Paper: Flash Memory

Martin Karrer, *Student - University of Innsbruck*

Contents

This paper is supposed to give a short overview of some of the most interesting cases of usage of "Flash Memory", the Hardware and also a short insight to the purposes of ash memory. In this overview, we cannot discuss all of the interesting features and I will not be able to satisfy the needs of a hardware prospective. For more detail and if someone wants to look below the surface I recommend the IEEE Papers.[1]

1 Introduction

Flash memory is a type of electrically erasable programmable read-only memory (EEPROM[2]). [4] flash memory becomes more and more important in this communication age. You, Dear Reader, also may have a flash memory in your Hand, if you read the hard copy of this Paper, the flash memory may is in your pocket. Nowadays flash memory is everywhere - in smartphones, tablets, notebooks and even within the new stove of my mum's kitchen. The flash memory sector continues to expand and it seems there is no better alternative at the Moment for a fast storage. The next sections will cover, what a flash storage is, how it works and also what are the advantages and the purpose of use/designated use are.

2 What is a "Flash Memory"?

In computer science a life without an flash memory would be possible but really slow and not as comfortabel as we know it at the moment. The Reason is: flash storgaes devices are small, fast, shock robust, also energy efficient and silent. A Flash Memory is used to store Data, to keep them and to reuse the Information again. Nowadays it is used like an harddrive, because the features of an flash drives are used to build mobile devices and embedded systems fast, efficient and small. SolidStateDrives (aka SSD), which are top sellers [11], are also a flash storage type called NAND.

3 Different Types of Flash Memory

As we learned above (or already knew) - there are different types of flash memory. IEEE is using the phrase "Flash Memory" only for non-volatile Memory, so the RAM is according to this definition not a so called Flash Memory.

3.1 Floating Gate Transistor Flash

In flash memory, each memory cell resembles a standard MOSFET [3], except for the transistor, it has two gates instead of one. The Floating Gate Transistore Flash Memory is the base of every flash memory structure like NAND and NOR memory. The big disadvantage is, that you need very high Voltage to erase memory cells, which the newer memory techniques eradicated. [3]

3.2 NOR Flash

In NOR gate flash, each cell has one end connected directly to the ground, and the other end connected directly to a bit line. This arrangement is called "NOR flash" because it acts like

[1] Some good Papers are listed in Reference
[2] Electrically Erasable Programmable Read-Only Memory
[3] MetalOxideSemiconductor Field-Effect Transistor

a NOR gate. NOR flash memory supports one-byte random access, which allows machine instructions to be retrieved and run directly from the chip, in the same way a traditional computer will retrieve instructions directly from main memory. [4]

3.2.1 Advantages

One of the biggest benefits is getting the data in and out very easily and without using a big logic or controller-software. It is the best use for an Microcontroller Storage and also for embedded systems with less resources. Sometimes a NOR storage chip offers a Read-While-Write feature, which can be really awesome and save some time for a single file request. [8]

3.2.2 Disadvantages

The storage can only read in random access. The Floating Gates in an NOR flash doesn't have such a high endurance as the NAND Storage. After 10.000 to 100.000 a memory cell will be irreparable damaged and can't be used anymore. [8] Intelligent Software has to recognise the failure of the hardware and should mark the block as "dead", so the memory will get smaller and smaller. The Storage isn't optimized for very high I/O rate, because the oxide layer will be damaged every erase cycle. It is only available in a very small capazity (max 1Gbit).

3.3 NAND Flash

NAND flash architecture was introduced by Toshiba in 1989. These memories are accessed much like block devices, such as hard disks. Each block consists of a number of pages. The pages are typically 512 [6] or 2,048 or 4,096 bytes in size. Associated with each page are a few bytes (typically 1/32 of the data size) that can be used for storage of an error correcting code (ECC) checksum. [4]
The Typical Block Size is: 128 pages of 4,096+128 bytes each for a block size of 512 KB. [2]

3.3.1 Advantages

It is more robust against erasing blocks. In an NAND memory you can delete 1 up to 10 Million times a block. [10] Lower price per megabyte, also a very high read and write rate. Also a big advantages in this mobile age is the power consumotion. NAND Storage is very energy efficient, and also produces less heat. NAND storages are offering high storage capacities. (todo: up to 3TB per SSD) [7]

3.3.2 Disadvantages

One of the biggest disadvantges is the software effort to get the data in and out of the chip. So it isn't easy to use this type of memory for an direct storage on an microcontroller. Also often written blocks can get corrupt or defect.

4 Usage

4.1 Consumer

Private and company customers have big interest in flash memory especially in SSD. Now they are cheap and very fast. It's very easy to get an older PC faster with an HDD

to SSD exchange. [9] Some Papers are calling the SSD the Afterburner for new and old PC's. [1] [5] [8]Also USB-Thumb Drives and SD-Cards for a camera or mobilephone are falsh memories. They are getting smaller with more capazity and cheaper. [5]

4.2 Server Infrastructure

In modern Filesystems SSD drives are often used as a Cache (mostly HotSwapCaches). For Example in an ZFS File System you can add an remove an SSD as an Cache without an Problem. [12] Also the extremely expensive ServerSSD are often used in HighPerformance Machines or in Stand-By Hosts because they have to boot up extremely fast. [13]

References

[1] *NAND Evolution and its Effects on Solid State Drive Useable Life*. Western Digital, 2009.

[2] Nitin Agrawal, Vijayan Prabhakaran, Ted Wobber, John D Davis, Mark S Manasse, and Rina Panigrahy. Design tradeoffs for ssd performance. In *USENIX Annual Technical Conference*, pages 57–70, 2008.

[3] Roberto Bez, Emilio Camerlenghi, Alberto Modelli, and Angelo Visconti. Introduction to flash memory. *Proceedings of the IEEE*, 91(4):489–502, 2003.

[4] Wikipedia Commonity. Flash storage memory, June 2014.

[5] Zsolt Kerekes. Charting the rise of the solid state disk market.

[6] Jesung Kim, Yookun Cho, Jesung Kim, John Min Kim, Sang Lyul Min, and Sam H. Noh. A space-efficient flash translation layer for compactflash systems. *Proceedings of the IEEE*, 48"(2):366–375, 2002.

[7] AnAndTech lal Shimpi. Ocz z-drive 3tb ssd.

[8] Seung-Ho Lim and Kyu-Ho Park. An efficient nand flash file system for flash memory storage. *Computers, IEEE Transactions on*, 55(7):906–912, 2006.

[9] Lyth0s and Lyth0s. *SSD vs. HDD*. elitepcbuilding.com, 2011.

[10] Chanik Park, Prakash Talawar, Daesik Won, MyungJin Jung, JungBeen Im, Suksan Kim, and Youngjoon Choi. A high performance controller for nand flash-based solid state disk (nssd). In *Non-Volatile Semiconductor Memory Workshop, 2006. IEEE NVSMW 2006. 21st*, pages 17–20. IEEE, 2006.

[11] StorageNewsletter.com. Market report ssd. http://www.storagenewsletter.com/rubriques/market-reportsresearch/ihs-ssd-2012/, January 2014.

[12] OpenZFS Development Team. *Performance Tuning*. OpenZFS, Open-ZFS.org, v1.31 edition, March 2014.

[13] Dimitris Tsirogiannis, Stavros Harizopoulos, and Mehul A Shah. Analyzing the energy efficiency of a database server. In *Proceedings of the 2010 ACM SIGMOD International Conference on Management of data*, pages 231–242. ACM, 2010.