APPLICATION CASE STUDY

OptSim Circuit

Travelling-Wave Mach-Zehnder Modulator (TW-MZM) PIC and Impact of Silicon Photonic Foundry Process Variations

Overview

Information about overall yield of a PIC is of utmost importance from commercial perspective. Wafer-to-wafer (WFW) and run-to-run (RTR) variations in the multi-project wafer (MPW) runs have direct impact on the yield. This OptSim Circuit application case study examines estimation of foundry yield for a travelling-wave Mach-Zehnder modulator-based transmitter PIC.

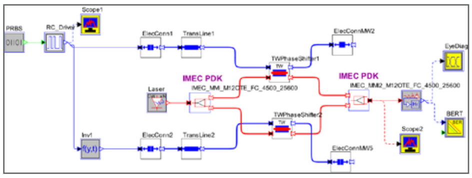

Figure 1: OptSim Circuit topology of TW-MZM

The Challenge

One of the bottlenecks in current high-speed fiber-optic systems is lack of efficient modulators that can support data rates of 40 Gbps and above. To achieve wider bandwidths, travelling-wave electrodes are required in the MZM design. The performance of the TW-MZM depends on the matching between the effective index of the optical waveguide and the electrical transmission line. For efficiency, speed and power consumption reasons, these electrodes require impedance and velocity matching, as well as low loss. The traveling wave nature of the modulator makes it sensitive to reflections due to impedance mismatch in the traveling wave electrodes. This case study focuses on the performance impairments due to the impedance mismatches arising from the wafer-to-wafer (WTW) and run-to-run (RTR) variations in the silicon photonic foundry processes.

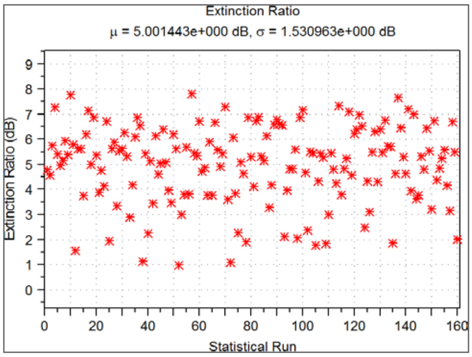

Figure 2: Distribution of extinction ratio

The Solution

OptSim Circuit simulations take into account the stochastic variations in component and process parameters for performing Monte Carlo runs to obtain performance bounds. Figure 1 shows the OptSim Circuit topology of the TW-MZM using IMEC foundry PDK elements for the photonic components, and transmission line elements for the RF electrodes. A back-to-back receiver is used to estimate the performance of the transmitter chip. The travelling wave nature of the modulator makes it sensitive to reflections due to impedance mismatch in the travelling wave electrodes. This application case study focuses on the performance impairments due to the impedance mismatches as a result of WTW and RTR variations at the foundry. Figure 2 shows the effect of the impedance between the electrode and the load on the modulator's extinction ratio as measured from the optical eye at the modulator. The extinction ratio varies from as low as 1 dB to as high as 8 dB. Figure 3 shows the impact in terms of back-to-back bit-error-rate (BER).[1]

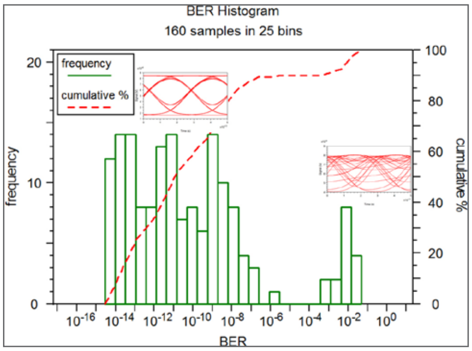

Figure 3: Distribution of back-to-back BER

As this case study demonstrates, it is important to take into account tolerances in the fabrication process, since it not only helps photonic foundries estimate the yield, but also helps system and chip designers understand the performance bounds.

1 J. Patel, E. Ghillino, C. Xu, D. Herrmann, and E. Heller, "Silicon photonic foundry processes and travelling-wave Mach-Zehnder modulators," Novus Light Technologies Today, Nov. 2015, http:// www.novuslight.com/silicon-photonic-foundry-processes-and-traveling-wave-mach-zehndermodulators_N4838.html

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