Nanospheres stretch limits of hard disk storage

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(PhysOrg.com) -- A new magnetic recording medium made up of tiny nanospheres has been devised by European researchers. The technology may lead to hard disks able to store more than a thousand billion bits of information in a square inch.

With consumer PCs now being sold with hard disks of a terabyte or more - enough to record more than two years of music - storage capacity seems to be expanding without limit. But the limits are there and industry insiders know that they are approaching fast.

Present-day hard disks record information on a ferromagnetic layer. The layer is made up of grains about 7 nanometres across and each 'bit' of information is contained in a magnetised cell covering perhaps 60 to 80 grains. When the magnetic field is pointing one way a '1' is stored and when it points the opposite way a ‘0’ is stored.

One way of packing information on to a disk would be to make the cells smaller. But with fewer grains per cell, the signal to noise ratio rises and with it the probability of a bit being misread.

The obvious answer is to use a recording medium with smaller grains, but then thermal stability problems arise. “Over time, if the thermal stability is not large enough, the magnetic orientation will flip to the opposite direction so it will lose its information,” says Manfred Albrecht of the Chemnitz University of Technology.

Nanospheres

He favours a completely new approach using techniques from nanotechnology to construct a ‘patterned’ recording surface made up not of irregular grains but of purpose-made magnetic cells. “The problem now is how can you produce these nanostructures on a large scale at low cost?”

Albrecht coordinated the EU-funded MAFIN project which sought to build regular arrays of cells from tiny magnetised nanospheres. The spheres are made of silica and are commercially available in a range of sizes. After testing many different sizes the MAFIN team settled on spheres 25 nanometres in diameter, bigger than conventional grains but smaller than normal storage cells.

The attraction of using nanospheres is that they will assemble themselves into a regular array. The nanospheres are mixed with an alcohol-based solution that is dropped on to the substrate. As the alcohol evaporates the spheres are left in a regular pattern.

“We then deposited a magnetic film on top of the particles to form a magnetic ‘cap’,” Albrecht explains. “And if you do it right then this magnetic cap acts as a single magnet, with a north and a south pole, and the array can be used as a storage device.”

Whether the cap is magnetised with a north or south pole upwards determines whether it is storing a ‘1’ or a ‘0’.

Iron-platinum alloy

The magnetic film is an iron-platinum alloy that has already attracted interest within the magnetic storage industry. It is coated on to the nanospheres by magnetron-sputter deposition. As silica itself is non-magnetic, each cap is isolated from its neighbours and can hold its magnetisation well.

Self-assembly of the nanospheres is guided by pre-patterning of the silicate substrate by x-ray lithography to create tiny pits for the spheres to settle into.

“I believe that self-assembly-based approaches have the largest potential because they are not expensive,” Albrecht says. “They are very low cost.”

A spacing of 25 nanometres between spheres is equivalent to a storage density of one terabit (1000 gigabits) per square inch. Using the same approach with smaller spheres researchers should be able to attain densities up to six times higher.

As well as looking at the recording medium, MAFIN researchers have also investigated recording techniques. Iron-platinum is harder to magnetise than conventional media, so modifications will be needed to allow information to be easily recorded and read.

Opportunities for industry

The team investigated using a probe with a fine magnetic tip to magnetise and read each of the nanospheres instead of a conventional recording head.

MAFIN finished in May 2009 but its work has carried over into a successor EU project, TERAMAGSTOR. While MAFIN was concerned with a proof of concept, the new project aims to demonstrate a hard disk with a storage density exceeding one terabit per square inch.

Albrecht sees opportunities for European industry to develop the manufacturing processes that new, nanostructured storage media will require. “In Europe we don't have a real industry that produces hard drives,” he says. “It's all in Asia and the USA. But we have manufacturers of deposition tools and expertise in sputter technology.”

The glass substrates of conventional hard disks will not be suitable for the high-temperature processes needed to deposit alloys, so European companies with know-how in ceramic materials may also have a role to play.

More information: MAFIN project - www.mafin-project.de/

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