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Comparing SLC and MLC Flash Technologies and Structure

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NOR versus NAND Memory

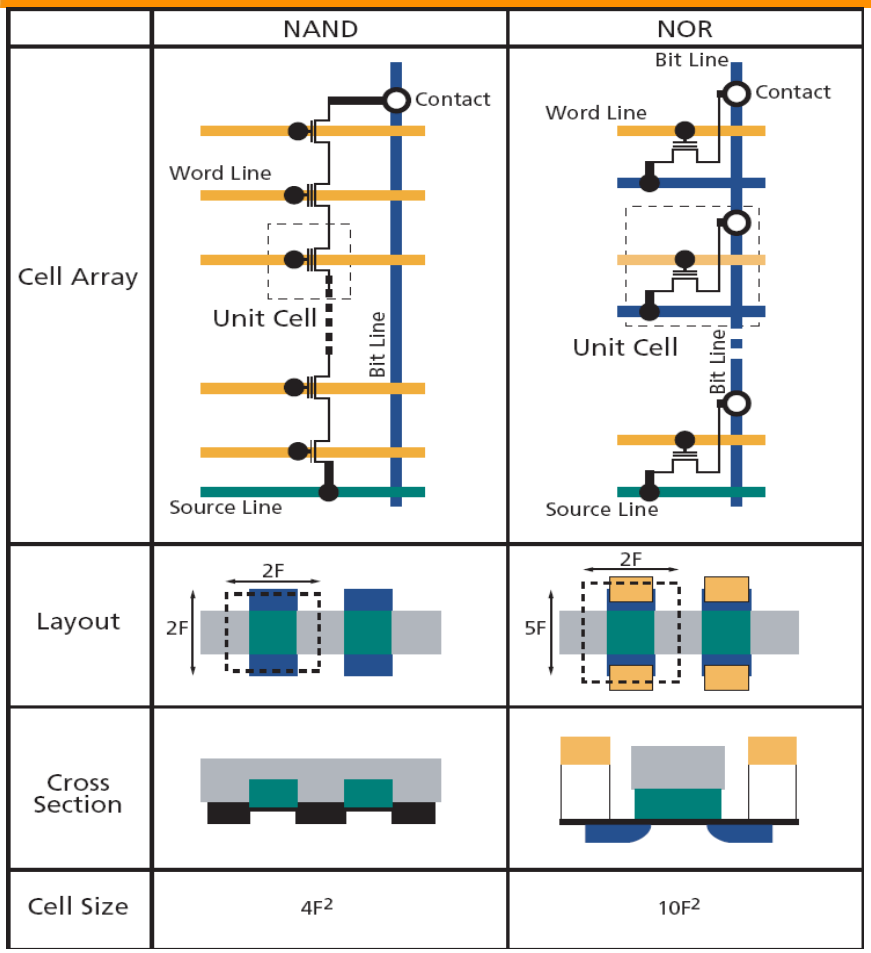
NOR and NAND Technologies

In simplest terms, NAND Flash memory refers to sequential access devices that are best suited for handling data storage such as pictures, music, or data files. NOR Flash, on the other hand, is designed for random access devices that are best suited for storage and execution of program code. Code storage applications include STBs (Set-Top Boxes), PCs (Personal Computers), and cell phones. NAND Flash memory can also be used for some boot-up operations.

The Cell Structure of NOR and NAND Memory

A NAND Flash array is grouped into a series of blocks, which are the smallest erasable entities of the Flash device. A NAND Flash block is 128 Kbytes. Erasing a block sets all of its bits to “1” (and all bytes to hex “FF”). Changing the erased bits from “1” to “0” must be done programmatically, with the smallest unit addressable being a byte. NAND Flash cannot perform simultaneous READs and WRITEs, although it is possible to accomplish READ/WRITE operations at the system level using a method called shadowing. Shadowing has been used on personal computers for many years to load the BIOS from slower ROM into higher-speed RAM. In contrast to NAND Flash, some NOR Flash memory does have the ability to perform READ-while-WRITE operations.

There is a limit to the number of times NAND Flash blocks can reliably be programmed and erased. Nominally, each NAND Flash block will survive 100,000 PROGRAM/ERASE cycles. A technique known as wear leveling ensures that all physical blocks are exercised uniformly. To maximize lifespan, it is critical to implement both wear leveling and bad-block management. NAND Flash efficiencies are due in part to the small number of metal contacts in the NAND Flash string. A NAND Flash cell’s size is much smaller (4F2 compared to 10F2) than that of a NOR Flash cell, because NOR Flash cells require a separate metal contact for each cell.

