Error-Free Kerr Comb-Driven SiP Microdisk Transmitter

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Abstract: We demonstrate the first SiP microdisk modulated Kerr comb source with BER better than 1E-9 up to 16 Gb/s/λ. The modulated lines span 44.3 nm bandwidth, paving the path to a comb-driven integrated SiP transmitter.

1. Introduction

The growing demand for bandwidth in high performance computing and data center systems will require silicon photonic (SiP) chip-based interconnects for future on-board and co-packaged solutions to meet the required energy-per-bit and bandwidth density metrics. On-chip silicon microresonator-based modulators operating in depletion-mode have shown particular promise due to their inherent wavelength selectivity, small device footprint, large bandwidth, and CMOS-compatible drive voltages [1]. Furthermore, many microresonators can be cascaded on a single bus with different operating wavelengths, providing a natural platform for wavelength division multiplexing (WDM) applications [2].

Microresonator-based Kerr frequency combs are a promising compact integrated source for WDM applications [3]. In particular, Kerr combs operating in the normal group velocity dispersion (GVD) regime have been shown to produce a flatter spectrum, higher pump-to-comb conversion efficiency, and higher power per line when compared to soliton Kerr combs operating in the anomalous GVD regime [4]. Prior demonstrations of data transmission with Kerr comb sources have been limited to using bulk telecom components for modulating, filtering, and receiving each wavelength channel [5–8].

Here, for the first time, we demonstrate error-free transmission up to 10 Gb/s/λ and better than or equal to a bit error rate (BER) of 1E-9 up to 16 Gb/s/λ using a Kerr comb source with a SiP transmitter chip. We show error-free operation for comb lines spanning over 44.3 nm of spectral bandwidth in the C- and L-bands, enabling a new class of SiP interconnects which take advantage of the many distinct WDM channels provided by Kerr combs to allow for extreme scaling in the wavelength domain.

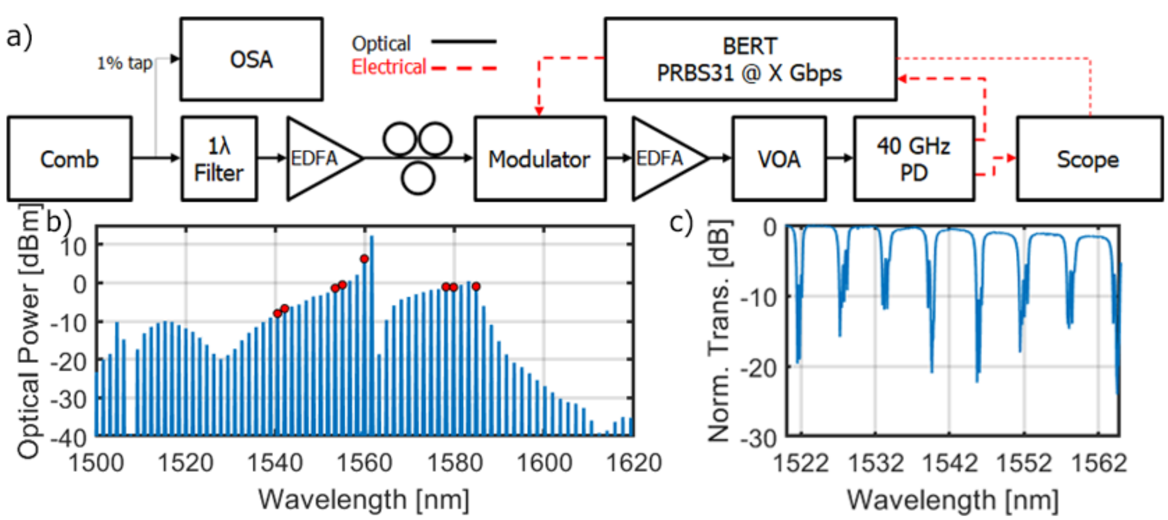

Fig. 1. a) Experimental setup to modulate individual comb lines and measure BER. A fiber polarization controller is on the modulator input side to optimize TE light into the modulator bank chip. b) Measured comb spectrum in the mode-locked state. λ_{pump} = 1561.5 nm, channel spacing ≈ 202 GHz, with 30+ lines with power greater than -10 dBm. Red markers signify modulated lines. c) Normalized transmission spectrum of the microdisk modulator bank.

