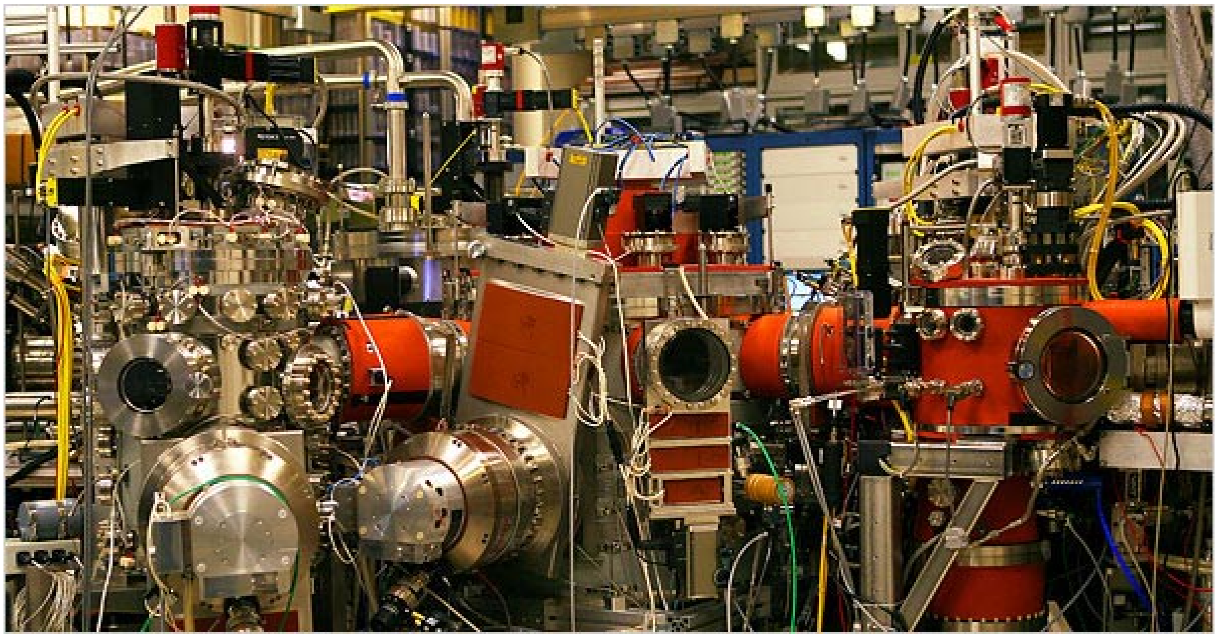
Reshaping the Architecture of Memory



Jim Wilson/The New York Times

At I.B.M.'s research lab in San Jose, Calif., Stuart S. P. Parkin is working on a device that could increase chip data storage by 10 to 100 times.

By JOHN MARKOFF
Published: September 11, 2007

SAN JOSE, Calif. — The ability to cram more data into less space on a memory chip or a hard drive has been the crucial force propelling consumer electronics companies to make ever smaller devices.

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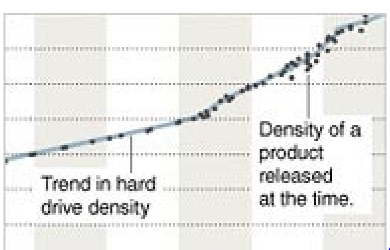

Graphic

More Data in Smaller Space

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Jim Wilson/The New York Times

Stuart S. P. Parkin, a physicist, is developing "racetrack memory," a technology that makes it possible to read and write data far faster than is possible with existing storage devices.

It shrank the mainframe computer to fit on the desktop, shrank it again to fit on our laps and again to fit into our shirt pockets.

Now, if an idea that Stuart S. P. Parkin is kicking around in an I.B.M. lab here is on the money, electronic devices could hold 10 to 100 times the data in the same amount of space. That means the iPod that today can hold up to 200 hours of video could store every single TV program broadcast during a week on 120 channels.

The tech world, obsessed with data density, is taking notice because Mr. Parkin has done it before. An I.B.M. research fellow largely unknown outside a small fraternity of physicists, Mr. Parkin puttered for two years in a lab in the early 1990s, trying to find a way to commercialize an odd magnetic effect of quantum mechanics he had observed at supercold temperatures. With the help of a research assistant, he was able to alter the magnetic state of tiny areas of a magnetic data storage disc, making it possible to store and retrieve information in a smaller amount of space. The huge increases in digital storage made possible by giant magnetoresistance, or GMR, made consumer audio and video iPods, as well as Google-style data centers, a reality.

