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NAND flash memory chips have already made a huge impact on global electronics devices. Without them, there would probably be no iPod revolution, and MP3s would still be burned onto CDs. Computers would still require 2.5-inch floppy drives, since there wouldn't be any USB (Universal Serial Bus) flash memory sticks, and memory cards in digital cameras would hold far fewer photos than they do today.

And with recent changes in the NAND industry, namely the arrival of a huge new competitor and signs of industry maturity, users can look forward to plenty more from the chips, which boast a storage capacity that has grown so fast that they're starting to take the place of hard disk drives in some portable devices.

There are two major reasons why there may be no better chip to fuel the consumer electronics gadget revolution than NAND flash memory. The first is they have no clear rivals in the market, except for maybe hard disk drives. NAND flash memory is special for its ability to store massive amounts of data and retain that data when power is shut off.

The nearest competitor to NAND is NOR flash memory, which Intel and Spansion both produce. The names, NOR and NAND, refer to the type of logic gate, a fundamental building block of a digital circuit, used in each storage cell. Loosely, NAND stands for Not AND, while NOR stands for Not OR.

The two chips work differently. Because NOR runs software quickly, it's ideal for mobile phones, it's main end market. But NAND beats NOR in storage capacity, which is why NAND is perfect for devices such as MP3 players. Other kinds of chips don't match up well against NAND either. DRAM (dynamic RAM), for example, could meet NAND's storage ability, but DRAM doesn't retain data after the power is cut off -- and who would want an MP3 player that lost all its songs after being shut down?

The second reason NAND is perfect for the consumer electronics gadget revolution is because it's relatively easy for DRAM makers to produce. Production line equipment requires just a few, relatively inexpensive tweaks to switch from DRAM to NAND, and DRAM vendors have been looking for a new product to help them escape the boom-bust cycle of DRAM for years. Users also can thank the DRAM makers for their hard work in ensuring NAND is cheap enough to gain a foothold in so many devices.

NAND flash memory has received such a strong push from major DRAM vendors that its price has dropped as fast as its storage capacity has increased. A year ago, 256M bit NAND chips were the mainstream and, therefore, the capacity of most MP3 music players was 256M bytes. Then the storage capacity doubled, prices came down, and capacity doubled again, so on, so that now, 1G bit chips are already heading into the sunset and 2G bit parts are mainstream.

Coming next to the fore: 4G bit NAND chips. Market leader Samsung Electronics unveiled the 4G bit chips in June and has been pushing them on the market ever since. The result is that devices from Apple Computer's iPods to digital cameras are gaining massive increases in storage space.

"Because the price is going down so fast, companies are doubling the amount of memory in devices," said Mario Morales, vice president of semiconductor research at market researcher IDC. He expects to see NAND flash memory used in a range of new gadgets going forward, and next year to become standard in mobile phones for data storage.

Within the past few weeks, there have been changes in the chip industry that will further drive NAND prices down, storage capacity up and device innovation forward. Mainly, a potent new NAND flash memory maker has emerged. IM Flash Technologies, a new joint venture by Intel and Micron Technology, will add another major competitor to an industry currently dominated by Samsung and Japan's Toshiba.

The two U.S. companies each pledged to inject about US\$1.2 billion into the joint venture, which will produce flash memory for consumer electronics devices, removable storage, handheld devices and more. Each company will add another \$1.4 billion to the project over the next three years.

"The new competitor will accelerate price declines and therefore accelerate the uptake of NAND in new applications," says Crystal Lee, a memory chip analyst at ABN AMRO Asia Ltd. in Taipei.

NAND production is also showing signs of maturing, which normally hits a market when competition and price erosion causes some companies to opt out. This month, Japan's Renesas Technology bowed out of the NAND flash market race because it didn't want to join the mass production game. It's leaving NAND to the manufacturing experts, mainly DRAM makers such as Samsung, Hynix Semiconductor, and Micron.

"The NAND market has claimed its first victim. Fierce competition and a 'Last Man Standing' mindset are requirements in this market, which has many of the same players and the same set of rules as the DRAM market used for many a year," wrote Jim Handy, director of nonvolatile memory analysis at Semico Research, in a Tuesday report. "Participants must be willing to invest heavily in a high-stakes game while enduring some profitable years and others of heavy losses....Renesas did not devote the enormous production resources to this tough market that their competitors did."

All this jockeying for position adds up to good news for users, because cheap, plentiful NAND flash memory will likely bring even more innovations to the information technology industry than we've already seen, analysts say.

One area NAND flash memory is already expanding to is mobile phones, to store pictures, songs and other data, a trend that is expected to continue. The chips are perfect for the job, they're small, with no moving parts that task batteries, and they can hold huge amounts of data.

A NAND-inspired innovation likely headed for notebook computers is Intel's Robson cache technology. The technology uses NAND flash memory in laptops to significantly reduce the time it takes to power up or access programs, while improving battery life. Instead of using the hard drive for boot up or to access oft-used programs, a Robson-enabled laptop would use NAND instead.

In a demonstration during October's Intel Developer Forum in Taipei, a laptop with Robson cache technology ensured an almost immediate start-up of a Centrino-based notebook PC, while a laptop with identical hardware but without Robson took several seconds to boot up.

The laptop with Robson also opened Adobe Reader in 0.4 seconds, while the other notebook required 5.4 seconds. It opened Quicken in 2.9 seconds, while the laptop without Robson needed 8 seconds to do the job.

In addition, the US\$100 notebook computer currently being promoted for children in developing countries uses NAND as a replacement for a hard drive. The laptop, from the One Laptop Per Child (OLPC) nonprofit group headed by Nicholas Negroponte, the chairman of the Massachusetts Institute of Technology's Media Lab, uses 500M bytes of NAND flash memory instead of a hard disk, according to the organization's Web site: <http://laptop.media.mit.edu/>.

The idea that NAND could replace hard-disk drives in portable computers someday soon has been much debated in IT circles, and it's an idea Samsung is championing. Naysayers believe the hard

disk industry will be able to keep up by reducing the price and size of their drives, as well as offering greater storage space. But the race is still in its early days, and the competition means users will be able to look forward to ever-expanding storage space in the devices they use, regardless of whether it's from NAND or hard disks.

One example of NAND used as a hard disk was revealed in May by Samsung. The company announced a Solid State Disk (SSD) based on NAND Flash memory technology for consumer and mobile PC products. The 16G-byte, NAND-based SSD has no moving parts, so it consumes less power than a hard disk drive and produces less noise.

ABN AMRO's Lee believes NAND flash memory will overtake most storage devices used today, including DVDs and CDs, because the chips are so easy to use and prices are dropping so fast. A NAND flash card, like the ones used in digital cameras, for example, could someday replace DVDs as the main medium for movies, she said. Portable hard drives are also being made using NAND, mainly in mini form, but as its storage ability grows, the chips could come out to end users as tiny devices on a key ring that hold the entire contents of their computer.

Some companies are already pushing out products similar to Lee's description. Taiwan's Transcend Information Inc. in November announced an 8G-byte USB flash drive dubbed the Ultra-Speed JetFlash that fits in one's pocket. That's a lot of storage space in such a small device, and it's possible thanks to NAND flash memory.