WAVELENGTH CONVERSION OVER A 50nm INPUT AND 21nm OUTPUT WAVELENGTH RANGE USING A MONOLITHICALLY INTEGRATED TUNABLE ALL-OPTICAL MMI-MZI(TAOMI) WAVELENGTH CONVERTER

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Abstract : *Power-efficient wavelength conversion over wide input and output wavelength span is reported using a novel, monolithically integrated SOA-MMI-MZI wavelength converter and SGDBR widely- tunable laser.*

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Introduction

One of crucial components needed for WDM optical switches, add/drop multiplexers and the future deployment of all optical networks is a monolithically integrated tunable all-optical wavelength converter. Tunable all-optical wavelength converters allow data to be transferred from an input wavelength to a tunable output wavelength without passing the signal through electronics. The semiconductor optical amplifier Mach-Zehnder interferometer (SOA-MZI) wavelength converter is an important class of integrated wavelength converters that work for both RZ and NRZ data formats while also acting as a 2R signal regenerator due to their nonlinear transfer function. InP integration of SOA-MZIs has been reported [1,2] and an SOA-MZI was integrated with a non-tunable DFB laser but with significant performance tradeoffs due to reflections from the MZI back to the laser [3].

More recently we have demonstrated what we believe to be the world's first monolithically integrated widely-tunable wavelength converter and its static operation. The design of that device was similar to the one used in this work [5].

Device Design and Fabrication

The wavelength converter consists of an InP SGDBR [4] laser integrated with a MZI (Figure 1). The laser is 1.5mm long and has five sections: front mirror, gain section, phase section, back mirror and back facet detector.

The interferometer branches are defined by a combination of two wide MMI 1x2 light splitters, straight waveguides and 1mm long SOAs (Figure 1). The input signal is coupled onto the chip through a tapered input waveguide, and then amplified by a 800 µm long input semiconductor optical amplifier. A 3dB MMI coupler is used to mix the data with the CW signal in one of the interferometer's SOAs. The total device length is 5.2mm.

Device is fabricated using our offset quantum well integration platform and details of the process are described elsewhere [4,5]. It is of importance to note that only one MOCVD InP regrowth is required to fabricate the device.

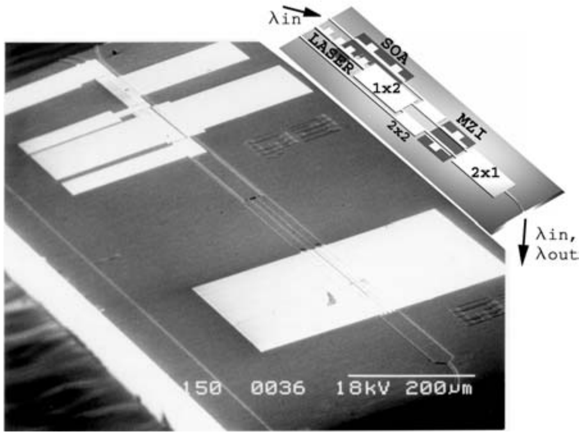

Figure 1 – Electron Micrograph of the Device

Experimental Results

Experiments were performed with the device soldered on a gold plated copper mount and cooled to 17°C using a thermo-electric cooler. Light was coupled to and out of the device using conical-tipped lensed-fibers mounted on piezo-controlled translational stages. The input signal was generated using a tunable laser source and modulated using a lithium-niobate electro-optic modulator. Then, the signal was amplified through an EDFA to constant power levels of approximately 14dBm before being coupled into the device. To obtain gain in the L-band, an additional spool of 60m of Er-doped fiber was used in line with our C-band EDFA for input wavelengths in the L-band. The data was generated using a BERT with NRZ 2^{31}-1 PRBS data at 2.5Gbps. The converted output wavelength was filtered using a 1.2nm thin-film tunable filter and detected with a PIN receiver. Average output power of -6dBm was measured at the receiver. Overlapped optical spectra of the on-chip laser over its 21nm tuning range are shown in Figure 2a). A typical electrical extinction of the device for high MZI-SOA bias currents is shown in Figure 2b). The gain peak of the SOAs was at 1555nm.

