### **The Differences Between SSDs and HDDs:**

**1. Storage medium and read/write method:**

HDDs fix a stack of magnetic platters onto a motor and determine 0s and 1s based on the magnetisation direction of each area on the platters. They write data by changing the magnetisation direction using the current direction through the read/write head, and read data by sensing the polarity of the induced current.

SSDs use floating-gate transistors. The floating gate is a conductor that stores electrons, sandwiched between two silicon dioxide layers. The silicon dioxide comes from the silicon substrate after undergoing an oxidation process. The structure of the entire floating-gate transistor looks like this:



| （Black Concrete）：Si substrate | （Block of Iron）：Source |
| --- | --- |
| （Block of Diamond）：Drain | （White Concrete Powder）：SiO₂ insulating layer |
| （Waxed Copper Block）：Cu contact | （Purple Concrete）：Floating gate |
| （Waxed Chiseled Copper）：Control gate | |

**When reading,** different voltages are applied to the control gate and the drain. According to Coulomb’s law, free electrons in the Si substrate will be attracted by the voltage of the control gate. However, due to insulating SiO₂, electrons will accumulate between the source and the drain. When the accumulation reaches a certain level (threshold voltage), these electrons will connect the source and drain to form a conductive path, and a current is formed due to the voltage at the drain. When the source detects the current, it reads out 1.

Suppose there are more electrons in the floating gate than the threshold. In that case, the electric field generated can counteract the electric field of the control gate through superposition so that the number of free electrons attracted in the Si substrate does not reach the threshold voltage. If no current is detected at the source, 0 is read out.

**When writing,** there are usually two methods: ***Hot carrier injection*** and ***Fowler–Nordheim tunnelling (FN tunnelling)***.

* Hot carrier injection applies a high voltage between the control gate and the drain, converting electric potential energy into electron kinetic energy. The electrons punch through the insulating layer and are injected into the floating gate. However, repeated impacts can cause the oxide layer to age and leak.
* FN tunnelling is based on the wave-particle duality of electrons. When the electron’s wave function approaches the edge of the barrier (the insulating layer), part of the wave function extends into the barrier region and decays slowly due to the barrier. Suppose the decayed wave function still has a chance to extend to the other side of the insulating layer. In that case, there is a non-zero probability of finding the electron on the other side (inside the floating gate). When a high voltage is applied to the control gate, a strong electric field lowers the barrier, increasing the probability of electrons tunnelling into the floating gate, allowing electrons to enter the floating gate. When reverse voltage is applied, electrons can similarly be “pulled back.”
* If the number of electrons in the floating gate is less than a certain threshold or none, it represents 1; otherwise, it means 0.

**2. Read/write speed:**

Due to its physical structure, an HDD requires a lot of time for seek operations, rotational delay, etc., and is limited by motor speed (after all, it can't spin so fast that the platter explodes like an ageing angle grinder). Therefore, its random read/write performance is not high.

SSD has no seek or rotational delay, so compared to HDD, the latency for accessing any area is almost the same, and the performance difference between sequential and random read/write is slight (especially performing better under low latency and high concurrency).

**3. Lifespan:**

* HDD platters can be overwritten repeatedly, while SSDs, due to their writing principle, cause the insulating layer to age with each write, resulting in limited read/write cycles for each block.
* Because of their mechanical structure, HDDs are very sensitive to vibration. During operation, if an external force causes vibration, the read/write head can easily scratch the platter surface and damage it. In contrast, SSDs are not so fragile.

**4. Noise:**

When operating, HDDs produce a lot of noise due to the spinning motor and the back-and-forth seeking of the head (and the noise is worse for ageing HDDs). At startup, besides the cooling fan, the most obvious beep~ and buzzing noise usually comes from the HDD. SSDs do not make such noise.

**5. Price:**

Currently, a consumer-grade HDD with 4TB capacity can be bought in China for around CNY 500 (about CAD 100), while an SSD costs around CNY 1700 (about CAD 360). Converting this, HDD costs about CAD 25/TB, while SSD costs about CAD 90/TB. In Canada, this number is only higher.