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Strong Lateral Coupling from VCSEL to Slow Light Waveguide by Width Modification

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INTRODUCTION

Internet traffic is increasing rapidly by a factor 6 every decade. Electrical interconnect has been reached to the bottle neck due to their limitations [1], while the optical interconnect is getting matured for their potentials [2]. VCSELs are the great candidate in optical interconnects because of low power consumption, cheap cost and so on. However, in order to realize new functionalities of VCSEL, lateral integration scheme has been employed, such as: on-chip beam scanner [3], and modulator [4]. We also have been working on the 3-dB bandwidth extension based on transverse coupled cavities of VCSEL [5]. Despite all of the achievements, realization of strong lateral coupling was remained an issue. In this paper we have shown the novel concept to perceive and handle a huge lateral coupling from the VCSEL to slow light waveguide.

STRUCTURE

Figures 1(a) and (b) show the top view of the fabricated TCC-VCSEL and the infrared image of the aperture, respectively. The vertical structure is the same as conventional 980 nm 3QW InGaAs/GaAs VCSEL. The bottom mirror consists of a 41.5 period Si-doped $Al_{0.92}GaAs$/ $Al_{0.16}GaAs$ DBR. The active region has three $In_{0.2}GaAs/GaAs$ quantum wells embedded in one-λ cavity. An oxide aperture includes 30 nm thick $Al_{0.98}GaAs$ in order to form the oxide confinement. The top mirror consists of a 26-period carbon-doped $Al_{0.92}GaAs$/ $Al_{0.16}GaAs$ DBR.

CONCEPT AND MEASUREMENT

The cut-off wavelength of the waveguide can be alerted by shrinking the width of waveguide. Besides this, the localized light in the laser side should be localized at the center of aperture. Figures 2(a) and (b) illustrate the proposal of the oxide aperture and the expected cut off wavelength for each side (laser and slow light), respectively. Proton implementation region was made between the laser and slow light waveguide. According to the SIMS data, implementation depth is about 4 µm (entire top DBR). Thus electrical current leakage between the p-electrodes would to be negligible (below 2 µA). Figure 3(a) depicts the NFP images of the proposed device, while the injected current in laser side is only 1.1 mA and the other side is open circuited. We could realize the lateral coupling with very low current injection. Figure 3 (b) shows the reverse operation, while the laser side is open circuited, 2.7 mA is injected in the slow light side.

CONCLUSION

In conclusion, we have shown that by waveguide width modification we are able to alter the cut off wavelength, while by enlarging the waveguide width the cut off wavelength ambulates far from the resonance wavelength, the as a results by lateral coupling from narrower to wider waveguide width will extremely increase. The proposed device can be used for various applications such as: beam scanner, modulator and so on.

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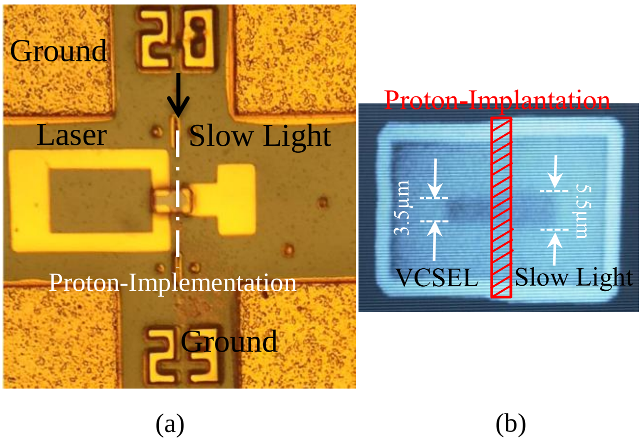

Fig. 1(a) Top view of the fabricated device, and (b) infrared image of oxide aperture

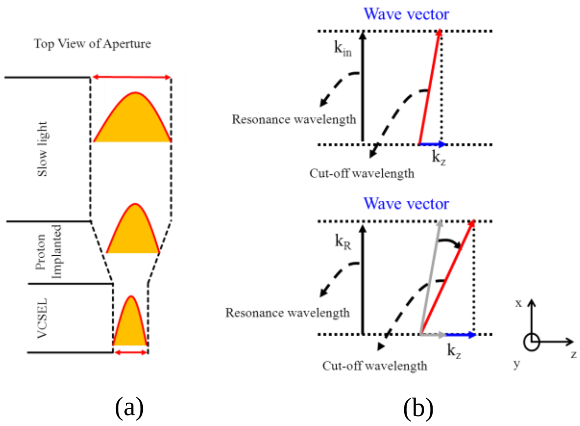

Fig.2 (a) Proposal of aperture shape, and (b) Mechanism of coupling enhancement

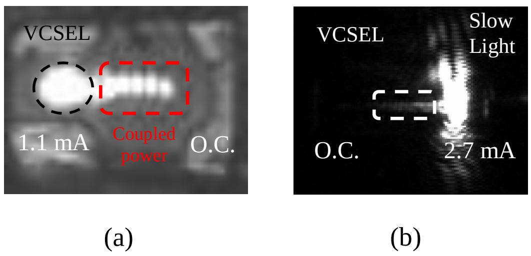

Fig.3 Lateral coupling from (a) narrower to wider waveguide width while 1.1 mA is injected at narrower (VCSEL) side and the other side is O.C., and (b) wider to narrower side, while 2.7 mA is injected in the wider (slow light) side and other side is O.C.