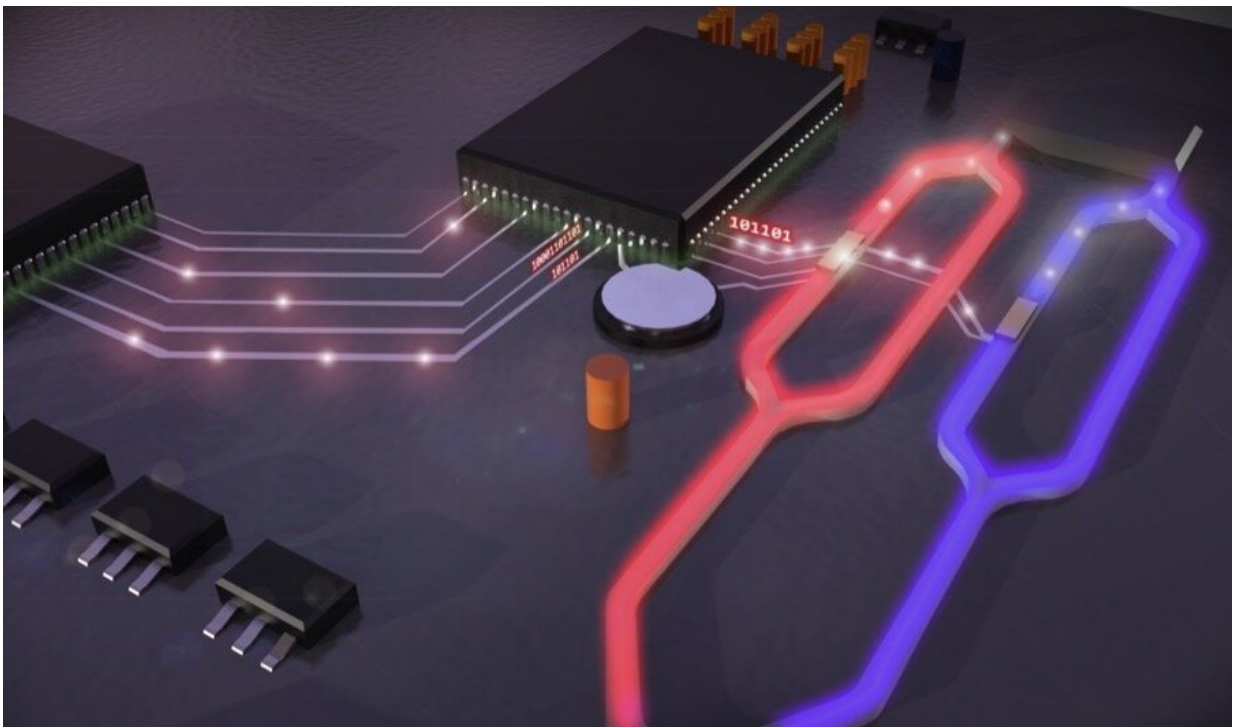


Researchers develop fast, micrometer-size electro-optical modulator

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On this illustrated silicon chip (grey), electrical data (white) travels through the Mach-Zehnder interferometer (MZI) based electro-optical modulators, encoding electrical data into the optical domain by means of tunable plasmonic ITO-based phase shifters (golden patches atop both MZI sections) capable of operating at multiple wavelengths of light in the telecommunication-relevant C-band (red & purple). capable of operating at multiple wavelengths of light in the telecommunication-relevant C-band (red & purple), thus enhancing the speed and efficiency of optical applications such as data transmission or neural networks for artificial intelligence. Credit: Mario Miscuglio and Rubab Amin

Researchers at the George Washington University developed and demonstrated for the first time a silicon-based electro-optical modulator that is smaller, as fast as and more efficient than state-of-the-art technologies. By adding indium tin oxide (ITO)—a transparent conductive oxide found in touchscreen displays and solar cells—to a silicon photonic chip platform, the researchers were able to create a compact device 1 micrometer in size and able to yield gigahertz-fast, or 1 billion times per second, signal modulation.

Electro-optical modulators are the workhorses of the internet. They convert electrical data from computers and smartphones to optical data streams for fiber optic networks, enabling modern data communications like video streaming. The [new invention](#) is timely since demand for data services is growing rapidly and moving towards next generation communication networks. Taking advantage of their compact footprint, electro-optic converters can be utilized as transducers in optical computing hardware such as optical artificial neural networks that mimic the [human brain](#) and a plethora of other applications for modern-day life.

Electro-optical modulators in use today are typically between 1 millimeter and 1 centimeter in size. Reducing their size allows increased packaging density, which is vital on a chip. While [silicon](#) often serves as the passive structure on which photonic integrated circuits are built, the light matter interaction of silicon materials induces a rather weak optical index change, requiring a larger device footprint. While resonators could be used to boost this weak electro-optical effect, they narrow devices' optical operating range and incur high energy consumption from required heating elements.

By heterogeneously adding a thin material layer of [indium tin oxide](#) to the silicon photonic waveguide chip, researchers at the George Washington University, led by Volker Sorger, an associate professor of

electrical and computer engineering, have demonstrated an optical index change 1,000 times larger than silicon. Unlike many designs based on resonators, this spectrally-broadband device is stable against temperature changes and allows a single fiber-optic cable to carry multiple wavelengths of light, increasing the amount of data that can move through a system.

"We are delighted to have achieved this decade-long goal of demonstrating a GHz-fast ITO modulator. This sets a new horizon for next-generation photonic reconfigurable devices with enhanced performance yet reduced size," said Dr. Sorger.

The paper, "Broadband Sub- λ GHz ITO Plasmonic Mach Zehnder Modulator on Silicon Photonics," was published today in the journal *Optica*.

More information: Rubab Amin et al, Sub-wavelength GHz-fast broadband ITO Mach–Zehnder modulator on silicon photonics, *Optica* (2020). [DOI: 10.1364/OPTICA.389437](https://doi.org/10.1364/OPTICA.389437)

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