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STUDY ON 3DX POINT MEMORY

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Abstract*--Memory storage and memory accessing always play a key role in the field of computers. There was always a need for high performance and nonvolatile memory. With the use of existing memory storage devices, the user is made to compromise in any of these aspects like cost, speed, or volatility. So a lot of research is being done on this field and there were many inventions in the timeline. One of the latest inventions in this field made by the Intel and Micron Technology is 3D X point memory (pronounced as three Dee cross point). 3D X point memory arrival had fundamentally changed existing the memory storage hierarchy at the hardware, application levels, and system software [5]. This memory technology will be able to meet most of the needs of users. 3D X point memory was brought into effect as a block addressable storage device and this storage device will be known as Intel Optane SSD. 3D X point memory technology is a breakthrough in-memory process technology and the first new memory category since the introduction of NAND flash in 1989. 3D X point technology combines density, performance, non-volatility, power, and cost advantages of all the available memory technologies on the market today.

Keywords: Non Volatile Memory, Volatility, Hierarchy, Point Memory, SSD.

I.INTRODUCTION

Memory refers to storing information and accessing when required. For many decades computer memory is being stored in metal-oxide-semiconductor memory cells on silicon integrated chips. Computer memory is divided into two types.

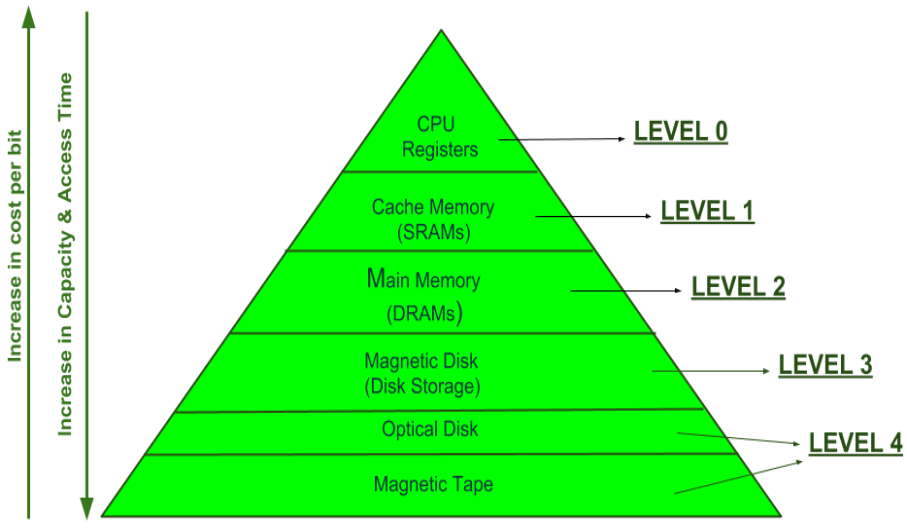

Fig 1. Memory Hierarchy Design

They are Volatile and Non-volatile. The nonvolatile memory is a slow memory and stores data even without power supply. Flash Memory, ROM, PROM EPROM, hard disks, etc., come under this category [3]. The non-volatile memories are far away from the CPU and require more time for accessing data. The volatile memory is fast but needs a continuous power

supply. The memory type DRAM and SRAM comes under this category. Volatile memories are close to the CPU, so we can access data in less time when compared to non-volatile memory.

From the above figure, we can observe that a decrease in access time, increases the cost per bit, and decreases the space available. Storage can be said as a better storage memory when it is fast, cost-effective, and non-volatile. The existing Dynamic Random Access Memory (DRAM) is fast and volatile but very expensive. And also its density is doubling every two years. The NAND memory which is used in Solid State Devices (SSD) is cost-effective and nonvolatile. Though NAND is 1300 times faster than hard drives but 1500 times slower than DRAM. So NAND has a speed disadvantage. To overcome these problems 3D X point memory was introduced by Intel and Micron Technologies in the year 2015 after three years of developing efforts. It was made available in the markets since 2017.

3D X point memory is a non-volatile memory whose bit storage is based on the change of bulk resistance. The speed and endurance of 3D X point memory are a thousand times larger than NAND and 1o times denser than conventional memory. The special feature of 3D X point memory is the replacement of transistors by threshold switches as selectors in memory cells. The merits of this 3D X point memory are

- *Cross Point Array Structure:*
  The bit line and word line connect 128 billion densely packed memory cells which stores one bit of data. This structure results in high performance and high density.
- *Stackable:*
  The initial technology stores 128 gigabytes of data. By increasing the number of layers stackable we can also increase the storage level.
- *Selector:*
  Memory bits can be read or write by varying the voltage sent to the selector. This process has eliminated the use of transistors which lead to an increase in capacity and reduction in cost.
- *Fast Switching Cell*
  Due to small cell size, fast switching selector, low latency cross-point array, and fast write algorithm, the cell is capable of switching states than any other existing non-volatile memory technologies.
- 3D X point memory technology performance is higher than NAND but not as high as DRAM.
- Its cost lies in between DRAM and NAND memory. It gives higher storage density than NAND
- It offers persistent memory, unlike DRAM
- 3D XPoint SSDs are faster than conventional NAND-based SSDs
- Low-cost DRAM substitute.
- Enables to change single bit data easily.

II.LITERATURE SURVEY

In the past, there are various types of memories. The table below gives information about past invented memories.