For the first set of measurements, data streams at 2.5Gbps from different input wavelengths were converted onto one device output wavelength (1571.5nm). BER curves and eye diagrams (Fig 2c))

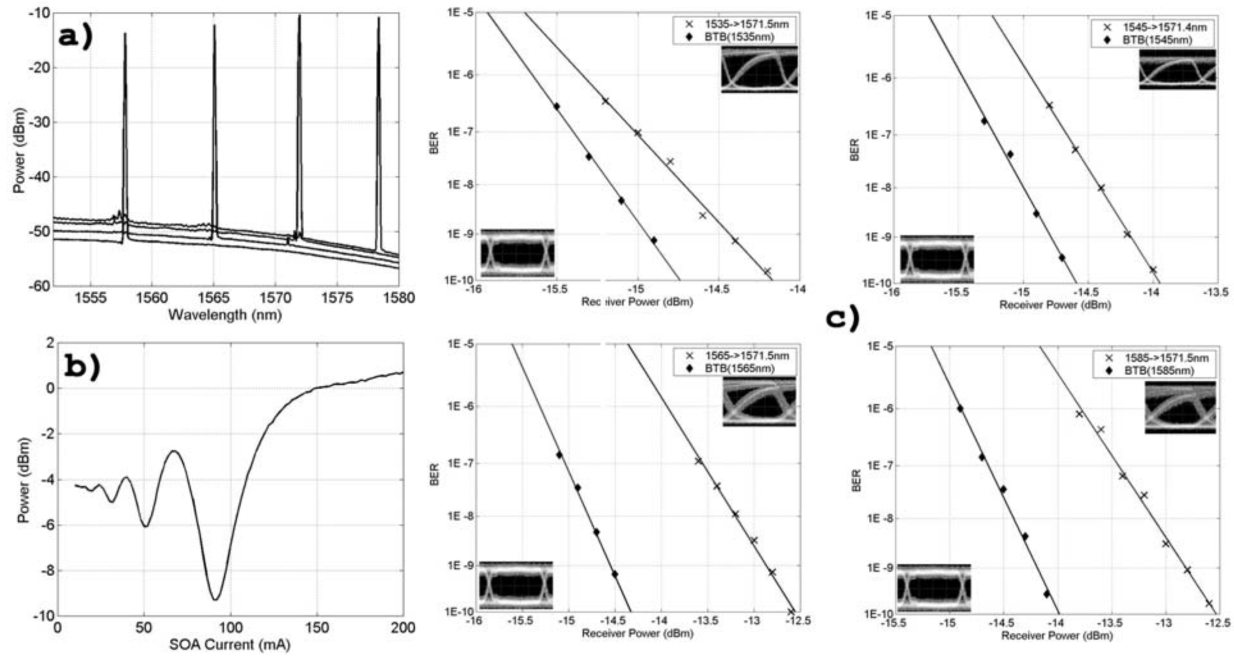

Figure 2 – a) Overlapped spectra of the device output wavelengths b) Typical electrical extinction curve for high SOA currents (SOA2 is biased at 200mA) c) BER results for conversion from 4 different input wavelengths

indicate error free operation over 50nm input wavelength range, with a maximum power penalty of 1.6 dB. While the upper limit of the input wavelength was set by cross-phase modulation degradation due to finite SOA gain bandwidth, the lower limit was set by the filters available to us (1535nm). We expect that error free conversion range extends over the entire C-band.

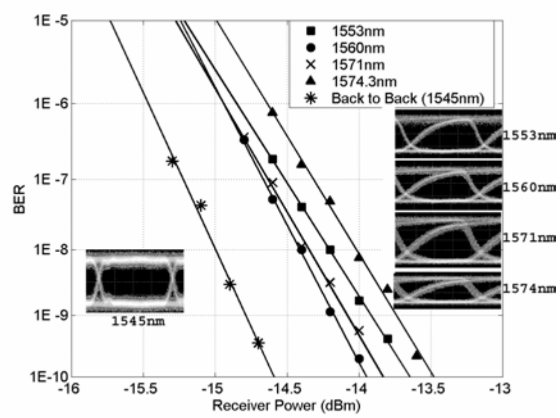

Figure 3 – BER results for conversion onto 4 device wavelengths

In the subsequent set of measurements, one input wavelength (1545nm) was chosen, and 2.5Gbps data were converted onto 4 different output wavelengths of the device (21nm range). Error free conversion was obtained with maximum power penalty of 1dB (Fig. 3). Increase in power penalty and eye noise for input wavelengths above 1565nm can be attributed, in part, to the input signal-to-noise ratio degradation due to our non-optimum L-band amplifier. This noise did not affect our back-to-back measurements, since those were performed without the EDFA. Another cause for power penalty increase in this wavelength range would be higher ASE noise levels as the laser is tuned away from the SOA gain peak.

The carrier dynamics in the SOAs is influenced, among other things, by bias current and optical power level in the SOA. Therefore, an optimized SGDBR design with higher output power and wider tuning range would further improve the device performance.

Conclusions

Wavelength conversion at 2.5Gbps over wide wavelength range (50nm input, 21nm output) was demonstrated using a novel monolithically integrated tunable MZI wavelength converter in InP. Conversion was error free, with maximum power penalty of 1.6dB. This device, with proper adjustments in laser design, could be used for wavelength conversion between L and C bands.

Acknowledgments

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