-high speed VCSEL is a key device for data center photonics. It is a challenge to go beyond the limit of relaxation oscillation frequencies. One way to go beyond the limit is using the Push-Pull modulation scheme [1]. In this paper, a unique concept to couple transversely-integrated VCSELs is proposed and demonstrated. Lasing characteristics of far-field/near-field patterns indicate clear evidence of coherent lateral coupling of two cavities.

2. Device Structure

A schematic cross-section of lateral coupled-cavityVCSEL is depicted in Fig. 1. The vertical structure is the same as that of conventional 980nm InGaAs/GaAs 3QW VCSELs. Lateral optical confinement is formed using an oxide layer. Double bit felling axes with the joint region of less than few microns, leads to a leaky travelling wave in the transverse direction, which makes the lateral optical coupling between two cavities. Ion implantation was carried out in the middle to increase electrical isolation.

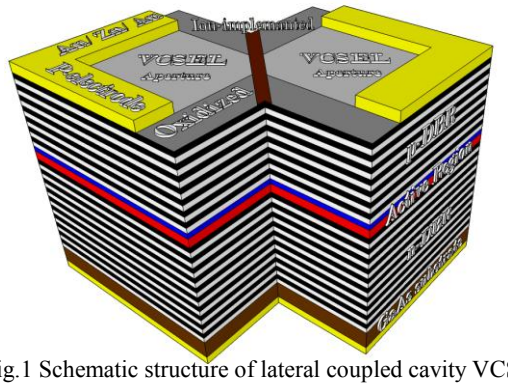

Fig.1 Schematic structure of lateral coupled cavity VCSEL.

3. Static Characteristics

We measured near-filed patterns (NFP) and far-field patterns (FFP)of fabricated coupled cavityVCSELs. Figures 2(a) and 2(b) show the NFP of non-coupled and coupled states with different bias currentsin the two cavities while the total injection current is same as 4mA in both cavities. Merely one cavity is pumped above the threshold in Fig. 2(a) while both cavities are equally pumped in Fig. 2(b). Figures3(a) and (b) illustrates the FFP while the total relative intensity of the NFP and FFP of the two states is unchanged. Figures 2(a) and (b) clearly show the localized field and the spreading field in the two cavities, respectively. From the NFP and FFP evidence we are claiming that two cavities are coherently coupled.

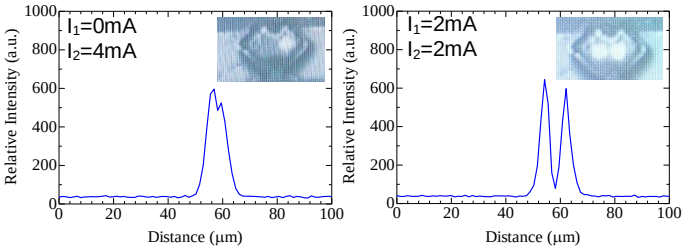

Fig. 2. Measured NFP of (a) non-coupled VCSELs and, coupled VCSELs.

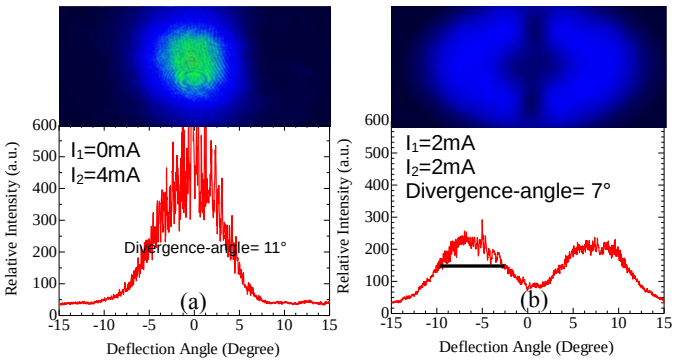

Fig. 3. Measured FFP of (a) non-coupled VCSELs and, (b) coupled VCSELs with different current distributions. The injection current in each cavity is shown extracting the leakage current between the two top electrodes.

3. Conclusions

Experimentally we realized the electrical switching of far-field and near field patterns.The FFP and spectrum data show coherent coupling of the two cavities.This basic idea is useful for enhancing the modulation speed of VCSELs, mutual injection locking, new functionalities such as beam steering [2], and so on.

References

[1] C. Chen, K.L. Johnson, M. Hibbs-Brenner and K.D. Choquette, IEEE JQE, vol. 46, no.4, pp. 438-446, 2010.

[2] K. D. Choquette, J. J. Raftery, Jr., and A. C. Lehman Aerospace Conference, IEEE, 2006.