# InGaAsP/InP gain-levered tunable lasers

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**Abstract**

A tunable gain-levered laser is fabricated on an InGaAsP ridge waveguide, and demonstrates increased CW differential efficiency and sharp DC turn-on, with hysteretic characteristics. The devices can be directly modulated up to > 2.5 Gb/s.

## I. Introduction

Bistable laser diodes have been proposed for use in optical networks due to their enhanced differential quantum efficiency (DQE), signal regeneration properties, and even implementation of all-optical flip-flops[1]. Gain-levered lasers have demonstrated improved noise figure (NF) in passive microwave fiber-optic links[2]. Fabry-Perot ridge lasers with saturable absorber sections are one additional implementation and have demonstrated sharp DC turn-on characteristics[3].

In this work, we report on the implementation and performance of a gain-levered widely-tunable laser. The design utilizes a tunable sample-grating distributed Bragg reflector (SGDBR) laser [4] and splits the laser gain cavity into two electrically segmented sections. The gain-levered cavity yields high quantum efficiency and sharp turn-on. The SGDBR mirrors ultimately allow full C-band tunability from the vernier effect. The gain levered SGDBR may be particularly useful getting the most efficient modulation out of a limited photocurrent for optical wavelength converters[5].

## II. Gain levered SGDBR Laser Design

The device is illustrated schematically in Fig. 1(left) and consists of six sections with (from right-to-left) a SGDBR rear mirror, phase section, the QW cavity split into a 460 µm long section (gain) and a 90 µm long section (lever), a SGDBR front mirror and a 550 µm long output SOA. The device is fabricated with a common 1.4 Q InGaAsP waveguide, offset 1.55 µm QW for the amplifier, gain and lever sections, and a single blanket InP ridge regrowth. Details of the fabrication process are given in [5]. The output SOA is provided to boost the laser output power. Typical operation conditions are $I_{gain}$ = 50 mA, $I_{lever}$ = 5 mA, $I_{SOA}$ = 50 mA for $T_{subs}$ = 16ºC.

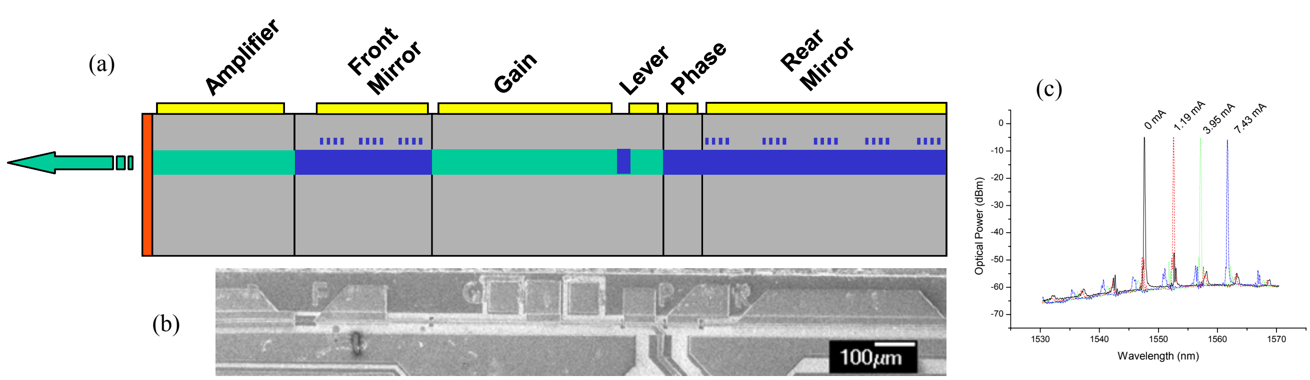
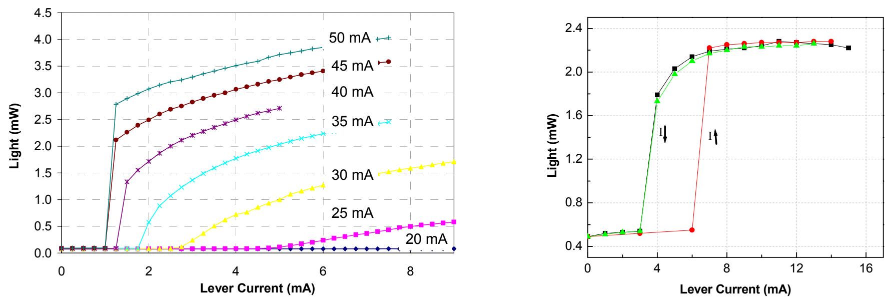



