Demonstration of Regenerative Any λ_{in} to Any λ_{out} Wavelength Conversion using a 2-Stage All-Optical Wavelength Converter Consisting of a XGM SOA-WC and InP Monolithically-integrated Widely-tunable MZI SOA-WC

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Abstract – Demonstration of 2-stage wavelength conversion using SOA-XGM followed by XPM in a widely-tunable monolithically-integrated MZI SOA wavelength converter. Performance of the design at 2.5Gbps is reported exhibiting zero power penalty.

1. Introduction

All-optical tunable wavelength conversion is a critical function for next generation all-optical networks, with application to all-optical label swapping, wavelength translation, WDM optical switches, and add/drop multiplexers. Conversion between any input wavelength to any output wavelength (including same to same), digital signal regeneration, and low polarization sensitivity are enabling requirements for advanced all-optical packet routing, and are satisfied by 2-stage wavelength converter architectures. Previous work has demonstrated 2-stage wavelength conversion using an SOA and Michelson interferometer [1]. In this paper we present results of 2-stage wavelength conversion based on cross-gain modulation (XGM) in an SOA followed by cross-phase modulation (XPM) in a widely tunable monolithically integrated Mach-Zehnder Interferometer (MZI) SOA-WC [2]. This system acts as a 2R digital regenerator and allows any input wavelength within the gain spectrum of the first stage SOA to be converted to any wavelength within the tuning range of the integrated SGDBR laser of the second stage without the need for tunable filters. We demonstrate high extinction ratio (17.7 dB) and signal regeneration with zero power penalty.

2. Concept and Experimental Setup

The wavelength converter shown in Figure 1 consists of two stages. The first stage utilizes the XGM effect in an SOA to perform wavelength conversion from any input wavelength λ_{in} to a fixed internal wavelength λ_{int} via down conversion, which is the optimal type of conversion for XGM in SOAs. The polarization state and intermediate wavelength can be optimized for conversion in the second stage. The second stage consists of an InP SGDBR laser integrated with an SOA-MZI WC [3]. An SEM image of the tunable all-optical wavelength converter (TAO-WC) is included in Figure 2. Incoming data at the fixed wavelength λ_{int} enters the chip through an input amplifier and is combined with CW light from the on-chip SGDBR laser in one branch of the interferometer. This induces XPM of the SGDBR generated light, transcribing the data to the new wavelength, λ_{out} set by the integrated laser. Details about the device design and performance may be found in [3].

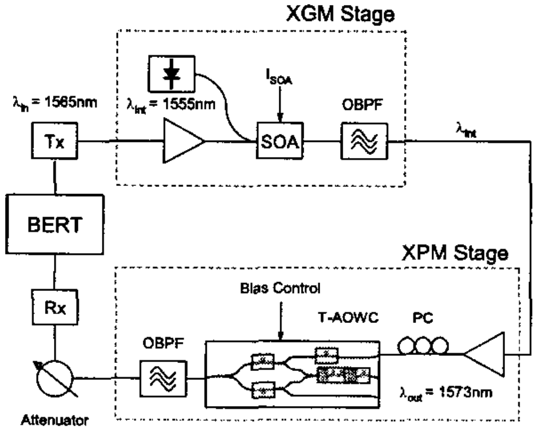

Figure 1. 2-Stage Wavelength Converter

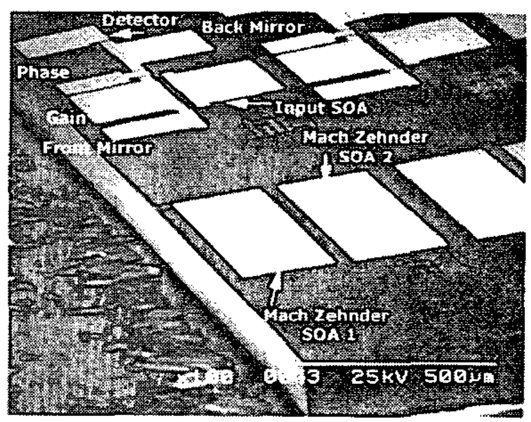

Figure 2. SEM image of tunable all-optical wavelength converter (TAO-WC)

