Concurrent Error-Free Modulation of Adjacent Kerr Comb Lines on a Silicon Chip

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Abstract: We demonstrate the first error-free simultaneous modulation of multiple Kerr comb lines with cascaded SiP microdisk modulators. Data rates up to 20 Gb/s/λ are shown, supporting the feasibility of Kerr comb-driven SiP DWDM transmitters.

1. Introduction

With the exponential growth of high performance computing and data traffic within data-centers, optical interconnects must be used to meet the bandwidth and energy per bit requirements of future exascale systems. Silicon photonics (SiP) provides a promising platform for optical interconnects because of its high bandwidth, low power consumption, small footprint, and complementary metal-oxide-semiconductor (CMOS) compatibility [1]. On-chip SiP resonator-based devices have shown promise in providing a platform for dense wavelength division multiplexing (DWDM), because many resonators, operating at different wavelengths, can be cascaded on the same bus [2].

Early demonstrations of data transmission using Kerr frequency comb sources were limited to bulk telecom components for modulating, filtering, and receiving individual frequencies [3, 4]. However, recent studies have shown error free Kerr-comb driven SiP transmitters, modulating individual comb lines at data rates up to 16 Gb/s/λ using cascaded microdisk modulator (MDM) arrays [5, 6]. These and other recent demonstrations have been limited to modulating a single carrier frequency at a time, and extrapolating performance across the spectrum. In this work, we show the first ever demonstration of multiple Kerr comb lines modulated simultaneously with an array of cascaded MDMs on a single bus.

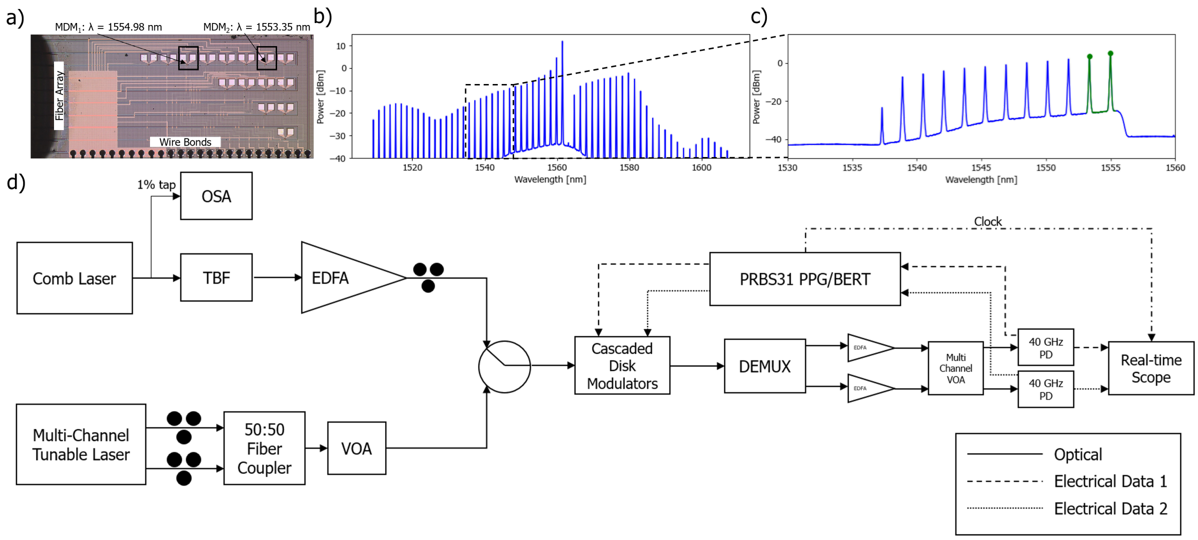

Fig. 1. a) Microscope image of PIC with cascaded MDMs. b) Full comb spectrum spanning over 100 nm, with a channel spacing of 200 GHz. c) Filtered and amplified comb spectrum; the right most lines ($\lambda_{1,2}$ = 1554.98 nm and 1553.35 nm) are modulated, with an additional 10 lines within a single MDM FSR ($\approx$ 25.6 nm). d) High level block diagram of experimental setup (VOA is used to match tunable laser power to comb line powers for equivalent measurements).

