



IMPACT

Photodiode in silicon key to faster, smaller and more affordable data communications

The bragging rights for the world's fastest high-speed, fully-integrated optical receiver in silicon have been earned by electrical engineers at the University of Toronto. The group recently proved their device at a data rate of 5 Gb/s, a significant improvement over the 3 Gb/s rate previously documented as the speediest.

“This is a big research topic in Asia, Europe, and North America. We’re excited to have designed and proven the world’s fastest such device in a relatively short time span. The prior top rate of 3.125 Gb/s published by another group resulted from five years of development. With CMC’s support for manufacturing and testing services, we were surprised to surpass this research in only two years.”

Dr. Tony Chan Carusone
Associate Professor
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The optical receiver—designed and tested by Tony Kao, Master’s student in the Department of Electrical and Computer Engineering and supported by Broadcom Corporation—involves the monolithic integration of a photodetector, together with receiver circuitry, integrated on a tiny piece of silicon less than 1 mm². Typically, at such high data rates, implementation would require three separate chips, a package, and a printed circuit board.

The goal of this research is to efficiently convert photons (or light) to electrical energy on a complementary metal oxide semiconductor (CMOS) platform with a small footprint. The 5 Gb/s data rate achieved by the project is sufficient to transfer three parallel streams of high-definition video. Dr. Carusone, Associate Professor in the Department of Electrical and Computer Engineering, explains: “Today that’s an area where electrical connections are used. But how do you transfer high-quality video around a room with electrical components? This becomes a lot easier with optical, where the reach is 10 times as great.”

Motivated by the interests of consumer electronics, semiconductor, and computing industries, researchers all over the world are aiming to improve the data rate, footprint, and costs associated with optoelectronic data communications. Dr. Carusone explains: “Even vendors involved in related cutting-edge research don’t have a way to efficiently convert light to electrical energy on a CMOS platform. Their solution is to co-package separate dies.” The University of Toronto project focuses on monolithic integration of the functions on one device.

By increasing the speed, more data can be transferred to enable, for example, higher definition in consumer electronics. Scaling down the technology enables broader applications,

such as in high-performance computing, where dozens of these designs would be required side-by-side on a single microprocessor. Finally, researchers want to implement the technology in standard CMOS manufacturing to make it affordable. Kao explains: “Use of a standard CMOS process is the key to making our high-speed, fully integrated optical receiver a much more cost-effective alternative compared to traditional multi-die solutions.”

The prototype was proven in the 0.18-micron CMOS manufacturing technology, provided through CMC in partnership with TSMC and MOSIS. Kao explains that physical prototyping was crucial to this project as it is “practically impossible to simulate the behavior of a photodiode in CMOS technology.”

The test support provided by the Advanced Photonics Systems Lab of the National Microelectronics and Photonics Testing Collaboratory, managed by CMC, was critical to proving the device at 5 Gb/s. “The improved stabilization and alignment of the fiber to the photodetector provided by this equipment was key to achieving such a high data rate. Without it, we were only able to prove our device to 3 Gb/s,” says Kao. He also explains that this discovery will have important implications for future designs, as well as end applications.

Further reducing the size of the photodetector will open the door to a wider range of applications, says Dr. Carusone. Herein lies the team’s biggest integration challenge: it’s the detector that limits the data rate and yet as the technology is scaled down, the structure becomes less efficient at converting light to electrical energy. The team’s next frontier involves a deeper nanoscale CMOS technology, where reduced size, good light sensitivity and efficient optoelectronic conversion all need to come together. *cmc*