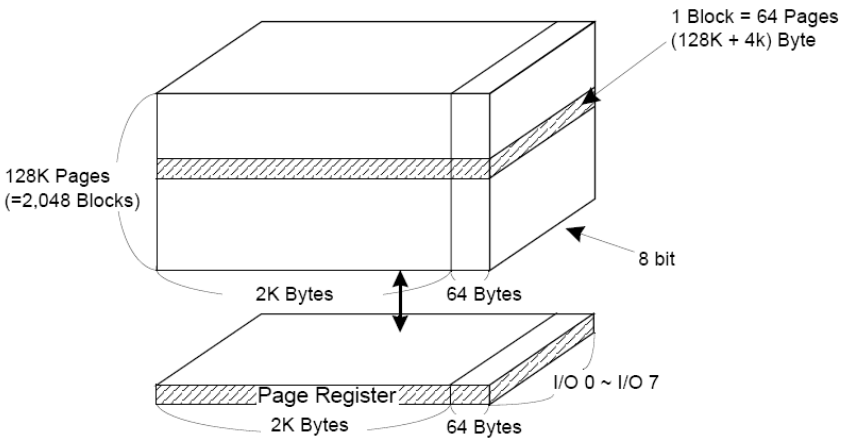


Source: Micron

NAND Flash is very similar to a hard-disk drive. Although random access can be accomplished at the system level by shadowing the data to RAM, doing so requires additional RAM storage. Also, like a hard-disk drive, a NAND Flash device may have bad blocks which require ECC (Error Correction Code) to maintain data integrity.

NAND Flash cells are 60% smaller than NOR Flash cells, providing the higher densities required for today's low-cost consumer devices in a significantly reduced die area. NAND Flash is used in virtually all removable cards, including USB drives, secure digital (SD) cards, memory stick cards, CompactFlash® cards, and multimedia cards (MMCs). The NAND Flash multiplexed interface provides a consistent pinout for all recently manufactured devices and densities. This pinout allows designers to use lower densities and migrate to higher densities without any hardware changes to the printed circuit board.

Ex: 16 Gbit NAND Flash Memory



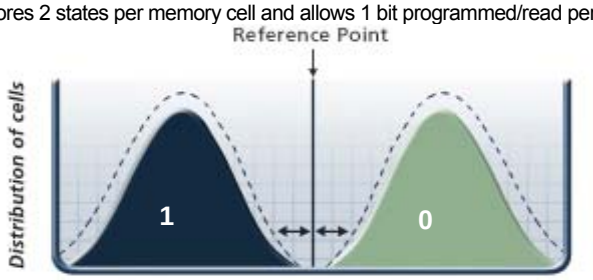
Comparing Single-Level Cell and Multi-Level Cell Flash Technologies and Structure

Mobile product designers are always looking for high-capacity storage—memory solutions that can store increasingly more pictures, movies, MP3s, or simple data files. The differences between SLC and MLC Flash are shown in the list below:

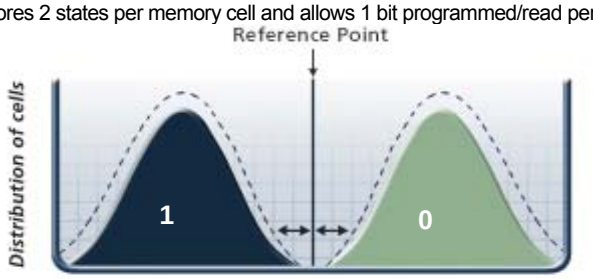
	SLC (Single-Level Cell)	MLC (Multi-Level Cell)
Storage	One bit of data in one memory cell	Two bits of data in one memory cell
Program / Erase Cycle	100,000	3,000 ~ 10,000
Program / Erase time	Program: 300 µs/page Erase: 2 ms/block	Program: 800 µs/page Erase: 2 ms/block
Cell array to register	30 µs (max.)	50 µs (max.)
Cost-per-bit	Higher	Lower
Density	Lower	Higher
Power Consumption	Lower	Higher

Generally, MLC Flash offers twice the capacity of SLC Flash in the same size device, and it comes at a significantly lower cost-per-bit. Designers, however, do have to make some trade-offs in terms of performance and reliability (SLC Flash is about three times as fast as MLC Flash and offers up to 10 times the endurance). MLC Flash represents nearly 90% of all NAND Flash shipments.

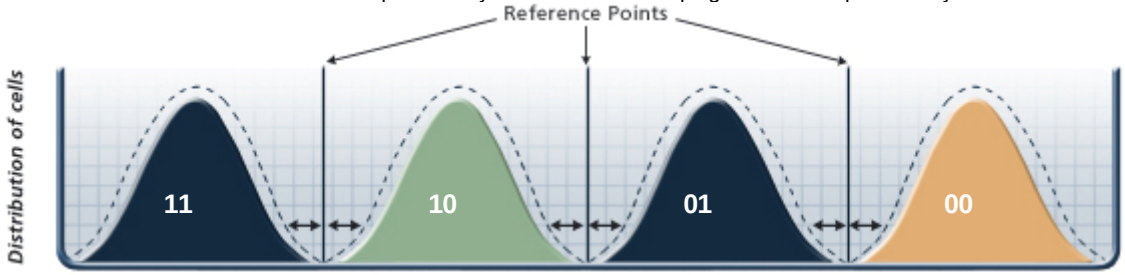
SLC: One Bit per Cell
SLC NAND stores 2 states per memory cell and allows 1 bit programmed/read per memory cell.



