Selecting the Right NAND Flash

A Selection guide on SLC, MLC, TLC

A Playbook for Designers- by Designers

What is Flash Memory?

Understanding the technology and different forms of flash available will effect your deployment strategies

As technology continuously advances, the demands for greater density and better performance with flash memory become dominant as well. Each NAND flash type has its own advantages and disadvantages; therefore, engineers often encounter difficulty in selecting the right flash type for their application.

The purpose of this playbook is to provide an overview on the difference of NAND flash types for SLC, MLC, & TLC comparison and also Advantech's Ultra MLC

What's NAND Flash Memory

NAND flash memory is built up of many cells that hold bits, and those bits are either turned on or off through an electric charge. How those on/off cells are organized represents the data stored on the SSD.
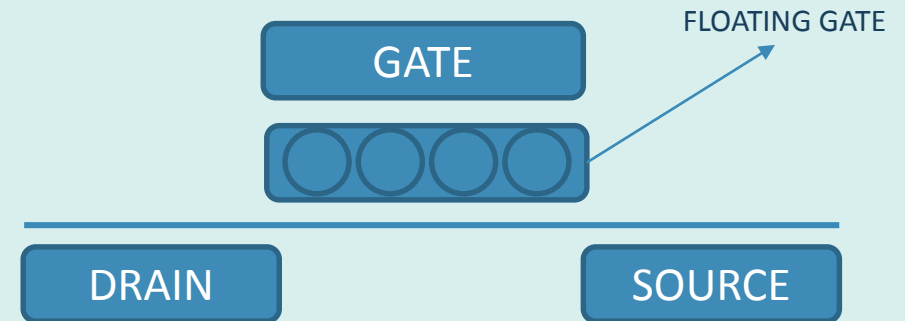
NAND flash memory is categorized into three types:

| SLC (single-level cell) |
| MLC (multi-level cell) |
| TLC (triple-level cell) |

Basis Structure of a Memory Cell

FLOATING GATE

GATE

DRAIN   SOURCE

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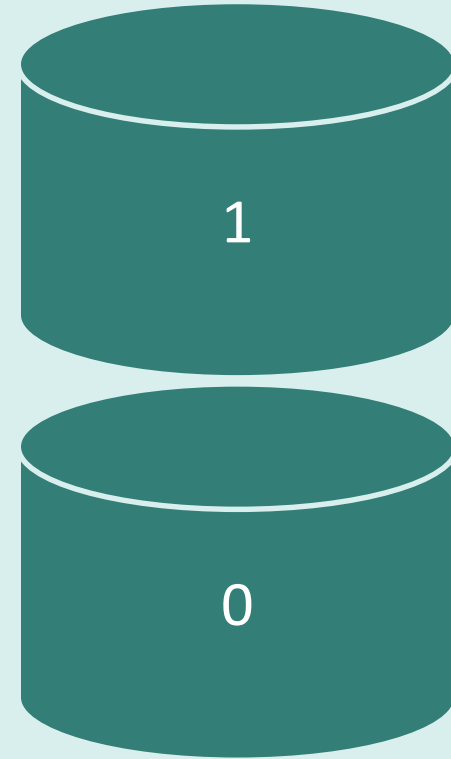
Single-Level Cell (SLC) Flash

SLC flash stores one bit value per cell, which basically is a voltage level. The bit value is interpreted as "0" or a "1".

PROS

- Long lifespan and charge cycles
- Reliable smaller room for read/write error
- Operate in a broader temperature range

CONS

- Uneconomical
- Smallest capacity support among all flash types

1
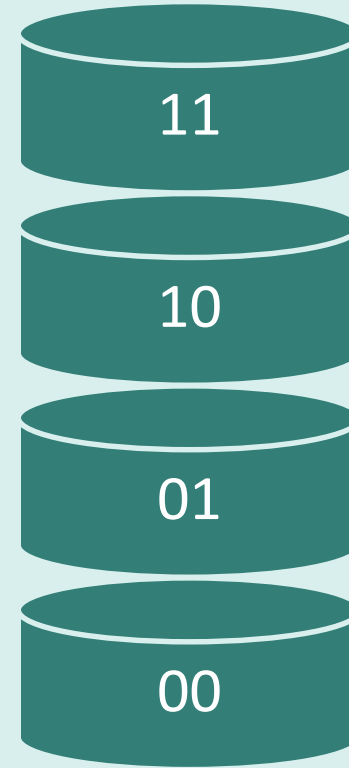
0

Multi-Level Cell (MLC) Flash

MLC flash stores multi bits of data on one cell. The value can be interpreted as 4 distinct stages: 00,01,10,11.

