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Memory and Storage

# MLC vs TLC vs QLC NAND SSDs: What's the Difference?



Areej • March 27, 2021



0 3 minutes read





If you want a top-of-the-line system, especially for gaming or content creation, then an SSD is absolutely necessary. However, before you go hunting for one, you should know what to look for. There are multiple different types of SSDs. As far as the basic SSD storage cells are concerned, you've got SLC, MLC, TLC, and QLC. Out of these, TLC is the most popular, though, QLC is going to eventually replace them. In terms of I/O, there's SATA and NVMe.

Lastly, the latest SSDs are also based on 3D NAND/VNAND technology. This can make it really confusing to decide on one particular SSD. Let's break down all these terms.

## SLC, MLC, TLC, and QLC: These are Memory Cells

SLC	MLC	TLC
1	11	111
		110
		101
0	10	100
		011
		010
0	01	001
		000
	00	

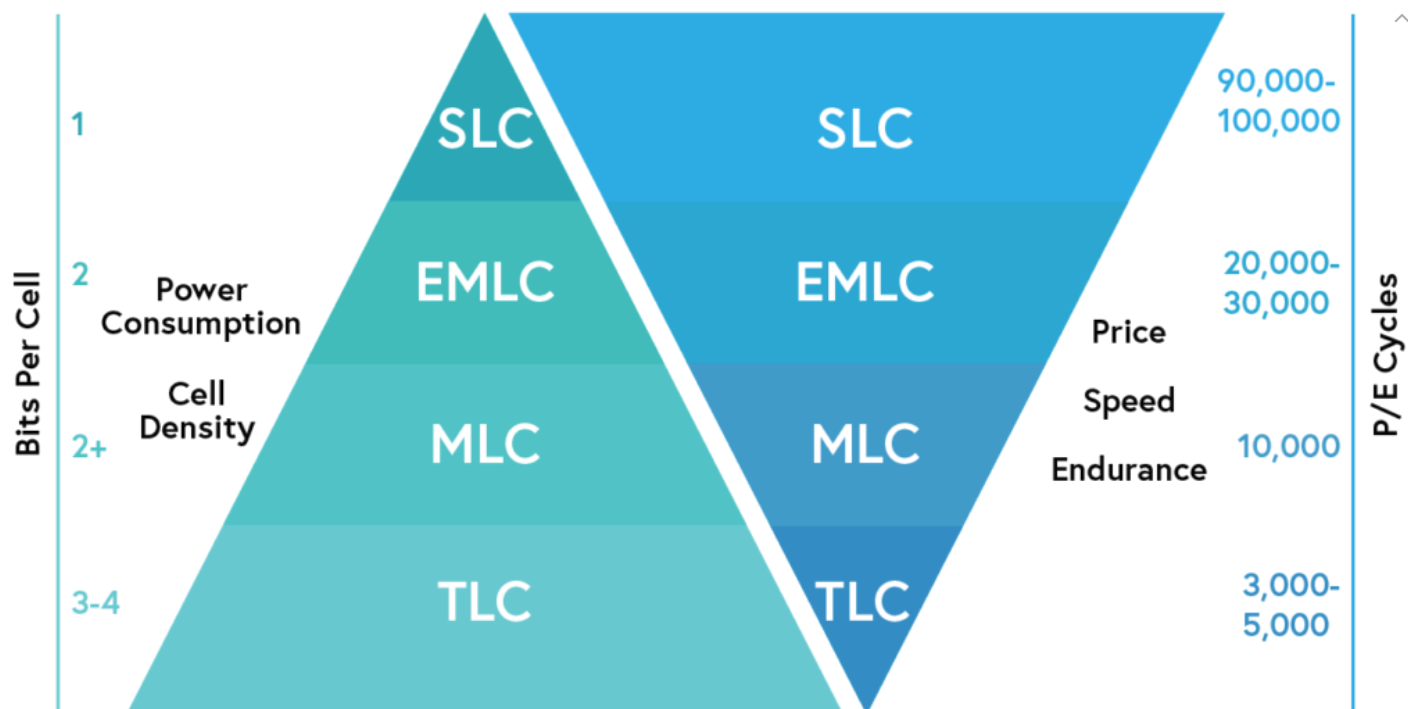
In HDDs, tracks are the building blocks of the storage memory. In SSDs, that same functionality is provided by cells. A cell is essentially a Gate Circuit. How much memory each cell can store depends on the type of cells an SSD uses. The most popular ones are: SLC, MLC, TLC, and QLC. These stand for Single-Layer Cell, Multi-Layer Cell, Triple-Layer Cell, and Quad-Layer Cell.

