THE ANCIENT ABACUS MAY BE THE BASIS FOR STORAGE CAPACITIES OF 100,000GB.

Beads for bytes

HAVING ALMOST QUADRUPLED in the past 12 months, the storage capacity of hard disks continues to increase at an amazing rate. But although it's getting bigger, faster and cheaper all the time, magnetic disk technology has its limits. Researchers are now looking at alternative storage technologies that work at the molecular level, and a bizarre hybrid of food chemistry and mechanics is emerging as a possibility.

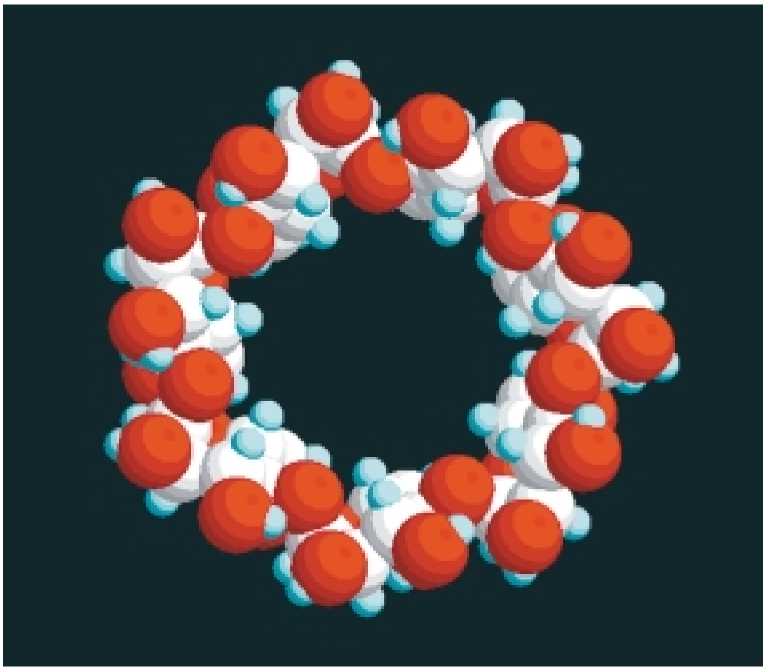
The trouble with hard disks is simply one of scale. When the magnetic storage space allocated on the disk's surface for each bit gets too small, the effects of random molecular noise come into play, such that the magnetic fields used to encode the zeros and ones can no longer be reliably maintained.

Now researchers in Japan have built a prototype device that can store data at the molecular level. In effect, Makoto Komiyama of Tokyo University and his colleague Hidemi Shigekawa of Tsukaba University have built a molecular abacus.

Each bead of the abacus is a single molecule of a glucose complex called cyclodextrin, a substance used commercially to improve the solubility of drugs and food additives. The cyclodextrin molecule is shaped like a truncated hollow cone. Each molecular bead slides along a 'wire' made from another molecule, a polymer called polyethylene glycol, used widely in the pharmaceutical and cosmetics industries, and also as a food thickener.

The idea was pioneered in 1993 by Akira Harada of Osaka University, who was interested in collecting together sets of cyclodextrin beads – like the mints in a packet of Polos – to form tiny molecular tubes. He first strung them on a polymer wire, then removed the wire. But Komiyama and Shigekawa kept the wire, and placed the whole arrangement on a flat bed of molybdenum disulfide, to which the beads adhere. Then they used the tip of an electron microscope to push the beads along the wire: a bead could represent a zero if located at one end of the wire, and a one at the other end (dora.ims.tsukuba.ac.jp/indexE.html).

In principle this works fine, but in practice the use of an electron microscope to set a bead's position, and to later detect that position, is cumbersome and slow. Current research is focusing on a much better idea: to use light beams to push the beads around. The key to this approach is to use a wire that can be made to kink in the middle, pushing a bead threaded onto it away from the kink. The new wire is made from a molecule based on a nitrogen-benzene complex, which has the unusual property of switching from being straight to kinked when illuminated by a flash of light. Since the abacus is now light-controlled, it can switch very rapidly indeed. And by splicing lengths of kinky wire into the polyethylene wire, you can have multiple beads on a single wire.



Komiyama and Shigekawa's molecular abacus is made up of cyclodextrin molecules, stacked together like the mints in a pack of Polos

The research is still in its early stages, and there are still formidable problems to be solved, such as a mechanism for optically reading back the beads' positions, and separately controlling each of several beads on the same abacus. One idea is to differentiate the beads using coloured molecular dyes attached to them, and to then manipulate the beads with correspondingly coloured light.

Problems aside, the rewards of this technology could be astounding, providing data storage at unheard of densities, perhaps 100,000GB in a square centimetre. Today, such capacity might seem absurdly high – what on earth would we ever use it for? I have the feeling we'll think of something soon enough.

TOBY HOWARD