Magnetic vortex memory shows memory potential of nanodots

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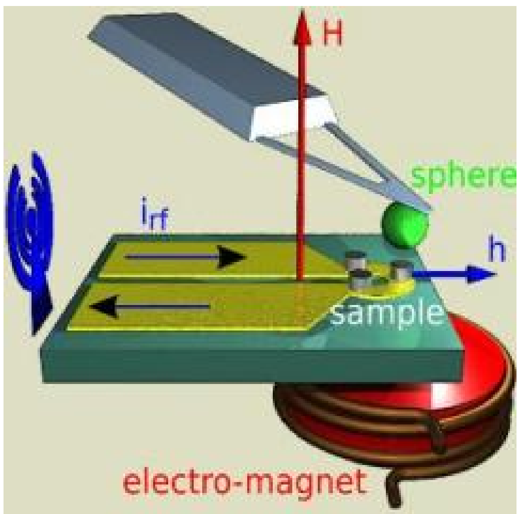

In this illustration of the frequency-controlled magnetic memory, a magnetic spherical probe attached to the end of a soft cantilever is used to detect magnetization dynamics in the vortex-state nanodisk underneath. Image credit: B. Pigeau, et al.

(PhysOrg.com) -- Using magnetic nanodots in the vortex state, researchers have designed a new kind of non-volatile memory that could offer increased speed and density for next-generation non-volatile random access memories (RAM). The new design takes advantage of magnetic vortices' ability to store binary information as positive or negative core polarities, which can be controlled by simply changing the frequency of the rotating vortex cores of the nanodots.

The new technique, called frequency-controlled magnetic vortex memory, was developed by a team of researchers, B. Pigeau, et al., from France, Germany, and the US. Their study is published in a recent issue of Applied Physics Letters.

As the researchers explain, the concept of using magnetic nano-objects to store binary information for magnetic RAM has previously been investigated, but it's been difficult to find a mechanism to reverse the magnetization inside individual nano-objects. Here, the researchers achieve this reversal by using microwave pulses in combination with a static magnetic field. In this scheme, large and small rotating core frequencies are associated with positive and negative core polarities, respectively. In a positive core polarity, the core is parallel to the applied magnetic field, while in a negative core polarity, the core is antiparallel to the applied magnetic field. An extremely sensitive magnetic resonance force microscope (MRFM) is used to address the resonant frequency of magnetic nanodots' vortex core rotations, allowing the researchers to control the polarity states of individual nanodots.

The researchers' memory design consists of an array of magnetic nanodots and an electromagnet that generates a static magnetic field perpendicular to the array of dots. The MRFM's small (800-nanometer-diameter) magnetic probe can scan the one-micrometer-diameter nanodots and locally control this magnetic field.

To read the core polarity state of a nanodot, a weak microwave magnetic field is used to read the rotating core frequency with the probe. As the researchers explain, the microwave magnetic field used to read the polarity state must be weak enough so that the core polarity is not reversed during the reading sequence.

By increasing the strength of this applied microwave magnetic field, it is possible to reverse the nanodot's core polarity, hence to write data. Once reversed, the core polarity is out of resonance with the writing pulse so that it cannot be switched back unless the pulse's frequency is changed. The researchers demonstrated this writing technique hundreds of times without failure, and without affecting neighboring nanodots.

"This dynamical reversal mechanism is of fundamental interest but also has potential application in information technology, with the vortex core polarity coding the binary information," coauthor Grégoire de Loubens, from the Commissariat à l'Énergie Atomique de Saclay in Gif-sur-Yvette, France, told *PhysOrg.com*.

"In sum, our frequency-controlled magnetic vortex memory prototype has two main advantages," he said. "Owing to the frequency discrimination allowed by a small perpendicular bias field, there is no need to control the circular polarization of the microwave field and to precisely time the writing pulse as it has to be in zero field. Also, deterministic and local addressing in a large array of memory cells is easily obtained by using the stray-field of the MRFM probe, that can be scanned laterally."

The researchers plan to improve the new frequency-controlled magnetic memory in several ways, such as by arranging the dots in a regular square array and increasing the dot aspect ratio. They are also considering replacing the MRFM, which contains moving parts, with local electrical detectors for the reading process. In addition, they hope to investigate stacking dots of different aspect ratios (and different resonance frequencies) on top of each other to create a multiregister memory.

More information: B. Pigeau, et al. "A frequency-controlled magnetic vortex memory." *Applied Physics Letters* 96, 132506 (2010). [Doi:10.1063/1.3373833](Doi:10.1063/1.3373833)
Nanomagnetism Group webpage: Frequency control of vortex core

polarity in a magnetic nanodisk iramis.cea.fr/spec/Phocea/Vie_ … marquant&id_ast=1567