H.P. Reports Big Advance in Memory Chip Design

By JOHN MARKOFF
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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.

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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.

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."

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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.

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