High peak power pulsed operations of VCSEL amplifier

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Abstract Nano-second pulses with high peak power obtained numerically by solving travel-wave equations of slow-light VCSEL amplifier. The pulse peak can be increased by extended the length of amplifier.

Introduction

Vertical cavity surface emitting laser (VCSEL) is always preferable light source for many applications. Fast growing up in smart world and development technology gives VCSEL a great interest because of its advantages. Small cavity size of VCSELs makes it single mode and high beam quality but on other hand power limited to several milliwatts [1]. Boosting power of VCSELs to watt or even killo – 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.

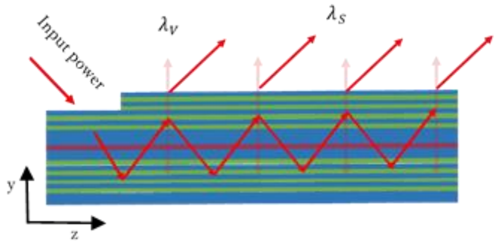

Fig. 1: VCSEL amplifier structure. Amplifier work above threshold. Vertical light λ_v and slow light λ_s.

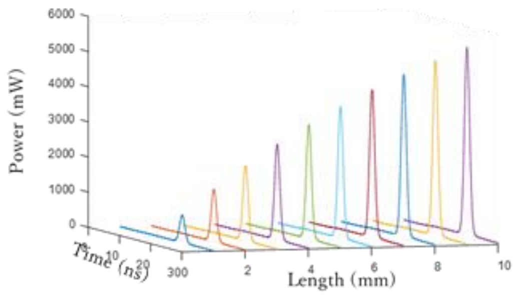

Fig. 2: output pulses at lengths from 1mm up to 10 mm. Current is 40 Ith and pulse width is 2ns.

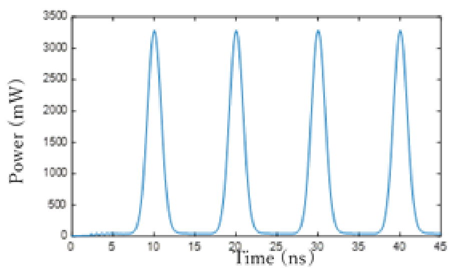

Fig. 3: output pulse with repetition frequency of 0.1 GHz for 5mm length amplifier.

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

Vertical lasing mode suppressed by input power coupled into slow-light mode. Threshold current increased when input power increased because of consuming of carrier density by slow light. To generate optical pulses, injection current is assumed to be pulses with pulse widths 2ns and amplitude of injection current is 40 I_{th}. Output pulse of slow light has same width as current pulse. Peak power increased by increasing the length of amplifier as shown in fig.2. The pulse width has low limit by group velocity of slow-light mode. Gain switching of VCSEL amplifier also can be used to generate shorter pulse width in pico-second.

Conclusions

High peak power pulses in watt level can be obtained. Almost 6.0 W obtained for 10 mm. Increase injection current and amplifier length increases the power to more than 10 W with nanosecond pulse width which is promising for LiDAR applications.

References

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