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3. Results and Discussion

Performance through the 2-stage WC was characterized at 2.5 Gbps. The input electro-optic modulator in the transmitter was biased to provide highest extinction. The first-stage SOA was biased at 133 mA and driven in saturation to effect XGM. The input wavelength was 1565 nm at a power of 8.8 dBm and further amplified by an EDFA. The internal wavelength was 1555nm at a power of -10 dBm. Both wavelengths were coupled together and sent through the first-stage SOA and an optical bandpass filter centered at λ_{int} to filter the converted signal and reject the input wavelength. The data at the internal wavelength was then subsequently sent through an EDFA and the integrated wavelength converter. The input wavelength range into the TAO-WC spans 50 nm, covering both C and L bands, while the output wavelength from the SGDBR laser on the integrated WC can be tuned over 22 nm in the L-band and was set to 1573 nm, with a maximum output power of 4 dBm. The TAO-WC MZI's bias currents were optimized for maximum extinction ratio in the inverting mode of operation. The wavelength converted signal from the TAO-WC was filtered with a 1.2 nm optical BPF and the internal wavelength was rejected. BER measurements were performed on the XGM and XPM wavelength-converted signal and are shown in Figure 3. Receiver sensitivity of -17 dBm was achieved without optical preamplification in the receiver. The 2.5 dB power penalty due to XGM can be attributed to the reduced extinction and addition of ASE noise from the SOA. Measured eye diagrams are also included illustrating the extinction ratio degradation of the XGM process as well as extinction ratio and noise improvement of the 2-stage process.

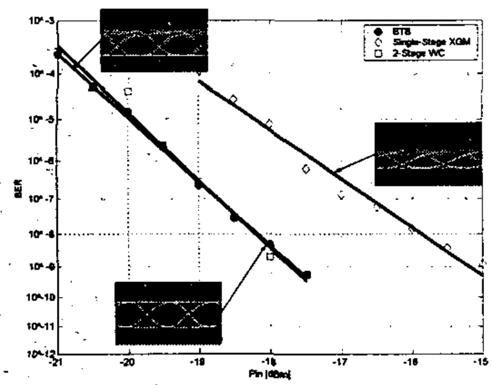

Figure 3. BER measurement and eye diagrams for each stage of wavelength conversion

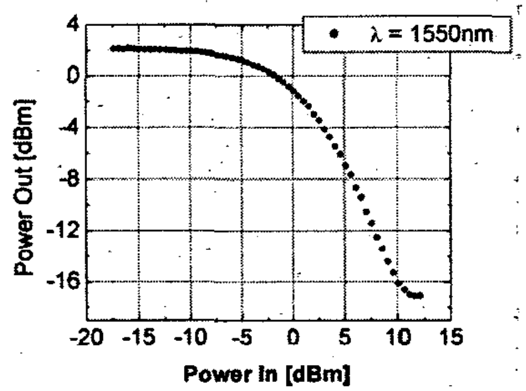

Figure 4. TAO-WC nonlinear transfer function

Regeneration in the XPM stage is due to the nonlinear transfer function of the TAO-WC, as seen in Figure 4 for the inverting mode of operation. The high slope of the transfer function improves the ER from 10.7 dB after the XGM stage to 17.7 dB after the XPM stage. The extinction ratio of the device can be improved further by decoupling the phase and gain control in each arm of the MZI [3]. Nonlinear thresholding of the incoming data also provides noise suppression and improves SNR.

4. Conclusion

Any λ_{in} to any λ_{out} wavelength conversion has been successfully demonstrated in a 2-stage converter using a XGM-based wavelength conversion in an SOA and XPM-based wavelength conversion in a monolithically-integrated widely tunable MZI-SOA wavelength converter. Wavelength conversion over a wide tuning range, as well as signal regeneration are clear benefits seen from the integrated XPM SOA-MZI structure used in the second stage.

5. Acknowledgments

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