PROS

Lower production costs because some costs are passed onto consumers

CONS

Not as durable and reliable as SLC

11

10
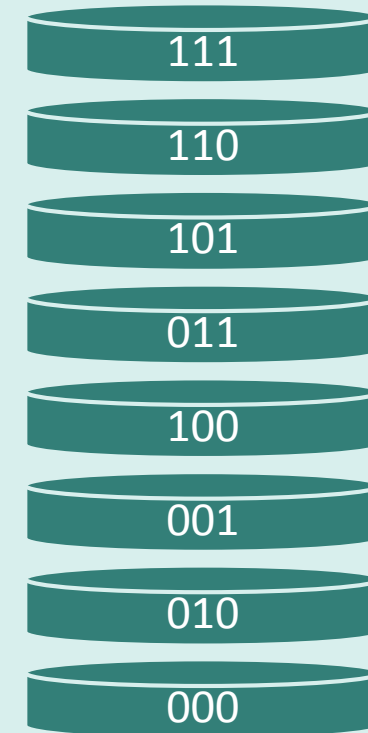
01

00

Triple-Level Cell (TLC) Flash

TLC Flash stores 3 bits of data per cell. The value can be interpreted as 8 distinct stages: 000, 001, 010, 011, 100, 101, or 111.

PROS

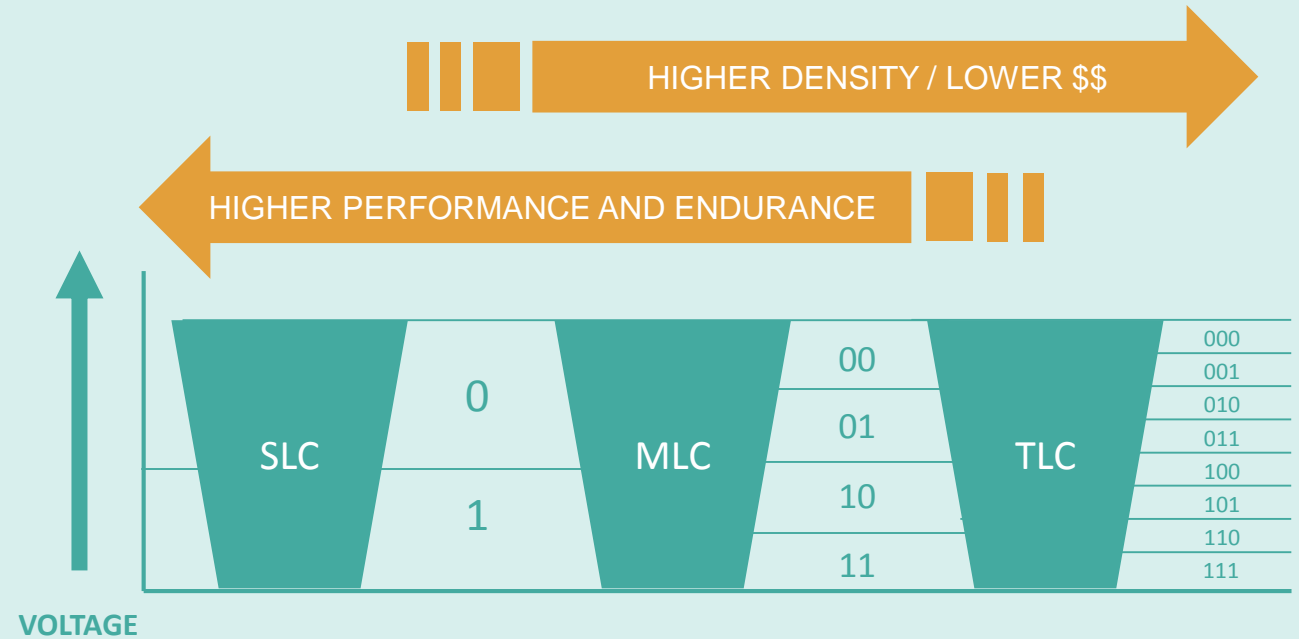TLC is the most cost effective form of flash to manufactures!