2. Experimental Setup and Results

Figure 1d shows a high level block diagram of the experimental setup. Initially, a two λ source, matched in wavelength and power per line to known comb source lines, is generated using a multi-channel tunable laser source, 50:50 fiber splitter, and VOA. This comb-matched DWDM source is coupled into our packaged photonic integrated circuit (PIC) containing an array of 8 cascaded AIM PDK microdisk modulators [1].

Once aligned to respective wavelengths using the integrated heaters, a PPG/BERT generates a PRBS31 signal which is sent to the MDMs via high bandwidth RF electrical probes. The optical signals are then demultiplexed using a multi-channel programmable optical filter, amplified, attenuated, and converted back to an electrical signal using 40 GHz differential output photodetectors. The inverted signal eye is monitored on a real time oscilloscope, while the non-inverted signal is sent back to the PPG/BERT to directly measure bit error rate (BER).

After testing using the tunable laser, the filtered and amplified comb laser is coupled into the PIC. Though two lines are modulated, 10 additional comb lines are sent into the MDM array and later filtered out using the demultiplexer, further validating this approach for scalable DWDM. Figure 2 shows the resulting BER as a function of optical power at various data rates from both sources. The measured BER values show simultaneous modulation using an integrated Kerr comb source with 200 GHz-spaced adjacent channels at data rates up to 20 Gbps. Modulation at 10, 16 and 20 Gbps yielded BERs on the order of 10^{-12}, 10^{-10} and 10^{-7}, respectively. Interestingly, we were unable to resolve BER values for the CW source at 20 Gbps despite being able to do so for the comb source, indicating that the generated comb lines may possess superior noise properties.

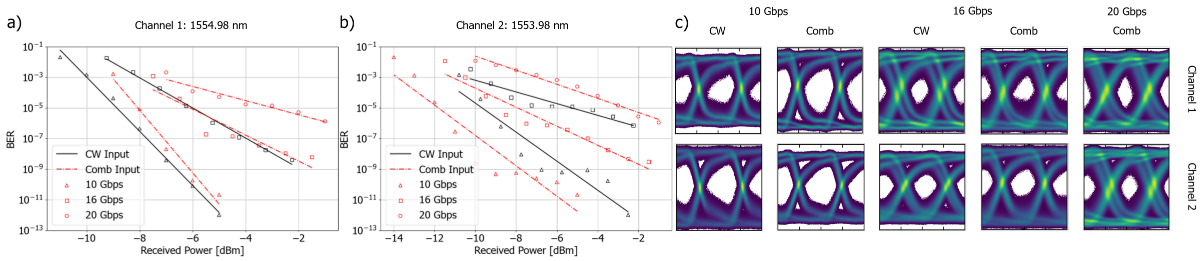

Fig. 2. a) BER vs. Received power for channel set to $\lambda = 1554.98$) b) BER vs. Received power for channel set to $\lambda = 1553.35$ nm c) Corresponding eye diagrams for both CW and Comb lasers.

3. Conclusion

To the best of our knowledge, this demonstration represents the first time that multiple lines from an integrated Kerr frequency comb were simultaneously modulated using an on-chip resonator-based transmitter. This demonstration solidifies the efficacy of Kerr frequency combs as true DWDM sources for future co-packaged silicon photonic interconnects with multi-Tb per fiber bandwidths and sub-pJ/b energy consumption.

Acknowledgments

This work was supported in part by the U.S. Advanced Research Projects Agency–Energy under ENLITENED Grant DE-AR000843 and in part by the U.S. Defense Advanced Research Projects Agency under PIPES Grant HR00111920014.

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