Toward Achieving 1 Million Times Increase in Computing Efficiency

Modern-day computers are based on logic circuits using semiconductor transistors. To increase computing power, smaller transistors are required. Moore's Law states that the number of transistors that can fit on an integrated circuit should double every two years due to scaling. But as transistors reach atomic dimensions, achieving this feat is becoming increasingly difficult. Among the most significant challenges is heat dissipation from circuits created using today's standard semiconductor technology, complementary metal-oxide semiconductor (CMOS), which give off more heat as more transistors are added. This makes CMOS incapable of supporting the computers of the future. Engineers are therefore seeking alternatives to CMOS that would allow for highly efficient computer logic circuits that generate much less heat. Northwestern University researchers may have found a solution: an entirely new logic circuit family based on magnetic semiconductor devices. The advance could lead to logic circuits up to 1 million times more power-efficient than today's. Unlike traditional integrated circuits, which consist of a collection of miniature transistors operating on a single piece of semiconductor, the so-called "spin logic circuits" utilize the quantum physics phenomenon of spin, a fundamental property of the electron. "What we've developed is a device that can be configured in a logic circuit that is capable of performing all the necessary Boolean logic and can be cascaded to develop sophisticated function units," said Bruce W. Wessels [1], Walter P. Murphy Professor of Materials Science and Engineering, one of the paper's authors. "We are using 'spintronic' logic devices to successfully perform the same operations as a conventional CMOS circuits but with fewer devices and more computing power." The spin-logic circuits are created with magnetoresistive bipolar spin-transistors, recently patented by McCormick researchers. A paper describing the findings, "Emitter-Coupled Spin-Transistor Logic," was presented July 5 at the International Symposium on Nanoscale Architectures held in the Netherlands. Additional Northwestern authors include graduate student Joseph Friedman, the paper's lead author; Gokhan Memik [2], associate professor of electrical engineering and computer science; and Alan Sahakian [3], professor of electrical engineering and computer science. The new logic family, which takes advantage of the magnetic properties associated with electron spin, could result in a computer 1 million times more power-efficient than those on the market today. While that achievement is optimistic and could take a decade to realize, "We think this is potentially groundbreaking," Friedman said. The research utilizes devices whose discovery was funded by the National Science Foundation and the Air Force Office of Scientific Research.

[4]Northwestern Engineering [5]

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