Lighting the way to speedier circuits

The rate at which an electronic switch turns on and off is limited by the speed at which electrons travel through a semiconductor. Now, researchers have circumvented that limitation with the first switch controlled entirely by light. The new optical switch turns on or off at least 20 times faster than the maximum rate possible for an electronic system, they report.

"We use light to control light," says Alan Huang of AT&T Bell Laboratories in Murray Hill, N.J. "There are no semiconductors."

Previously reported "optical" switches incorporated semiconductor components and usually involved converting a signal from light to electrons, then back to light.

The new switch, together with recently developed optical amplifiers, completes the list of components necessary for building circuits in which light does all the work. "We have the makings of a new technology in optics that can go faster than electronics," Huang says. He described the switch's development and its implications for the design of optical computers at last week's Physics Computing '91 conference, held in San Jose, Calif.

Light travels through a medium such as glass considerably more slowly than it does in a vacuum. The new switch takes advantage of an extremely weak, barely discernible optical effect – namely, that bright light travels through an optical fiber slightly faster than dim light.

The Bell Labs researchers send a laser beam into a 100-meter loop of optical fiber, splitting the beam into two components that travel through the loop in opposite directions. The two separate beams produce an interference pattern where they meet again and recombine. Any slight change that disturbs one beam but not the other alters the interference pattern.

Injecting a short light pulse into the loop so that it travels in the same direction as one of the two interfering light beams makes this beam slightly brighter and speeds it up. The temporarily brightened segment of the beam arrives at the meeting place a fraction of a second earlier than it would otherwise, shifting the interference pattern.

The researchers use this brief, rapid shift in the pattern to control the exit of light from the device. Whereas a purely electronic switch takes at least 10 picoseconds to turn on and off, the optical switch needs only 0.5 picosecond. "We think we can push that even lower," Huang says.

Although this technology can't yet be used to construct a supercomputer, scientists now have all the ingredients they need to create a rudimentary all-optical computer. Huang and his co-workers have already used their optical switches, along with optical amplifiers, to construct simple circuits. They are investigating ways of building more complicated circuits and have taken the first steps toward miniaturizing the optical components.

"There's a lot of work that still must be done," Huang says. But because the components needed to build optical circuits are relatively easy to obtain, "my prediction is that within a couple of years, all the major universities are going to be doing experiments like ours." *– I. Peterson*

Speeding the search for new human genes

A group of genetics researchers has proposed a new way of tackling the Human Genome Project, the $3 billion, 15-year federal initiative to decipher every gene in the blueprint for human life. The new scheme, they say, could shave several years and millions of dollars off the project, which began about a year ago.

The team, led by J. Craig Venter at the National Institute of Neurological Disorders and Stroke in Bethesda, Md., sketched out a rough picture of part of the human genome by identifying segments of genes that are turned on in the brain. Venter says such bits of genes – called expressed sequence tags – could serve as dots outlining the genome, providing researchers with starting points for locating and deciphering the code for all of the estimated 50,000 to 100,000 human genes.

Researchers in Venter's laboratory, together with geneticists at St. Elizabeth's Hospital in Washington, D.C., demonstrated their approach using molecular "libraries" of all of the genes actively functioning in the human brain. They chose to focus on the brain because its functioning requires 30,000 genes, 20,000 of which are thought to be used by no other body tissues.

Venter's group randomly selected and deciphered 609 short stretches of DNA from the molecular libraries. Because the libraries had been back-translated from messenger RNA – the chemical intermediate DNA uses to make proteins – these researchers knew they were working with genes that code for proteins, and not with the regulatory sequences of DNA or the "filler" segments that together constitute 97 percent of the human genome. The team reports in the June 21 SCIENCE that most of the deciphered bits matched known genes, but 230 of the tags identified genes never before discovered.

"We tried this approach to see if just a little bit of sequence from each gene would be enough to identify it . . . and it worked," Venter says.

He estimates that the technique could identify and decipher genes up to 1,000 times faster than the current approach, which requires geneticists to read the sequence of roughly 1,000 overlapping stretches of DNA to identify a single gene. With the new method, Venter says, "we can get partial sequences from 1,000 genes" with the same amount of effort. Moreover, because the partial sequences need to be read only once – instead of the multiple times now required – he calculates that the approach could slash the cost of reading one unit of DNA from the present $1 to $4 to just 12 to 15 cents.

In August, Venter will receive a $1 million grant from the Department of Energy (DOE) to apply the new technique to the Human Genome Project, which is jointly sponsored by DOE and the National Institutes of Health (NIH). He says he hopes to identify all of the genes functioning in the human brain within the next three to five years. If the technique is adopted by other gene-mapping labs around the world, all human genes can be identified by 1996, Venter predicts.

Benjamin Barnhart, who manages DOE's human genome activities, says his agency supports Venter's strategy because it "gives us a handle on the functional portion of the human genome." Barnhart expects the panel of outside experts who advise DOE and NIH on the Human Genome Project to discuss the proposal when they meet next week. At the same time, he stresses that the genome project's ultimate aim is to decipher every human DNA sequence, not just to locate protein-encoding genes. Venter's approach "hasn't in any way detoured us from the long-term goal of providing the scientific community with the sequence of the entire genome," Barnhart says. The DNA sequences interspersed among protein-encoding genes in the human genome could turn out to have surprising functions, he contends.

Elke Jordan, deputy director of the NIH's National Center for Human Genome Research, remains noncommittal about the new strategy. She says Venter's group has essentially refined an approach outlined a year ago by Maynard Olson at Washington University in St. Louis. Olson proposed identifying random unique DNA sequences – not just those that are part of genes – to expedite the Human Genome Project. When asked whether NIH will adopt Venter's technique, Jordan replied that the agency will use "whatever approaches make sense." *– C. Ezzell*