CONS

Cells have less read/write cycles so TLC flash is only suitable for consumer usage

111
110
101
011
100
001
010
000

SLC/MLC/TLC Comparison

As the levels of voltage increase, error, misjudgment and bad block are more likely to occur. Therefore, the performance and reliability will decrease from SLC to MLC then to TLC.

It's critical to select the right Flash type for your application!

HIGHER DENSITY / LOWER $$

HIGHER PERFORMANCE AND ENDURANCE

SLC — 0 / 1

MLC — 00 / 01 / 10 / 11

TLC — 000 / 001 / 010 / 011 / 100 / 101 / 110 / 111

VOLTAGE

NAND TYPES	SLC	MLC	TLC
Bits/Cell	1	2	3
P/E Cycles	100,000	3,000	1,000
Read Time	25 µs	50 µs	~75 µs
Program Time	200-300 µs	600-900 µs	900-1350 µs
Erase Time	1.5-2 ms	3 ms	4.5 ms

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Challenges in Selecting Flash Type

- **SLC flash** is more durable and provides high performance, but it's uneconomical.

- **MLC flash** offers high density and lower bit-cost but it requires greater power consumption.

- **TLC flash** is only suitable for end consumer use.

Q:
Can we have a flash type that delivers greater performance and endurance, but yet at the same time, is an economical solution?

A:
YES! Advantech has a solution called **Ultra MLC!**

Major Advantages of ULTRA MLC

The very idea with Ultra MLC is that MLC flash consists of a number of fast and slow pages, and only fast pages will be used for programming when using Ultra MLC. One can think of Ultra MLC as an extended version of MLC flash.

PERFORMANCE ENHANCEMENT

Only fast pages are programmed with Ultra MLC flash and therefore the write performance is improved.

EXTENDED LIFESPAN

Ultra MLC's endurance is better than that of MLC by at least 10X.

COST-EFFECTIVE SOLUTION

The characteristics of Ultra MLC are similar to that of SLC flash, but Ultra MLC is a much more economical solution cost-wise

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What NAND Flash type is suitable for your application?

Choosing the right flash type for you application can be challenging, our experts at Advantech have intensively studied features and capabilities of each flash type. It's recommended that engineers should check their application behavior in order to choose the most suitable flash type for their industry.

Application Behavior	Suggested Flash Type	Ideal Industries
High Writing Frequency	SLC	Machine Automation, Data I/O, Applications with massive logging
High Writing Intensity	Ultra MLC	Video Recording, Multimedia Rendering, Applications with non-stop big block data writing
General Usage	MLC	POS, ATM, KIOSK, neither frequently nor continuously data writing

Ask the Expert with Pres Lee

What is your top tip for design engineers selecting storage?

"It depends on the application. Since we offer a wide range of storage options, you have to first look at what your end goal is and make your selection with the longest lasting effect."

What applications/industries are using Ultra MLC flash?

"Although Ultra MLC has 10x endurance than MLC, but due to bigger page size compare with SLC flash, Ultra MLC is better fitting larger file size intensive writing. Such as multimedia editing, medical image, scientific graphic, DVR, or video recording. For frequent small file (several KB or even smaller) accessing, SLC is still better."

What key features should engineers consider when selecting a flash type for their application?

"SSD performance nowadays can achieve quite high no matter flash type. So the most important guideline of selecting NAND Flash is always endurance. The more frequent writing behavior or the more volume of writing needs a higher tier of Flash IC."

Pres Lee
SQFlash Product Manager
Advantech

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Commitment to Premium Quality & Longevity

Take the Next Step

SQFlash is verified with all Advantech platforms and fully tested in rugged environments to ensure its high compatibility and reliability. It provides 3-year longevity and at least 15-month lifecycle information to service long design-in schedules for embedded projects.

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