Switching to glass makes device ultrafast

Electrons are the best foot soldiers for doing computations, and photons are the speediest messengers for communications. Taking this technological tenet to heart, communications companies over the last few years have laid thousands of miles of optical fiber cables. These pathways for light promise to transmit unprecedented volumes of information — from telephone conversations to computer data and high-definition television signals — much faster and more efficiently than their conventional copper counterparts.

But as the optical fiber networks grow, companies will be faced with the increasingly difficult problem of policing all that photon traffic. And someday they will need devices that can almost instantaneously switch or route light signals between optical fibers.

While that day is not yet here, the first-generation ultrafast optical switch is — at least in its laboratory version. Scientists at Bell Communications Research in Red Bank, N.J., will soon unveil an all-optical, fused-quartz device that can repetitively shuttle a light beam into different optical fibers in less than a picosecond (10^{-12} second). That, says physicist Peter W. Smith, head of the group that designed the switch, is thousands of times faster than existing electro-optic switches, which use electrical signals to control the routing of light beams.

"This is really the first demonstration of such fast repetitive switching in any type of device," he notes. "It's the world's fastest switch."

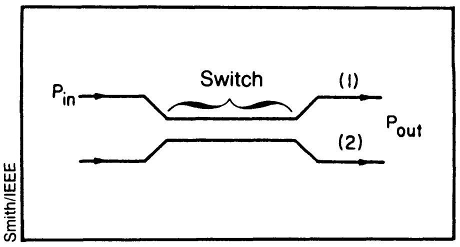
Behind this technological benchmark stands a new realization about the optical properties of glass and, in particular, their nonlinear qualities. Nonlinearity means that what goes in does not necessarily come out in the same manner; put another way, not all light signals passing through a nonlinear device are treated equally. The kind of nonlinearity that most interests Smith's group is the way a glass refracts a beam of light: The more intense a light beam is, the more it will change the glass's index of refraction, which is related to the light wave's velocity and, in this case, its ability to be routed into a switch's optical pathways.

Other scientists have been aware that they could exploit this nonlinearity to route beams of light by changing their intensities. But they had largely dismissed *glasses* as useful candidates for optical switches because their nonlinearities are very small — meaning that relatively large increases in intensity would be required to change the glass's refractive index. Instead, most research has focused on semiconductors and other materials that have much greater nonlinearities, and hence lower intensity requirements.

But the problem with these materials is that they absorb energy from the light beam. Not only can this degrade the light signal, but the resulting heating also changes the material's refractive index, causing the beam to act in undesired ways. "Although these semiconductor materials can switch fast once, they can't switch again for a very long time — that is, until they cool off," says Smith.

A switch made of optical glasses, on the other hand, is so transparent that it absorbs essentially no energy as the light passes through, thereby avoiding the heating effects that have plagued the development of optical switches, says Smith. In the Dec. 12 IEEE JOURNAL OF QUANTUM ELECTRONICS, he and Stephen R. Friberg defined a "figure of merit" that quantitatively balances a material's intrinsic nonlinearity against its adverse heating effects. After comparing the figures of merit for a number of different materials, the researchers concluded that optical glasses are the clear choice for optical switches. Smith plans to present the details of his work in April at the Conference on Lasers and Electro-Optics, to be held in Anaheim, Calif.

— S. Weisburd



Smith/IEEE

The switch's fast speed is due to the use of both a novel material and a novel geometry: It is a fused-quartz fiber that contains two closely spaced cores, (1) and (2). When the light intensity is low, the refractive index of both cores is equal and light traveling in (1) leaks into and gradually builds up in (2). Higher intensities change the refractive index of (1), altering the beam's speed in a way that prevents light from coupling to (2).

Trashes to ashes, all fall down

Two lawsuits filed last week by environmental groups may spur resolution of a longstanding dispute over the disposal of ash from municipal trash incinerators. The suits, filed by the Environmental Defense Fund (EDF) in Washington, D.C., and the Chicago-based Citizens for a Better Environment, claim that toxic ash from energy-producing municipal incinerators, or resource recovery plants, is not being disposed of in accordance with relevant hazardous waste regulations. At issue is a disputed interpretation of the federal Resource Conservation and Recovery Act (RCRA), which defines hazardous wastes and how they are to be disposed.

The suits are significant because municipalities are becoming increasingly reliant upon resource recovery incinerators for trash disposal. Such facilities generate moderate amounts of electricity by burning household garbage. Since the advent of new technologies for minimizing air pollution, more than 100 such incinerators have gone on line in U.S. cities, and thousands more are on the drawing boards. If the court rules that the ash from these plants must be disposed of as a hazardous waste, the cost of operating the incineration facilities will increase substantially.

"In our haste to adopt incineration as a panacea for the serious health threats that have resulted from landfilling trash, we can't afford to repeat the same mistakes by improperly managing the ash, which must also be landfilled," says Richard A. Denison of the EDF. Test data compiled by the EDF show that landfilled ash from municipal incinerators typically contains toxic metals such as lead and cadmium in concentrations considered hazardous by the EPA. The lawsuits single out resource recovery plants in Chicago and Peekskill, N.Y.

According to Wheelabrator Environmental Systems, the nation's largest municipal incinerator company and owner of the Peekskill plant, the management and disposal of its ash residues "are in strict compliance with applicable state and federal requirements." The Hampton, N.H.-based company contends that toxic ash from municipal waste incinerators is exempt from RCRA disposal regulations. The EDF says this is "wishful thinking."

In fact, both Congress and the Environmental Protection Agency (EPA) have been struggling to clarify how RCRA should apply to municipal facilities. The issue is complicated because it involves both statutory and regulatory provisions that use slightly different language. Moreover, according to Robin Woods, a spokesperson for the EPA, the agency is considering changing its hazardous disposal regulations. But for now, she says, "We do have a policy in effect that says if the ash tests hazardous . . . then it must go to a hazardous waste facility."

Also at issue is the reliability of the test commonly used to determine the toxicity of incinerator ash. The so-called Elution Procedure Toxicity Test, currently accepted by the EPA, is meant to mimic landfill conditions to determine the rates at which metals and pesticides leach into groundwater. Industry representatives claim the test overestimates leach rates. Environmentalists say the test is too