Optical high-bitrate nanoantenna developed for use with optical waveguide

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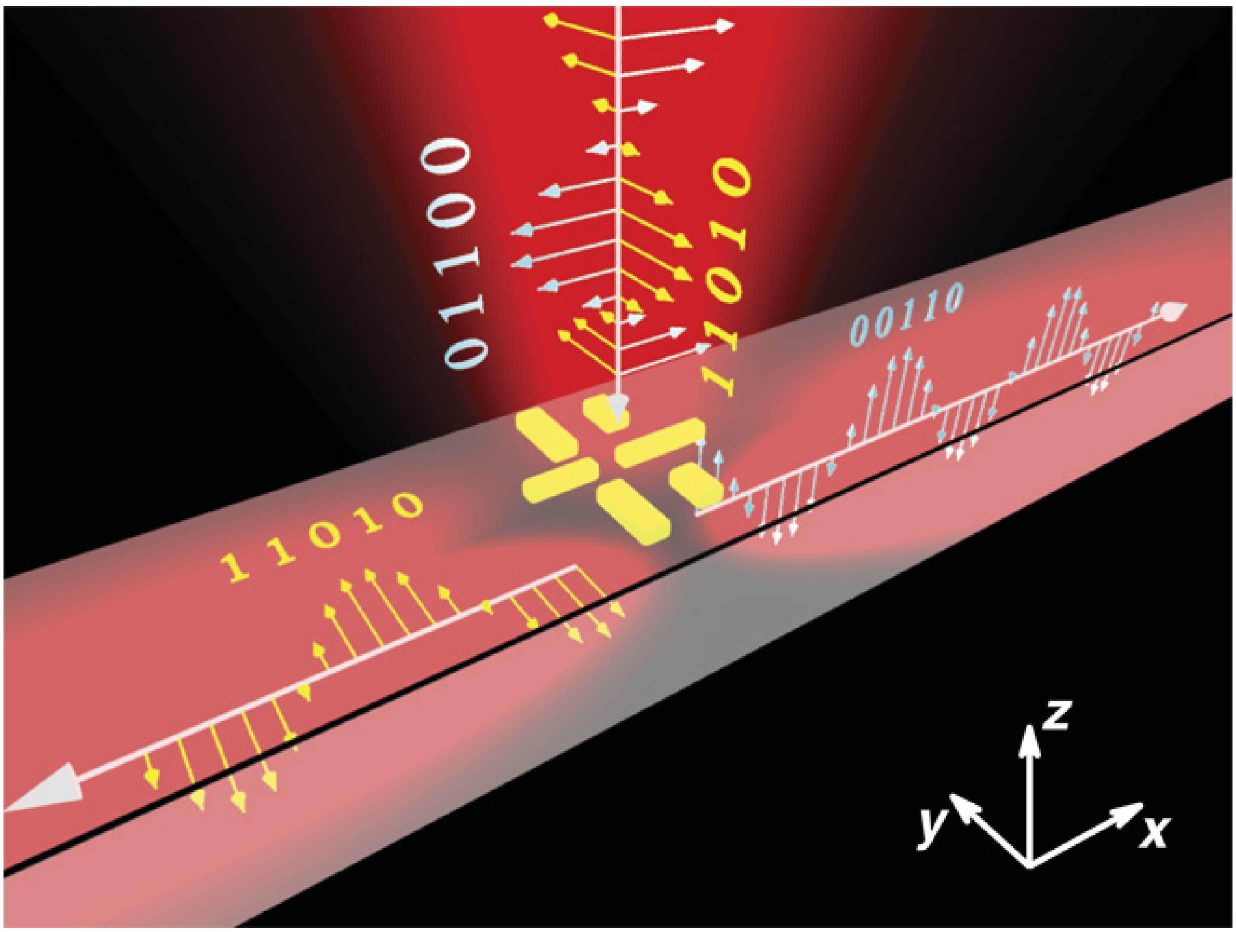
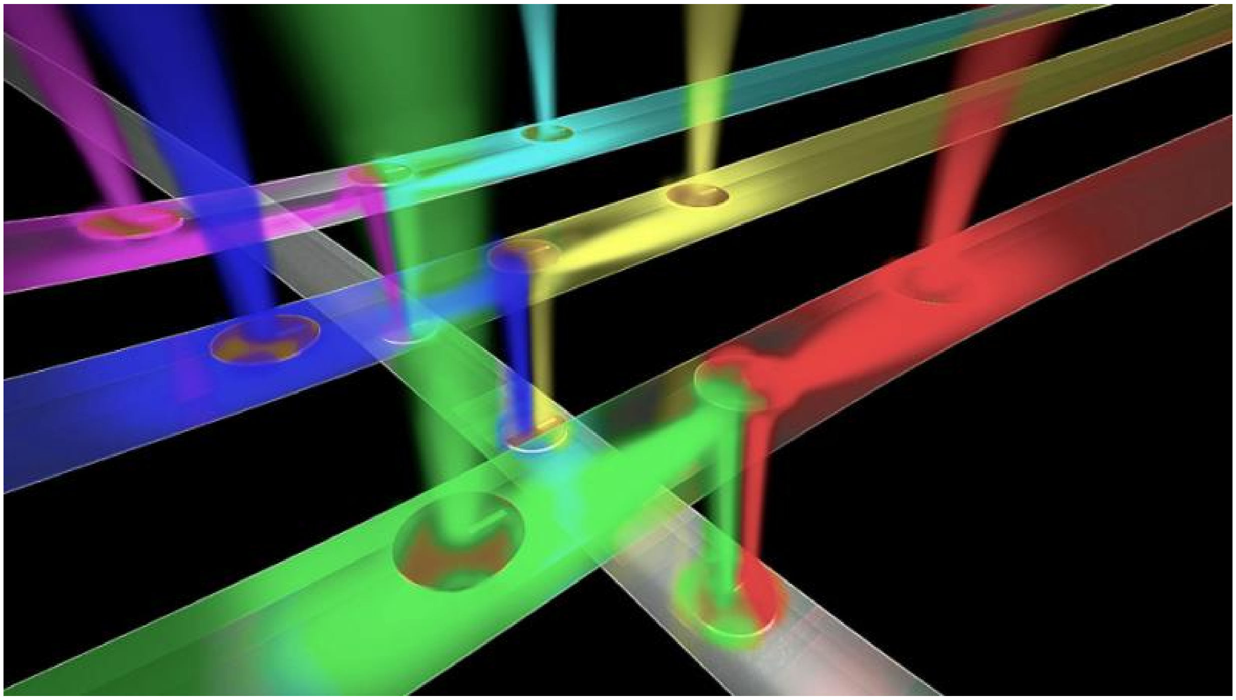