- [HDDs and SSDs: Which is Better for Gaming: Speed, Reliability, Lifespan, and Prices](https://www.hardwaretimes.com/hdds-and-ssds-which-is-better-for-gaming-speed-reliability-lifespan-and-prices/)

As the names suggest, cells in SLC SSDs can store only one bit per cell. MLC stores two, TLC stores three, and QLC stores four. While this might seem like a “bigger is better,” situation, that’s not quite the case here. It’s easiest to increase capacity (at the same price point) with QLC drives since they require 1/4 as many cells as an SLC drive for the same amount of storage.

### Bigger isn’t always better

# NAND Flash Specs



However, it takes more time to write multiple bits to a single cell. This affects SSD durability, too. What this means is that SLC SSDs are actually the fastest and most reliable. But they're substantially more expensive. Most commercial SSDs out there are TLC, which offers a reasonable compromise between performance, reliability, and cost.

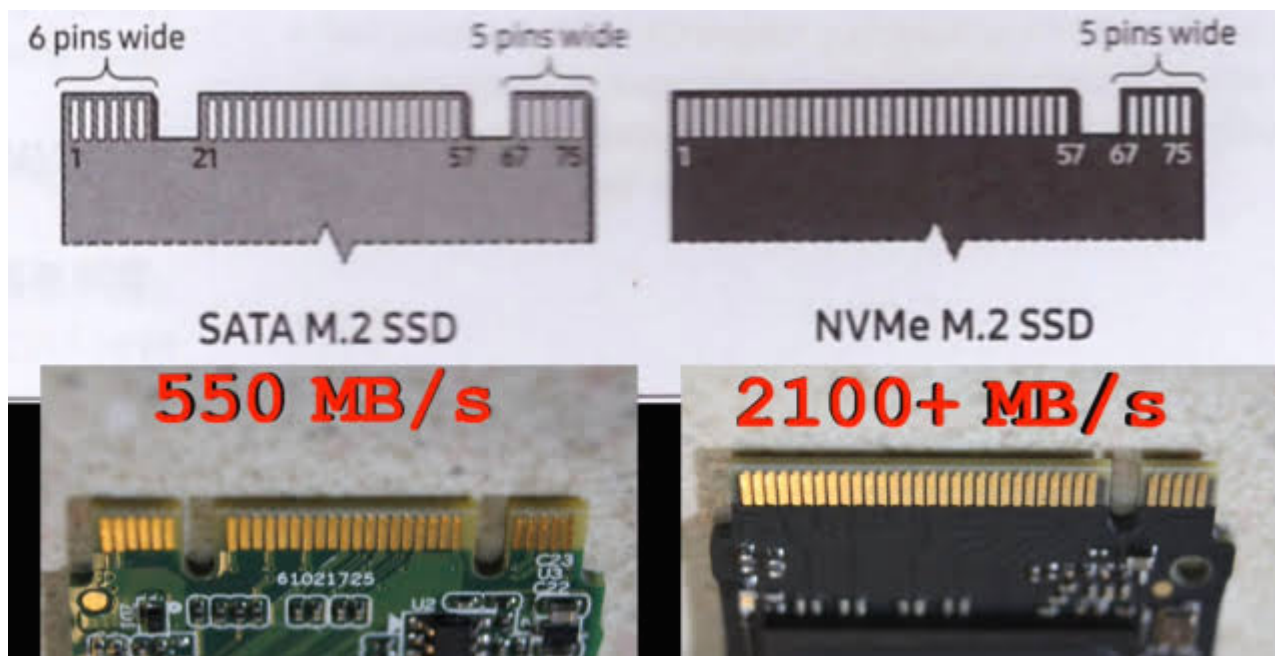
	SLC	3D TLC	SLC mode	INDUSTRIAL MLC	TLC
Reliability	Highest	High	High	Medium	Low
Speed	Fastest	Fast	Fast	Medium	Slow
Price	£ £ £ £	£	£ £ £	£ £	£
P/E Cycles/Endurance	*****	**	*****	***	**
Warranty	5 years	2-5 years	2-5 years	2 years	2 years
Operating Temp -40°C to 85°C	✓	✓	✓	✓	✗
Operating Temp 0°C to 70°C	✓	✓	✓	✓	✓
Controlled BOM	✓	✓	✓	✓	✗
Typical NAND Production cycle	5 years	1-2 years	3 years	3 years	6-12 Months

There's a finite number of times that a cell can be read to and written from before it stops working. This is usually on the scale of several hundred thousand reads and writes. However, it does mean that SSDs have a finite limit to their usability, even if it can take several years to get there.

