H.P. Reports Big Advance in Memory Chip Design

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NYT May 1, 2008 Hewlett-Packard scientists reported Wednesday in the science journal Nature that they have designed a simple circuit element that they believe will make it possible to build tiny powerful computers that could imitate biological functions.

The device, called a memristor, would be used to build extremely dense computer memory chips that use far less power than today's DRAM memory chips. Manufacturers of today's chips are rapidly reaching the limit on how much smaller chips can be.

The memristor, an electrical resistor with memory properties, may also make it possible to fashion advanced logic circuits, a class of reprogrammable chips known as field programmable gate arrays, that are widely used for rapid prototyping of new circuits and for custom-made chips that need to be manufactured quickly.

Potentially even more tantalizing is the ability of the memristors to store and retrieve a vast array of intermediate values, not just the binary 1s and 0s conventional chips use. This allows them to function like biological synapses and makes them ideal for many artificial intelligence applications ranging from machine vision to understanding speech.

Independent researchers said that it seemed likely that the memristor might relatively quickly be applied in computer memories, but that other applications could be more challenging. Typically, technology advances are not adopted unless they offer large advantages in cost or performance over the technologies they are replacing.

"Whether it will be useful for other large-scale applications is unclear at this point," said Wolfgang Porod, director of the Center for Nano Science and Technology at the University of Notre Dame.
The technology should be fairly quickly commercialized, said R. Stanley Williams, director of the quantum science research group at Hewlett-Packard. "This is on a fast track."

The memristor was predicted in 1971 by Leon Chua, an electrical engineer at the University of California, Berkeley. There have been hints of an unexplained behavior in the literature for some time, Mr. Chua said in a phone interview on Tuesday.

He noted, however, that he had not worked on his idea for several decades and that he was taken by surprise when he was contacted by the Hewlett-Packard researchers several months ago. The advance clearly points the way to a prediction made in 1959 by the physicist Richard Feynman that "there's plenty of room at the bottom," referring to the possibility of building atomic-scale systems.
"I can see all kinds of new technologies, and I'm thrilled," he said.

The original theoretical work done by Mr. Chua was laid out in a paper, "Memristor — The Missing Circuit Element." The paper argued that basic electronic theory required that in addition to the three basic circuit elements — resistors, capacitors and inductors — a fourth element should exist.
The Hewlett-Packard research team titled their paper, "The Missing Memristor Found."

The Hewlett-Packard researchers said that the discovery of the memory properties in tiny, extremely thin spots of titanium dioxide came from a frustrating decade-long hunt for a new class of organic molecules to serve as nano-sized switches. Researchers in both industry and academia have hoped they would be able to fashion switches as small as the size of a single molecule to someday replace transistors once the

semiconductor industry's shrinking of electronic circuits made with photolithographic techniques reached a technological limit.

The memristor is a radically different approach from another type of solid state storage called phase-change memory that is being pursued by I.B.M., Intel and other companies. In phase-change memory, heat is used to shift a glassy material from an amorphous to a crystalline state and back again. The switching speed of these systems is both slower and requires more power, according to the Hewlett-Packard scientists.

The Hewlett-Packard team has successfully created working circuits based on memristors that are as small as 15 nanometers (the diameter of an atom is roughly about a tenth of a nanometer.) Ultimately, it will be possible to make memristors as small as about four nanometers, Mr. Williams said. In contrast the smallest components in today's semiconductors are 45 nanometers, and the industry currently does not see a way to shrink those devices below about 20 nanometers.

Because the concept of a memristor was developed almost 40 years ago by Mr. Chua, it is in the public domain. The Hewlett-Packard scientists, however, have applied for patents covering their working version of the device.

The most significant limitation that the Hewlett-Packard researchers said the new technology faces is that the memristors function at about one-tenth the speed of today's DRAM memory cells. They can be made in the same kinds of semiconductor factories that the chip industry now uses, however.

Paul Sakuma/Associated Press

R. Stanley Williams, Hewlett-Packard's director of the quantum science research group, and his team designed a circuit element that may make it possible to build tiny powerful computers.

HP makes breakthrough in computer memory

It could enable phones to go weeks without a charge
Jordan Robertson AP

Article Launched: 05/01/2008 01:36:09 AM PDT For nearly 40 years, scientists have speculated that basic electrical circuits have a natural ability to remember things even when the power is switched off. They just couldn't find it.

Now researchers at Hewlett-Packard have proved them right, with a discovery they hope will lead to memory chips that store more data but consume far less power than those found in today's personal computers and other digital devices.

The newly discovered circuit element - called a memristor - could enable cell phones that can go weeks or longer without a charge, PCs that start up instantly and laptops that retain your session information long after the battery dies.

It also could challenge flash memory, which is now widely used in portable electronics because of its ability to retain information even when power is off. Chips incorporating the HP discovery would be faster, suck up less power and take up far less space than today's flash.

"It certainly looks promising," said Wolfgang Porod, professor of electrical engineering at the University of Notre Dame and director of the university's Center for Nano Science and Technology. "However, if it's going to be 100 times better or 1,000 times better (than today's flash), it's very hard to say at this point."

Scientists have suspected since the 1970s that along with the three well-known elements of a basic circuit - the resistor, the capacitor and the inductor - a fourth fundamental building block is possible.

The memristor built by HP Labs researchers and reported today in the scientific journal Nature is made with a layer of titanium dioxide sandwiched between two metal electrodes. The researchers discovered that the amount of resistance it exerts depends on how much electric charge had previously passed through it.

That characteristic gives the memristor an innate ability to remember the amount of charge that has flowed through it long after the power to it is turned off. That means the circuit itself can be built with a memory function baked in.

Otherwise, data has to be stored in power-hungry transistors configured for storage. That also takes up valuable real estate on microprocessors or requires separate memory chips.

Some outside researchers, however, said more study is required before the memristor upsets the memory business. The HP Labs team said commercial viability is at least "a few years" away.

"These structures are going to be very small. It's obvious to me one could make very dense memory out of them, but how it could compete against other memory like flash remains to be seen," said Porod, who was not involved in the HP research.

Leon Chua, a professor in the electrical engineering and computer sciences department at the University of California-Berkeley, published a paper in 1971 theorizing that it should be possible to build such a structure.

Over the years, researchers observed behavior that seemed to suggest circuits possessed this ability, but they either dismissed it as a fluke or didn't realize the significance of the observation.

Stan Williams, a senior fellow at HP Labs and one of the four researchers on the Nature paper, said his team was able to identify the behavior and build a structure to harness its power because the effect is more apparent - and gets stronger - as the wiring in the circuits gets smaller and smaller.

Chua, who wrote the first paper on the topic when he was a new professor at Berkeley, is now 71 years old and says he's nearing retirement from the university.

"I never thought I'd live long enough to see this happen," Chua said with a laugh. "I'm thrilled because it's almost like vindication. Something I did is not just in my imagination, it's fundamental."