How Solid-state Drives Work

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**What is the History of Hard Drives?**

The history of hard drives started in 1956 when IBM shipped the world's first **hard disk drive(HDD)**, since then they have grown smaller with a larger capacity.

The first hard drive shipped by IBM used 24-inch magnetic platters to store 5 megabytes of information while taking up more room than two refrigerators. The cost was $50,000 ($441,277 in 2016 dollars).

Since then, hard drives have grown smaller, with a larger capacity and cheaper price. A new kind of hard drive has arrived known as a **solid-state drive** (**SSD**), it uses semiconductor chips to store information.

**What Does a Solid-state Drive Look Like?**

On the outside a solid-state drive looks just like a hard disk drive.

SSDs look like a rectangular shaped box covered in metal, typically 2.5 by 3.5 inches (shown in Figure 1). Beneath the metal shell, there is an array of chips organized on a board that take up very little room. SSD components are placed in a metal shell larger than needed to make sure they fit into existing drive slots of laptops and desktop PCs.



Figure 1. Standard SSD

**IMAGE COURTESY blackmagicdesign.com**

**How Does a Solid-state Drive Save Information?**

A solid-state drive saves information on NAND, a type of flash memory; it uses transistors to control the flow of electricity using gates, which can be saved to only a limited number of times.

Solid-state drives save information on flash memory. Flash memory may sound familiar, as it is used in thumb drives officially called USB flash drives. Thumb drives use the same flash technology as SSDs and can be thought of as the predecessors of today's solid-state drives.

SSD uses flash memory of the type NAND to store information. NAND has transistors (devices that control the flow of an electric current) arranged in a grid of columns and rows. At each intersection of a column and a row, two transistors form a NAND cell. One of the transistors in the NAND cell is known as a **control gate,** which is separated by an **insulator** to the other transistor known as a **floating gate**. All of this is sitting on a **silicon substrate** (figure 2)which holds the grid of NAND cells.

A NAND cell saves information by controlling the flow of electricity by using the gates. When current reaches the **control gate**, electrons flow onto the **floating gate**, creating a net positive charge that interrupts current flow. If a NAND cell conducts current, it has the value of 1. If it doesn't conduct current, it's 0. At first, all transistors are set to 1. But when a save operation begins, current is blocked to some transistors, turning them to 0. By applying a precise amount of electricity to the transistors a unique pattern of 1s and 0s emerges on the grid of NAND cells.

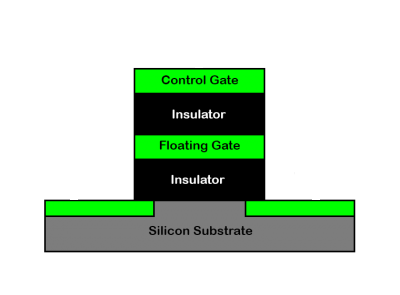


Figure 2. NAND Cell

**IMAGE COURTESY CACTUS-TECH.COM**

The NAND flash used in SSDs can only be used for a limited number of times to save information. Each time a NAND cell goes through an erase cycle, some charge is left in the floating-gate transistor. As the amount of charge left builds up, the amount of current required to change the gate increases. Eventually, the gate can't be flipped at all, making it impossible to save new information. This process doesn't affect the read capabilities of a SSD because reading only requires checking, not changing, the electrical state of NAND cells. As a result, NAND flash can "rot" into a read-only state.

**How do Solid-state Drives Perform?**

Solid-state drives perform more reliably, using less power with more speed that even casual users will notice.

Because they have no moving parts, SSDs can perform with more reliability than HDDs even taking into the account the limited times a SSD can save information. With no moving parts, SSDs are also super quiet with none of the whirring and clicking of HDDs.

SSDs perform using less power than traditional hard drives, which means they preserve battery life and stay cooler.

The speed performance of SSDs is better than HDDs. With no moving heads and spinning platters, SSDs can access one piece of data as quickly as any other piece, even if they aren't in the same proximity. The speed of the device manifests itself in many key computer tasks, from booting up system software to opening files to reading and writing data.

Even a casual user will notice a significant increase in the performance of a computer equipped with an SSD. But a power user will really feel the difference.  Today, gamers, photographers and anyone editing graphics or video files will appreciate the boost in speed a solid-state drive delivers.

Solid-state drives, the newest form of hard disk drives, looks like a traditional HDD, yet saves information differently using flash memory, which results in higher performance and reliability.

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