Optical Waveguides and Photodiodes in 0.18µm CMOS SOI with No Post-processing

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Why CMOS for optics?

CMOS technology is one of the most important factors that lead to the blossom of the electronic industry. If the photonics industry can utilize the highly-mature CMOS platform, we could have:

1. Reduced cost for photonics components
2. Seamless integration of the photonics and electronics parts
   - Even lower cost
   - Higher performance
3. New applications previously thought impossible

However, there are several major challenges:

1. CMOS is highly optimized for electronics, but not necessary for photonics.
2. The designers do not have any control over the process, and may not be aware of the process details.
3. There are thousands of strict design rules to obey.

1550nm Waveguides

Previously reported waveguides implemented in CMOS technology either needs to change the process or requires post-processing to reduce the loss. Otherwise the waveguide loss could be higher than 500dB/cm.

In this work, the 1µm buried oxide suppresses the leaky modes, hence reducing the waveguide loss. Therefore, no post-processing is needed. The implemented waveguides utilize both active Si and Poly Si as the waveguide core, with a cross-section dimension of approximately 300nm by 400nm.

The fitted waveguide loss is 37dB/cm, representing the lowest loss ever achieved in CMOS waveguides without any post-processing or process tuning.

Potential causes for the waveguide include:

- The use of Poly Si as part of the waveguide core.
- The edge roughness.

Photodiode layout study

In this work we use IBM 7RF/SOI process. Here is the highlight for this process:

- 180nm technology node
- 4 metal layers
- 1µm thick buried oxide
- 1.5V core $V_{DD}$

During the design, in order to fulfill design rules while improve component performance, we have:

- Carefully added dummy metal structures.
- Blocked silicide doping and metalization above waveguides.

No post-processing is used!

850nm Photodiodes

Compared to photodiodes implemented in bulk CMOS process, photodiodes in CMOS SOI process have larger bandwidth inherently, because the buried oxide layer blocks the slow diffusion current generated deep in the substrate.

Two factors will affect the bandwidth of a photodiode:

1. The extrinsic bandwidth, limited by the RC time constant.
2. The intrinsic bandwidth, limited by the carriers transit time.

While there are many circuit techniques to improve the extrinsic bandwidth, not to much can be done with regard to the intrinsic bandwidth. Therefore, the intrinsic bandwidth usually represents the ultimate speed limit of a photodiode.

We have implemented photodiodes with different dimensions: 50µm by 50µm and 10µm by 10µm. They would differ in extrinsic bandwidth because of different capacitance, but will have identical intrinsic bandwidth.

Apparently, the small photodiode have much larger bandwidth. This means the intrinsic bandwidth of the photodiode should be at least 9.2GHz. This is the highest bandwidth ever achieved in CMOS photodiodes.

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