Figure 1. (a) Cross-section schematic of gain lever SGDBR (b) Top-down micrograph of fabricated device (c) optical spectra for as a function of rear mirror current.

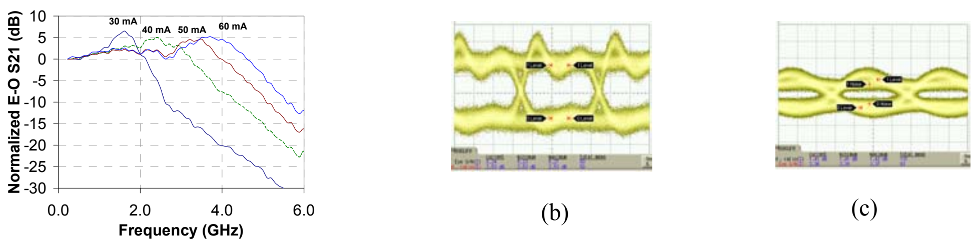
## III. Device Results

The optical spectra for various rear mirror currents are superimposed in Figure 1(c) showing ~15nm of tuning with >35dB side mode suppression ratio. Continuous wave room temperature light-lever current measurements were taken as a function of gain section current (Figure 2a). With separately biased gain and lever contacts, $I_{th}$ is reduced and slope efficiency at threshold is increased for increasing $I_{Gain}$. With shorted gain and lever contacts, threshold current ($I_{th}$) was 30 mA. The L-I curve also shows hysteretic effects (Figure 2b). Small signal modulation response was measured on un-terminated devices (Figure 3a). Although we see hysteretic behavior in the L-I curve, the modulation bandwidth is at least as good as a conventional laser produced by shorting the contacts, 5.0 GHz for $I_{gain}$ = 60mA and $I_{lever}$ = 8mA. The devices were digitally modulated at 2.5 and 5 Gb/s and demonstrated open eyes as shown in Figure 3b and c.




(a) (b)

Figure 2. (a) CW L-I data for gain-levered SGDBR with $I_{gain}$ as a parameter (1548nm emission, 30 mA $I_{SOA}$) (b) hysteresis L-I curve showing dependence of L-I on increasing vs. decreasing lever current (1548nm emission, 70 mA $I_{SOA}$).




(a)

Figure 3. (a) Small signal gain lever laser bandwidth with $I_{GAIN}$ as a parameter ($I_{SOA}$= 30mA, $I_{LEVER}$ = 8 mA) (b) 2.5 Gb/s NRZ eyes ($2^{31}$-1 PRBS, $I_{SOA}$= 30mA, $I_{GAIN}$ = 60mA, $I_{LEVER}$ = 11 mA, $V_{RF}$ = 1V ) (c) 5 Gb/s NRZ eyes ($2^{31}$-1 PRBS) (same conditions as b)

## IV. Conclusions

We have presented our design and the performance of a tunable gain-levered ridge laser. The gain-levered SGDBR tunable laser is fabricated on a robust InGaAsP waveguide, InP ridge process suitable for standard ridge lasers, and demonstrates increased differential efficiency and sharp DC turn-on characteristics. Small-signal RF bandwidth of 5 GHz and clearly open eyes at 2.5 Gb/s were demonstrated.

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## References


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