Mini disks for data storage: Slanted edges favor tiny magnetic vortices

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Slanted exterior edges on tiny magnetic disks could lead to a breakthrough in data processing. Materials researchers of the Helmholtz-Zentrum Dresden-Rossendorf, Germany, were able to create magnetic vortices with a diameter of only one third of a thousandth of a millimeter - structures which were impossible in the past. They could help to store larger amounts of data on increasingly smaller surfaces with as little energy as possible.

Tiny magnets organize themselves in vortices in the researchers' mini disks. The individual magnets can twist either in a clockwise or a counterclockwise direction in the disk. These two different states can be used in data processing just like switching the electricity "on" and "off" in conventional computers. In contrast to conventional memory storage systems, these magnetic vortices can be switched by the electrons' intrinsic spin and with far less power consumption.

In the exterior section of a vortex the magnetic particles align nearly parallel to one another while the space in the disk's center is insufficient for such a parallel arrangement. Therefore, the elementary magnets in the center of a vortex twist away from the surface of the disk in order to gain space and thus, orient themselves once again next to one another without consuming much energy.

The formation of a vortex only works smoothly if the individual magnetic disks maintain some distance to one another or are relatively big. In order to achieve a high data storage density for compact and efficient devices, manufacturers and users ask for the smallest possible data processing units, which in turn also feature small magnetic vortices and require a closely packed structure. Then, however, the tiny magnets in each disk "feel" their neighbors in the adjacent disks and start to interact. This interaction, though, is a poor prerequisite for memory storage systems.

Therefore doctoral candidate Norbert Martin and materials researcher Jeffrey McCord eliminated the cylindrical shape of the small magnetic disks and instead prepared them with slanted edges. The tiny magnets at the edges are thus forced in the direction of the slant. This orientation creates in turn a magnetic field perpendicular to the disk surface, which then is in the preferred direction of the slant. This requires a lot less energy than the symmetric orientation of this magnetic field for the disks with vertical outer edges. Accordingly, magnetic vortices form more easily with slanted edges.

To create these vortices, Norbert Martin places tiny glass spheres with a diameter of 0.30 thousandth of a millimeter (300 nanometers) on top of a thin magnetic layer. Under specific conditions, all of these glass spheres arrange next to each other and therefore form a mask of tiny hexagons with small gaps. When the scientists direct argon ions at this layer, these atomic and electrically charged projectiles penetrate the gaps between the glass spheres and force particles out of the magnetic layer located under the gaps. The array of the glass spheres, thus, functions as a mask: One magnetic disk remains below each individual glass sphere, while the magnetic layer under the gaps erodes. During the bombardment, though, the argon ions remove material from the glass spheres which, according to that, continuously decrease in size. At the end of the process the diameter of the glass spheres is only 260 nanometers, instead of the original 300 nanometers. This permits the argon ions to reach also areas which are located further inside the magnetic disks that are emerging beneath the glass spheres over time.

Because the time of bombardment is shorter in these places, less material is removed on the inside. The desired slanted edge is therefore created virtually on its own.

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