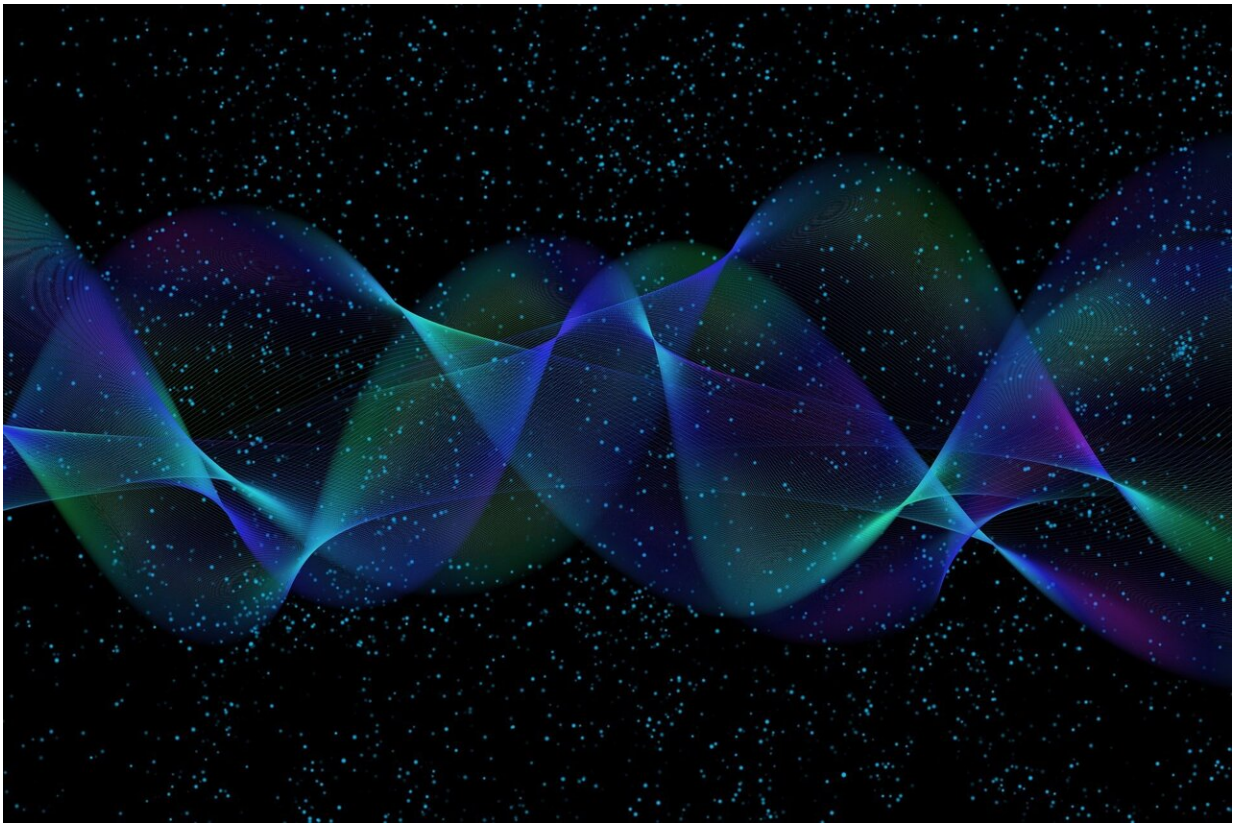


# Ultra-compact integrated photonic device could lead to new optical technologies

March 17 2022

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Photonic integrated circuits are essential to many technologies, including fiber-optic communications, mapping systems, and biosensors.

These circuits—which use photons instead of electrons—employ optical isolators that allow photons to travel in only one direction, which prevents light from re-entering the system and destabilizing it. But guiding light in one direction often requires large magnets, making these circuits difficult to create on a small scale.

Researchers at University of Chicago's Pritzker School of Molecular Engineering (PME) have developed a new way to guide light in one direction on a tiny scale. By coupling light confined in a nanophotonic waveguide with an atomically thin, two-dimensional semiconductor, the researchers exploited the properties of both the light and the material to guide photons in one direction.

The result – a small, tunable on-chip photonic interface – could lead to smaller photonic integrated circuits that could be more easily integrated into modern technologies, including computing systems and self-driving cars.

"We see this research as paving the way towards a whole new class of integrated photonic circuits," said Asst. Prof. Alex High, who led the research with graduate students Amy Butcher and Robert Shreiner, and postdoctoral fellow Kai Hao. The results were published in *Nature Photonics*.

## **Coupling light with a 2-D material**

In [electronic circuits](#), electrons move through wires to transfer energy. Photonic integrated circuits work similarly, but instead of electrons in wires, light is channeled along waveguides.

To create a new element for [photonic circuits](#), High and his team interfaced a two-dimensional material—tungsten diselenide—with a photonic waveguide. The unique properties of the material's band

structure enables it to interact with light differently based on the helicity of the light's polarization. In nanophotonic structures, where light is confined below its wavelength, [circular polarization](#) arises naturally, and the helicity is locked to the light's propagation direction.

This means that light emitted from the tungsten diselenide will couple into the waveguide in a preferred direction. The team can also switch this biased coupling on and off by adding electrons to the system, creating a tunable emission router on a tiny micron-sized length scale.

"We've figured out a scalable method for putting photonics and 2-D semiconductors together in a way that adds new control knobs and preserves the high quality of the sensitive material," Shreiner said. "This interface opens new doors for designing ultra-compact, one-way photonic devices."

## **Advancing everyday applications and cutting-edge research**

That small scale design and versatile fabrication method will help integrate such photonic elements into existing optoelectronic systems. An obvious application would be for on-chip lasers, which could find application in self-driving cars as part of a LIDAR navigation system (a system that uses [laser pulses](#) to measure ranges). The photonic element could be configured as an on-chip isolator, allowing compact protection of the laser system.

Ultimately, these types of photonic devices could be integrated into future optical computers, which would compute with light instead of electrons, using less energy and creating less heat.

"We already use photonics to carry information throughout the country

in fiber-optic networks, but advances like this could help fully control the flow of light on the nanoscale, thus realizing on-chip optical networks," Hao said.

**More information:** Alexander High, Electrically controllable chirality in a nanophotonic interface with a two-dimensional semiconductor, *Nature Photonics* (2022). DOI: [10.1038/s41566-022-00971-7](https://doi.org/10.1038/s41566-022-00971-7).  
[www.nature.com/articles/s41566-022-00971-7](https://www.nature.com/articles/s41566-022-00971-7)

Provided by University of Chicago

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