For a Bigger Hard-drive, Just Add Water

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Imagine having computer memory so dense that a cubic centimeter contains 12.8 million gigabytes of information. Imagine an iPod playing music for 100 millennia without repeating a single song or a USB thumb-drive with room for 32.6 million full-length DVD movies. Now imagine if this could be achieved by combining a computing principle that was popular in the 1960s, a glass of water and wire three-billionths of a meter wide. Science fiction? Not exactly.

Ferroelectric materials possess spontaneous and reversible electric dipole moments. Until recently, it was technologically difficult to stabilize ferroelectricity on the nano-scale. This was because the traditional process of screening the charges was not completely effective. However Jonathan Spanier from Drexel University and his research colleagues have proposed a new and slightly unusual mechanism stabilizing the ferroelectricity in nano-scaled materials: surrounding the charged material with fragments of water.

All ferroelectric materials, even Spanier's wires that are 100,000 times finer than a human hair, need to be screened to ensure their dipole moments remain stable. Traditionally this was accomplished using metallic electrodes, but Spanier and his team found that molecules such as hydroxyl (OH) ions, which make up water, and organic molecules, such as carboxyl (COOH), work even better than metal electrodes at stabilizing ferroelectricity in nano-scaled materials, proving that sometimes water and electricity do mix.

"It is astonishing to see that molecules enable a wire having a diameter equivalent to fewer than ten atoms to act as a stable and switchable dipole memory element," said Spanier, an assistant professor of materials science and engineering at Drexel.

If commercialized, ferroelectric memory of this sort could find its way into home computers, rendering traditional hard-drives obsolete. The extreme capacity offered by such a device could easily put a room full of hard-drives and servers into a jacket pocket, but this idea can be applied to other computer components, such as ferroelectric RAM.

RAM is necessary in a computer because it stores information for programs that are currently running. As this news release was written, RAM stored the words in a file. Because RAM can transfer files faster than a hard-drive, it is used to handle running programs. However most RAM is volatile, and if the computer loses power all the information in RAM is lost. This is not the case with ferroelectric memory.

Ferroelectric memory is non-volatile, so it is entirely possible for files to be stored permanently in a computer's RAM. Applying nano-wires and the new stabilization method to existing ferroelectric RAM would deal a double blow to hard-drives in size and speed.

Spanier and his colleagues, Alexie Kolpak and Andrew Rappe of the University of Pennsylvania and Hongkun Park of Harvard University, are excited about their findings, but say significant challenges lie ahead, including the need to develop ways to assemble the nanowires densely, and to develop a scheme to efficiently write information to and read information from the nanowires. In the interim, Spanier and his colleagues will continue to investigate the role of molecules on ferroelectricity in nanowires and to develop nano-scaled devices that exploit this new-found mechanism.

Source: Drexel University