SCIENCE NEWS of the week

Fast Times in Silicon Circuits

In the ultrafast world of microelectronics, the blink of an eye seems to last a century. It is a world in which time is measured in picoseconds — trillionths of a second. Recently, a team of IBM researchers generated electrical pulses so short that each one lasts only half a picosecond. In that fraction of a second, light travels a distance of less than a millimeter.

The IBM technique is one of several methods now being developed for measuring the characteristics of high-speed integrated circuits. As researchers develop electronic devices that switch on and off faster and faster, the need for measurement techniques that can keep up with such devices grows.

"The problem," says IBM's Dan Grischkowsky, "is that standard electronic measurement capability is not as fast as the fastest devices." Techniques for generating and detecting extremely short electrical pulses make it possible to time brief events and to track a pulse as it travels along microscopic transmission lines laid down on a silicon chip.

To generate ultrashort electrical pulses, scientists at IBM in Yorktown Heights, N.Y., refined a technique first developed more than a decade ago. They fabricated a transmission line consisting of a pair of parallel, micron-wide aluminum strips, 2 microns apart, on a thin piece of silicon. That transmission line, in normal operation, is maintained at a certain voltage.

When a laser pulse strikes the silicon between the two aluminum strips, the light frees electrons. The presence of that electrical charge in the gap momentarily shorts the circuit, abruptly changing the voltage that moves down the line. A similar "photoconductive" switch is used to detect an electrical pulse later in its travels.

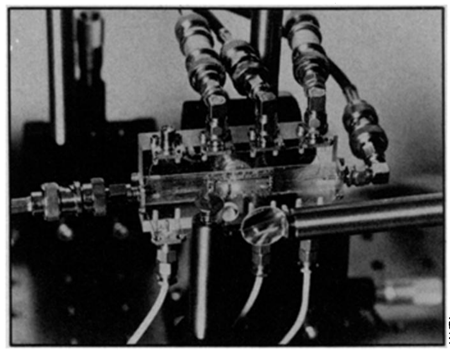
To keep the electrical pulse sharply defined so that it matches the shortness of the triggering laser pulse, IBM scientists bombard the silicon surface with atoms to create a large number of defects capable of quickly swallowing up the loose charge carriers. Thus, the short circuit is brief, and the resulting pulse starts and stops sharply.

By incorporating a set of transmission lines within experimental, high-speed integrated circuits, researchers can use ultrashort electrical pulses to test how well the devices work. The pulses can also be used for scientific studies, says Grischkowsky. IBM researchers have, for instance, watched what happens to such electrical pulses as they travel down a superconducting transmission line. "We see an enormous amount of structure and ringing," says Grischkowsky. For these and similar scientific studies, he says, "you need as short a pulse as you can get."

"The applications are very interesting, particularly the work on superconducting transmission lines," says David H. Auston of AT&T Bell Laboratories in Murray Hill, N.J. Auston and his colleagues invented the photoconductive switch subsequently refined by the IBM researchers. Using a different process, Auston's group in 1984 reported generating electromagnetic pulses lasting a quarter of a picosecond. However, these pulses travel through space inside a crystal rather than along a transmission line.

For testing integrated circuits, the IBM approach has the disadvantage of requiring the installation of suitable transmission lines on a chip. But at Stanford University, a group of researchers, led by David M. Bloom, avoids this. They inspect integrated circuits built on gallium arsenide by shining 2-picosecond bursts of infrared light directly onto the chip's surface. Gallium arsenide is transparent to infrared light and changes the transmitted light's speed, depending on the voltage applied to the material. This phenomenon is known as the electro-optic effect. By monitoring light reflected from gallium-arsenide chips, researchers can track what happens to an electrical signal as it travels through the chip's circuits.

Bloom's indirect, noninvasive approach has the advantage that no contact with or modification of the chip is necessary for making measurements. However, the use of infrared rather than visible light limits the shortness of the laser pulses needed for probing a chip. And the method doesn't work with silicon, which is not an electro-optic material.



IBM

Apparatus for generating and detecting an ultrashort electrical pulse.

Researchers at Bell Labs have overcome some of these disadvantages. To get shorter pulses, they construct photoconductive switches that inject sufficiently short electrical pulses into any circuit or electronic device. To probe the interior of an integrated circuit, Janis Valdmanis of Bell Labs has shown it's possible to pick up faint traces of electrical activity by bringing a small electro-optic crystal close to a chip's surface. The advantage of his method is that it works for both silicon and gallium-arsenide chips.

Although most integrated circuits don't operate yet in the sub-picosecond range, says Auston, "it's very important to have a capability to characterize integrated circuits." The most important areas for improvement are in sensitivity and convenience, he says. At the moment, it's not the duration of the probing pulse that matters so much as the time it takes to make a measurement. — *I. Peterson*

Putting the freeze on liver tumors

For nine out of 10 people whose colon cancer has spread to the liver, there is essentially no treatment. Their tumors are either too close to major blood vessels or too numerous to allow conventional surgery. And "there is no effective treatment other than surgery," says Gary Onik, a radiologist at Allegheny General Hospital in Pittsburgh. "There is nothing we can do for them."

Now Onik and his colleagues offer a ray of hope for some of the 50,000 people diagnosed with this form of liver cancer each year in the United States. They have developed a new surgical procedure that destroys liver tumors while leaving most of the liver tissue and blood vessels intact. The technique combines two existing surgical tools: the cryoprobe, which freezes and kills tumors, and ultrasound, which images tumors and guides the cryoprobe.

Of the seven patients on whom this procedure has been tried, reports Onik, four show absolutely no evidence of having the disease today. The longest follow-up time so far is 14 months, he says. He discussed the findings in Edmonton, Alberta, at a recent meeting of the Society for Cryobiology.

Oncologist Robert J. Mayer of the Dana-Farber Cancer Institute in Boston says the procedure is "a promising technique that will probably prolong survival in patients who are unresectable [can't have their tumors cut out]. But I doubt very much that it will cure people and I don't think it will be a substitute for surgical resection."

Onik, however, points out that without