High throughput testing for photonic chips

Photonic integration technology is on the verge of breaking through to large-scale production. But to be able to guarantee the quality of photonic integration circuits, tests that enable high throughput process control are essential. At the Photonic Integration group of the department of Electrical Engineering, PhD student Dzmitry Pustakhod developed high throughput, high quality testing methods for different levels in the production process.

In the semiconductor industry, standardized, automated testing procedures are applied to guarantee the quality and performance of the produced electronic circuits. For photonic circuits, the development of similar process control modules is more challenging. Electronic contacts have a large contact area, and can be found on top of the chip. Their optical counterparts are often only accessible from the side of the chip, so the wafer should be cleaved. And the access areas typically range from 10 micron to submicron dimensions.

As part of the NWO-TTW project ProCon, Dzmitry Pustakhod developed new methods to provide foundries with the means to test performance of the individual photonic building blocks and complete photonic circuits in a fast, detailed and reproducible way.

High level functional testing
'Before this project started, there were some testing methods available already,' Pustakhod says. 'But most of them are slow, hard to operate and require manual operation or inspection. Also the vast majority of the previously available testing methods was aimed at detecting low level errors in for example material properties or geometry. We focused on higher level functional testing on different levels,' he explains. 'Usually, foundries can only test individual building blocks and low level processes. But they cannot measure circuits. Customers on the other hand can only measure circuits, and don't have any insights in the separate building blocks. We wanted to correlate those two, to identify if a problem in performance is caused by the circuit design, or by the fabrication process.'

On a components level, Pustakhod developed methods to measure gain and absorption. 'Some of the challenges were which method to choose to get accurate data in a fast and reliable way, and how to design and develop the setup to actually perform the measurements. Furthermore, for the absorption measurements, we first had to gain full understanding of the behavior of the circuit to be able to interpret the spectra we were measuring.' This worked out well, and finally, he was able to model and calculate the expected absorption, and measure it reliably.

On a circuit level, a very sensitive, small-sized multi-wavelength meter was developed that is able to measure wavelengths with a resolution of 0,32 picometer (a millionth of a millionth of a meter), over a range of 10 nanometer. 'To our knowledge this is the best relative resolution currently available for these types of systems. Therefore our method can also be relevant for sensing applications.'

Toward automated testing
All of the methods Pustakhod developed so far have been implemented in the standard practice of the PhI lab. 'With these methods, we can compare different fabrication processes or different wafers processed in the same foundry and get quick and reliable results. We will use this information to improve and calibrate our models further and optimize fabrication technology, closing the gap between design intent and product that can be manufactured. The final aim is to establish a

complete infrastructure for automated testing, that enables a computer to automatically determine the quality of the produced chip, similar to the current practice in electronics.'

After defending his PhD thesis, Pustakhod will stay in Eindhoven: he has been appointed as a researcher at the recently established Photonic Integration Technology Center, where he will develop the testing methods further.

Dzmitry Pustakhod defends his thesis entitled 'Process Control Modules for Photonic Integration Technology' on Wednesday July 4th at Eindhoven University of Technology. Promotors prof. dr. K. A. Williams, dr. X. J. M. Leijten