The Industry's First 4-bit/cell Flash Memory MirrorBit Quad Technology

Spansion™ MirrorBit Quad technology, the industry's first 4-bit-per-cell Flash memory, is the next-generation technology for high-density data storage. It enables Flash memory solutions for electronic devices with low cost production and excellent reliability and productivity.

Overview

As consumers use more data and content at work, at home and on the go, Flash memory solutions are enabling a more mobile, digital, media-rich global society. Semiconductor companies are continually challenged to produce higher capacity storage at lower cost and with greater capabilities than earlier generations. Spansion is leading the charge with continuing innovation in non-volatile storage. Following the introduction of revolutionary MirrorBit® technology in the first half of the decade, Spansion is now taking the next step with the development of MirrorBit Quad, the world's first 4-bit-per-cell technology that will enable new innovation in Flash memory.

Technological Breakthroughs in Flash Memory

Today Spansion is the leading manufacturer of commercial nitride-based non-volatile memory solutions with its proprietary, patented MirrorBit technology. Spansion is the first company to have successfully scaled nitride production into high volumes, with MirrorBit technology-based product sales of approximately $1.4 billion through the second quarter of 2006. The technology provides the foundation for an entire line of value-added Flash memory solutions in Spansion's target markets including wireless, automotive, networking, telecommunications and consumer electronics. Major semiconductor companies are now acknowledging the potential for nitride storage and researching nitride-based solutions following Spansion's success with 2-bit-per-cell technology and because of the anticipated issues associated with floating-gate technology in the future. Now on the horizon is Spansion's plan to ramp to production the industry's first commercially viable 4-bit-per-cell technology—Spansion MirrorBit Quad technology. MirrorBit Quad technology stores two distinct quantities of charge in a non-conducting nitride storage medium to deliver fundamental cost, reliability and manufacturing advantages over floating-gate technology.

MirrorBit Technology

MirrorBit technology allows Spansion to deliver value-added code and data storage solutions for customers across the integrated electronics market with a single technology platform. For code-optimized solutions, MirrorBit products are designed with a NOR architecture, which enables fast read speed and reliable code storage. For data-optimized applications for today's integrated electronics, the MirrorBit ORNAND™ architecture supports fast read and write speed for high-density data storage performance with higher quality and reliability when compared to competing floating-gate NAND products.

Spansion believes that MirrorBit Quad technology is the next step for mass data storage within the integrated electronics market. The Spansion MirrorBit cell is significantly different from a floating-gate cell because it doubles the intrinsic storage capacity by storing two physically distinct charges on opposite sides of a memory cell.

Unlike the standard floating-gate cell which uses a conductive polysilicon floating gate to store charge, the MirrorBit cell employs a non-conductive nitride storage medium to prevent distinct charges from flowing together and equalizing throughout the storage medium. MirrorBit technology therefore eliminates the use of a floating gate, which improves reliability and saves process steps.

By developing symmetric and interchangeable source and drain regions in the cell, two non-interactive physically distinct charge-storage regions are created, with each region physically representing one bit of information mapped directly to the memory array and each cell literally containing two bits of information.

Fig.1 presents a comparison between floating gate and MirrorBit technology.

Another important benefit of MirrorBit technology's simpler process technology compared to floating gate is the efficient integration of logic, effectively solving one of industry's long established challenges by integrating significant Flash memory density with significant logic capability of up to one million logic gates. The ability to integrate significant logic reduces cost and enables solutions that would otherwise require additional discrete logic silicon.

Next-Generation MirrorBit Quad Technology

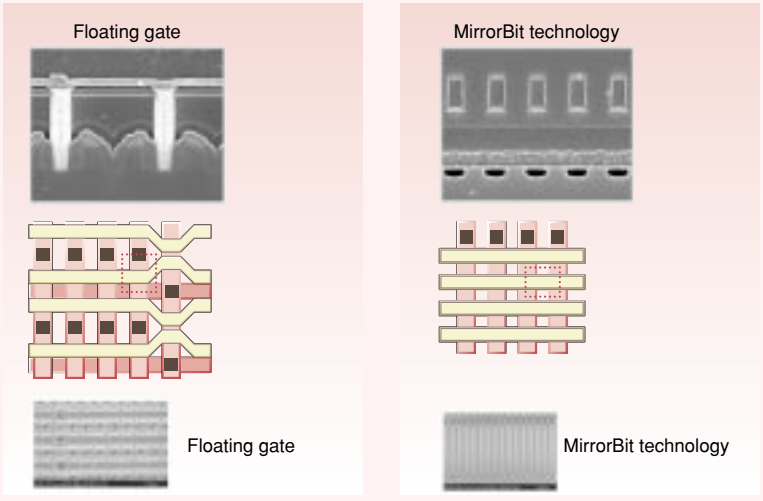
Spansion has taken the next step forward with MirrorBit Quad technology—an architecture that stores 4-bit-per-cell. MirrorBit Quad doubles the density of MirrorBit by continuing to store charge in each of the two charge locations but now adds the ability to store different quantities or charge states in each of the two locations.By storing four different quantities of charge at each location the cell now stores 4×4 or 16 different combinations of charge providing the equivalent of 4-bit-per-cell.

