2.5 Gb/sec wavelength conversion using monolithically-integrated photodetector and directly modulated widely-tunable SGDBR laser

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Abstract: A novel monolithically-integrated tunable wavelength converter is presented. The wavelength converter provides >0 dBm output power, a tuning range of 20 nm and allows signal monitoring. Error free operation at 2.5 Gb/s with an NRZ 2^{31}-1 PRBS is demonstrated.

1. Introduction

Tunable wavelength converters represent a novel class of highly sophisticated photonic integrated circuits that are crucial in the function of future optical networks. They allow for the manipulation of wavelengths in WDM optical switches, routers and add/drop multiplexers. Many different implementation of non-tunable wavelength converters have been proposed using cross phase modulation in SOAs and fiber (XPM) [2,3], and cross absorption modulation(XAM) of SOAs [1]. Many of these architectures have been demonstrated to perform the significant feature of digital signal regeneration – including improvements in extinction ratio, signal to noise ratio, pulse width etc. Monolithically-integrated tunable all-optical wavelength converters (TAO-WC)[4] have been demonstrated and have shown promise to allow for the conversion of one wavelength to another without requiring the signal to pass through electronics.

In this work, a novel monolithically-integrated widely-tunable wavelength converter based on an optically pre-amplified waveguide photodiode receiver directly modulating a widely-tunable SGDBR laser transmitter is described. The integrated device allows signal monitoring, transmits at high speed, and removes the requirements for filtering the input wavelength at the output[4]. Integrating the SOA pre-amplifier, and laser SOA post-amplifier allows higher detector sensitivity, higher output power, and improved conversion efficiency. Integrating the SGDBR yields a compact wavelength agile source that requires only two fiber connections. This design ultimately provides a small footprint and low cost.

2. Wavelength Converter Design

The device (Fig. 1) uses a ridge-based SGDBR with laser design similar to the one described in [4,5]. An electrically pumped 300 μm SOA is provided on the laser output to boost signal levels and improve conversion efficiency. The receiver consists of a separate electrically pumped 500μm long SOA to boost input signal levels and a 100μm long quantum well photodetector to directly drive the gain section of the integrated SGDBR laser via an on-chip metal interconnect. Independent bias to the laser is provided through an off-chip bias-tee to the common laser-PD P-contact. An absorber section is on the back-end of the device for measurement of power, and to eliminate the requirement of the back-end anti-reflective coating. The outputs are angled to reduce the AR coating requirements. The total device chip size is 0.5mm x 2.5mm.

This design uses a common 1.4Q InGaAsP waveguide structure for both laser and photodetector sections grown on a semi-insulating Fe-doped InP substrate. The ridge waveguides for the photodetector and laser sections are electrically isolated by removing conducting semiconductor between the two ridges. Contacts to the n side of the diodes are provided by an N+ InGaAs layer underneath the quaternary waveguide material. The optically passive sections are formed by etching off the offset quantum wells down to the 10nm InP stop-etch layer prior to blanket InP regrowth. The process is similar to that described in [4,5].

3. Photodetector and laser characteristics

The quantum well detector in this wavelength converter offers high photocurrent generation at high optical input powers, necessary for direct laser modulation. Fig. 2(a) shows the photocurrent characteristics as a function of optical fiber input power and optical pre-amplifier bias current. The photodetector was biased at -4 V in order to provide 12 mA photocurrent at nominal 25 mW optical input power. Due to the flaring and angling of the waveguide and the use of lensed fiber, we experience approximately 5dB of coupling losses at the facet. The monolithically integrated laser can be tuned over a 20 nm wavelength range and demonstrates a threshold current of 34 mA (Fig. 2 b)

4. Wavelength conversion results

NRZ 2^{31}-1 PRBS 2.5Gb/s data was generated at an input wavelength of 1548.1nm using a 3 Gb/s BERT and Agilent 83433A transmitter. The converted signal from the integrated transmitter was fed into an Agilent 83434AA receiver. A typical eye opening diagram of the photoreceiver monitor, and converted light output at 1545 nm and 1565 nm are shown in Fig. 3. A 2.5 Gb/s BER of 10^{-9} was obtained for a receiver sensitivity of –15 dBm. The device was biased with the following currents. Gain section = 55mA at 1545 nm and 68mA at 1565nm, pre-amp SOA = 70mA, post-amp SOA = 50mA

5. Conclusion

We have demonstrated novel compact monolithically-integrated wavelength converter providing >0 dBm output power, a tuning range of 20 nm and error-free operation at 2.5 Gb/s.

