Silicon photonics becomes more flexible with the first monolithic photodetectors that can be used with wire waveguides

A monolithic silicon photodetector that could be used at low cost on a variety of silicon photonics platforms has been presented by researchers from McMaster University working with Wilfrid Laurier University in Canada. The detector is compatible with wire waveguides which could benefit many silicon photonics applications.

**Touching base**

The field of silicon photonics using the silicon-on-insulator (SOI) platform has been strongly driven by the need to replace the short-scale metal interconnects in optical communication systems. Server-to-server optical links are now starting to emerge, and in the future we should see fully integrated on-chip links connecting cores within a CPU.

Optical biosensors are another application that makes use of the silicon photonics platform. These devices use SOI waveguides to provide a low cost and compact system for molecular detection in a liquid solution in which the waveguide is immersed.

Depending on the application, two different geometries of SOI waveguide are used to realise silicon photonics devices. A wire waveguide, in which the silicon layer is etched to the buried oxide, is easier to fabricate but is more difficult to integrate with electronics as dopants and metal contacts in the vicinity of the waveguide disrupt the optics. A rib waveguide, which uses a shallow etch that does not reach the buried oxide, keeps the electronics at a safe distance but introduces an extra dimension to control during fabrication.

**All-in-one**

Silicon photonic biosensors are more effective when based on the wire waveguide layout, as a larger fraction of the optical field is located outside the silicon, allowing a larger contrast in refractive index. The monolithic silicon photodetectors that have been achieved previously, however, consist of a pin photodiode created across the rib waveguide geometry. This is because the p- and n-doped regions have a high optical loss and therefore need to be located in the shallow etched region of the rib waveguide.

A common solution to enable the use of wire waveguides is a hybrid material platform in which germanium or III-V semiconductor materials can be integrated onto any geometry of SOI waveguide. The necessary electrical contacts are made in the extra material leaving only optical functionality in the silicon, and this option offers the highest performance.

With a single molecular biosensor chip containing many individual single-use sensors, however, a low fabrication cost is critical. The McMaster University team have made progress towards this by being the first to create a monolithic silicon photodetector that can be used with a photonic wire waveguide. They had previously demonstrated silicon infrared detectors in which the optical absorption is increased by the introduction of lattice defects by ion implantation, and in their Letter in this issue they show how they have optimised them so that they can be incorporated in the etched slab region of the SOI.

“In a standard rib waveguide with a pin photodiode, the waveguide confines the light,” said Jason Ackert, one of the researchers from McMaster University. “In our detector structure there is high loss from the p and n doped regions and low confinement of light, meaning the device is most suited as a terminal detector. But these two disadvantages are balanced by the flexibility provided by the straightforward design.”

As well as being within one layer of silicon, the team have also designed their detector with features no smaller than 1 micron, which allows for a higher tolerance in fabrication and a lower cost. The large features and compatibility with a wire waveguide make this detector design very attractive for cost sensitive applications.

**A standard approach**

The McMaster team are continuing to develop their monolithic silicon photodetectors and other devices for optical interconnects such as modulators. There are still some big challenges to be overcome, however, to bring these devices into the mainstream.

“One thing that might not be apparent to those outside the field, is that there are not yet industry standards for silicon photonics as there exists for CMOS electronics,” said Ackert. “What will be beneficial to the field is more silicon foundry services being offered. This will allow designers to take advantage of a set of common processes that can speed up device and product development.”