Nano World: Magnet nanostructure for chips

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All-magnetic microchips without transistors that could pack more computing power, instantly turn on without need to wait for reboot and change function after they are built could one day develop from a novel device made of magnets only nanometers wide, experts told UPI's Nano World.

Conventional microchips rely on transistors, which in essence act like switches that can flip between one and zero, the binary digits computers use to symbolize information. Computer designers are trying to pack more computing power onto microchips by cramming transistors closer together. However, a fraction of the power each transistor requires gets wasted as heat that can interfere with transistor function, and efforts to pack transistors close together are reaching limits where the heat can no longer be dissipated fast enough, explained researcher Wolfgang Porod, an electrical engineer at the University of Notre Dame in Indiana.

In addition, since transistors rely on electrical charge, they are volatile, losing their data when they are shut off. Magnetic logic would instead store information by flipping the polarity of magnets, akin to spinning the way compass needles point. Such devices would prove non-volatile, retaining their data even after turned off.

Alexandra Imre and their colleagues at Notre Dame and the Technical University of Munich have developed a magnetic equivalent of a transistor. This universal logic gate is made from nickel-iron magnetic "islands" only 70 nanometers wide.

Scientists can pass information up and down a chain of nanomagnets by flipping the way the poles of any one magnet point, which in turn would flip the way nearby magnets point, such that north attracts south between neighboring magnets. Imre, Porod and their colleagues developed more complicated networks of nanomagnets that can, like transistors, perform logic computations when correctly arranged. They described their findings in the Jan. 13 issue of the journal Science.

In principle, Porod explained their device would be low power, allowing more computing power to get crammed onto devices.

"The magnetic data storage industry is moving toward patterned magnetic media, where information is stored in small magnetic 'islands' similar to the ones we have been studying. It appears quite feasible that magnetic memory systems could be endowed with logic capability, thus merging memory and logic," Porod said. The researchers are communicating with labs at companies such as IBM, Motorola and Intel, he added.

"They've developed a universal logic gate, from which you could really build any circuit you want. It's extremely powerful to be able to do that," said physicist Russell Cowburn at Imperial College London. For instance, the device could in theory get its function changed within a few nanoseconds any time after the hardware is built. This could allow a single chip to be used for many different applications, reducing both costs and time to market, he explained, or allow a magnetic logic device to adapt itself to the best form for the computation in hand at any given moment.

Simulations of the device suggest an operating speed of roughly 100 megahertz, and in the future they could reach gigahertz speeds, comparable to modern consumer processors, said electrical engineer Dmitri Litinov of the University of Houston. In the future, the researchers will have to show their device can controllably get switched back and forth, he said. Porod added fabricating the nanomagnets with uniform shape and size will also prove a major challenge.