Memristor chip could lead to faster, cheaper computers

17 March 2009

(PhysOrg.com) -- The memristor is a computer component that offers both memory and logic functions in one simple package. It has the potential to transform the semiconductor industry, enabling smaller, faster, cheaper chips and computers.

A University of Michigan electrical engineer has taken a step toward this end by building a chip composed of nanoscale memristors that can store up to 1 kilobit of information.

Previously, only a few memristor circuits had been demonstrated, rather than such a large-scale array, due to reliability and reproducibility issues. While 1 kilobit is not a huge amount of information, the researchers consider it a leap that will make it easier to scale the technology so it can store much more data.

"We demonstrated CMOS-compatible, ultra-high-density memory arrays based on a silicon memristive system. This is an important first step." said Wei Lu, an assistant professor in the Department of Electrical Engineering and Computer Science. CMOS stands for complementary metal oxide semiconductor. It is the technology used in modern microchips.

Moore's law, which predicts that technology will double the number of transistors that fit on an integrated circuit every two years, has held true since the mid 1960s. The more transistors on a chip, the faster the chip can operate. But this is getting more and more difficult to achieve, Lu said.

"This transistor scaling now faces several practical and fundamental challenges including increased power dissipation as transistors shrink, difficulties in laying out all the necessary interconnects, and the high cost to minimize device variations," Lu said. "Memristors have a simpler structure and are attractive for applications such as memories because it is much easier to pack a large number of them on a single chip to achieve the highest possible density."

The density of a memristor-based memory chip could be at least an order of magnitude—a factor of 10—higher than current transistor-based chips. Such high density circuits can also be very fast, Lu says. You could save data to a memristor memory three orders of magnitude faster than saving to today's flash memory, for example.

Another benefit of memristor memory is that it's not volatile, as today's DRAM memory is. DRAM, which stands for dynamic random access memory, is part of your computer's quick-access memory that helps the machine run faster. DRAM is overwritten multiple times a second because it fades with time. Memristor memory would not have to be overwritten. It is more stable.

Lu says memristors could open the door to universal memory. And because of how densely they can be crammed onto integrated circuits, memristors also offer hope for robust biologically-inspired logic circuits. Each neuron in the human brain is connected to 10,000 other neurons through synapses, Lu says. Engineers can't achieve that kind of connectivity with today's transistor-based circuits. But memristor circuits could potentially overcome this problem.

More information: A paper on this research, "High-density crossbar arrays based on a Si memristive system," is published in *Nano Letters*. Other authors are Sung Hyun Jo and Kuk-Hwan Kim, doctoral students in Lu's department.

Provided by University of Michigan