Scheme of a waveguide-integrated plasmonic nanoantenna for mode-selective polarization (de)multiplexing. The device couples light of orthogonal polarizations into different directions and modes of the underlying silicon waveguide. Credit: *Science Advances* (2017). DOI: 10.1126/sciadv.1700007

(Phys.org)—A team of researchers from several institutions in Germany and Australia has developed an optical high-bitrate nanoantenna that they used with an optical waveguide. In their paper published on the open access site *Science Advances*, the team explains how their device works and their plans for improving it to make it more commercial.

Imprinting an optical nanoantenna onto an optical waveguide, as the researchers note, is still a new idea—most such efforts have involved devices that couple light to a waveguide mode. In this new effort, the researchers have advanced the idea with a device capable of sorting and routing streams of information that has been encoded into a beam of light using varying polarizations. What's more, they have found a way to do it using optical components that are much smaller than other devices—down to sub-micrometer size, which opens the possibility of high-density photonics components on a chip. They report that their device is capable of directional, polarization-selective and mode-selective routing on a silicon rib waveguide. Their efforts, they note, demonstrate that nanoantenna integration into waveguides holds the potential for developing new high-bitrate telecommunications applications.

An optical nanoantenna works by taking advantage of plasmonics—light striking a metal causes electrons on the surface to move in plasmon waves. These have wavelengths that are smaller than the smallest light wavelength, which means researchers can create devices so small that they are able to convey information using photons. One of the goals of researchers in this field is to create integrated circuits that process and move information using photons instead of electrons. Achieving such a goal requires optical waveguides capable of routing information represented by photons.



"Our invention can be used to connect these processors with optical wires that will transmit data between processers thousands of times faster than metal wires. This will enable smooth rendering and large-scale parallel computation needed for a good gaming experience." Credit: Australian National University

The new device was created using extremely small gold bars, which, the team notes, presents a problem for commercialization—the precious metal must be replaced with another to make it CMOS compatible. The team also plans to improve the transmission efficiency of their device, and are considering attempting to create circuits by joining their devices together.

More information: Rui Guo et al. High–bit rate ultra-compact light routing with mode-selective on-chip nanoantennas, *Science Advances* (2017). DOI: 10.1126/sciadv.1700007

Abstract
Optical nanoantennas provide a promising pathway toward advanced manipulation of light waves, such as directional scattering, polarization conversion, and fluorescence enhancement. Although these functionalities were mainly studied for nanoantennas in free space or on homogeneous substrates, their integration with optical waveguides offers an important "wired" connection to other functional optical components. Taking advantage of the nanoantenna's versatility and unrivaled compactness, their imprinting onto optical waveguides would enable a marked enhancement of design freedom and integration density for optical on-chip devices. Several examples of this concept have been demonstrated recently. However, the important question of whether nanoantennas can fulfill functionalities for high-bit rate signal transmission without degradation, which is the core purpose of many integrated optical applications, has not yet been experimentally investigated. We introduce and investigate directional, polarization-selective, and mode-selective on-chip nanoantennas integrated with a silicon rib waveguide. We demonstrate that these nanoantennas can separate optical signals with different polarizations by coupling the different polarizations of light vertically to different waveguide modes propagating into opposite directions. As the central result of this work, we show the suitability of this concept for the control of optical signals with ASK (amplitude-shift keying) NRZ (nonreturn to zero) modulation [10 Gigabit/s (Gb/s)] without significant bit error rate impairments. Our results demonstrate that waveguide-integrated nanoantennas have the potential to be used as ultra-compact polarization-demultiplexing on-chip devices for high–bit rate telecommunication applications.

Press release