Fig.2 presents a comparison between MirrorBit and MirrorBit Quad technology.

All MLC Flash architectures must deal with the problem of different charge states, which increases the complexity of accurately injecting and detecting the reduced number of electrons in the storage medium. However, MirrorBit Quad has two distinct advantages over traditional floating gate MLC Flash memory.

First, the charge in a MirrorBit Quad cell, as in the original

Figure 1 Floating gate and MirrorBit Technology



Because of its symmetrical memory cell and non-conductive storage element, MirrorBit Flash technology has been engineered to take advantage of a simple, efficient memory array. This array design is implemented with a highly planar structure which greatly simplifies a device's topography and manufacturing process significantly reducing cost.

MirrorBit cell, resides on a non-conducting nitride medium. This makes the stored charge in a MirrorBit cell much less sensitive to charge leakage compared to the potential for charge leakage through the isolating oxide of a conductive polysilicon gate of a regular Flash memory cell. Any defect anywhere in the isolating oxide will cause charge to leak.

As the number of bits/cell increases, the difference in the number of electrons stored between adjacent states is reduced, exacerbating the leakage problem.

Second, having two charge storage locations in a MirrorBit memory cell enables just four different charge states in each location to achieve 4-bit-per-cell. By contrast for a traditional MLC floating-gate Flash memory cell 4 bits/cell requires 16 (24) different charge states in a single location. The technical challenge in storing and detecting one of 16 different charge states is significant and requires powerful ECC solutions in order to operate at all.Spansion designed the MirrorBit Quad architecture for very dense layout compared to floating-gate NAND and NOR architectures. Due to the increased storage capacity per cell, MirrorBit Quad technology is capable of delivering up to 30% smaller effective cell size per bit than floating-gate multi-level cell NAND Flash memory technology at the same process technology node. In addition to its intrinsic efficiency compared to floating-gate technology, MirrorBit Quad technology is also expected to scale to smaller process nodes than floating-gate technology which is expected to face significant challenges when scaling below 40nm.

Fig.3 shows the relationship between process mode miniturization and effective cell size.

