Widely tunable, photocurrent-driven wavelength converter for narrowband analog applications

L.A. Johansson[1], Y.A. Akulova[2], G.A. Fish[2] and L.A. Coldren[1,2]

[1] Department of Electrical and Computer Engineering, University of California, Santa Barbara, CA 93106.
Tel: (805) 893 2875, Fax: (805) 893 4500, Email: leif@ece.ucsb.edu. [2]Agility Communications, Inc.

Abstract: A widely-tunable photocurrent-driven, directly modulated wavelength converter is demonstrated for narrowband applications. Wavelength conversion RF gain up to 30 dB and spurious-free dynamic range up to 105 dB·Hz$^{2/3}$ are measured at 2.5 GHz.

OCIS codes: (190.2620) Frequency conversion; (140.3600) Lasers, tunable; (250.5300) Photonic Integrated Circuits

Summary

A widely-tunable, photocurrent driven optical wavelength converter for digital, broadband applications have been demonstrated using direct modulation of a sampled-grating DBR (SGDBR) laser, monolithically integrated with an optical receiver [1]. The overall performance of such device is ultimately limited by the requirement to produce sufficient photocurrent for various applications. One approach to increase the performance of photocurrent-driven wavelength converters is to trade-off bandwidth to modulation sensitivity in a resonated configuration.

In this work, a hybrid approach to achieve a wavelength converter for narrowband applications has been adopted using separate receiver and transmitter chips, as illustrated by the schematic of Fig. 1. The SG-DBR laser is integrated with an SOA and has >20mW output power and >40dB sidemode suppression ratio over >40nm tuning range [2]. The receiver consists of a bulk waveguide detector that can produce more than 70mA of linear photocurrent [3], also integrated with an SOA. The detector, with on the order of ~1pF total capacitance, was directly wirebonded by a ~5mm long bondwire (~1nH/mm) to the gain section of the SGDBR laser. Decoupled DC-biasing was achieved by separated, but AC-shorted ground planes.

The resulting optical-to-optical wavelength conversion frequency response is shown by Fig. 2. A resonantly enhanced peak is seen around 2.6 GHz with a 3dB passband of 370 MHz. The greatest signal gain occurs at around 40mA bias current when the resonance frequency of the directly modulated laser matches in frequency. It is estimated that the resonant configuration enhances the response by 20-30 dB, compared to using no resonance. Figure 3 shows the gain and spurious-free dynamic range (SFDR) of the wavelength converter as a function of gain section bias. The SFDR was measured by wavelength converting the output of two 1555nm DFB lasers, separated in wavelength by 60GHz and modulated at 2.505 GHz and 2.495 GHz, respectively, and detecting the 1547nm converted signal in a linear detector. The peak SFDR is 105 dB·Hz$^{2/3}$ and occurs away from peak conversion gain, due to worsened distortion at laser resonance. At higher gain section bias, the SFDR degrades due to non-linearities of the preamplified receiver, as higher photocurrent is needed to compensate for the reduced conversion gain.

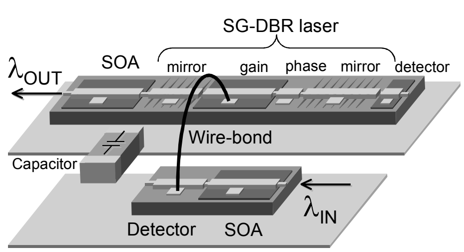

Fig. 1. Schematic overview of photocurrent-driven wavelength converter.

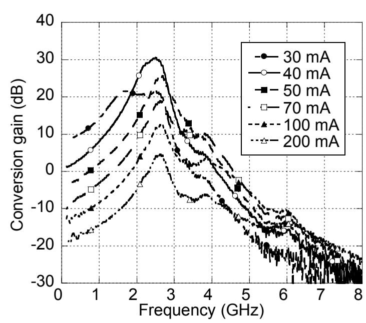

Fig. 2. Wavelength conversion RF frequency response for different gain section bias currents.

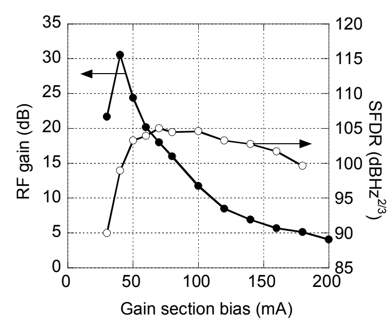

Fig. 3. Conversion gain and SFDR as a function of gain section bias current at 2.5 GHz.

References

1. J.M. Hutchinson, J.A. Henness, L.A. Johansson, J.S. Barton, M.L. Mašanović and L.A. Coldren, "2.5 Gb/sec wavelength conversion using monolithically-integrated photodetector and directly modulated widely-tunable SGDBR laser," *LEOS Annual Mtg. 2003, WU4.*
2. Y. A. Akulova, G. A. Fish, P. C. Koh, C. Schow, P. Kozodoy, A. Dahl, S. Nakagawa, M. Larson, M. Mack, T. Strand, C. Coldren, E. Hegblom, S. Penniman, T. Wipiejewski, and L. A. Coldren, "Widely-Tunable Electroabsorption-Modulated Sampled Grating DBR Laser Transmitter", *IEEE J. Selec. Top. in Quantum Electron.*, 8, 1349-1357, Nov/Dec 2002.
3. L.A. Johansson, Y.A. Akulova, G.A. Fish, L.A. Coldren, "High optical power electroabsorption waveguide modulator," *Electron. Lett.,* 39, pp. 364-365, 2003.