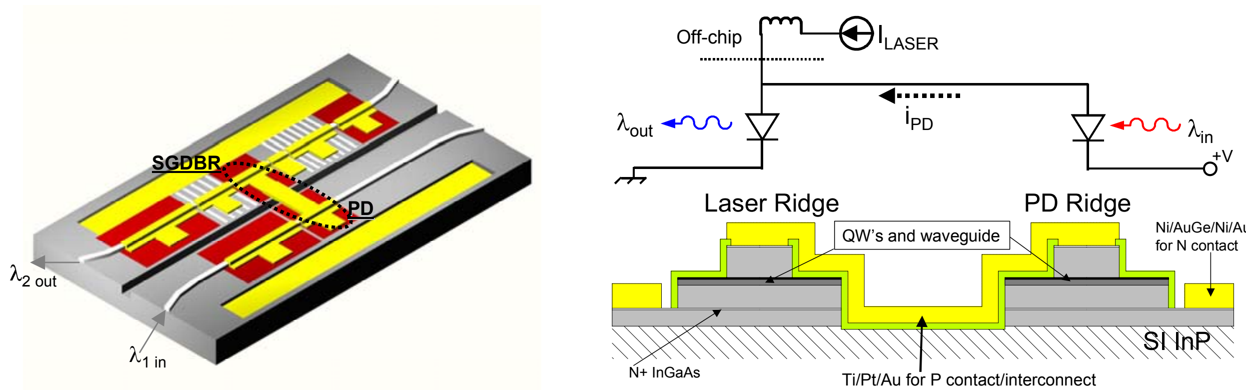

Figure 1 : Schematic of integrated waveguide wavelength converter (left), equivalent circuit and cross-section of circled area (right).

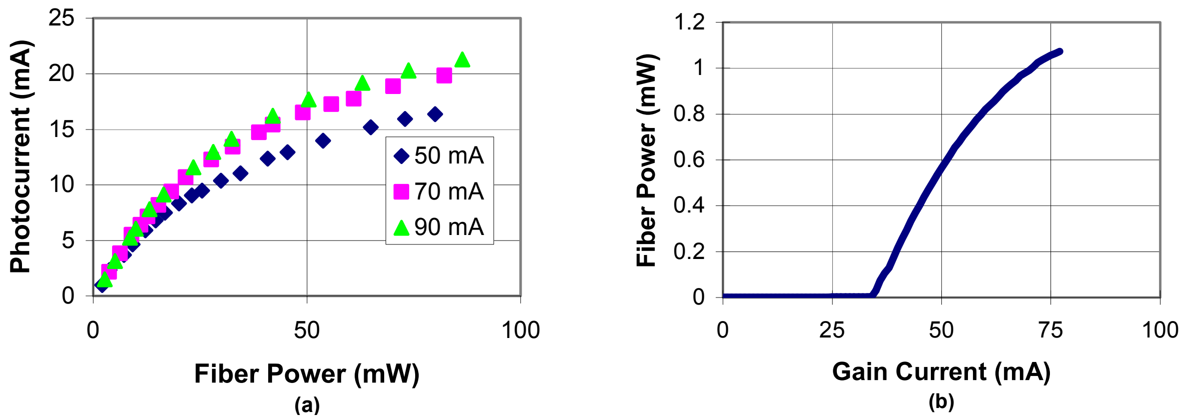

Figure 2 (a) Photodetector I-L DC characteristics at 1548.1nm as a function of pre-amp SOA bias current. (b) SGDBR-SOA L-I characteristics at 1545 nm (post-amp SOA = 50 mA)

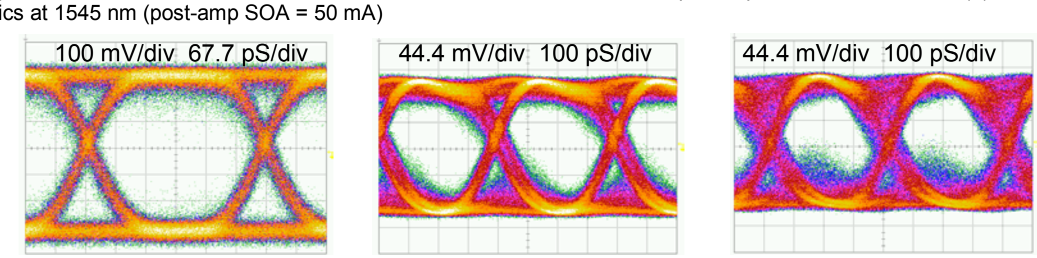

Figure 3 : 2.5 Gb/s eye opening of photodiode monitor signal, and wavelength converted output signal at 1545 nm and 1565 nm.

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