Mr. Parkin thinks he is poised to bring about another breakthrough that could increase the amount of data stored on a chip or a hard drive by a factor of a hundred. If he proves successful in his quest, he will create a "universal" computer memory, one that can potentially replace dynamic random access memory, or DRAM, and flash memory chips, and even make a "disk drive on a chip" possible.

It could begin to replace flash memory in three to five years, scientists say. Not only would it allow every consumer to carry data equivalent to a college library on small portable devices, but a tenfold or hundredfold increase in memory would be disruptive enough to existing storage technologies that it would undoubtedly unleash the creativity of engineers who would develop totally new entertainment, communication and information products.

Currently the flash storage chip business is exploding. Used as storage in digital cameras, cellphones and PCs, the commercially available flash drives with multiple memory chips store up to 64 gigabytes of data. Capacity is expected to reach about 50 gigabytes on a single chip in the next half-decade.

However, flash memory has an Achilles' heel. Although it can read data quickly, it is very slow at storing it. That has led the industry on a frantic hunt for alternative storage technologies that might unseat flash.

Mr. Parkin's new approach, referred to as "racetrack memory," could outpace both solid-state flash memory chips as well as computer hard disks, making it a technology that could transform not only the storage business but the entire computing industry.

"Finally, after all these years, we're reaching fundamental physics limits," he said. "Racetrack says we're going to break those scaling rules by going into the third dimension."

His idea is to stand billions of ultrafine wire loops around the edge of a silicon chip — hence the name racetrack — and use electric current to slide infinitesimally small magnets up and down along each of the wires to be read and written as digital ones and zeros.

His research group is able to slide the tiny magnets along notched nanowires at speeds greater than 100 meters a second. Since the tiny magnetic domains have to travel only submolecular distances, it is possible to read and write magnetic regions with different polarization as quickly as a single nanosecond, or one billionth of a second — far faster than existing storage technologies.

If the racetrack idea can be made commercial, he will have done what has so far proved impossible — to take microelectronics completely into the third dimension and thus explode the two-dimensional limits of Moore's Law, the 1965 observation by Gordon E. Moore, a co-founder of Intel, that decrees that the number of transistors on a silicon chip doubles roughly every 18 months.

Just as with Mr. Parkin's earlier work in GMR, there is no shortage of skeptics at this point.

Giant storage companies like Seagate Technology are starting to turn toward flash to create a generation of hybrid storage systems that combine silicon and rotating disk technologies for speed and capacity. But Seagate is still looking in the two-dimensional realm for future advances.

“There are a lot of neat technologies, but you have to be able to make them cost-effectively,” said Bill Watkins, Seagate’s chief executive.

So far, the racetrack idea is far from the Best Buy shelves and it is very much still in Mr. Parkin’s laboratory here. His track record, however, suggests that the storage industry might do well to take notice of the implications of his novel nanowire-based storage system in the not too distant future.

“Stuart marches to a little bit of a different drummer, but that’s what it takes to have enough courage to go off the beaten path,” said James S. Harris, an electrical engineering professor at Stanford University and co-director of the I.B.M.-Stanford Spintronic Science and Applications Center.

A visit to Mr. Parkin’s crowded office reveals him to be a 51-year-old British-American scientist for whom the term hyperactive is a modest understatement at best. During interviews he is constantly in motion. When he speaks publicly at scientific gatherings, his longtime technology assistant, Kevin Roche, is careful to see that Mr. Parkin empties the change from his pockets, lest he distract his audience with the constant jingling of coins and keys.

Today, a number of industry analysts think there are important parallels between Mr. Parkin’s earlier GMR research and his new search for racetrack materials.

“We’re on the verge of exciting new memory architectures, and his is one of the leading candidates,” said Richard Doherty, director of the Envisioneering Group, a computing and consumer electronics consulting firm based in Seaford, N.Y.

Mr. Parkin said he had recently shifted his focus and now thought that his racetracks might be competitive with other storage technologies even if they were laid horizontally on a silicon chip.

I.B.M. executives are cautious about the timing of the commercial introduction of the technology. But ultimately, the technology may have even more dramatic implications than just smaller music players or wristwatch TVs, said Mark Dean, vice president for systems at I.B.M. Research.

“Something along these lines will be very disruptive,” he said. “It will not only change the way we look at storage, but it could change the way we look at processing information. We’re moving into a world that is more data-centric than computing-centric.”

This is just a hint, but it suggests that I.B.M. may think that racetrack memory could blur the line between storage and computing, providing a key to a new way to search for data, as well as store and retrieve data.

And if it is, Mr. Parkin's experimental physics lab will have transformed the computing world yet again.

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