Undoing a Traffic Jam at the Light

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Scientists have created a device that they say could result in as much as a tenfold increase in the speed and capacity of modern fiber-optic communications systems, including parts of the Internet, cable television transmission and defense radar networks.

The tiny apparatus is a type of "electro-optic modulator" made from a novel form of plastic. It is designed to cope with a major bottleneck in information flow: the time it takes to convert comparatively sluggish electrical signals carried by wires, such as the data produced by computers, into bits of laser light that fly along glass fiber cables.

The device, said chemist and co-inventor Larry R. Dalton, allows the translation of electrical to optical signals much faster than comparable conventional technology, can be easily integrated into "opto-chips" on standard silicon chip blocks, and performs at less than one-sixth the voltage of existing modulators.

If the devices were to be widely used along the world's more than 60 million miles of optical fiber, "instead of waiting nine minutes for a big file to download, you're going to get it in seconds," said Dalton, a professor at both the University of Washington and the University of Southern California. Dalton and colleagues report their invention in today's issue of the journal Science.

"It's a very promising result," said Pat Iannone of AT&T Labs, who heads the optical communications committee of the Institute of Electrical and Electronics Engineers.

So far, the new modulator material doesn't seem "ready for prime time in telecommunications" and still needs to prove that it can live up to its speed claims, Iannone said. But it eventually might have a considerable impact on "the world's very largest" data conduits--such as international trunk lines--where signal traffic is most densely compressed.

The paramount problem in communications is the titanic volume of data trying to make its way around the planet in the shortest possible time, said Andrew Lovinger, director of the polymers program at the National Science Foundation, which sponsored the new research along with the Air Force and Navy.

"We don't want to be laying more [fiber-optic] cable across the Atlantic. To increase the capacity, we have to increase the speed," Lovinger said.

That speed depends on the number of times per second that laser light can be switched from bright to dark; each change represents one digital "bit" of information.

The problem is equivalent to figuring out the best way to send Morse code by flashlight. One is for the sender to move his hand in front of the flashlight lens, alternately blocking the light and letting it go; that is, "modulating" the light beam into a pattern that contains information.

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In fiber-optic communication, engineers achieve the same effect by running laser beams through a transparent modulator substance whose optical properties change when it is exposed to a voltage from an electrical data source such as a computer.

When no voltage is applied to the modulator, light moves through it at one speed. When a voltage is switched on, the light moves at a different speed. In one condition, light waves will reinforce each other, creating a bright spot, or a "1" in digital terms. In the other condition, the waves are out of phase and cancel out each other, leaving a dark space or "0."

At present, such modulators are typically made of a mineral-like crystal called lithium niobate. It is very stable and easy to control, but it has three disadvantages, according to co-author James H. Bechtel of TACAN Corp. in Carlsbad, Calif.

It can't be switched faster than a few billion times per second. It takes a relatively hefty 5 or 6 volts to operate, thus creating an undesirable amount of heat and requiring a secondary device to amplify the electrical signal, which is often far weaker than 5 volts. And it cannot be incorporated directly onto integrated-circuit chips.

The new material is a plastic strip created by embedding special molecules into a polymer base. The molecules are optimized for modulation and aligned to achieve the maximum effect.

The notion of a polymer device has been around for years, but every previous formulation was unstable or didn't perform up to requirements. Dalton and colleagues, however, used a new molecular design scheme to eliminate the problems.

The resulting material, part of which the researchers have patented, operates at 0.8 volts or lower, Dalton said. It can be switched 110 billion times per second or faster, although Dalton's team did not show that in their paper in Science.

The low power requirement is very important, Lovinger said, in order to "reduce the heat that can cause polymer devices to degrade. This is a main reason why polymers have not been used commercially."

"Another tantalizing feature," said Bechtel, "is that it appears to be very tolerant to radiation," a desirable characteristic in space vehicles and satellites that are constantly bombarded by gamma rays and X-rays.

Experts differ on where the new device might fit in to the world's communications system.

"It's extremely clever chemistry. But many people are not using these modulators any more," said Christopher C. Davis of the University of Maryland's Department of Electrical and Computer Engineering. "Instead, they directly modulate the laser" with the computer electrical signals. (In the flashlight analogy, this is equivalent to switching the flashlight on and off rather then using a hand to block the beam.) "They add to system cost and complexity," Davis said of the new electro-optic modulators, "and I don't see them taking over most of the high-speed data transfer that is done with direct modulation."

However, for the very largest networks and trunk lines, Iannone said, "it might be worth taking a cost hit to achieve the higher efficiency."

Whatever role the new modulator may play in the global fiber-optic net, numerous experts agreed, it certainly will not reduce the time it takes to download a file to a home computer.

"This isn't going to change the bottleneck into your house," Iannone said. That delay derives from the fact that the nearest fiber-optic cable typically ends a mile or more from a household, and for the final mile signals flow through old-fashioned copper wires.

Data in a Flash

A device made from a new plastic composite could speed up fiber-optic transmissions by increasing the rate at which electrical signals cause light beams to blink from dark to light.

1. Laser emits beam of light.

2. Fiber-optic cable splits wave into parallel beams.

3. "Opto-chip" modulator alters one wave path so it is out of sync with the other wave.

4. Out-of-phase waves rejoin, canceling each other out and creating darkness.

5. The modulator creates pulses of light and darkness at a blazing speed.

Its creators say the "opto-chip" could allow data to be sent along digital fiber lines as fast as 100 billion bits per second, or 100 gigahertz.

SOURCE: IPITEK