## The Samsung SLC NAND Flash Advantage

For today's media-rich mobile consumer electronics, NAND Flash has earned the reputation as the non-volatile memory-of-choice for multimedia and Internet capability. There are two types of NAND Flash memory architectures: Single-Level Cell (SLC) and Multi-Level Cell (MLC). SLC NAND Flash is the higher performing technology that is used to enable streaming video and Internet capability in handheld electronics such as 3G cell phones, PDAs, digital still / video cameras and MP3 players, etc. MLC NAND Flash is appropriate for short-term, price-sensitive applications, such as voice recorders, where streaming video is not required.

SLC NAND Flash: Straightforward Architecture

SLC NAND Flash's architecture is straightforward, providing a significant performance advantage over MLC NAND Flash whose architecture is convoluted. SLC NAND Flash ICs have one bit of data stored per memory cell and two states: erased (1) or programmed (0). MLC NAND Flash ICs have two bits of data stored per memory cell and four states: erased (11), two thirds (10), one third (01) or programmed (00). The complex architecture of MLC NAND Flash is a performance disadvantage when compared to SLC NAND Flash.

SLC NAND Flash Uses Less Energy

With only two states and one bit of data stored, SLC NAND Flash's Control Logic is able to conserve energy when managing the electrical charge during operations. This is why during the program operation SLC NAND Flash is faster than MLC NAND Flash. Since MLC NAND Flash has four states, and two bits of data stored, it must expend more energy to manage the electrical charge during operations. Applying higher voltage to program MLC NAND Flash degrades its memory cell characteristics. And with smaller margins, the chances of an incorrect reading are higher. Plus, due to leakage and other effects, the logic level of the cell may change. MLC NAND Flash must compensate with enhanced EDC (Error Detection and Correction).
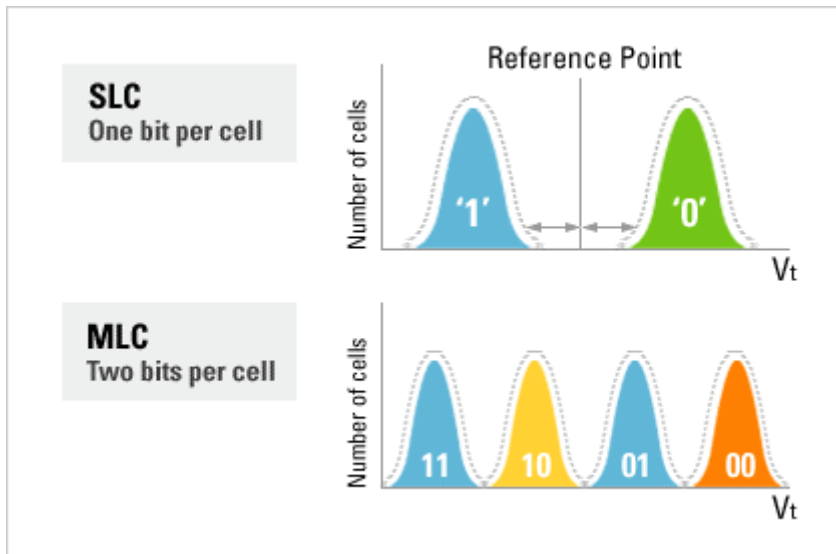
Analogy : A Glass of Water

This glass of water analogy demonstrates how SLC NAND Flash outperforms MLC NAND Flash. SLC NAND Flash has only two states: erased (empty) or programmed (full). MLC NAND Flash has four states: erased (empty), 1/3, 2/3, and programmed (full). It's easier to read the correct fill status when a glass is either empty or full, as in SLC NAND Flash. When a glass is partially full, as in MLC NAND Flash, the fill status is more difficult to read, taking more time and energy.

