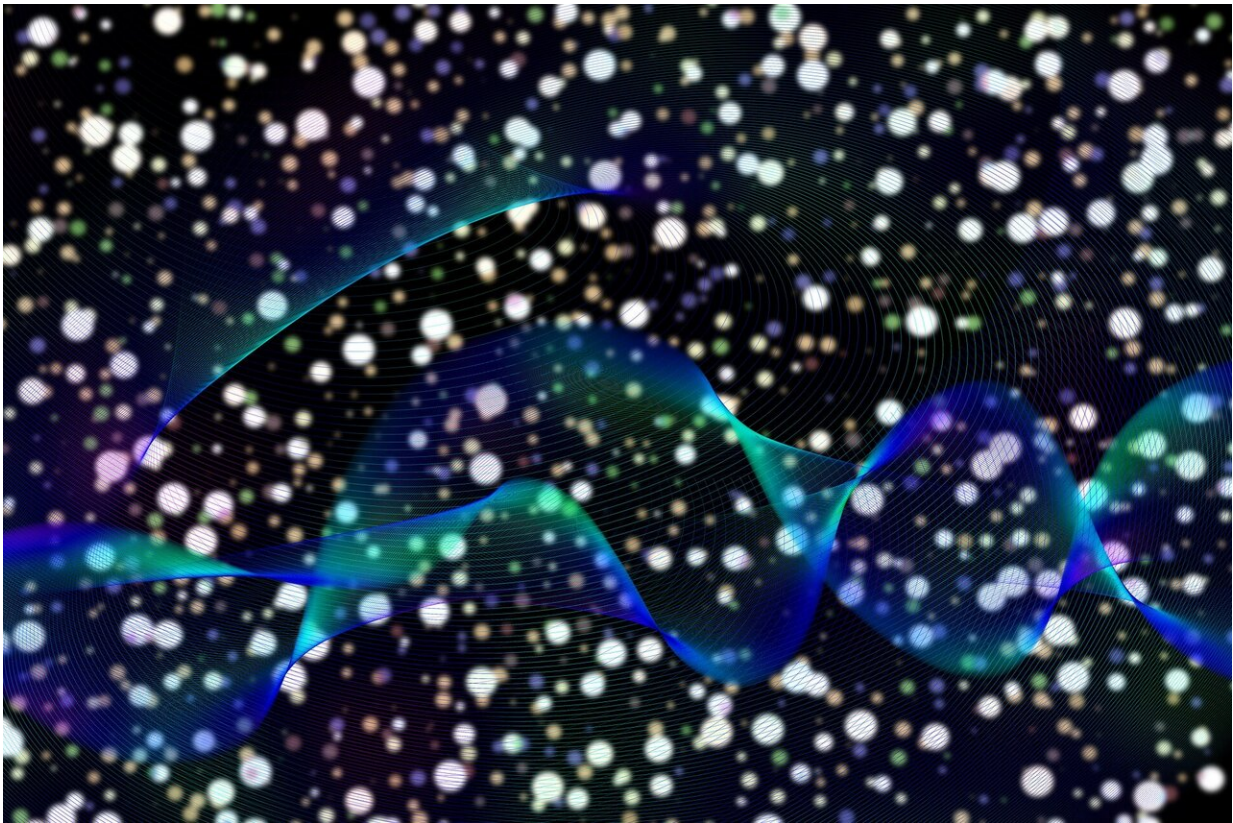


# Creating a next-generation photonic-electronic integration circuit

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Global internet is growing at a compound rate of 24% per year, reaching 3.3 zettabytes per year by 2021. High-speed optical communication is urgently needed in this ever-connected world, and to keep up with this

growth, developments in the fabrication of optical transceivers are sorely needed. Ph.D. candidate Xiao Liu, of the TU/e Department of Electrical Engineering, researched new ways to integrate the electronic circuits and photonic devices that make up optical transceivers. He will defend his Ph.D. thesis on 1 December 2020.

The electronic and photonic components of optical transceivers are usually fabricated with different technologies and then integrated, or packaged together, later. With the development of optical communication systems, which require higher speeds and further reduction of cost and power consumption, this packaging has become a significant bottleneck to the performance of combined electronic-photonic systems. New, small-size packaging technologies are needed that do not affect the optical transceivers' performance or increase their power consumption.

Liu studied electronic circuit and system approaches to develop a new 3-D photonic-electronic wafer-scale integration technology. In this new integration technology, the photonic wafer is bonded on top of the electronic wafer using adhesive polymer bonding technique. Then electrical connections are established through the polymer.

## **From AC to DC**

Liu's first step was to develop a new design methodology for high-speed optical modulator drivers. In general, the amplifier design targets frequency-domain parameters, such as bandwidth, group delay variation, linearity, etc. Both the specifications of the driver are generally described in the [time domain](#), such as data rate, eye diagram, etc. Liu's proposed methodology concentrates on the links between the two domains. Then he used different circuit design techniques to improve frequency-domain specifications with the aim of achieving in high data rate and high-quality eye diagrams in the time domain. This proposed

methodology resulted in the implementation of a distributed driver that achieves state-of-the-art 56 Gbaud PAM4 (112 Gb/s) transmission.

Liu's second research topic is related to the driver-modulator interface in 3-D wafer-scale integration. Currently, most photonic modulators require a DC bias to operate at their optimum. This is known as the AC-coupled scheme, which is easily realized through wire bonds and external surface-mount components. However, the move towards 3-D wafer-scale integration makes external components impossible: the driver-modulator interface is located inside the module. Therefore, a DC-coupled scheme is required, which is a direct connection between the driver's output and the optical modulator's input. Liu proposes two new DC-coupled driving schemes; one that helps improve the compactness of Mach-Zehnder modulator (MZM) transmitters and one to account for different modulation formats and fabrication tolerances of MZMs.

The proposed methodologies and 3-D electronic-photonic wafer-scale integration technology hold great promise for the future of optical communication.

**More information:** Broadband distributed drivers for 3-D photonic-electronic wafer-scale packaging. Technische Universiteit Eindhoven. [research.tue.nl/en/publication ... -electronic-wafer-scale-integration](https://research.tue.nl/en/publication/...-electronic-wafer-scale-integration)

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