Fiber-optic booster on a chip

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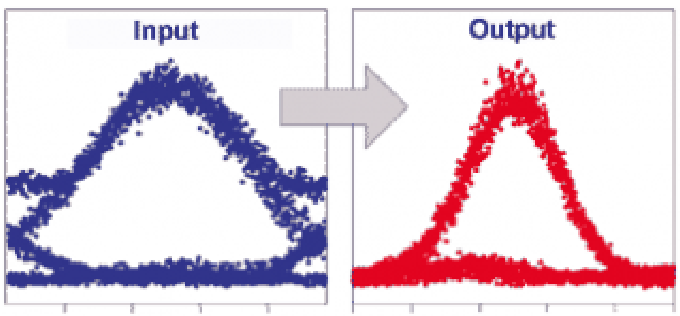

After traveling through 20 kilometers of optical fiber a pulse of light a few picoseconds long becomes distorted. "Pumping" with a clean pulse on a photonic microchip can sharpen the signal before sending it further down the line. Credit: Gaeta Lab

More and more of our communications -- from text messages to high-definition television -- travel over optical fiber. At last count the United States was crisscrossed by more than 80 million miles of it, with some 225 million miles worldwide.

But there's a problem: Light is dimmed by miles of fiber, and the crisp on-and-off pulses that represent the ones and zeros of a digital signal become misshapen and fuzzy. Every 50 miles or so the signal must be reamplified, cleaned up and relaunched.

Now Cornell researchers have demonstrated that all this can be done on a single photonic microchip, replacing bulky bundles of fiber or electronic amplifiers that slow down the signal.

The development is described in a forthcoming article by Alexander Gaeta, professor of applied and engineering physics, and Michal Lipson, associate professor of electrical and computer engineering, and colleagues, in the journal *Nature Photonics* and was posted in the online version of the journal in December 2007.

Previously the researchers had demonstrated a light amplifier on a silicon chip using a process called four-wave mixing, which could amplify an optical signal by "pumping" with another beam of light. In the new work they show that the same process can clean up and sharpen the pulses of fiber-optic communication. If the pumping beam consists of a series of pulses synchronized with the input signal, the process also cleans up "timing jitter," in which the pulses are not only deformed but also move slightly forward or back in time.

Four-wave mixing has been used to amplify light in devices made of optical fiber, but the process requires tens of meters of fiber. The Cornell researchers used silicon waveguides only a few hundred nanometers across and 1.8 centimeters long embedded in a single silicon chip (a nanometer is about the width of three atoms). The tight dimensions of the waveguide, smaller than the wavelength of the light traveling through it, forces two entering beams of light -- the signal and the "pump" -- to exchange energy over a very short distance. Some photons from the pump are converted to the same wavelength as the signal, amplifying it, while others come out at a wavelength equal to twice the pump wavelength minus the signal wavelength. That last effect can be used to convert a signal from one wavelength to another.

In a series of experiments all using the same nanoscale wave guides, the researchers found that pumping a pulsed signal with a continuous wave light beam at another frequency amplifies the signal but doesn't clean up the pulses. However, if the arrangement is changed so that the light carrying the signal acts as the pump, the output is both amplified and sharpened. If the pump is a pulsed beam synchronized with the pulse rate of the input signal, the output is amplified and sharpened, and timing jitter is also reduced.

The four-wave mixing approach also offers a broad bandwidth, the researchers report, so it could be used in multiplexed fiber-optic systems where several wavelengths are used simultaneously to carry multiple signals.

Source: Cornell University

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