The SLC NAND Flash Performance Advantage

The Write Data Rate of SLC is three to six times faster that of MLC, as shown

Item	SLC	MLC
Voltage	3.3V / 1.8V	3.3V
Technology / Chip Size	0.12um	0.16um
Page Size / Block Size	2KB / 128KB	512B / 32KB or 2KB / 256KB
Access Time (Max.)	25us	70us
Page Program Time (Typ.)	250us	1.2ms
Partial Program	Yes	No
Endurance	100K	10K
Write Data Rate	8MB/s+	1.5MB/s

SLC NAND Flash: Durability

The program and erase operations of SLC NAND Flash last 100,000 cycles - ten times longer than MLC NAND Flash, whose program and erase operations only last 10,000 cycles. After 10,000 cycles, the reliability of MLC NAND Flash's program and erase operations is not guaranteed.
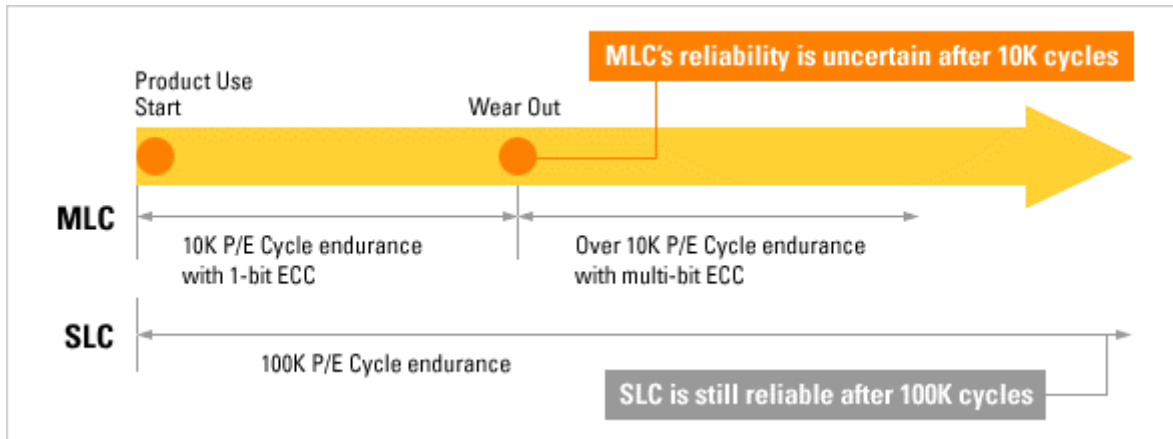

Analogy : Different Types of Tires

The endurance of SLC NAND Flash versus MLC NAND Flash is like the difference between a lower grade(thin) tire and a higher grade (thicker) tire. This means that SLC NAND Flash has a significant longer life span than MLC NAND Flash.

