Enhancing the modulation bandwidth of double transverse coupled cavity VCSELs

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1. Introduction

VCSELs have the advantages of low cost, low power consumption, small footprint, wafer-scale testing, low-cost packaging, and ease of fabrication into arrays [1, 2]. Therefore, VCSELs are attractive light sources for use in data center networks and cost-effective radio over fiber (RoF) networks. VCSELs with bandwidth in the mm-waveband are required for Broadband RoF links to enable dense information transmission. For increasing the modulation bandwidth of VCSELs, Dalir and Koyama proposed a lateral OFB scheme of VCSEL with a transverse coupled cavity (TTC) and predicted 60% improvement in the small-signal modulation bandwidth of VCSELs [3, 4]. In this paper we present a VCSEL with a double-transverse-coupled-cavity (DTTC) for larger enhancement of the modulation bandwidth in the mm-waveband.

2. Theoretical model DTCC- VCSEL.

The proposed structure of the DTCC-VCSEL is schematically illustrated in Fig. 1. The VCSEL is laterally coupled with two external cavities through an oxide aperture

3. Results and discussions

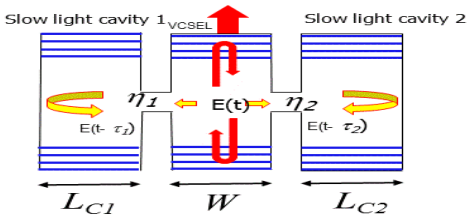

Fig.1. Schematic of double Transverse-coupled cavities VCS

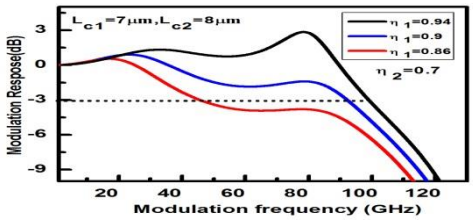

Fig. 2. IM responses when under different values of η_1.

We examine the IM modulation response of VCSEL by adding a second TCC to the TCC-VCSEL. First, we assume that the second TCC to be behind the VCSEL cavity, making it operating at fixed coupling ratio η_2, which is smaller than the coupling ratio of the first cavity η_1. Therefore, the PPR resonance peak is induced from the first coupled cavity of larger coupling ratio.

Figure 2 plots examples of the IM response of the DTCC-VCSEL with improved modulation characteristics at different values of coupling ratio η_1. In this figure, we fix the values of the lengths of the two coupled cavities as well as the coupling ratio η_2 of the second coupled cavity. The figure shows that when the $\eta_1 = 0.86$, the amount of OFB is not large enough to increase the PPR peak higher than the -3dB level, and the modulation bandwidth can be improved to 47 GHz due to the improvement of the CPR frequency only. The PPR results in a very weak peak around 92 GHz. The figure shows also that when the coupling ratio increase to $\eta_1 = 0.9$, the IM response does not drop below the –3dB level revealing another peak of -1.4 dB at the mm-wave frequency of f_m = 79 GHz, which is associated with improvement of f_{3dB} to 92 GHz. The figure shows also an interesting IM response under very strong OFB of $\eta_1 = 0.94$, where the mm-wave peak is more enhanced than the CPR peak and occurs at mm-wave frequency of ~ **100 GHz**. This IM response can be considered as a type of extended CPR resonance to the mm-wave region [5].

4. Conclusions

The transfer function of IM response in VCSELs can be tailored by double transverse coupled cavities, which exhibit a large enhancement in the modulation bandwidth by a factor ~ 4 comparing with VCSEL without OFB. The modulation bandwidth can increase beyond 100 GHz in the regime of very strong OFB.

References

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