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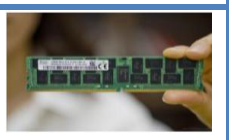
Type of Memory	Year of development	Invented By	Volatile/Non-volatile	Pictures
Random Access Memory (RAM)	1947	William Tube **Developed By :** University of Mancster, England	Volatile	
Programm-able Read-Only Memory (PROM)	1956	Wen Tsing Chow **Productized:** American Bosch Arms Corporation	Non-Volatile	
Static Random Access Memory (SRAM)	1961	Bob Norman **Productized:** Jay Last	Volatile	
Dynamic Random Access Memory (DRAM)	1966	Dr. Robert Dennard at IBM Thoms J. W. Research Center	Volatile	
Erasable Programm able Read-Only Memory (EPROM)	1971	Dov Frohman, Intel	Non-Volatile	
NOR Flash Memory	1984	Dr. Fujio Masuoka **Productized:** Intel	Non-Volatile	
NAND Flash Memory	1989	Dr. Fujio Masuoka **Productized:** Toshiba	Non-Volatile	

The initiation for development of 3d X point memory was started in 2012 and completed by 2015. Previously Intel and Micron together had developed many phase changed memories. 3d X point is the one that differs from all the previous memories. According to Simoneraoux, Fengxiong, Mattiaswutting and Eric pop, phase change memory is the emerging technology that combines all unique properties of phase change materials with the memory devices to build the new computer architectures [6].they used chalcogenide materials to build the storage and selector parts of the memory cell, which makes them a faster and stable working of 3dx point technology. In 3dx points, they used threshold switches as selectors instead of transistors [4]. 3dx point is not based on memristor technology. It works by changing bulk property and it changes the resistance level of a cell and it differentiates between 0 and 1[1]. There is a fundamental difference between the 3d XPoint and NAND. According to Jihangliu and Shiman Chen, 3dx point is the first commercially available main memory targeting for the computer [2]. They tested the AEP machines, they noticed it has two modules of 3d XPoint and they

named /dev/pmemX, where X is the number. Optane is based on 3D X point memory technology.3dx point is 1000x faster and 1000x more endurable than NAND memory [7] and 10x denser than conventional memory. In DRAM We just have memory and its latency is 10x and the size of data is 100times NAND. We have only stored the data, its latency is 100,000x and size is 1,000x.3d x point is the combination of accessing the memory and string the memory, its latency is 100x and size of the data is 1,000x.it is the biggest revolution in the era of memory .3d x will be the future memory used to build in every computer architecture.

III.CONSTRUCTION 3D X POINT MEMORY

3D X point memory is made by packing lots of capacity into a tiny footprint. The construction process is started by slicing sub microscopic layers of chalcogenide material into columns. Each column contains memory cell and selector as shown in figure 2. Then all the selectors and memory cells are connected through perpendicular wires in a cross structure. The wire at the selector side is bit line and the wire at the bottom is a word line. This enables memory cells to be individually addressed by selecting one layer on top and another at the bottom.

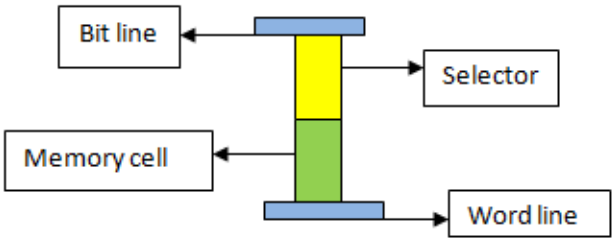


Fig 2. Parts at each column of 3D X point memory

We stack these memory grids three-dimensionally to maximize density as shown in figure 3.

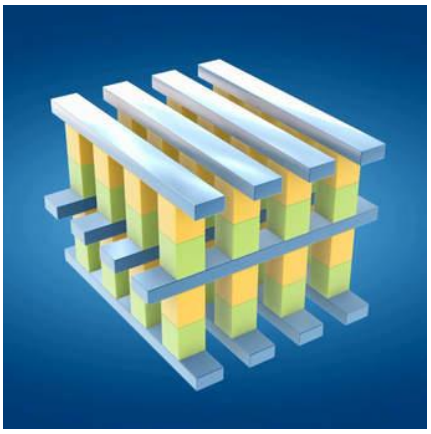


Fig 3. Three dimensionally stacked memory cells.

The density of 3D X point memory is high because we will not use transistors at each memory cell as in the case of DRAM to access each cell. The use of transistors at each level is one of the main reasons for the increase in the cost of DRAM.

IV.WORKING

3D X point memory technology works on the changing voltage of the metal lines. The selector and memory cell lies between the word line and bit line. Each cell has a capacity of storing a single bit of data. A memory cell is made to represent either '1' or '0' through the property

change of material of the cells which changes the resistance level of the memory cell. This cell can either be high or low resistance state and changing the resistance level of the cell can be read as either '1' or '0'. Applying voltage on the word and bit line they can be accessed for reading and write operations. When we apply voltage the selector activates. For a write operation, a specific voltage has to be sent to activate the selector. This voltage activates the selector and initiates bulk property change. For a read operation, different voltage is sent to read whether the cell contains high or low logic. The figure shows the voltage transmission in 3D X point memory. This is the working of 3D X point memory.

Fig 4. Voltage transition in 3D X Point

Experts say that 3D X point technology can influence computer-related fields like

- Video gaming
- Digital Media production
- Telecommunications
- Health care

V. CONCLUSION

We are generating lots of data every year. We have to choose a source that can be capable of storing all this data effectively. 3D X point memory technology can solve that problem to some extent. The AMR has surveyed the growth of 3D X point technology, it predicted that it will have enormous growth in the 2019-2025 period. From the past four years, 3D X points have an annual growth rate of 15 million dollars. Analysts stated that in the next few years, its market will expand more, and its annual growth increases by 2024. The possibilities of 3D X point are almost limitless and with it, we may soon reach a future of computing thought a decade away.

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