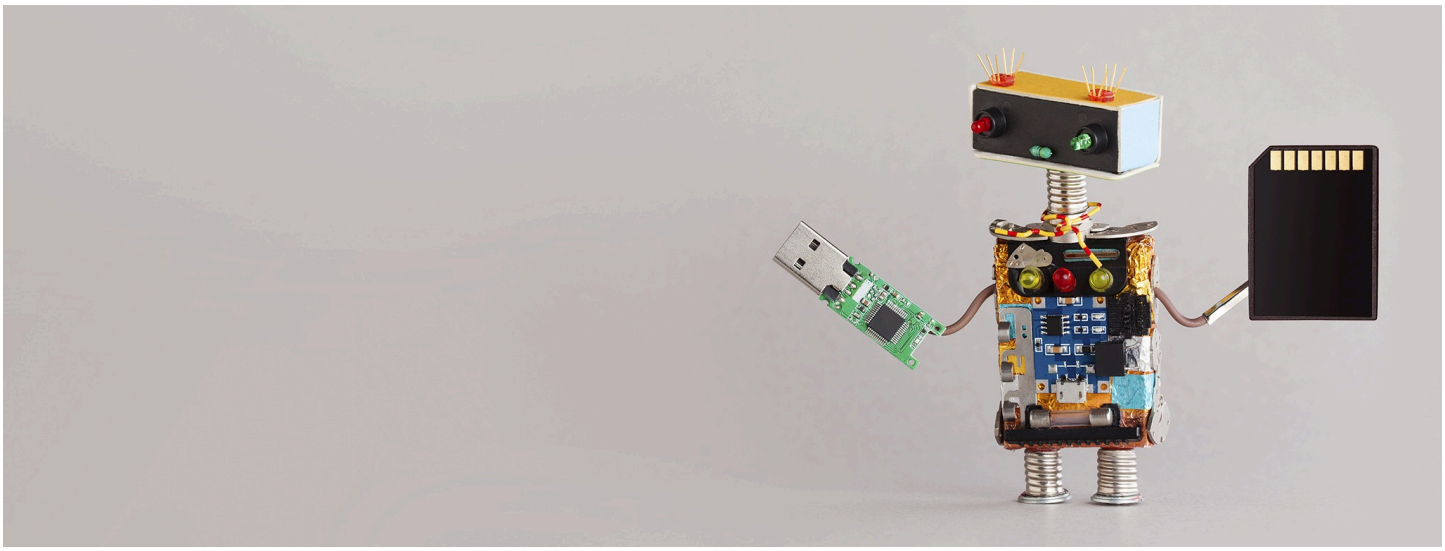
Difference between SLC, MLC, TLC and 3D NAND in USB flash drives, SSDs and Memory cards

14-18 minutes



What is NAND?

NAND is a non-volatile flash memory which can hold data even when it's not connected to a power source. The ability to retain data when the power is turned off makes NAND a great option for internal, external and portable devices. USB drives, SSDs and SD cards all utilise flash technology, providing memory for devices such as your mobile phone or digital camera.

There are several types of NAND on the market. In simplest terms, what separates each type is the number of bits that can be stored per cell. The bits represent an electrical charge which can only hold one of two values, 0 or 1, on/off.

The key differences between the types of NAND are the cost, capacity, and endurance. Endurance is determined by the number of Programme-Erase (P/E) cycles a flash cell can undergo before it starts to wear out. A P/E cycle is the process of erasing and writing a cell and the more P/E cycles that the NAND technology can sustain the better the endurance of the device.

Common types of NAND flash storage are SLC, MLC, TLC and 3D NAND. This article discusses the different characteristics of each type of NAND.

SLC NAND

Pro: Highest endurance - Con: Expensive and low capacities

Single-level cell (SLC) NAND stores only 1 bit of information per cell. The cell stores either a 0 or 1 and as a result, the data can be written and retrieved faster. SLC provides the best performance and the highest endurance with **100,000 P/E cycles** so it will last longer than the other types of NAND. However, its low data density makes SLC the most expensive type of NAND and therefore not commonly used in consumer products. It is typically used for servers and other industrial applications that require speed and endurance.

MLC NAND

Pro: Cheaper than SLC - Con: Slower and less endurance than SLC

Multi-level cell (MLC) NAND stores multiple bits per cell, although the term MLC typically equates to 2 bits per cell. MLC has a higher data density than SLC so can therefore be produced in larger capacities. MLC has a good combination of price, performance, and endurance. However, MLC is more sensitive to data errors with **10,000 P/E cycles** and therefore has a lower endurance compared to SLC. MLC is usually found in consumer products where endurance is less important.

TLC NAND

Pro: Cheapest and high capacities - Con: Low endurance

Triple-level cell (TLC) NAND stores 3 bits per cell. By adding more bits per cell, this reduces the cost and increases the capacity. However, this has negative effects on performance and endurance, with only **3,000 P/E cycles**. Many consumer products will use TLC as it is the cheapest option.

3D NAND

In the last ten years, 3D NAND has been one of the biggest innovations in the flash market. Flash manufacturers developed 3D NAND to correct the problems they were facing with scaling down 2D NAND in order to achieve higher densities at a lower cost. In 2D NAND, the cells that store the data are placed horizontally, side by side. This means that the amount of space that the cells can be placed onto is limited and trying to make the cells smaller reduces their reliability.

Therefore, NAND manufacturers decided to stack the cells in a different dimension, which led to 3D NAND where the cells are stacked vertically. The higher memory density allows for higher storage capacities without the huge price increase. 3D NAND also provides better endurance and lower power consumption.

Overall, NAND is an extremely important memory technology as it provides fast erase and write times at a lower cost per bit. With the growth of the gaming industry, NAND technology looks to develop further in order to help satisfy consumers ever-increasing storage needs.

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