## Connectivity: SATA vs NVMe: What's M.2?

You might've noticed these terms in descriptions of SSDs and HDDs. They look scary, but they're really not. Two of these simply refer to the type of input connector used. SATA is both a connector as well as an interface. It's an old, legacy standard and all conventional HDDs leverage it.

The main limiting factor is that SATA's maximum transfer rate is 600 MB/s. This isn't a problem with HDDs since they top out below 200 MB/s. But SATA SSDs will be substantially slower than their theoretical max speed. Furthermore, SATA based drives can perform only one kind of function at a time, read or write, not both. NVMe based M.2 SSDs can.



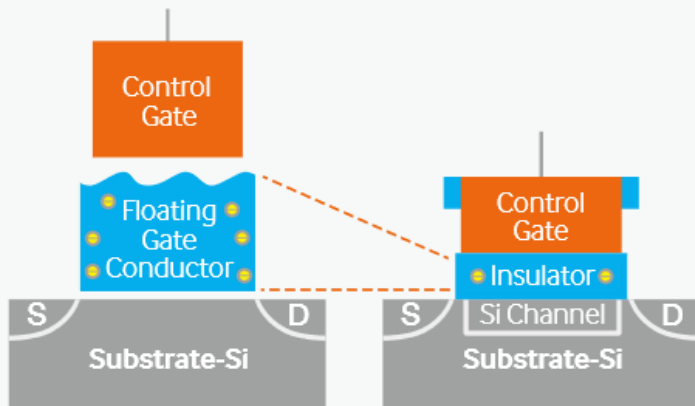
M.2 is simply a newer connection type. It slots right into your motherboard on an M.2 socket and can be connected to either a SATA or PCIe bus. M.2 SATA SSDs are smaller and thinner but still deliver SATA speeds. Meanwhile, M.2 NVMe SSDs connect through PCIe lanes on your motherboard and are smaller, thinner, and a whole lot faster. If you want the fastest storage, an NVMe SSD, connecting over M.2 is the way to go.

## 3D NAND and VNAND: These are Layers

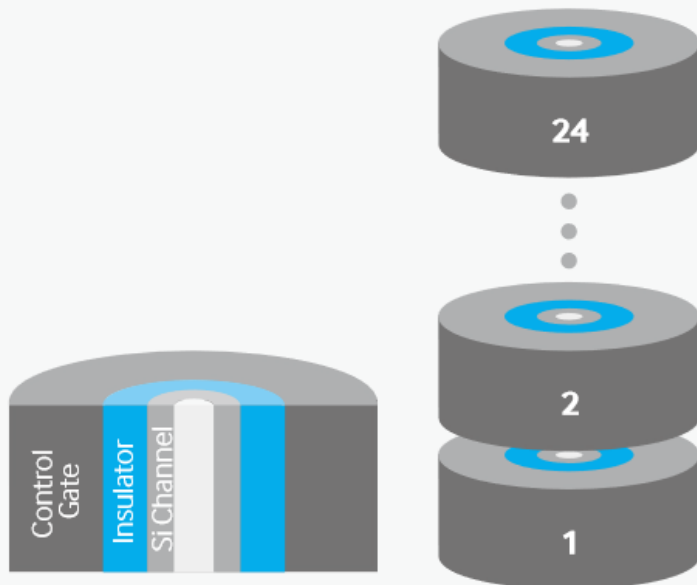
What happens when you got no space remaining around you? You go up. That's basically what 3D NAND does. Traditionally, NAND cells were arranged in 2D. The more the number of cells, the larger the drive capacity (increased memory per chip). But as the demise of Moore's Law has taught us, there's a limit to how much you can shrink silicon.

So since there's no place for the cells in 2D, we start stacking them one upon another. This is called 3D NAND. It is not only cheaper but faster as well as more power-efficient. [This video explains it quite well.](#) Manufacturers often pair TLC and QLC based SSDs with 3D stacking or VNAND to further improve the price-performance ratio, making the drives more affordable.