SLC NAND Flash: Partial Programming

SLC NAND Flash allows for partial page programming, while MLC NAND Flash does not. For instance, page size is usually 2KBytes. With SLC NAND Flash, 512Byte sectors can be written all at once, saving space. When programming partial data with MLC NAND Flash, the whole 2KByte page must be used.
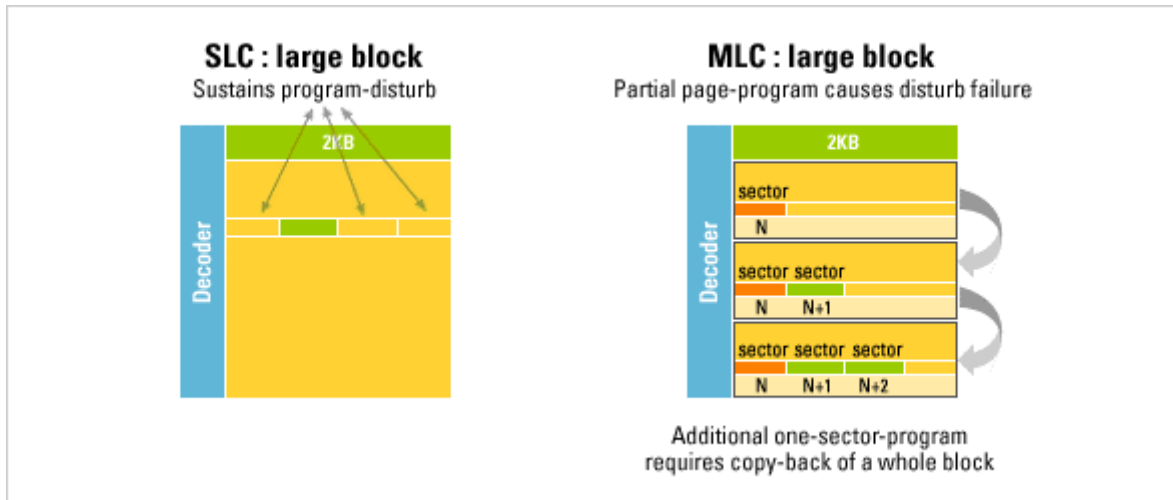
SLC NAND Flash optimizes information transfer and data flow, since all the pipes which are program-to-program communications, are the same. However, with MLC NAND Flash, the pipes are different and the information transfer and data flow can be uneven and slow.

SLC NAND Flash: A Generation Ahead

SLC NAND Flash is a technology generation ahead of MLC NAND Flash, enabling the same density using smaller geometry. Currently, there is a six to nine month time gap between the two technologies. And, as SLC NAND Flash technology moves to smaller geometry, this time gap becomes larger.
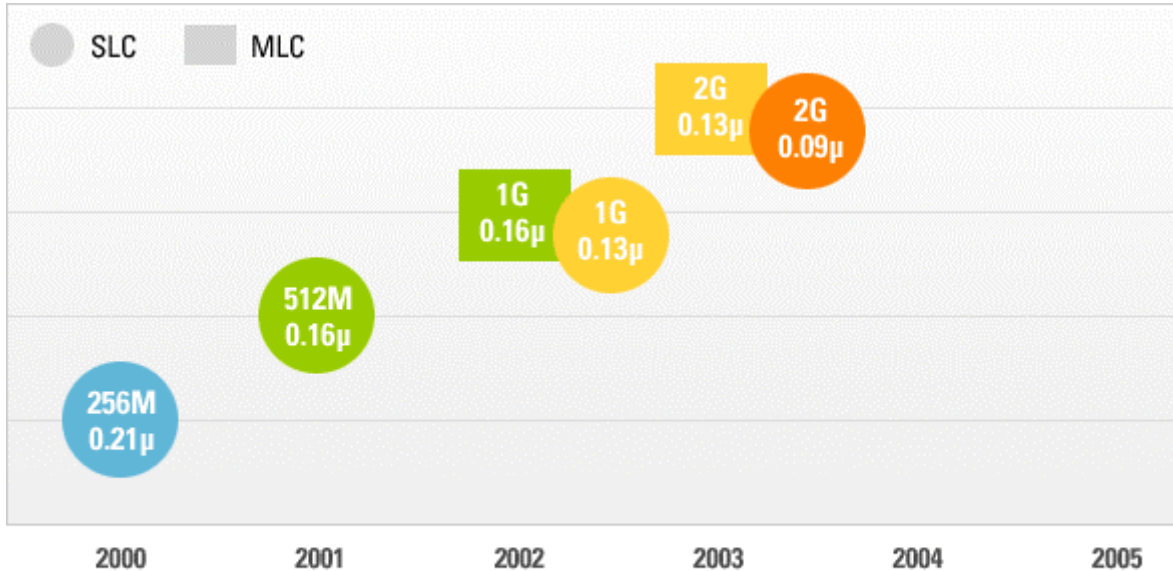
SLC NAND is currently 6 to 9 months ahead of MLC NAND with the same technology.
With smaller geometries, the gap becomes larger.