New All-Optical Modulator Paves the Way to Ultrafast Communications and Computing

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In the 1950s, a revolution began when glass and metal vacuum tubes were replaced with tiny and cheap transistors. Today, for the cost of a single vacuum tube, you can buy a computer chip with literally millions of transistors.

Today, physicists and engineers are looking to accomplish a similar shrinking act with the components of optical systems--lasers, modulators, detectors, and more--that are used to manipulate light. The goal: designing ultrafast computing and communications devices that use photons of light, instead of electrons, to transmit information and perform computations, all with unprecedented speed.

Researchers at the California Institute of Technology have now taken a significant step toward the creation of all-optical logic devices by developing a new silicon and polymer waveguide that can manipulate light signals using light, at speeds almost 100 times as fast as conventional electron-based optical modulators.

The all-optical modulator consists of a silicon waveguide, about one centimeter long and a few microns wide, that is blanketed with a novel nonlinear polymer developed at the University of Washington. As light passes through the waveguide, it is split into two signals, an input, or "gate," beam and a source beam. "We can manipulate where the source goes by turning on and off the gate," says Michael Hochberg, a postdoctoral researcher at Caltech. The modulator could be switched on and off a trillion times or more per second.

Hochberg and Tom Baehr-Jones developed the system, which is described in the September issue of the journal *Nature Materials*, with Caltech colleague Axel Scherer, the Neches Professor of Electrical Engineering, Applied Physics, and Physics. The optical polymers were developed in the laboratories of Larry Dalton and Alex K. Y. Jen at the University of Washington.

Because the system is silicon based, it is easily scalable. "We can add complexity through standard silicon processing," Hochberg says, which means the system "provides a path toward eventually making optical processors. Because all-optical devices are intrinsically faster, you could do computations at terahertz speeds, rather than gigahertz."

"In a few years, we hope to take a device like this and make all-optical transistors that give us signal gain-which means that you can put in a small amount of power on the gate and get out a large amount of power change on the drain, just as regular transistors do. Once we can do that, the whole world opens up," Hochberg says.

Source: Caltech