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Silicon photonics technology ready to speed up cloud and big data applications

May 13 2015, by Caroline Wardle

IBM today announced a significant milestone in the development of silicon photonics technology, which enables silicon chips to use pulses of light instead of electrical signals over wires to move data at rapid speeds and longer distances in future computing systems.

For the first time, IBM engineers have designed and tested a fully integrated wavelength multiplexed silicon photonics chip, which will soon enable manufacturing of 100 Gb/s optical transceivers. This will allow datacenters to offer greater data rates and bandwidth for cloud computing and Big Data applications.

"Making silicon photonics technology ready for widespread commercial use will help the semiconductor industry keep pace with ever-growing demands in computing power driven by Big Data and cloud services," said Arvind Krishna, senior vice president and director of IBM Research. "Just as fiber optics revolutionized the telecommunications industry by speeding up the flow of data—bringing enormous benefits to consumers—we're excited about the potential of replacing electric signals with pulses of light. This technology is designed to make future computing systems faster and more energy efficient, while enabling customers to capture insights from Big Data in real time."

Silicon photonics uses tiny optical components to send light pulses to transfer large volumes of data at very high speed between computer chips in servers, large datacenters, and supercomputers, overcoming the limitations of congested data traffic and high-cost traditional interconnects. IBM's breakthrough enables the integration of different optical components side-by-side with electrical circuits on a single silicon chip using sub-100nm semiconductor technology.

IBM's silicon photonics chips uses four distinct colors of light travelling within an optical fiber, rather than traditional copper wiring, to transmit data in and around a computing system. In just one second, this new transceiver is estimated to be capable of digitally sharing 63 million tweets or six million images, or downloading an entire high-definition digital movie in just two seconds.

The technology industry is entering a new era of computing that requires IT systems and cloud computing services to process and analyze huge volumes of Big Data in real time, both within datacenters and particularly between cloud computing services. This requires that data be rapidly moved between system components without congestion. Silicon photonics greatly reduces data bottlenecks inside of systems and between computing components, improving response times and delivering faster insights from Big Data.

IBM's new CMOS Integrated Nano-Photonics Technology will provide a cost-effective silicon photonics solution by combining the vital optical and electrical components, as well as structures enabling fiber packaging, on a single silicon chip. Manufacturing makes use of standard fabrication processes at a silicon chip foundry, making this technology ready for commercialization.

Silicon photonics technology leverages the unique properties of optical communications, which include transmission of high-speed data over kilometer-scale distances, and the ability to overlay multiple colors of light within a single optical fiber to multiply the data volume carried, all while maintaining low power consumption. These characteristics combine to enable rapid movement of data between computer chips and racks within servers, supercomputers, and large datacenters, in order to alleviate the limitations of congested data traffic produced by contemporary interconnect technologies.

Silicon photonics will transform future datacenters

By moving information via pulses of light through optical fibers, optical interconnects are an integral part of contemporary computing systems and next generation datacenters. Computer hardware components, whether a few centimeters or a few kilometers apart, can seamlessly and efficiently communicate with each other at high speeds using such interconnects. This disaggregated and flexible design of datacenters will help reduce the cost of space and energy, while increasing performance and analysis capabilities for users ranging from social media companies to financial services to universities.

Most of the optical interconnect solutions employed within datacenters as of today are based upon vertical cavity surface emitting laser (VCSEL) technology, where the optical signals are transported via multimode optical fiber. Demands for increased distance and data rate between ports, due to cloud services for example, are driving the development of cost-effective single-mode optical interconnect technologies, which can overcome the bandwidth-distance limitations inherent to multimode VCSEL links.

IBM's CMOS Integrated Nano-Photonics Technology provides an economical solution to extend the reach and data rates of optical links. The essential parts of an optical transceiver, both electrical and optical, can be combined monolithically on one silicon chip, and are designed to comply with standard silicon chip manufacturing processes.

IBM engineers in New York and Zurich, Switzerland and IBM Systems Unit have demonstrated a reference design targeting datacenter interconnects with a range up to two kilometers. This chip demonstrates transmission and reception of high-speed data using four laser "colors," each operating as an independent 25 Gb/s optical channel. Within a full transceiver design, these four channels can be wavelength multiplexed on-chip to provide 100 Gb/s aggregate bandwidth over a duplex single-mode fiber, thus minimizing the cost of the installed fiber plant within the datacenter.

More information: Further details will be presented by IBM at the 2015 Conference on Lasers and Electro Optics (May 10-15) in San Jose, California, during the invited presentation entitled "Demonstration of Error Free Operation Up To 32 Gb/s From a CMOS Integrated Monolithic Nano-Photonic Transmitter," by Douglas M. Gill, Chi Xiong, Jonathan E. Proesel, Jessie C. Rosenberg, Jason Orcutt, Marwan Khater, John Ellis-Monaghan, Doris Viens, Yurii Vlasov, Wilfried Haensch, and William M. J. Green.

Provided by IBM

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