The next generation: nanomagnets could replace semiconductors

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Just as compact discs all but wiped out vinyl records, semiconductors could be on their way out, too. A University of Houston professor has developed a similar 'disruptive technology,' using magnetic cellular networks, that could yield such benefits as increased computing power that rivals what is possible with semiconductor integrated circuits.

Integrated circuits, which are a microscopic array of electronic circuits and components that have been implanted on the surface of a single chip of semiconducting material, have become the principal components of almost all electronic devices. Compared to the vacuum tubes and transistors that preceded them, integrated circuits have provided a low-cost, highly reliable way for computers to respond to a wider range of input and produce a wider range of output.

Dmitri Litvinov, associate professor of electrical and computer engineering and of chemical and biomolecular engineering in the Cullen College of Engineering at UH, is working with specially arranged assemblies of nanomagnets, or magnetic cellular networks, to replace conventional circuitry and significantly improve computing operations. His research involves a system of interacting magnetic nanocells that could combine logic, random access memory and data storage in a single nanomagnetic computing system.

Working from logic gates, which are at the heart of a computer's ability to add, subtract, multiply and divide, Litvinov wants to demonstrate that the magnetization of adjacent magnets is possible and can be used to perform specific logic and computing operations, reversing the repulsive and attractive poles of magnets.

"The significance is potentially ultra-high density of magnetic computing components for significantly higher computing power beyond what is expected to be achievable with semiconductor integrated circuits," said Litvinov, who also is the director of the Center for Nanomagnetic Systems at UH. "Additional benefits include potential integration with magnetic random access memory that would result in all-magnetic computing, as well as extreme robustness, or resilience, against radiation that could be critical for space missions or military applications."

Funded by a $360,000 grant from the National Science Foundation's Grant Opportunities for Academic Liaison with Industry (GOALI) initiative, Litvinov, the principal investigator on this project, is working with co-PI Sakhrat Khizroev of the University of California-Riverside.

The two have successfully implemented a number of nanomagnetic concepts and rapid prototyping approaches in commercial magnetic data storage systems, many of which are directly applicable to this project. Also involved in this research is co-PI Song Xue of Seagate Technology, a major American manufacturer of hard drives and the largest magnetic information technology company in the world. Xue is strategically positioned to deliver key technology components, such as access to advanced device fabrication, to facilitate this research and bring industrial insight to the project.

"The long-term potential of developing integrated magnetic computing systems such as ours could foster a significant advance in information processing that rivals not just superconductors, but also the integrated circuit revolution of the past half century," Litvinov said. "It's an ideal fit with the NSF's GOALI initiative, since this program only funds projects with demonstrated interest from industry and seeks out projects such as ours with a potentially profound impact on the world's economic, political and social systems."

Source: University of Houston