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27 GHz Directly Modulated Transverse Coupled Cavity VCSEL by Utilizing the Photon-Photon Resonance

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INTRODUCTION

Perpetually enlarging demand of our era for faster access to giant amounts of information with lower power consumption needs high-speed optical interconnects in data centers, supercomputers and so on. The bandwidth of high-speed VCSELs [1] is primarily limited by relaxation oscillation frequencies. We have shown hypothetically [2] and experimentally [3] using the lateral coupling we are able to enhance the speed of modulation by a factor of 3, while the enhancement is sensitive to the feedback current/phase cavity. In this paper, the transverse-coupled cavity (TCC) scheme for boosting the bandwidth of VCSELs is demonstrated. The aperture is relatively small, leading to have a quasi-single mode operation. The measured results show that the 3-dB modulation bandwidth can reach 27 GHz, which is 3 times larger than a conventional VCSEL without optical feedback..

STRUCTURE

Figures 1 (a) and (b) show the schematic cross-section the top view of the fabricated TCC-VCSEL, respectively. The plump structure is the same as conventional 980 nm 3QW InGaAs/GaAs VCSEL. Lateral optical confinement is formed using an oxide layer and lateral bow-tie connection which leads to a leaky travelling wave in the lateral direction. The end interface functioning as a perfect mirror in the lateral direction makes the transverse optical feedback into the VCSELs. A several μm long feedback cavity is long enough for a few tens GHz spacing of photon-photon resonances thanks to slowing light. Proton implantation was carried out for the electrical isolation between the top two p-electrodes.

MEASUREMENT

Figure 2 depicts the measured small signal response of a TCC VCSEL with and without transverse feedback at the same injection current of 6 mA. It is shown that the injection current in the laser cavity enables us to control the phase and the amplitude for feedback light. Without the feedback of the coupled cavity, the bandwidth was clearly decreased to 9 GHz, which is in the same level of a conventional VCSEL. In our recent device control of the feedback phase and amplitude is not needed to go beyond 27 GHz. A 36 Gbps NRZ quasi-random large signal modulation was carried out as shown in Fig.3 under an optimal condition of feedback. An extinction ration is 4 dB.

CONCLUSION

A transverse-coupled-cavity VCSEL was PROPOSED FOR the bandwidth EXTENSION. The 3dB bandwidth was increased by a factor of 3 far beyond the relaxation oscillation frequency. Clear 36 Gbps eye opening was attained with an extinction ratio of 4 dB. 27 GHz 3-dB bandwidth was attained while the epi-structure and HAS not been optimized yet. Further increase in the bandwidth can be expected for new generation of high speed and low power consumption VCSELs for use in data-centers and so on.

REFERENCES

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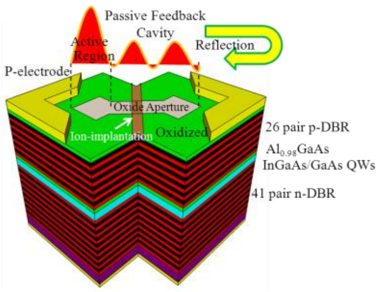
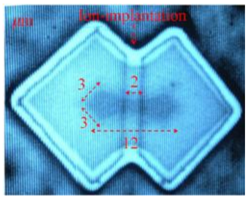


(a)



(b)

Fig. 1(a) Schematic cross-section and (b) the top view of the transverse coupled-cavity VCSEL.

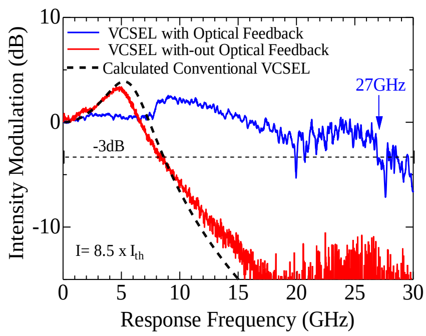


Fig.2 Measured small-signal modulation response of 980 nm transverse coupled cavity VCSEL.

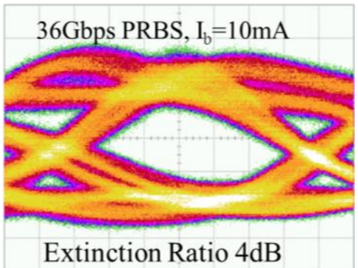


Fig.3 Measured eye pattern for TCC-VCSEL under the optimal condition of feedback cavity current for 36 Gbps PRBS with a 2^{31}-1 word length.