## 1 Innovation Material (2003)



## 3 Innovation Integration (2008)

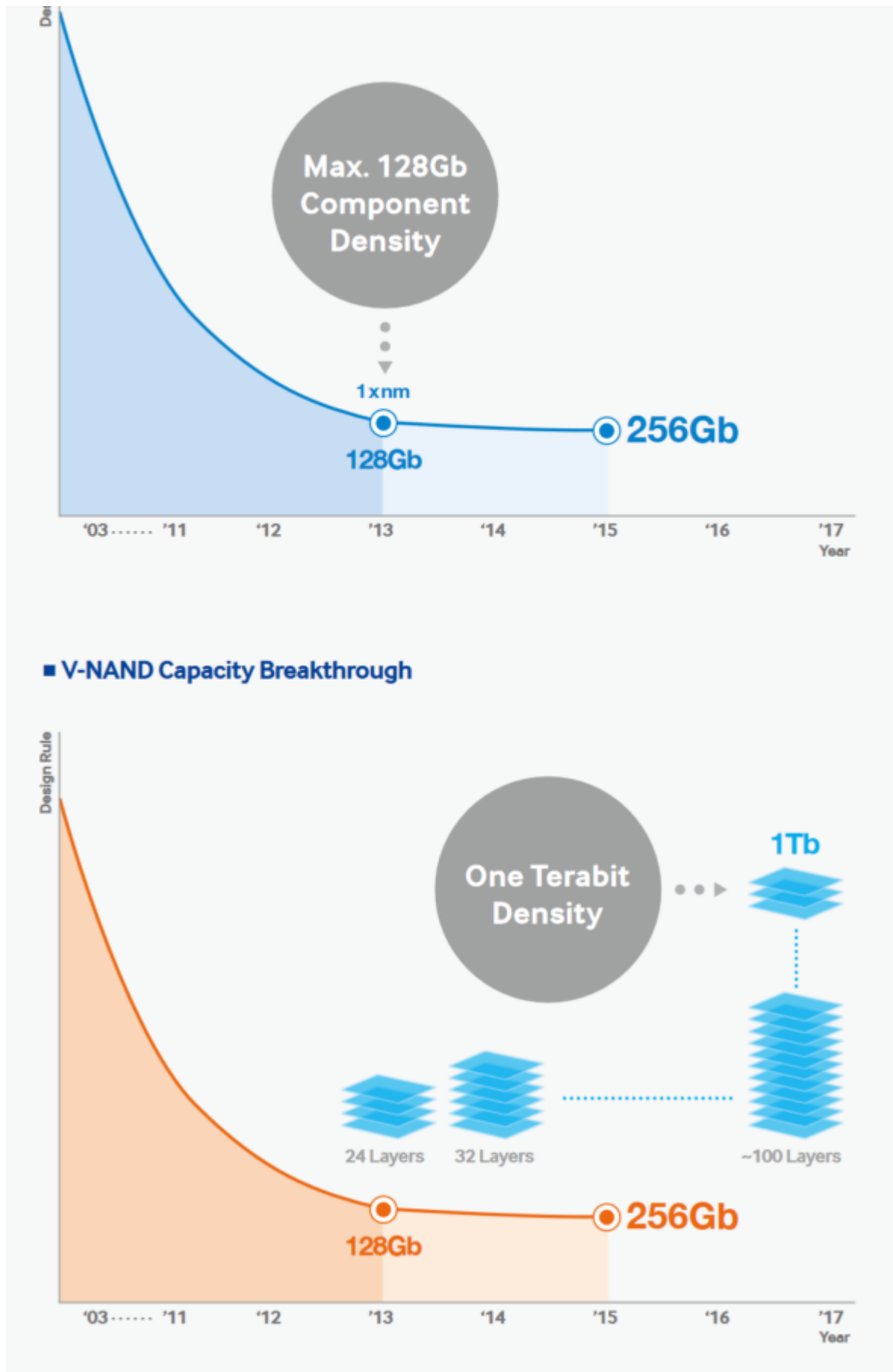


## 2 Innovation Structure (2008)



Samsung's VNAND technology is their version of 3D NAND, with some proprietary modifications in between.

### 2D Planar NAND Capacity Limitation



Higher density SSDs basically have a higher layer count. These days up to 96 layers of cells are stacked in consumer and enterprise SSDs. An estimated density of 1Tb is expected for 100-layer NAND chips.

We hope that cleared up everything about SSDs. If not, let us know in the comments section below. ^

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**Areej**

Computer Engineering dropout (3 years), writer, journalist, and amateur poet. I started Techquila while in college to address my hardware passion. Although largely successful, it suffered from many internal weaknesses. Left and now working on Hardware Times, a site purely dedicated to Processor architectures and in-depth benchmarks. That's what we do here at Hardware Times!



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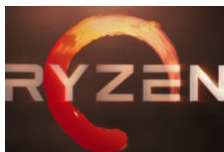
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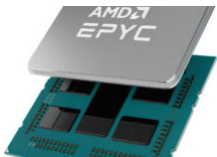
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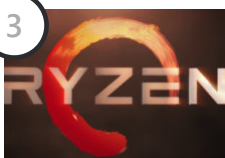
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