2. Experimental Setup & Results

Fig. 1a shows a block diagram of the experimental setup. The optical spectrum is generated from a dual-ring Kerr comb source, described further in [4]. The measured comb spectrum used in these experiments can be seen in Fig. 1b. A single line is selected for modulation and then amplified before coupling into the on-chip microdisk modulator bus. The chip was fabricated through AIM Photonics' 300 mm multi-project wafer service and the bus comprises of a waveguide with 20 AIM Process Design Kit vertical junction microdisk modulators, with 5 modulators per nominal design wavelength. The C band transmission spectrum for this channel can be seen in Fig. 1c, which shows the overlapped resonances at each nominal wavelength.

The bit error rate tester (BERT) generates a high-speed signal repeating a pseudorandom binary sequence 2^{31}-1 bits long (PRBS31), connected to the modulators via high bandwidth electrical RF probes. After modulation, the optical signal couples back into fiber and is amplified again before going through the variable optical attenuator (VOA). Finally, the attenuated optical signal is received by a differential output 40 GHz photodiode (PD). The inverted signal eye is monitored on a sampling oscilloscope, while the non-inverted signal is sent back to the BERT to measure the BER.

We select 8 comb lines for modulation over the C- and L-bands. The lines selected are denoted in Fig 1b with red markers at their peaks. Fig. 2 shows the measured BER vs received optical power for each of the 8 modulated lines at 10 Gb/s and 16 Gb/s.

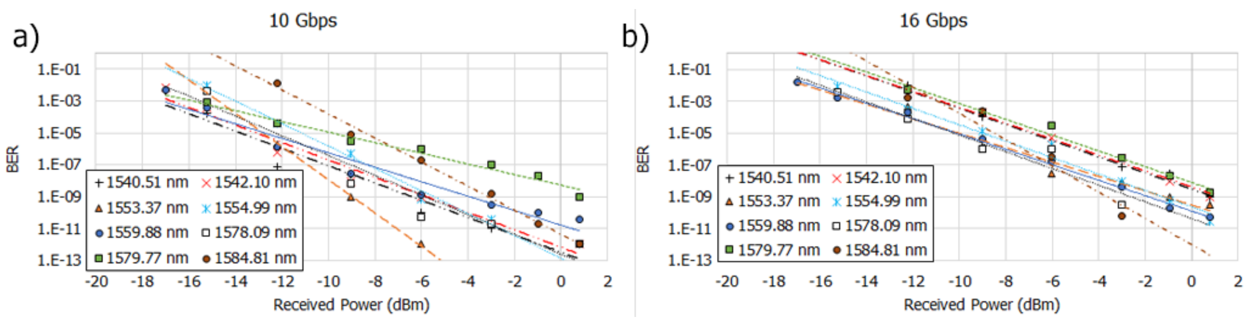

Fig. 2. Measured BER (markers) and fit curves (lines) using microdisk modulators on the bus to modulate comb lines. a) At 10 Gb/s all but one line can achieve BER = 1E-12 or better, which we consider to be error-free. b) At 16 Gb/s all lines can achieve BER = 1E-9 or better.

4. Conclusion

This is the first demonstration of error-free transmission up to 16 Gb/s/λ using a Kerr comb source with a SiP transmitter chip. Additionally, this performance was demonstrated over 44.3 nm optical bandwidth of the Kerr comb source, encompassing 30 lines. Scaling from the performance of the 8 sampled lines, we show potential for at least a 480 Gb/s comb-driven fully integrated SiP transmitter.

Acknowledgements
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