High power, high speed pulse generation of VCSEL amplifier

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Abstract, Numerical and experimental investigation of VCSEL amplifier has been carried out to produce high power and short optical pulses for LiDAR application. Watt level and nano-second pulses can be obtained numerically by seeding small input power as mW. We experimentally demonstrated the small signal response of the fabricated devices.

Introduction

Vertical cavity surface emitting laser (VCSEL) is of great interest for many applications. Fast growing up in smart world and development technology gives VCSELs more attractive because of its advantages. Small cavity size of VCSELs makes it single mode and high beam quality but on other hand the power is low as the several millitwatts [1].

Boosting power to watt or even k-watt is main challenge of VCSELs to use in application like material processing, printing, sensing and free space communications.
Our group demonstrated VCSEL devices with unique advantages. This device based on exciting slow light mode in VCSEL waveguide. High power in watt-class obtained theoretically and realized experimentally [2,3]. Light can be steered non-mechanically with deflection angle more than 45° with narrow divergent beam less than diffraction limit [2]. This results confirm that this device is highly promising for using in automotive in industry based on LiDAR, imaging processing and many other applications.

In this paper we study the generation of optical pulses with high peak power and the width in nano-second suitable for future LiDAR applications.

Structure of the device

VCSEL amplifier has the same vertical structure as convention oxide-confined VCSEL as shown in fig.1. External from tunable laser coupled into slow light by tilted lensed fiber. Slow light radiates light through DBR mirror which optimized to enlarge radiation loss. Since the effective radiation length is limited to several microns because of high loss, the injected current is increased to compensate the loss and increase the radiation length. Increasing the current above threshold of vertical light keeps the radiation loss uniformly a long amplifier and allows to extend the length of amplifier into cm range [2,3]. Thanks to uniformity and coherently of radiation light, the beam with is sub angle and power of watt class can be achieved [2].

Results

The modulation response of slow light mode is measured by inject the modulated current in to VCSEL amplifier. Because of group delay of slow light, 3dB response depends on the length of amplifier. Figure (2) shows the response of two different lengths 0.5 and 5 mm. For 0.5 mm the response is around 12 GHz which mean short pulse with high speed repetition can be generated. By extending the amplifier to 5 mm the response dropped to 1 GHz, but still the high power and nanosecond pulse also can be produced.

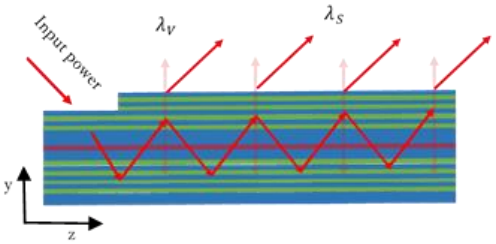

Fig. 1: VCSEL amplifier structure. Amplifier work above threshold. Vertical light λ_v and slow light λ_s.

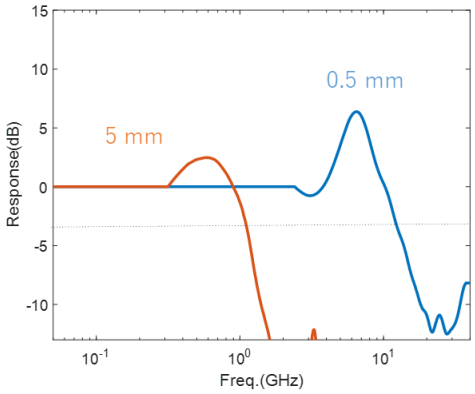

Fig. 2 Measured small signal response of VCSEL amplifier with different lengths.

References

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Conclusions

High peak power in short pulse width can be obtained. the pulse width limited by group delay of slow light. The experimental results have a good agreement with numerical analysis. This result shows that VCSEL amplifier is good candidate for LiDAR applications.