SLC: One Bit per Cell
SLC NAND stores 2 states per memory cell and allows 1 bit programmed/read per memory cell.



MLC: Two Bits per Cell
MLC NAND stores 4 states per memory cell and allows 2 bits programmed/read per memory cell.



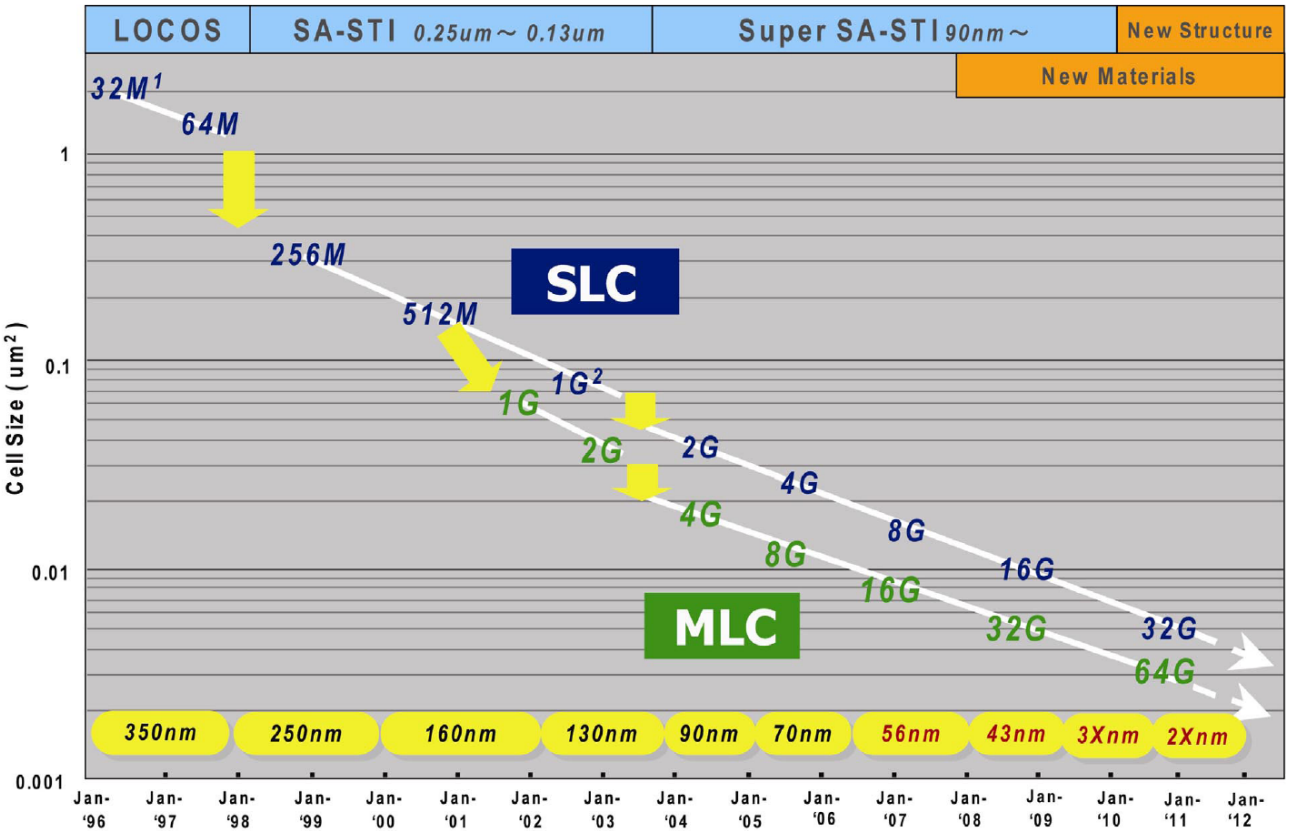
Source: Micron

Conclusion

Traditional SLC Flash stores one bit of information per memory cell. This basic technology enables faster transfer speeds, lower power consumption, and increased endurance. For designs using mid-range densities, SLC Flash will continue to be a good choice. MLC Flash stores two to four bits of information per memory cell, effectively doubling the amount of data that can be stored in a similar-size NAND Flash device.

SLC Flash offers high performance and reliability, is supported by all controllers, and requires only 1 bit error correction code (ECC). SLC Flash is suited for applications like high-performance media cards, hybrid disk drives, solid state drives, and other embedded applications with processors, where it is used for code execution. MLC Flash is a low-cost file storage solution for consumer applications like media players, cell phones, and media cards (USB, SD/MMC, and CF cards) where density is more important than performance. MLC Flash is supported only by controllers that include 4-bit or more ECC.

A Toshiba Flash planned roadmap is offered for reference in the table below:



For Further Information

Click here for a more information about Advantech SQFlash.

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