Read-write device offers new architecture for information processing

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(PhysOrg.com) -- "Silicon based logic devices may run out of steam soon because as devices get smaller, they run into different problems," Laurens Molenkamp tells *PhysOrg.com*. Molenkamp is a physics professor at Universität Würzburg in Würzburg, Germany. Along with a team of scientists, Molenkamp has been studying ways to make use of different materials and structures to improve logic devices, such as computers.

"Right now, information in computers has to be transferred between logic and memory," Molenkamp continues. "But with memory becoming so big, the process is becoming cumbersome." In order to remedy this problem, Molenkamp and his colleagues in Würzburg have developed a device that allows for memory storage and logic processing in the same structure. A description of their device can be found in Physical Review Letters*:* "Fully Electrical Read-Write Device Out of a Ferromagnetic Semiconductor."

Traditionally, information processing is based on different components. Metallic ferromagnets can be used to store information in a remanent manner, such as in a hard disk. Semiconductors are used for logic functions and for volatile memory (RAM). There must communication between memory and logic in order to get the type of computing we are used to. However, there are limitations to this. “Heat dissipation is a problem,” Molenkamp points out. “Additionally, the communication takes time and an enormous amount of interconnects, and there is only so much that can be done when logic and memory are separated in

information processing architecture."

The solution, then, is to create a new information processing architecture that puts logic and memory in the same device. "We have a sample device that we have shown works as a read-write device, putting logic and memory together to create the basis for a new information processing architecture," Molenkamp says.

In order to create the device, Molenkamp and his fellows used the ferromagnetic semiconductor (Ga, Mn)As. "Our device allows you to perform logic operation with the same circuits where you store info," he explains. "You can do away with the transfer between logic and memory parts." This would cut down on heat dissipation, as well as making information processing much faster.

So far, the team at Würzburg has created a one bit device. "There is a little disc in the middle of the device which is the logical bit," Molenkamp says. "However, in order for our design to be a full logic device, to actually make it programmable, we need two discs touching on each other." This is what the group is working on now.

In order to take the device further, Molenkamp says that a different set up might be needed. "We were able to show that we could use this device. It is more of a principle of operation," he points out. "Next, we will have to transfer to a different material that is magnetic at room temperature. We think that our new information processing architecture can carry over to metals." In order to accomplish this, Molenkamp continues, "one needs to grow crystalline metal layers to use as starting material." Once that is done, it is possible to begin developing devices that can operate at room temperature, as well as more advanced circuits.

"The adoption of our device could lead to much smaller computers," Molenkamp says. "Because the type of memory we describe stays

encoded, you wouldn't need RAM, and that would help with heat dissipation and size. We hope that, now that we have shown that you can integrate memory and logic in this new information processing architecture, that there will be interest in creating devices that use this technology."

More information: S. Mark, P. Dürrenfeld, K. Pappert, L. Ebel, K. Brunner, C. Gould, and L.W. Molenkamp, "Fully Electrical Read-Write Device Out of a Ferromagnetic Semiconductor," *Physical Review Letters* (2011). Available online: link.aps.org/doi/10.1103/PhysRevLett.106.057204