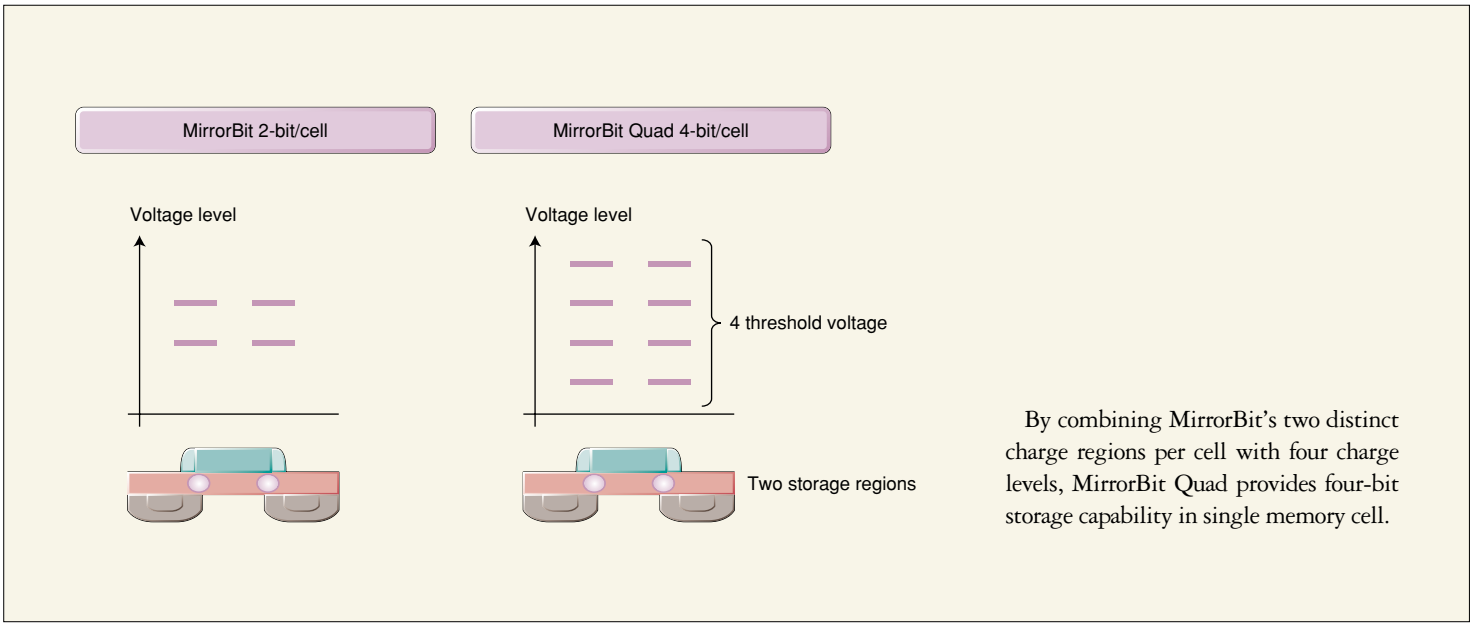
Leveraging MirorBit Advantages

Just as with MirrorBit technology, the ability to efficiently integrate logic on the same die as MirrorBit Quad technology will result in the creation of complex integrated controllers, processors and system level interfaces, which will enable more innovative products. This provides customers with Application Specific Standard Products (ASSP) that are much more than just memory subsystems, reducing the cost, size and complexity of the end-systems that use MirrorBit devices.

Future Development

What is particularly intriguing about using MirrorBit technology for high bit-per-cell solutions is the potential to scale to even greater bit-counts-per-cell in the future. By extending the technology to support just 6 charge states or voltage levels per charge location a cell might store 5-bits of information per cell or double the information stored in the most advanced MLC floating-gate technology which would

Figure 2 MirrorBit and MirrorBit Quad Technologies



By combining MirrorBit's two distinct charge regions per cell with four charge levels, MirrorBit Quad provides four-bit storage capability in single memory cell.

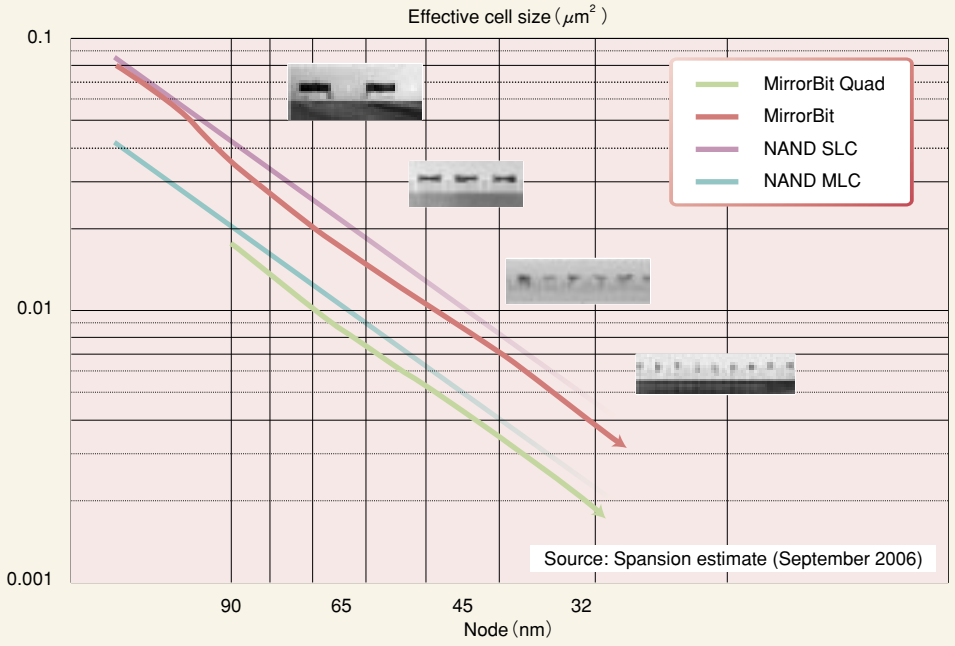
require 32 charge states to achieve similar storage capacity per cell.

Spansion believes that MirrorBit Quad will be the next generation technology for mass data storage, and has plans to implement solutions with many different interfaces and capabilities. These solutions will expand the Flash memory storage capacity of devices within the integrated Flash memory market, and potentially enable entirely news classes of products. *

NOTES

* For more information related to Spansion Flash memory solutions, please visit the Spansion web site:
  http://www.spansion.com/jp
* Spansion, the Spansion logo, MirrorBit, ORNAND, and all combinations of these are trademarks or registered trademarks of Spansion LLC.
* Other company names and brand names are the trademarks or registered trademarks of their respective owners.

Figure 3 Scaling of Process Node and Effective Cell Size



MirrorBit and MirrorBit Quad technology scales as processes support smaller feature sizes, resulting in a continuing bit-density advantage over traditional NAND Flash technology over time.