White Paper

Modern Solutions to Flash Data Retention & Read Disturbance

Introduction

The solid state drive (SSD) has become a mainstay in many industries. This is especially true for devices designed for hostile environments, as the SSD is generally sturdier than traditional storage mediums. Yet, data retention is still a pain point for many integrators.

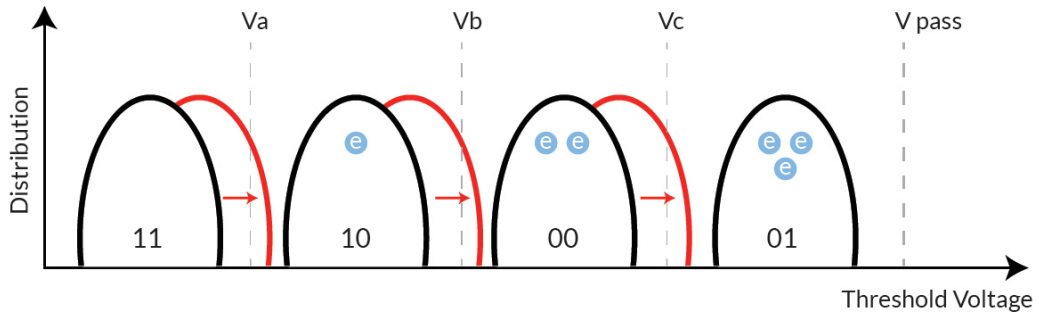
Data retention describes the NAND flash's ability to retain data that has been stored over time. It is a clock that starts ticking after data has been written to a NAND flash cell and the countdown continues as long as the data remains unrefreshed (data erased and re-written).

Read disturb, a phenomenon that effects neighbouring pages when a single page is read frequently can also lead to data loss in some circumstances. These challenges necessitate specialized features to combat data retention. In this paper we will discuss the aforementioned challenges in detail, and present modern solutions to these issues.

Challenges

Read Disturb

Read disturb can occur when frequently accessing the same page in a block, e.g. when a user checks a specific piece of information on their device, such as a phone number over and over again. This is because reading data from a page causes the threshold voltages of other pages in the same block to change to a slightly different value, as every time data that is stored on a page is accessed, a read voltage is sent through all the pages within the block. The pages to which the voltage is applied sometimes have electrons injected into their floating gate, thus causing the electrons stored in those pages to change. Although usually harmless, when a single page is read frequently, the effects of this voltage shift are compounded and in some cases, data on neighbouring pages can become totally inaccessible.



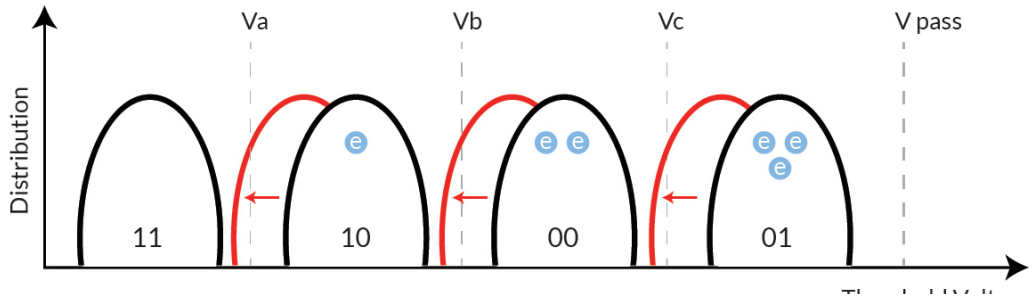
Graph 1: Read Disturb

Data Retention

The ability of NAND flash to store electrons is limited, and the stored electrons will slowly leak over time. When electrons leak, ECC errors occur, and data is lost. There are three main reasons why data retention is an issue for NAND flash. Due to the flash cell's structure, higher temperatures will cause data to degenerate at an extremely high rate. Additionally, heavy writing environments further exacerbate the data retention problem; as the number of P/E cycles increases, the cell further weakens, leading to reduced data retention capacity.

Since both program and erase operations of NAND use high electric fields, the oxide layer around the floating gate in the cell may degrade over time as the number of P/E cycles increases. This is especially true for the tunnel oxide layer below the floating gate.

Using 100 bits of error as the retention standard, after 2200 P/E cycles, data retention is about 48 days, but after 3200 P/E cycles, data retention is lowered to around 16 days.



Graph 2: Data Retention

Solutions

Innodisk's iRetention 2.0

Innodisk's iRetention 2.0 technology consists of preventative and corrective features to combat flash's data retention and read disturb shortcomings. Together these technologies virtually eliminate the risk of SSD data loss and improve data retention for Innodisk's customers.

Preventative

Dynamic micro-charging periodically and sequentially picks a block and randomly reads a page. This micro charges all the cells in the block once through the read action, which offsets the negative effects of retention. Similarly, smart read performs a read task across the whole SSD during boot up, in exchange for better data integrity in future reading cycles.

Dynamic scan regularly scans the SSD to detect potential defective data, and performs the refresh process, which involves flushing and recharging pages to renew the lifespan of each piece of data inside.

Corrective

Fast read retry prioritizes a few high hit rate retry combinations in the read retry process to achieve a higher success rate, reducing retry time.

Dynamic normal threshold voltage sets the previous successful retry combination to the default normal read value. This ensures a successful normal read the first time, which avoids going into a read retry loop.

Conclusion

Despite the risks that read disturb and data retention pose to customers, Innodisk's iRetention 2.0 solution, featuring five preventative and corrective measures helps combat, and virtually eliminate data loss. With iRetention 2.0 now being the standard for new Innodisk SSDs, customers need not worry about read disturb and data retention.

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